FIJI
FISHERIES RESOURCES PROFILES

Compiled by Andrew Richards[1] with contributions from
Maciu Lagibalavu[2], Subodh Sharma[2] and Krishna Swamy[2]

FFA Report No.94/4

[1]Research Coordination Unit, Forum Fisheries Agency

[2]Fiji Fisheries Division, Ministry of Agriculture, Fisheries and Forestry

PREFACE

The South Pacific Forum Fisheries Agency (FFA) was approached by the Fiji Fisheries Division, Ministry of Agriculture, Fisheries and Forests 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:

? With assistance from national fisheries staff, examine all closed and current files pertaining to fisheries resource matters in Fiji;

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

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

? Based on the information examined, produce a comprehensive set of resource profiles for the fisheries and marine resources of Fiji.

The report was prepared before, during and after a three week visit of FFA's Research Coordinator, Mr. Andrew Richards to Fiji in October/November 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 Fiji. 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 previously prepared Fishery Resource Profiles (Lewis, 1985a), and to Fiji Fisheries Division Annual Reports for the years 1985-1992. Tim Adams provided useful comments on a draft of this report. The Fiji Fisheries Bibliography (McDowell *et al.*, 1993) was an invaluable source of information.

Funding for this report was provided by the International Centre for Ocean Development of Canada. Opinions, where expressed, are those of the FFA Research Coordinator and in no way reflect the policy of FFA or the Fiji Fisheries Division, Ministry of Agriculture, Fisheries and Forests.

LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR	Australian Centre for International Agricultural Research
ACP	African, Caribbean and Pacific
ASEAN	Association of South East Asian Nations
AUD	Australian Dollar
BIDC	Business and Industrial Development Committee
C.I.F.	Cost, insurance and freight inclusive quotation
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE	Catch Per Unit Effort
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DWFN	Distant Water Fishing Nation
EEZ	Exclusive Economic Zone
FAD	Fish Aggregation Device
FAO	Food and Agriculture Organisation of the United Nations
FFA	South Pacific Forum Fisheries Agency
F.O.B.	Free On Board
FJD	Fiji Dollar
FTIB	Fiji Trade and Investment Board
GDP	Gross Domestic Product
IDA	Inside Demarcated Areas
ICOD	International Centre for Ocean Development
IMR	Institute of Marine Resources (USP, Fiji)
IOI	International Ocean Institute, South Pacific Regional Operation Centre
IUCN	International Union for the Conservation of Nature
JCU	James Cook University of North Queensland
JICA	Japan International Cooperation Agency
JOCV	Japan Overseas Cooperation Volunteer
MAFF	Ministry of Agriculture, Fisheries and Forests (Fiji)
MMDC	Micronesian Mariculture Demonstration Centre
MOP	Mother-Of-Pearl
MSP	Marine Studies Programme (at USP)
MSY	Maximum Sustainable Yield
NATCO	National Trading Corporation (Fiji)
NRS	Naduruloulou Research Station
N.Z.	New Zealand
ODA	Outside Demarcated Areas
PAFCO	Pacific Fishing Company Limited (Fiji)
PNG	Papua New Guinea
RAP	Rural Aquaculture Programme
SCUBA	Self Contained Underwater Breathing Apparatus
SPC	South Pacific Commission
SPADP	South Pacific Aquaculture Development Project
TBAP	Tuna and Billfish Assessment Programme
UNCLOS	United Nations Convention on the Law Of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
US/USA	United States of America

USD	United States Dollar
USP	The University of the South Pacific
VAT	Value Added Tax
YPR	Yield Per Recruit

TABLE OF CONTENTS

SUMMARY

Fiji comprises about 844 islands and islets (approximately 106 inhabited), scattered in the area 15º - 23º S, 177º E - 178º W. The main archipelago has a total land area of approximately 18,333 km^2, of which 87 per cent is accounted for by Viti Levu (10,386 km^2) and Vanua Levu (5,534 km^2). It is estimated that the population at the end of 1989 totaled 726,000; comprising 352,000 Fijians (48 per cent), 338,000 Indians (47), 18,000 Others (2), 10,000 Part Europeans (1), 4,000 Chinese and 3,000 Europeans. The total population in the year 2000 is forecast to reach 805,500. Fiji's Exclusive Economic Zone (EEZ) has an area of 1.26 million km^2.

Responsibility for fisheries matters lies with the Ministry (Minister) of Agriculture, Fisheries and Forests. Within this Ministry, the Director of Fisheries oversees the work of the Fisheries Division of the Department of Agriculture and Fisheries, which has its headquarters at Lami, on the western outskirts of Suva. Fisheries Division has Divisional offices in Lautoka (Western Division), Labasa (Northern Division), Nausori (Central Division) and Lami (Eastern Division). Respectively, these service subsidiary offices in Rakiraki, Tavua, Ba and Sigatoka (Western); Taveuni, Savusavu, Lekutu and Nabouwalu (Northern); Navua and Wainibokasi (Central) and Lakeba, Vunisea and Levuka (Eastern). The Fisheries Division also has fisheries research stations at Naduruloulou and Dreketi (freshwater aquaculture), Laucala Bay (product development) and Makogai Island (mariculture).

Fiji is host to several regional and international institutions and organisations which have an interest in the fisheries sector. Foremost among these is the University of the South Pacific, which offers courses in fisheries related subjects through its Institute of Marine Resources.

The laws relating to marine resources in Fiji are enshrined in Chapters 158, 158A and 149 of the Laws of Fiji. Chapter 158, the Fisheries Act, recognises the Fijian people's customary right to fish in traditional fishing grounds (**qoliqoli**), and allows the owners of customary fishing rights to advise the District Commissioner and Fisheries Division which commercial fishermen shall be allowed to fish in their area and to impose restrictions on commercial fishermen. Fisheries Division is responsible for providing advice on their fisheries to customary fishing rights owners and issuing fishing licences to commercial fishermen. It is also responsible for enforcing fisheries laws inside and outside the reef. Licences to fish in customary fishing rights areas are only issued to fishermen who have already obtained a permit from the head of the relevant ownership unit. Two types of licences are therefore issued: Inside Demarcated Areas (IDA) and Outside Demarcated Areas (ODA).

The Minister for Agriculture, Fisheries and Forests may make regulations under the Fisheries Act relating to the management of fisheries resources, which after Cabinet discussion and approval, are promulgated by publication in the Fiji Gazette. Fisheries Division relies on traditional administrations to take responsibility for the regulation of inshore fisheries, while it concentrates on the deep-sea fisheries, mainly those for tuna and deep water bottom-fish. Fisheries Division also has a network of Honorary Fish Wardens, appointed by the Minister on the request of the head of the unit which owns the customary fishing rights, their duties being centred on the prevention and detection of offences under the Fisheries Act and the enforcement of the provisions of the Act.

There is increasing emphasis on management and control of resources and acknowledgment of a need to encourage fishermen to fish offshore, so as to preserve inshore resources. The broad objectives for the development of Fiji's fisheries sector are to:

- further develop fisheries of the EEZ and territorial waters;

- improve quality of and increase value added to exports;
- regulate and control all fisheries on the principles of optimum utilization and long-term sustainability;
- encourage the implementation of sound business management methods by, and cooperation between, local fishermen and to devolve governmental activities to the private sector as far as possible.

Fisheries Division recognises four primary sub-sectors of the fisheries sector:

- The industrial fishery, which operates on a large-scale and is primarily export-oriented. It includes the Pacific Fishing Company (PAFCO) tuna cannery at Levuka, and tuna capture and supply by both local and overseas vessels. The deep-water snapper and domestic tuna longline fisheries have been included in this category since 1990.
- The artisanal fishery, which includes most small-scale commercial production for domestic sale. It is a significant source of domestic fish supply and employment.
- The subsistence fishery, involving catches for home consumption, with the occasional sale of surplus catch.
- Aquaculture, which is gradually moving out of the experimental stage and has the advantage of not being based on limited natural resources.

Sections of the industrial fishery, particularly the domestic tuna longline fishery, have been successful over the past few years. The concern by Local Administrations and the tourist industry over the possible effects on reef fish stocks by tuna bait-fishing, while having been addressed by Fisheries Division through a research programme, is still a potentially negative factor in consideration of the future profitability of the domestic pole-and-line tuna fishery.

There are continuing concerns regarding the artisanal fishery and its effects on Fiji's nearshore resources. Area closures and bans on gill-netting for reef fish, particularly in the north and west of the country, seem to have been effective in restoring stocks of some groups, such as **nuqa** and **kanace**. The promotion of Fish Aggregating Devices (FAD) by Fisheries Division may have been effective in shifting fishing pressure away from demersal reef fish to pelagic species.

For non-fish species, recent surveys and export information suggest that stocks of some sedentary organisms such as **civa**, **sici**, **vasua** and **dairo** are generally in very poor condition. Part of the reason for this is thought to be the previously uncontrolled proliferation of the use of hookah underwater diving equipment. However, adverse effects on the nearshore habitat of these and other species by water-borne pollution, dredging, removal of sand and degredation of existing mangrove stands, is likely to be another significant factor. Information from markets and non-market outlets suggests that the stocks of some non-fish species, such as **qari** and **kai** , may be in reasonable condition. Stock assessment surveys will be required to verify these assumptions.

The subsistence fishery is extremely important, supplying a large portion of the protein requirements of the rural population. Though the size of the subsistence catch is not known with any certainty, it is thought to be between 10,000-20,000 mt per year. The results of a subsistence fisheries survey of 2,553 households among Fijian villages and Indian settlements conducted during 1993 is expected to greatly refine this estimate.

The management of nearshore fisheries, both artisanal and subsistence, vested as it is with traditional fishing rights owners, will need to be geared towards co-management between these

owners and Fisheries Division. Fisheries awareness programmes could be used to emphasise the positive aspects of community-based management, which draws on scientific information about the various resources provided by government officers working closely with resource owners.

The Rural Aquaculture Programme (RAP) has shown that despite Fiji's long but inconsistent involvement with aquaculture, solid extension work can bring about successful production of farmed fin-fish. Despite several attempts by the government to promote the commercial culture of red seaweed by villagers, this aquaculture programme has not been sustainable. Extremely low prices for commercial seaweed, combined with shipping costs from Fiji to markets in Denmark, have meant that commercial red seaweed farms are simply unprofitable in Fiji, and the situation is unlikely to improve. There may be opportunities for the commercial culture of edible seaweeds, and these should be further investigated.

The Fiji Trade and Investment Board (FTIB), a statutory body, administers a series of incentives for potential investors. The FTIB liaises with relevant Government departments in making its final appraisal of proposals. Information on the known or suspected status of several commercial marine and fresh-water species has been supplied by Fisheries Division to FTIB to assist in the evaluation of investment proposals. In general, proposals most likely to be supported are those concentrating on resources which occur outside customary fishing rights areas; those which involve collection, processing and marketing of resources currently being exploited, and fish farming. The stocks of several of Fiji's nearshore fisheries resources are suspected to be in very poor condition. For this reason, careful selectivity will continue to be required in investment in their development and exploitation.

A. BACKGROUND

A.1 THE COUNTRY

Fiji comprises about 844 islands and islets (approximately 106 inhabited) scattered in the area 15º - 23º S, 177º E - 178º W. The country is divided into 14 provinces and Rotuma, and the islands may be divided into several distinct groups: Rotuma; Vanua Levu and associated islands, including Taveuni and the Ringgold Islands; the Lau Group; the Lomaiviti Group; the Yasawas; Viti Levu and associated islands; and Kadavu and associated islands.

The main archipelago comprises a total land area of 18,333 km^2, of which 87 per cent is accounted for by Viti Levu (10,386 km^2) and Vanua Levu (5,534 km^2). Other large islands are Taveuni, Kadavu and Gau. The shelf area to 200 m is approximately 15,000 km^2. Apart from the Eastern Division, the islands consist almost entirely of volcanic and plutonic rocks of various ages which have been subjected to degeneration and soil formation under typical tropical conditions of intense weathering.

The Fiji group lies within the influence of the predominantly westward-flowing, south sub-tropical currents. The strength of the surface currents depends mainly on the strength and regularity of the south-east trade winds, and is most marked from September to November. Its rate seldom exceeds one knot. Water temperatures are always above 20º C, with a summer ocean maximum of about 30º C and a mean annual variation of about 6º C. Tidal range is very small, neap tides having a mean range of 0.9 m and springs of 1.3 m. Tides are semi-diurnal with the lower low-water springs falling during the night in summer but during the day in winter.

The climate is tropical with high humidity, and temperatures may rise to 35º C, but these are modified by the south-east trade winds from May to November. Spells of northerly and north-westerly winds occur during the hurricane season from December to March, when light and variable winds predominate. Strong trade winds from September to December restrict fishing operations. The summer is hot and wet with several tropical cyclones while the winter months are drier and cooler. Mean monthly temperatures range from 23º C in July and August to 27º C in January. Annual rainfall is unevenly distributed owing to the rain shadow caused by the mountains and high plateaux (1,200+ m) of the larger islands (mean 3,000 mm on the east coast, 1,650 mm on the west coast) (UNEP/IUCN, 1988).

A.2 THE PEOPLE

Fiji is populated principally by Fijians and Indians, with Part Europeans, Chinese, Europeans and Others being the other categories recorded. According to archeological evidence, Fiji was originally settled in three different waves of migration, the earliest wave dating from about 1600 BC. Though scientists disagree about exactly when the forebears of Fijians first arrived, it is generally agreed that these people came from the New Britain area (now belonging to Papua New Guinea) and were most likely ancestors of present-day Polynesians. They practised agriculture, raised pigs, and fished.

A second wave of migration to the area may have come between 400 and 100 BC followed by a final massive movement from Melanesia in 1000 to 1800 AD. This wave of people practised a sophisticated form of terraced agriculture, which helped support a large population that may have risen to 200,000. People grew yams and taro, fished and evolved a highly developed culture (Kay, 1990).

Throughout much of the pre-colonial era, the Lau group of islands were enormously influential in determining the direction Fiji took. Many of the traditional chiefs of Fiji trace their lineage and connection to Lau and further east to Tonga. So while most Fijians may appear very much like Melanesians, especially to outsiders, the society's structure and much of the culture remain distinctly Polynesian.

Fiji's first sustained contact with Europeans came with the sandalwood rush of 1804-1810. The second stage, which lasted from the 1820s to the 1850s, came about from the sea cucumber (bêche-de-mer) trade. The latter contact had a greater impact on Fiji, as it was more widespread and longer lasting than the sandalwood trade and involved far more Fijians as labourers. By 1870, the European population numbered more than 2,000.

Fiji was ceded to Great Britain in 1874 and was a British Colony between 1874 and 1970. The island of Rotuma at 12? 30' S, 178? E was added to the colony of Fiji in 1881. After becoming a British colony, the establishment of sugar-cane plantations led to a serious labour shortage. The colony's first governor, Sir Arthur Gordon, convinced the planters to bring Indians to Fiji as plantation labourers. Between May 1879 and November 1916 when the final labour transport ship arrived, 60,000 people had come to work on the plantations (Kay, 1990). Fiji is now an independent Republic.

The most recent population census was in August 1986 which recorded a total population of 715,000. The annual growth rate between the 1976 and 1986 census was 2.4 per cent for Fijians, 1.8 per cent for Indians and 2.0 per cent for the total population. It is estimated that the population at the end of 1989 totaled 726,000, comprising 352,000 Fijians (48 per cent), 338,000 Indians (47), 10,000 Part Europeans (1), 4,000 Chinese, 3,000 Europeans and 18,000 Others (2) (Anon., 1993a). It is estimated that the total population in the year 2000 will be 805,500 (Doyle *et al.*, 1993).

A.3 THE ECONOMY

A.3.1 Recent Economic Performance

The economy of Fiji is considered to be more diversified and developed than that of most South Pacific countries. It is primarily agrarian, with subsistence farming on a village level still an important way of life for much of the population. Siwatibau (1993) describes Fiji's export base as "narrow", in common with most neighbouring countries in the region. The largest earner of hard currency is tourism, followed by sugar, the main export crop which generates up to three-fourths of export earnings, followed by coconut products and gold, generating up to half the remainder. In the first half of 1993, exports of sugar, gold, fish, timber, coconut oil, wood chips and timber earned FJD178.3 million (USD116.4 million) or 69.2 per cent of total earnings (Anon., 1993b).

Since the mid-1980s, there has been a marked diversification of fisheries exports, brought about by events such as the commercial development of the deepwater snapper export fishery and the opening up of non-fish commodity exports. The sustainability of the ranking of fisheries products in the list of Fiji's exported resources (prepared/preserved and other fish accounted for approximately 7 per cent of Fiji's total exports in 1991), will need to be based on offshore species such as tuna, since there is evidence that several of the inshore fish and non-fish stocks are under severe harvesting pressure.

In mid-1991, Fiji's Gross Domestic Product (GDP) was FJD2,635 per head of population, an increase on the GDP recorded in 1990 (FJD 2,474) and 1989 (FJD2,295). However, during the

same period the annual growth rate of GDP per head of population dropped from 15.2 per cent in 1989 to 7.8 per cent in 1990 and then to 6.5 per cent in 1991 (Anon., 1993a). The World Bank has recently reported there could by a drop in the annual growth rate of Fiji's GDP of up to 4 per cent in 1993 (Radio Australia News Report, 2 November 1993).

The declining competitiveness of Fiji's economy has been compounded by a further appreciation of the real effective exchange rate index by over 15 per cent since 1988, and an inflation rate above that of its major trading partners. The estimated inflation rate for 1993 is 5.6 per cent, up from 4.9 per cent in 1992. This is partly the result of the Value Added Tax (VAT) introduced in 1992, and partly due to the effects of cyclone Kina in 1993 (Grynberg and Forsyth, 1993).

A.3.2 Importance of foreign aid to fisheries development in Fiji

Levels of foreign aid to Fiji relative to other South Pacific countries is low, which is usually explained by Fiji's relatively high GDP per head of population. Foreign aid per capita rose sharply from AUD34 in 1987 to AUD96 in 1988, followed by a drop to AUD75 in 1989 before declining to AUD15 in 1990 (Doyle *et al*., 1993).

Adams (1989) lists overseas aid projects that relate to the development of fisheries in Fiji for the period 1979-1989 and relates aid to government expenditure, the Fiji economy and to other countries in the region. He concludes that despite the low relative level of overall foreign aid to Fiji, aid is extremely important to fisheries development in this country and is likely to continue to be so over the next decade. Given the recent rapid economic growth of the Fiji fisheries sector, it seems that it is money well spent. Foreign aid offers substantial assistance to the Fisheries Division in its task of ensuring that all the people of Fiji obtain maximum and sustained benefit from the country's fisheries and marine resources.

A.4 FISHERIES AND MARINE RESOURCES

A.4.1 Institutions

Fisheries Division

Fisheries Division is part of the Department of Agriculture and Fisheries, Ministry of Agriculture, Fisheries and Forests. Prior to 1992, the Ministry was known as the Ministry of Primary Industries and Cooperatives. The new Ministry also comprises the Department of Forestry and the Department of Cooperatives (Anon., 1993c).

Fisheries Division has its headquarters at Lami, on the western outskirts of the capital, Suva. The four administrative Divisions of Fiji are the primary organisational units and the Fisheries Division has Divisional offices in Lautoka (Western Division), Labasa (Northern Division), Nausori (Central Division) and Lami (Eastern Division). Respectively, these service subsidiary offices in Rakiraki, Tavua, Ba and Sigatoka (Western); Taveuni, Savusavu, Lekutu and Nabouwalu (Northern); Navua and Wainibokasi (Central) and Lakeba, Vunisea and Levuka (Eastern). The Fisheries Division also has fisheries research stations at Naduruloulou and Dreketi (freshwater aquaculture), Laucala Bay (product development) and Makogai (mariculture) (Anon., 1993d).

The 117 established positions of the Division are allocated as follows: Administration (10), Extension and Technical Services (81) and Resource Assessment and Development (26). Nine positions have been "frozen" by the Public Service Commission, thus barring recruitment to

them. At the end of 1993, 112 of the established positions were occupied; Administration (10), Extension and Technical Services (71), and Resource Assessment and Development (31) (Fiji Fisheries Division).

Five US Peace Corps volunteer posts were attached to the Division during 1992, to assist the Rural Aquaculture Extension Programme. Peace Corps involvement with this programme commenced in 1985. A Japanese Overseas Cooperation Volunteer (JOCV) joined the Resource Assessment and Development statistical unit during 1992, one of a series of replacements which have been made since 1986. Consultancy work on marine and refrigeration engineering was provided through Taiwanese Technical Cooperation.

Several local staff members holding supernumerary positions in the Division were supported by aid funds. Until recently, a New Zealand funded Seaweed Project employed 3 staff and an Australian funded Giant Clam Project employed 6. All Giant Clam Project staff have been on local funding since the beginning of 1994. Until late 1993, a Commonwealth Scientific and Industrial Research Organisation (CSIRO, Australia) research scientist was attached to the Australian Centre for International Agricultural Research (ACIAR) funded Baitfish Research Project (Fiji Fisheries Division).

South Pacific Aquaculture Development Project

In 1985, with an offer from the Japanese Government to support aquaculture development in the South Pacific, the Food and Agriculture Organization of the United Nations (FAO) decided to institute a regional project to accelerate the development of aquaculture at national and regional levels. It was considered that a regional project would encourage the optimal use of existing capabilities and minimize the duplication of efforts, by coordinating and sharing responsibilities for research, training and information exchange.

From its base in Suva, Fiji, the South Pacific Aquaculture Development Project (SPADP) served 15 countries in the South Pacific region; Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Solomon Islands, Tokelau, Tonga, Tuvalu, Vanuatu and Western Samoa from 1986 until mid-1992. SPADP worked closely with the now-defunct South Pacific Regional Fishery Support Programme, through the sharing of office space, facilities, support staff and costs (FAO, 1993). In 1993, FAO confirmed that the Japanese Government had agreed to fund a second phase of SPADP. SPADP (II) commenced in late May, 1994, once again based in Suva, Fiji.

International Ocean Institute

The University of the South Pacific (USP), through its Marine Studies Programme (MSP) houses the International Ocean Institute South Pacific Regional Operation Centre (IOI). The Centre's primary responsibility is coordination, marketing and servicing of the IOI objective, to improve the management of oceans. In the South Pacific region, the focus is on the development of a possible alumni and regional leader network, instituting of short courses, joint research projects with the MSP and collaborating with USP on deepening of IOI's experience in distance learning (Bulai *et al.*, 1993).

A.4.2 Fisheries Resources Legislation

The laws relating to marine resources in Fiji are enshrined in the Marine Spaces Act 1978 (Cap.158A), Continental Shelf Act 1978 (Cap.149) and Fisheries Act 1992 (Cap.158) of the

Laws of Fiji. These Acts, and Subsidiary Legislation of Fiji relating to marine resources are summarised in Table 1.

Chapter 158A is "An Act to make provision for the demarcation of the marine spaces appertaining to Fiji, declaring the rights of Fiji in relation thereto; to regulate the exploitation of the resources thereof and other activities therein and to make further provision for the regulation of fishing", known as the Marine Spaces Act. This Act establishes the archipelagic waters of Fiji and a twelve nautical mile territorial sea.

Table 1 Acts and Subsidiary Legislation of Fiji relating to marine resources (After Campbell and Lodge, 1993).

Marine Spaces Act (Cap.158A)	*Revised Edition 1978*
Subsidiary legislation	*Revised Edition 1985*
s.4 Marine Spaces (Territorial Seas) (Rotuma and its Dependencies) Order 1981	LN 118/1981
s.4,6 Marine Spaces (Archipelagic Baselines and Exclusive Economic Zone) Order 1981	LN 117/1981
s.8 Marine Spaces (Notification under s.8 (charts)) 1981	LN 119/1981
s.20 Marine Spaces (Foreign Fishing Vessels) Regulations 1979	LN 137/1979
Continental Shelf Act (Cap. 149)	*Revised Edition 1978*
Fisheries Act (Cap. 158)	*Unofficial consolidation 1992*
s.9 Fisheries Regulations	*Unofficial consolidation 1992*
am. 1988	LN 113/88
am. 1990	LN 25/90
am. 1990	LN 105/90
am. 1991	LN 140/91

The Continental Shelf Act (Cap. 149) establishes and defines the Continental Shelf of Fiji in a manner consistent with the definition in the 1958 Continental Shelf Convention. The area between 15? 30' S and 21? 30' S and 176? 30'E and 178? W has been designated as an area to which the provisions of the Continental Shelf Act apply.

Chapter 158 is entitled, "An Act to make provision for the regulation of fishing", but is usually cited as the Fisheries Act. There have been several reviews of the Fisheries Act, the most recent in 1985.

Although the sea-bed is Crown property, the Fisheries Act recognises the Fijian people's customary right to fish in traditional fishing grounds (**qoliqoli**), generally from the outer edge of the reef to the shore. Customary land-owing family groups are known as **mataqali**. All Fijians have the right to fish in their own **qoliqoli** to catch fish for their own consumption. The Act also allows the owners of customary fishing rights to advise the District Commissioner and Fisheries Division which commercial fishermen shall be allowed to fish in their area and to impose restrictions on commercial fishermen. The customary fishing rights law is executed by the Native Lands and Fisheries Commission, District Administrations, and Fisheries Division.

Access to traditional fishing grounds by commercial fishermen may be gained by the provision of royalty payments, also called "goodwill money". Fong (1994) notes that these payments do not appear to have explicit statutory support, but are widespread in practice. "Varying amounts are rumoured, (e.g. Kubuna FJD1,000 and Ba FJD500 per annum) but no one really knows the charges throughout Fiji" (Fong, 1994).

The Native Lands and Fisheries Commission has the responsibility of arranging for the survey of fishing rights areas, holding inquiries to settle boundaries with traditional owners, maintaining a register of all owners and handling appeals. The District Administration is responsible for deciding, in consultation with customary fishing rights owners and Fisheries Division, which commercial fishermen shall be allowed to fish in customary areas. Fisheries Division is responsible for providing advice on their fisheries to customary fishing rights owners and issuing fishing licences to commercial fishermen. It is also responsible for enforcing fisheries laws inside and outside the reef (Fiji, Ministry of Agriculture, Fisheries and Forestry).

Licences to fish in customary fishing rights areas are only issued to fishermen who have already obtained a permit from the head of the relevant ownership unit. In practice, permits may be issued at a higher level (**yavusa**) than the individual **mataqali** level. Beyond the reef, such conditions do not apply. Two types of licences are therefore issued: Inside Demarcated Areas (IDA) and Outside Demarcated Areas (ODA) (Lewis, 1985a).

A.4.3 Educational Institutions

The Ministry of Education has responsibility for education in Fiji. Re-created in 1991, the Ministry oversees pre-school, primary, secondary, technical and vocational education, teacher training and a variety of ancillary and support services. Included in the latter category are the Nasinu Residential College, Fiji Institute of Technology, careers services, School's Broadcast Unit, Curriculum Development Unit, Educational Resources Centre, Fiji Museum and Fiji Arts Council (Anon., 1990a).

Fiji's education system compares favourably with those of most of its neighbours in the South Pacific. Enrolment is nearly 100 per cent for primary school children and tuition for grades one to eight is free. Classes are taught at first in the pupil's parent tongue, and later in English when the pupil's grasp of English is sufficient to make it the medium of instruction.

There are two kinds of primary schools in Fiji; those catering for Classes 1-6 and those for Classes 1-8. In 1991, there were 144,000 children taught by 4,672 teachers in 681 primary schools, 98 per cent of which were owned by non-government organisations. Secondary schools cater for students from Forms 1-7. In 1990 there were 142 secondary schools; 214 offered education up to Form 4 level, 93 up to Form 6 and 35 up to Form 7. There were 2,684 teachers serving in these schools, with 52,000 students (Tauvoli, 1993). There are 37 vocational schools, where training includes courses in engineering, maritime studies, telecommunications, agriculture, carpentry, hotel and restaurant management, and business. (Kay, 1990).

At the tertiary level, there is a government teacher's college for primary school teachers, two other teacher's colleges owned by religious bodies, and a university, The University of the South Pacific (USP). USP, established in 1969 as a regional university, has an annual enrolment of about 2,500 students from throughout the Pacific, including approximately 250 Fiji students. It is funded primarily by Fiji and grants from overseas. There is also a separate Fiji School of Medicine, associated with USP.

Since the establishment in 1978 of the Institute of Marine Resources (IMR) at USP, the training of fisheries personnel from the South Pacific region has been an important role of the university. A total of 130 candidates have completed the USP Diploma in Tropical Fisheries. Situated adjacent to IMR at Laucala Bay is the School of Maritime Studies, under the control of the Fiji Institute of Technology. The School of Maritime Studies plans to accommodate

cadet programmes required for certification of seamanship, according to national regulations in Fiji (Sutherland *et al*., 1991).

A.4.4 Management of Fisheries Resources

The Minister for Agriculture, Fisheries and Forests (previously The Minister for Primary Industries) may make regulations under the Fisheries Act relating to the management of an aquatic resource or group of resources, which after Cabinet discussion and approval, are promulgated by publication in the Fiji Gazette.

Fisheries Division relies on traditional administrations to take responsibility for the regulation of inshore fisheries while it concentrates on the deep-sea fisheries, mainly those for tuna and deep water bottom-fish. The Division plans to assist customary fishing rights owners by performing resource surveys in critical areas to provide the customary owners with the information they need to manage the fishery in their own area.

Fisheries Division also has a network of Honorary Fish Wardens, usually members of a group which owns the fishing rights area which is to be protected. They are appointed by the Minister on the request of the head of the unit which owns the customary fishing rights, their duties being centred on the prevention and detection of offences under the Fisheries Act and the enforcement of the provisions of the Act. However, the legal responsibilities of customary fishing rights owners and the government are in urgent need of definition. Harassment of commercial inshore fishermen is becoming a major problem (Cavuilati, 1993).

A.4.5 Development Plans

From 1981-1990, during the period of Fiji's eighth and ninth development plans (DP8 and DP9), the major objectives of the fisheries sector were to:

- ✍ generate further employment opportunities in the exploitation and processing of marine resources
- ✍ increase production to satisfy local demand for fish and other marine products
- ✍ increase value added in fish production for exports
- ✍ regulate and control the exploitation of fin and non-fin fishery products

To pursue these objectives, Fisheries Division promoted four major fisheries sector programmes.

1. Rural Fisheries Development Programme was designed to:
   - ✍ promote development of fisheries potential of remote regions of the country;
   - ✍ create further opportunities for employment and income generation.
2. Commercial Artisanal Fisheries Development Programme aimed to:
   - ✍ provide suitable fishing vessels to commercial fishermen to enable them to fish at greater distance from larger urban centres both inside and beyond the reef;
   - ✍ ensure adequate ice supply, storage improved marketing, fishing gear and equipment;
   - ✍ provide technical assistance, training and facilitate credit;

- ✍ provide berthing and slipping facilities.

3. Industrial Fisheries Development Programme was designed to:
   - ✍ expand the skipjack tuna industry;
   - ✍ expand the utilization of tuna processing capacity;
   - ✍ encourage alternative fishing methods such as purse-seining and longlining or a combination of such methods where applicable.
4. Rural Aquaculture Extension Programme aimed to:
   - ✍ provide an alternative protein source for the inland population;
   - ✍ release grass carp into rivers and water-ways throughout Fiji as a biological control measure for introduced water weeds;
   - ✍ provide fish fry to fish farmers as part of government support;
   - ✍ promote fish farming as a viable business and a source of employment in the rural sector;
   - ✍ provide training to fish farmers.

Fisheries Division has employed several strategies to enhance these objectives, particularly in regard to the Rural Fisheries Development and Commercial Artisanal Fisheries Development programmes. Two strategies with far-reaching effects have been the operation of the Fisheries Division boatyard at Lami where some 298 FAO-designed 8.6 m vessels have been constructed and the Rural Fisheries Training Programme which has conducted a variety of training courses since 1982, involving participants from all over Fiji (Walton, 1991).

Towards the end of DP9, Fisheries Division re-stated its position regarding fisheries development. Anon. (1989a) notes: "Given the experience of the recent past, the Fisheries Division has had to review existing policies and priorities to guide development initiatives at least for the immediate future." National priority needs were to channel development away from:

- ✍ inshore exploitation towards offshore exploitation;
- ✍ increasing exploitation towards adding value to products;
- ✍ increasing capture fisheries towards culture methods.

This change in direction of national priorities is further defined in (Anon., 1990b) a Fisheries Sector Development Plan for the 1990s, the objectives of which are to:

- ✍ further develop fisheries of the EEZ and territorial waters;
- ✍ improve quality of and increase value added to exports;
- ✍ regulate and control all fisheries on the principles of optimum utilization and long-term sustainability;
- ✍ encourage the implementation of sound business management methods by, and cooperation between, local fishermen and to devolve governmental activities to the private sector as far as possible.

Thus the 1990s priorities have clearly shifted from those of the 1980s, with increasing emphasis on management and control of resources and acknowledgment of a need to encourage fishermen to fish offshore so as to preserve inshore resources. It has led to such initiatives as

the institution of a bêche-de-mer producers association (now defunct), the development of a Fish Aggregating Device (FAD) programme, strengthening of the rural aquaculture extension programme, re-development of the commercial seaweed programme and plans to privatise the operations of the Lami boatyard.

A.4.6 The Fisheries

Fiji has a 200 mile exclusive economic zone (EEZ) of 1.26 million km^2 of territorial and pelagic waters, which was declared in 1981. Fiji has maritime boundaries with France, Tuvalu, Vanuatu, Tonga and Solomon Islands. A maritime boundary agreement has been negotiated with France, with respect to Wallis and Futuna (Campbell and Lodge, 1993), and Matthew and Hunter Islands. The sovereignty of Matthew and Hunter Islands, situated between the EEZs of Fiji and New Caledonia, is claimed by both Vanuatu and France. There have been discussions between officials of Fiji and Tuvalu regarding their maritime boundary.

Fisheries Division recognises four primary sub-sectors of the fisheries sector:

- The industrial fishery, which operates on a large-scale and is primarily export-oriented. It includes the Pacific Fishing Company (PAFCO) tuna cannery at Levuka, and tuna capture and supply by both local and overseas vessels. The deep-water snapper and domestic tuna longline fisheries have been included in this category since 1990.
- The artisanal fishery, which includes most small-scale commercial production for domestic sale. It is a significant source of domestic fish supply and employment.
- The subsistence fishery, involving catches for home consumption, with the occasional sale of surplus catch.
- Aquaculture, which is gradually moving out of the experimental stage and has the advantage of not being based on limited natural resources.

The fisheries sector has encountered several notable events in recent years. These include bêche-de-mer and trochus shell booms, the establishment of a domestic longline/dropline fleet, rapid developments in traditional reef-tenure systems, and a shift in government policy from an import-substitution to an export-oriented economy. It is therefore expected that the distinction between the sub-sectors listed above will become less clear-cut as they develop and diversify (Anon., 1993d).

A.4.7 Regional and international agreements relating to fisheries and marine resources

Fiji is a member of the South Pacific Forum and is an ACP state of the European Community. Fiji is also a member of the South Pacific Forum Fisheries Agency, South Pacific Commission, South Pacific Regional Environment Programme, South Pacific Applied Geoscience Commission and FAO.

Fiji was the first country to sign and ratify the United Nations Convention on the Law of the Sea on 10 December 1982. It is a party to the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America (Campbell and Lodge, 1993). Fiji is not a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), the purpose of which is to monitor and control international trade in wildlife and plants, and to protect those that are vulnerable or endangered by such trade.

A.4.8 Procedures for investors

The Fiji Trade and Investment Board (FTIB), a statutory body, administers a series of incentives for potential investors. These include tax exemptions, duty-free import of equipment and accelerated depreciation provisions. It is general practice for investors to work initially with FTIB, which then advises the Business and Industrial Development Committee (BIDC), the Ministerial-level final authority, on whether or not a proposed venture should be approved. The FTIB liaises with relevant Government departments in making its final appraisal of proposals. Its operations are in line with the government's policy to shift production from import substitution to export-oriented industries.

Information on the known or suspected status of several commercial marine and fresh-water species has been supplied by Fisheries Division to FTIB to assist in the evaluation of investment proposals. In general, proposals most likely to be supported are those concentrating on resources which occur outside customary fishing rights areas; those which involve collection, processing and marketing of resources currently being exploited, and fish farming. Given the suspected precarious state of stocks of several of Fiji's nearshore marine resources, there is a continuing need for careful selectivity in investment in their development and exploitation.

References

Adams, T.J.H. 1989. Fiji fisheries aid 1979-1989. Forum Fisheries Agency, Honiara, Solomon Islands. 14p.

Anon. 1989a. The 1989 Fisheries Division Work Programme. Fiji Fisheries Division, Suva, Fiji. Pag.var.

Anon. 1990a. Fiji Ministry of Education Annual Report for 1987. 64p.

Anon. 1990b. Fisheries Sector Development Plan for the 1990s. Fiji Fisheries Division, Suva, Fiji. 17p + appendices.

Anon. 1993a. Current Economic Statistics, October 1992, Bureau of Statistics, Suva. 120p.

Anon. 1993b. Islands Business, November 1993. Islands Business International Limited, Suva, Fiji.

Anon. 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Bulai, N., V.Ram and G.R.South. 1993. Marine Studies 1993 Programme Handbook. University of the South Pacific, Suva, Fiji. 39p.

Campbell, B. and M.Lodge (eds.). 1993. Regional compendium of fisheries legislation (Western Pacific Region). Fisheries Management and Law Advisory Programme Vol.III. GCP/INT/466/NOR, Field Report 93/31, FL/WPSCS/93/19. South Pacific Forum Fisheries Agency, Honiara/Food and Agriculture Organisation of the United Nations, Rome. 1,708p.

Cavuilati, S.T. 1993. Managing Fisheries Resources: The Fiji Experience. In G.R.South (ed.). Marine Resources and Development - Ray Parkinson Memorial Lectures 1992. PIMRIS, USP, Suva, Fiji. 37-62.

Continental Shelf Act (Cap.149) Ed. 1978. Laws of Fiji. Government Printer, Suva, Fiji.

Doyle, B., V.Wichman and P.M.Jimmy. 1993. South Pacific Economies Statistical Summary: SPESS Number 13. South Pacific Commission, Noumea, New Caledonia. 47p.

FAO, 1993. Terminal Report: South Pacific Regional Aquaculture Development Project. FI:GCP/RAS/116/JPN.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Grynberg, R. and D.Forsyth. 1993. Current economic trends in the South Pacific. Pacific Economic Bulletin, Volume 8, Number 2, December 1993. National Centre for Development Studies, Australian National University, Canberra, Australia. 1-21.

Kay, R. 1990. *Fiji, a travel survival kit* (2nd Edition). Lonely Planet Publications, Hawthorn, Australia. 211p.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Marine Spaces Act (Cap.158A) Ed. 1978. Laws of Fiji. Government Printer, Suva, Fiji.

Siwatibau, S. 1993. Macroeconomic management in the small open economies of the Pacific. In: R.V.Cole and S.Tambunlertchai (eds.). *The future of Asia-Pacific economies: Pacific Islands at the crossroads?* Asian and Pacific Development Centre/National Centre for Development Studies, Canberra, Australia. p135-186.

Sutherland, P.H., S.T. Cavuilati, A.C.Robertson and G.R.South.1991. Human Resource Development and Planning in the Pacific Islands Fisheries Sector. South Pacific Commission, Noumea, New Caledonia. pag.var.

Tauvoli, M. 1993. Education in Fiji. In: Tok Blong SPPF: A quarterly of news and views on the Pacific Islands. August 1993 #44. Victoria, B.C. Canada. 10-11.

UNEP/IUCN. 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific*. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

Walton, H. 1991. Progress and planning in Fiji's artisanal fishery: a review of past activity and future options in the rural fisheries development programme. FAO/UNDP Regional Fishery Support Programme, Suva. 80p + appendices.

B. FISHERIES RESOURCES PROFILES

Bony fish (Osteichthyes)

1. Estuaries and Lagoons [gusuniwai, lomaloma]

1.1 INSHORE FISH

1.1.1 The Resource

Species Present: Lewis (1984;1985b) lists 39 species (Table 2) in the "Estuaries and Lagoon" category on the posters "Food fishes of Fiji" and "Food fishes of Fiji-II", though many more species than these are used for food and for sale.

Table 2 Names of "Estuary and Lagoon" fin-fish depicted on the posters, "Food fishes of Fiji" and "Food fishes of Fiji-II".

Common	Scientific	Fijian
milkfish	*Chanos chanos*	yawa
bonefish	*Albula neoguinaica*	yawakio
queenfish	*Scomberoides lysan*	votonimoli
garfish	*Hyporhamphus dussumieri*	buse, nise
barred garfish	*Hemirhamphus far*	busa, gaka
bigeye scad	*Selar crumenophthalmus*	yatule, tuqadra
blue-spot mullet	*Valamugil seheli*	kanace, sevou
diamond-scale mullet	*Liza vaigiensis*	kava
sea mullet	*Mugil cephalus*	koto, uralo
hairtail	*Trichiurus haumela*	tovisi
silver biddy	*Gerres* sp.	matu
milk trevally	*Lactarius lactarius*	kela
threadfin	*Polydactylus plebeius*	uculuka
yellow-striped goatfish	*Upeneus vittatus*	ki
crescent perch	*Therapon jarbua*	qitawa, qiawa
ponyfish	*Leiognathus equulus*	cebe, kaikai
stout chub mackerel	*Rastrelliger brachysoma*	salala
pike eel	*Muraenesox cinereus*	ikasa
long tom	*Tylosurus crocodilus*	saku
Forster's seapike	*Sphyraena forsteri*	dulutoga, silasila
slender chub mackerel	*Rastrelliger kanagurta*	salalanicakau
thumbprint emperor	*Lethrinus harak*	kabatia, kabatiko
orange-spotted cod	*Epinephelus malabaricus*	soisoi, votosiga
goatfish	*Mulloidichthys vanicolensis*	ose (gen.), osekula
brown sweetlip	*Plectrorhinchus nigra*	drekeni, drekenikuro
bluefin trevally	*Caranx melampygus*	tauta, saqanivata
blue-spotted ray	*Amphotistius kuhlii*	vaidina, tinanivai
little priest	*Thrissina baelama*	vaya, vaca
Fiji sardine	*Sardinella fijiense*	vosevose, niva
goldspot herring	*Herklotsichthys quadrimaculatus*	daniva, tanive
eeltail catfish	*Plotosus lineatus*	kaboa, kabo
conger eel	*Conger cinereus*	tunatuna, baku
finny scad	*Megalaspis cordyla*	moli, salanitoga

black-spotted swallowtail	*Trachinotus bailloni*	iribuli, qawaqawa
snubnosed dart	*Trachinotus blochi*	lalitarawau, qawaqawa
fringefin trevally	*Carangoides hedlandensis*	saqadrau
seapike	*Sphyraena flavicauda*	sasa, motomoto
great trevally	*Caranx ignobilis*	saqa (gen.), saqaleka
wolf herring	*Chirocentrus dorab*	voivoi

The predominant families in terms of the artisanal catch are Scombridae, Lethrinidae, Carangidae, Mugilidae, Serranidae and Sphyraenidae. Anon. (1993d) lists approximately 99 species from 39 families in the category of " food fishes ".

Distribution: Figures on production by area are difficult to obtain, but about 49 per cent of the artisanal fish catch is sold in the Central Division (Anon., 1993d).

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. This is 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: Estuary, lagoon and reef fish are important to the subsistence and artisanal fisheries sectors. There are approximately 2,000 registered artisanal fishing vessels, used full or part-time in reef and lagoon fisheries (Cavuilati, 1993). In the subsistence fishery, fishing methods and equipment vary widely from traditional to modern: hand-collecting in the shallows, netting, spearing, fish drives, fish fences and traps, and hook-and-line (Zann, 1981). Fong (1994) reports that in the Sasa fishing rights area in Macuata Province, Vanua Levu, a variety of spears (**moto**) are still in use, and the village communal fishdrive (using a type of leaf-sweep) called **yavirau** is occasionally undertaken. Only big fish are caught, partly as a direct conservation measure.

Women play an important role in nearshore fishing and are probably responsible for a greater proportion of the catch than men (Zann, 1981). At Sasa, women still use handnets called **taraki** (Fong, 1994).

Zann (1981) states that the use of dynamite, and fish poison or derris (**duva**) to catch fish are banned, but still widely practised. Dynamiting is very seasonal, according to the abundance of target species. At Sasa, Fong (1994) reports that there does not seem to be any use of dynamite, and no cases of the use of **duva** have been detected.

In relation to subsistence fish consumption, Zann (1981) quotes Ministry of Agriculture, Forestry and Fisheries figures as 70 g/person/day for the national average, 30 g/person/day for the urban sector and 330 g/person/day for the subsistence fishing sector. In a study at Dravuni Island in the Great Astrolabe Reef, Vuki (1991) noted that fish was eaten by villagers on an average of 6 days per week, and average daily fish consumption was approximately 300 g/person/day. The high price of fish in urban areas was cited by Vuki (1991) as a contributing factor to lower fish consumption in these areas, as reported by Zann (1981).

Zann (1981) reports that most non-poisonous fish are eaten by villagers, though some reef and lagoon species are avoided because of their known implication in cases of poisoning. It appears that the incidence of fish poisoning is rather widespread in Fiji, but may be localised and/or seasonal. Sorokin (1975) notes the common belief in Fiji that fish are toxic towards the end of the year, a phenomenon associated with the annual rising and spawning of the polychaete worm, the "**balolo**" (*Eunice viridis*). However, he adds that according to information available, if there is an association, it is not one of cause and effect. Banner and Helfrich (1964) report two categories of fish poisoning from Fiji:

- ciguatera, including shark liver poisoning and well as that by snappers, groupers etc.
- clupeoid or "**daniva"** poisoning

Fish from Fijian waters reported to be toxic include: red snapper (**bati** - *L. bohar*), moray eel (probably **boila -** *Gymnothorax* sp.), moray eel (**dabea** - *Gymnothorax* sp.), sardine (**daniva -** *Clupea venenosa*), mangrove jack (**damu** - *Lutjanus argentimaculatus*), unidentified (**delabulewa**, long-nosed emperor (**dokonivudi -** *Lethrinus microdon = elongatus*), coral trout (**donu** - *Plectropomus* spp.), unidentified (**dravu** or **drevu**), black-spot sea perch (**kake, kwake -** *Lutjanus monostigma*), sea bass (**kawakawa -** *Epinephelus fuscoguttatus*), barracuda (**ogo** - *Sphyraena barracuda*), Maori snapper (**regua -** *Lutjanus rivulatus*), trevally (**saqa -** *Caranx* spp.) and Spanish mackerel (**walu** - *Scomberomorus commerson*) (Banner and Helfrich, 1964).

Production And Marketing: Anon. (1993d) reports that in the artisanal fishery during 1992, an estimated 3,965 mt of fresh or frozen fin-fish worth FJD13.4 million were sold through various outlets. Since 1988, there has been an overall drop in annual production of about 800 mt. Fin-fish production estimates and values for the artisanal fishery by market outlet for the years 1988-1992 is given in Table 3.

Table 3. Artisanal fin-fish production (mt) and value (FJD'000) by market outlet, 1988-1992. (Source: Anon., 1993d).

Outlet	1988		1989		1990		1991		1992	
	Wt. (mt)	Value ('000)	Wt. (mt)	Value ('000)	Wt. (mt)	Value ('000)	Wt. (mt)	Value ('000)	Wt. (mt)	Value ('000)
Municipal markets	898.0	2289.8	618.4	1778.8	610.1	2003.8	494.1	1842.5	509.8	1832.3
NMA/RFMF			183.4	388.4	51.4	115.7	29.2	76.2	116.0	279.0
Other outlets	3812.0	9580.6	3940.6	12435.5	3962.0	14975.8	3419.2	14878.8	3330.9	11268.3
Smoked fish	32.5	95.1	19.3	62.4	21.2	98.1	11.6	56.3	4.5	21.8
Salted fish	5.8	43.4	6.1	50.7	2.6	25.2	3.8	25.5	3.9	37.0
Total	4748.3	12008.9	4767.8	14715.9	4647.3	17218.6	3957.9	16879.3	3965.1	13438.4

For the 1992 calendar year, fish from six categories made up 86 per cent of the artisanal fish catch; Scombridae 641 mt, Lethrinidae (584 mt), Carangidae (434 mt), Mugilidae (494 mt), Serranidae (442 mt) and Sphyraenidae (522 mt). Reliable estimates of the subsistence catch are not available. Survey data collected from 9 per cent of Fijian coastal villages in 1980 is generally used for this purpose - some 14,000 mt per annum with an additional annual

increment of 200 mt, giving a figure of 16,400 mt for 1992. A subsistence fisheries survey of 2,553 households among Fijian villages and Indian settlements on Viti Levu was conducted during 1993. It is planned to extend this survey to Vanua Levu and the other islands during 1994.

1.1.3 Stock Status

There is a general impression that the inshore fin-fish resources have been over-exploited, due to the dependence on it of an increasing population. According to Anon. (1992) and Anon. (1993d), "...concerns about localised overfishing have prompted several customary fishing rights areas (**qoliqoli**) to restrict the use of gillnets or limit the number of commercial fishermen in these **qoliqoli**." Fong (1994) states that "Indian and other commercial fishermen agree that catch rates and sizes of fin-fish...(have) declined rapidly."

The Fish Aggregation Device (FAD) deployment programme was instituted by the Fisheries Division in 1981, with the aim of diverting fishermen away from over-stressed lagoon fisheries, and in supplementing reduced supplies of fish to urban markets (*Qitawa*: The Fisheries Newsletter, 1992). The catches by weight of six families of fin-fish from 1985-1992 (Table 4) suggest that while catches of reef fish (lethrinids, mugilids and serranids) have decreased over this period, those of reef-associated fish (carangids, scombrids and sphyraenids) have increased. These trends may indicate the success of the FAD programme, the deleterious effect of fishing pressure on reef stocks, or both.

Table 4. Catch by weight (mt) of six fish families in the artisanal fishery, 1986-1992 (Source: Fiji Fisheries Division Annual Reports 1986-1992).

Year	Emperors	Mullets	Rock cods	Mackerels/ Tunas	Barracudas	Trevallies
1986	867	662	478	544	168	310
1987	864	578	497	542	152	302
1988	882	1087	453	463	208	295
1989	739	369	601	921	221	380
1990	682	320	392	1062	436	447
1991	512	483	302	1000	286	499
1992	584	494	442	641	522	434

1.1.4 Management

Current Legislation/Policy Regarding Exploitation: A ban on the use of gillnets is one of four prohibitions or "chiefly bans" which have been in place since 1989 in the combined **qoliqoli** of the districts of Dreketi, Macuata, Sasa and Mali, Macuata Province, Vanua Levu. The other measures are a ban on the use of SCUBA diving equipment for spearing fish, no Sunday fishing being a condition of granting a fishing permit and a ban on the commercial taking of bêche-de-mer for an initial period of 5 years from the beginning of 1989 (Fong, 1994). Gillnets have been banned in the Raviravi/Sowana, Nadogo and Bucaisau areas of Macuata Province and in Burenitu in Bua Province. The latter is a fishing rights area which includes the islands of Lekutu, Galoa, Tavea and Yaqaga, where Indian commercial fishermen have been banned from using gillnets (Fong, 1994).

In November 1991 the section of the Fisheries Act concerning dynamite fishing was amended. Fishermen now convicted of catching fish using explosives will face fines of up to FJD5,000 (for a third offence) and mandatory jail terms for all convictions (*Decree No.46 of 1991, s3*). The previous penalty was a fine of FJD100.

Recommended Legislation/Policy Regarding Exploitation: Fong (1994) discusses the extent to which the Sasa management system has been emulated in other parts of Fiji. In her opinion, the interest shown in the Sasa system by heads of Fiji Fisheries Division Offices "....may lead to a wider encouragement of fishing rights area authorities, to use their powers to manage their own areas in consultation with Fisheries Division." Co-management of nearshore marine resources, as described by Fong (1994) in Macuata Province, should be promoted as widely as possible.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Banner, A.H. and P.Helfrich. 1964. The distribution of ciguatera in the tropical Pacific. Hawaii Marine Laboratory Technical Report No.3, University of Hawaii, Honolulu, Hawaii. 7p.

Qitawa: The Fisheries Newsletter. 1992. March/April issue. Volume 7(2). Fisheries Division, Suva.

Cavuilati, S.T. 1993. Managing Fisheries Resources: The Fiji Experience. In G.R.South (ed.). Marine Resources and Development - Ray Parkinson Memorial Lectures 1992. PIMRIS, USP, Suva, Fiji. 37-62.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Lewis, A.D. 1984. Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Sorokin, M. 1975. Ciguatera poisoning in north-west Viti Levu, Fiji Islands. Hawaii Medical Journal, Vol.34, No.6. 207-210.

Vuki, V.C. 1991. A fish consumption survey of Dravuni Islanders, Great Astrolabe Reef, Fiji. Marine Studies Programme Technical Report, Series 1991, Number 1. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 7p.

Wright, A. 1993. Shallow water reef-associated finfish. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 203-284.

Zann, L.P. 1981. Fiji's artisanal fisheries and fishing vessels: recommendations in development and training. USP/IMR Misc.Rep.83/1. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 35p + appendices.

1.2 MULLET [**kanace**]

1.2.1 The Resource

Species Present: Seven species in four genera of mullet (Family Mugilidae, Order Mugiliformes) are recorded as present in Fiji waters; warty-lipped mullet (**kanace**(gen.) - *Crenimugil crenilabis*), diamond-scale mullet (**kava -** *Liza vaigiensis*), sea mullet (**koto, uralo -** *Mugil cephalus*), blue-spot mullet (**kanace, sevou -** *Valamugil seheli*) and acute-jawed mullet (*C. leuciscus*) (Lewis, 1984;1985b). Carlson (1975) also lists green-back or flat-tailed mullet (*L. subviridis*) and large-scaled or big-belly mullet (**ketelaka, buileka, ketetuku -** *L. macrolepis*). Blue-tail or Buchanan's mullet (**tabutale**? **molisa**? - *V. buchanani*) and cream or giant-scale mullet (*L. melinoptera*) may also be present.

Distribution: Mullets occur in all tropical and temperate seas, usually near shore, frequently in brackish estuaries and fresh water. Table 5 lists the Indo-Pacific distributions and Fiji collection information for three mullet species taken in Fiji.

Biology And Ecology: Mullets are algal grazers and detrital feeders on the surface of bottom sediments. Much of the inorganic sediment is expelled through the gill chambers, while some of it passes with the organic material through a thick-walled, gizzard-like stomach and long intestine. In sea mullet, the inorganic material passing to the stomach is thought to assist in the grinding of food in that organ (Thomson, 1951 In: Kailola *et al*., 1993). Mullets may also consume insects, fish eggs and plankton (Myers, 1991).

Because of their method of feeding, mullets are usually found in association with shallow sand or reef habitats. Most species can tolerate a wide range of salinities, some ranging into purely fresh water while a few species are found on coral reefs (Myers, 1991). *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. (1988b) reports that the breeding season for **kanace** in Fiji is in early summer (October - December), while in the west and north of Viti Levu, spawning migrations are reported to occur in mid-late December (A.Sesewa, Fisheries Officer, pers. comm.). A study on the biology of mullets in Tonga indicates that mullets in Tongan waters, principally *M. cephalus* and *Liza* spp., are reproductively active between July and September, with spawning commencing in the third quarter of the year, during the cooler months. Some Tongan fishermen report that spawning of some mullet species extends from September to March (Langi, *et al*., 1992).

In Australian waters, female *M. cephalus*, depending on size, produce between 1.6 million and 4.8 million pelagic eggs, averaging 0.6 mm in diameter (Grant and Spain, 1975 In: Kailola *et al*., 1993). Knowledge of larval biology in *M. cephalus* is limited to laboratory studies.

Postlarval *M. cephalus* first enter Australian estuaries when 2-3 cm long (Chubb *et al*., 1981). The fish form schools of a few hundred individuals after entering the estuaries, and move to shallow nursery areas, which may be located from the lower estuaries to freshwater reaches of tidal creeks (Thomson, 1955 In: Kailola *et al*., 1993).

Table 5. Indo-Pacific distribution and Fiji collection information for three species of mullet taken in Fiji (Sources: Myers, 1991; Carlson, 1975; Randall *et al.*, 1990)

Common Name	Scientific Name	Fijian Name	Indo-Pacific Distribution	Fijian Collection Information
warty-lipped mullet	Crenimugil crenilabis	kanace	Red Sea to the Line and Tuamotu Islands, northern to southern Japan, south to Lord Howe Is.	Namara Is., Kadavu
acute-jawed mullet	Chaenomugil leuciscus		Mariana and Bonin Is., to the Hawaiian, Line and Ducie Is.	Kia Is., Macuata, Lau
blue-spot mullet	Valamugil seheli	kanace, sevou	Red Sea to Samoa, northern to southern Japan, south to New Caledonia; Marianas in Micronesia	Suva, Viti Levu

In Australian waters, juvenile *M. cephalus* reach an average size of 15 cm fork length at an age of 1 year, 24 cm at 2 years and 33 cm at 3 years. They reach maturity at the end of their third year, at sizes between 30 cm to 35 cm. *M. cephalus* in Australian waters are reported to reach a total length of 76 cm and a weight of 8 kg (Thomson, 1951; Grant, 1982 In: Kailola *et al.*, 1993). Langi *et al.*, (1992) report that in Tonga, both *M. cephalus* and *Liza* spp. exhibit sexual size dimorphism, with females growing larger than males.

1.2.2 The Fishery

Utilisation: Mullet are an important food fish in Fiji. The optimum fishing season for **kanace** is August-September, though they can be caught all the year round. In the early months of the year, the large post-spawners have very dry flesh, and the new generation is not yet mature (Anon., 1988b). The use of 5.1 cm and 7.6 cm stretched mesh gillnets to catch mullet was common in some areas, until the recent imposition of local bans on their use (see 1.2.3 below). In these areas, villagers now use spears to catch mullet, up to 200-300 fish per man-day during spawning migrations. (A.Sesewa, Fisheries Officer, pers. comm.).

Production and Marketing: Approximately 11 mt of dried fish (mostly **kanace**) was exported from Fiji in 1987, of which 10 mt went to Hong Kong (Anon., 1988b). Artisanal production of mullet has fluctuated somewhat in recent years. Table 6 shows production (weight) and value (FJD) for the years 1989 to 1992. The figures show that production dropped sharply to 369 mt following a massive catch of 1,087 mt in 1988, and dropped further in 1990 to 320 mt. This may be a reflection of the local bans on the use of gillnets during the past 2-5 years (Watling and Chape, 1992) or a result of over-fishing. Artisanal catches have increased slightly over the last two years.

The average market price for fresh **kanace** was FJD2.35/kg in 1987 and FOB prices for dried fish exports appear to be around FJD4.00/kg. In 1987, salted **kanace** sold locally for FJD3.50-

4.50/kg. After a sharp increase in price to FJD6.56/kg in 1991, the price of fresh mullet in 1992 had returned to 1988 levels (Table 6).

Table 6. Production (mt) and value (FJD'000) of mullet (mt) in the artisanal fishery, 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).

Year	Catch Weight (mt)	Market Value (FJD'000)	Average Market Value (FJD/kg)
1986	662	1,386	2.09
1987	578	1,383	2.39
1988	1,087	2,549	2.35
1989	369	1,144	3.10
1990	320	1,094	3.42
1991	483	3,169	6.56
1992	494	1,192	2.41

1.2.3 Stock Status

Lal (1984) reports that overfishing by commercial fishermen residing in urban centres may be partly responsible for the observed decline in mullet landings. The introduction of cash economies and efficient gear in rural areas has also led to depletion of certain fish species, including mullets (*Mugil* sp.). This decline in the abundance of mullet was noted by villagers at Sasa, Macuata Province (Fong, 1994) and by villagers in the west and north of Viti Levu (A. Sesewa, Fisheries Officer, pers.comm.), prior to the imposition of a ban on the use of gillnets in 1989. Since the imposition of the gillnet bans, the latter villagers report that the numbers and average size of mullet have been increasing annually (A.Sesewa, Fisheries Officer, pers. comm.).

1.2.4 Management

Current Legislation/Policy Regarding Exploitation: The Sixth Schedule of the Fisheries Act (Regulation 18) lists 200 mm as the minimum length for fished **kanace**. There are also traditional controls on fishing for **kanace**, e.g. there is no fishing allowed during the breeding season at Fulaga, Lau, perhaps indicating a sensitivity of local stocks to overfishing. A ban on the use of gillnets is one of four prohibitions or "chiefly bans" which have been in place in the Sasa fishing rights area since 1989 (Fong, 1994). Gillnets have been banned in the Raviravi/Sowana, Nadogo and Bucaisau areas of Macuata Province and in Burenitu in Bua Province. The latter is a fishing rights area which includes the islands of Lekutu, Galoa, Tavea and Yaqaga, where Indian commercial fishermen have been banned from using gillnets (Fong, 1994).

Recommended Legislation/Policy Regarding Exploitation: The local bans on the use of gillnets to catch mullet appear to be effective in boosting local stock numbers. While the introduction of further management measures by the government are not indicated, scientific information and advice (as well as certain basic conservation laws) should be provided by Fisheries Division to local leaders who have imposed bans on the use of gillnets, or are considering doing so.

References

Anon., 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon., 1988b. Mullets in Fiji. Internal memorandum. Fiji Fisheries Division, Suva. 1p.

Anon., 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon., 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Carlson, B.A. 1975. A preliminary check-list of the fishes of Fiji: based on specimens in the Marine Reference Collection of the University of the South Pacific, Suva, Fiji. 94p.

Chubb, C.F., I.C.Potter, C.J.Grant, R.C.J.Lenanton and J.Wallace. 1981. Age structure, growth rates and movements of sea mullet, *Mugil cephalus* L., and yellow-eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon River system, Western Australia. Australian Journal of Marine and Freshwater Research **32**: 605-628.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Kailola, P.J., M.J.Williams, P.C.Stewart, R.E.Reichelt, A.McNee and C.Grieve (eds.). 1993. *Australian Fisheries Resources*. Bureau of Resources Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation, Canberra, Australia. 422p.

Lal, P.N. 1984. Environmental implications of coastal development in Fiji. Ambio, Volume 13(5-6). 316-321.

Langi, S.A., T.F.Latu and S. Tulua. 1992. Preliminary study of the biology of mullets (Pisces: Mugilidae) from Nuku'alofa, Tonga. In: Dalzell, P (ed.). Papers on fisheries science from the Pacific Islands, Vol.1. Inshore Fisheries Research Project, Technical Document No.1. South Pacific Commission, Noumea, New Caledonia. 37-42.

Lewis, A.D. 1984. Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Myers, R.F. 1991. *Micronesian Reef Fishes.* 2nd Ed. Coral Graphics, Guam.

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.

Watling, D. and S.Chape (eds.). 1992. Environment Fiji: The National State of the Environment Report. International Union for the Conservation of Nature, Gland Switzerland. 154p.

1.3 REEF FISH

1.3.1 The Resource

Species Present: There are probably more than 700 species of fish inhabiting Fiji's extensive coral reefs, many of which are either too small or uncommon to be utilised as food. However, a very diverse array of fish species is captured for subsistence or commercial purposes, including:

- herbivorous (algae or coral eating) families such as Scaridae (parrotfish - **ulavi**), Siganidae (rabbitfish - **nuqa**) and Acanthuridae (surgeonfish - **balagi**);
- carnivorous families such as Serranidae (groupers - **kawakawa**, **donu**), Lutjanidae (snappers - **kake**, **damu**) and Muraenidae (moray eels - **dabea**);
- omnivorous families such as Lethrinidae (emperors - **sabutu**, **kawago**).

Reef fish species presented in the posters; "Food fishes of Fiji" and "Food fishes of Fiji-II" are listed in Table 7.

Table 7. Reef fish species from the posters "Food fishes of Fiji" and "Food fishes of Fiji-II" (Lewis, 1984; 1985b).

Common Name	Scientific Name	Fijian Name
spinefoot, rabbitfish	*Siganus vermiculatus, S. spinus*	**nuqa**, **volaca**
yellowfin surgeonfish	*Acanthurus xanthopterus*	**balaginawa**, **balagi**
reef surgeonfish	*A. guttatus*	**tabacenitoga**
long-snouted unicornfish	*Naso unicornis*	**ta lele**, **tivitivi**
double-headed parrotfish	*Bolbometopon muricatus*	**kalia**, **kelia**
five-banded parrotfish	*Scarus ghobban*	**ulavi**, **lau**
bicolour parrotfish	*Cetoscarus bicolor*	**ulavidraniqai**, **dogosasa**
hump-headed maori wrasse	*Cheilinus undulatus*	**varivoce**
orange-lined triggerfish	*Balistapus undulatus*	**cumulathai**, **vaovao**
green triggerfish	*Pseudobalistes flavimarginatus*	**dredamu**, **cumudamu**
porcupine fish	*Diodon hystrix*	**sokisoki** (gen.), **sokisokitagane**
harlequin sweetlip	*Plectorhynchus chaetodontoides*	**sevaseva**
topsail drummer	*Kyphosus cinerascens*	**sirisiriwai**, **renua**
soldierfish	*Myripristis violaceus*	**corocoro** (gen.), **matalevu**
moray eel	*Gymnothorax fimbriatus*	**dabea** (gen.), **yalu**
red bass	*Lutjanus bohar*	**bati**
blue-lined snapper	*L. quinquinlineatus*	**sarau**, **kake**
red tail snapper	*L. fulvus*	**tanabe**, **dadreu**
paddletail	*L. gibbus*	**bo**, **yabo**, **taen**

blackspot seaperch	*L. fulviflamma*	**kake**, **kwake**
green jobfish	*Aprion virescens*	**utoutu**, **utu**
large-eyed bream	*Monotaxis grandoculis*	**bu**, **mama**
blue-lined large-eye bream	*Gymnoranius robinsoni*	**mama**
slender emperor	*Lethrinus xanthochilus*	**kacika**, **kasika**
yellow-spotted emperor	*L. kallopterus*	**sabutudamu, belenidawa**
spangled emperor	*L. nebulosus*	**kawago**
long-nosed emperor	*L. elongatus*	**dokonivudi**, **leu**
yellow-tailed emperor	*L. mahsena*	**sabutu**, **cabutu**
variegated emperor	*L. variegatus*	**kabatianicakau**
peacock rockcod	*Cephalopholis argus*	**kawakawaloa**, **tikilo**
coral cod	*C. miniatus*	**kasaledamu**
lunar-tailed cod	*Variola albimarginatus*	**varavaranitoga**
coral trout	*Plectropomus leopardus*	**donu**, **droudroua**
big-spot coral trout	*Plectropomus* sp.	**lava**, **donu**
white-lined rockcod	*Anyperodon leucogrammicus*	**kawakawabatilotu**
honeycomb rockcod	*Epinephelus merra*	**senikawakawa**, **sinusinu**
purple rockcod	*E. hoedti*	**ceva**, **raravuya**
marbled cod	*E. polyphekadion*	**kasala**, **kawakawa**, **kerakera**
lunar-tailed bullseye	*Priacanthus* sp.	**isulutavoi**

Other fishes which occur in less close association with reefs, such as trevallies (Carangidae-**saqa**) and barracudas (Sphyraenidae-**ogo**) are treated separately in Profile 2.1.

Distribution: Reef fish species are found throughout Fiji where there is coral reef. They are less common in areas of high turbidity and low salinity; e.g. near the mouths of large rivers. The abundance of several species is highly seasonal in nature.

Biology And Ecology: Life-history patterns of reef fish are very variable. Eggs are normally shed in the water column, but may also be mouth-brooded, attached to vegetation and hatched internally by various species. Larvae can be planktonic or demersal. Many species in some families, such as the Serranidae, Scaridae and Lethrinidae, are hermaphroditic, functioning as both male and female at stages in their development. Size and growth vary widely amongst families. Most species are sedentary, not moving far during their adult life. Some species aggregate for spawning and at such times are vulnerable to exploitation (Lewis, 1985a).

1.3.2 The Fishery

Utilisation: Coral reefs are not conducive to most forms of net fishing, (e.g. trawl and ring net), and most fish are caught in Fiji by relatively inefficient handlining, spear and gillnetting methods. In the latter method of fishing, fish are typically driven towards a staked net.

Reef fish are sold whole-gutted, with the exception of large parrotfishes (**kalia**) which are sold head-off. Local demand for processed and packed reef fish, especially frozen fillet blocks, is increasing.

Local species preferences vary; subsistence catches contain a higher percentage of herbivores (**parrotfish**, **balagi**, **nuqa**) partly reflecting methods used, whereas commercial fishermen target the white-fleshed carnivorous species such as cods, emperors or snappers. High prices

are paid for **kawaga** (*Lethrinus nebulosus*), **nuqa** (*Siganus* spp.), **kawakawa** (*Epinephelus* spp.), **sabutu** (*Lethrinus atkinsoni*) and **donu** (*Plectropomus* spp.).

Production and Marketing: As many species are caught both in reef areas and other habitats, it is difficult to partition available catch figures. The commercial sales for the years 1984-1992, by the major families which can essentially be considered reef fish, are presented in Table 8.

Table 8. Commercial sales (mt) for major families which can be considered as "reef fish", 1986-1992. (Figures in parentheses represent the percentage of the total commercial fish sales for a particular year, for the selected families) (Source: Lewis, 1985a; Fiji Fisheries Division Annual Reports).

Year	Emperors	Parrotfish	Rock cods	Surgeonfish	Snappers	Sub-total	Total Sales
1986	867	230	478	83	383	2041 (61%)	3345
1987	864	227	497	87	498	2173 (58%)	3740
1988	881	194	453	116	381	2025 (43%)	4748
1989	739	309	601	90	426	2165 (45%)	4768
1990	682	245	392	78	374	1771 (38%)	4647
1991	512	197	302	47	802	1360 (35%)	3958
1992	584	87	442	68	319	1500 (38%)	3965

Fluctuations in the combined total weight of the sales of these family groups from 1986 until the present are closely linked to fluctuations in total commercial sales. The proportion of reef fish in total sales declined from the mid-1980s to the early 1990s. It is interesting to note that the combined total weight of these family groups and their contribution to total artisanal fish sales in 1992 is very similar to the situation in 1984, i.e. approximately 1,500 mt contributing approximately 40 per cent of commercial fish sales).

Marketing of reef fish is hampered by the diversity of species and fish poisoning, mainly ciguatera (See Section 1.1.2). The latter is a less serious problem in Fiji than in some other South Pacific countries. Reasonably reliable ciguatera test kits have now been developed which can be used for high risk fish.

1.3.3 Stock Status

Reports from the early to mid-1980s state that during that period, over-fishing was generally not a problem in the rural areas, though reef fish stocks were under heavy pressure near main population centres (Lal, 1984; Lewis, 1985a). However, with the increase in the commercial catch since then combined with an unquantified increase in subsistence catch, sustained local depletions of species groups such as mullet (**kanace**), rabbitfish (**nuqa**), coral trout (**donu**), and individual species such as the double-headed parrotfish (*Bolbometopon muricatus* - **kalia**), have prompted some resource owners to ban the use of gillnets and SCUBA diving equipment in several fishing rights areas of Fiji (Fong, 1994). Prior to the imposition of the bans, gillnets of 7.4 cm stretched mesh were becoming commonplace in some areas. Some bans have been in place for two years and others as long as five years. It is reported that as a result of the bans,

the numbers and sizes of the depleted reef fish resources have increased dramatically in the closed areas (A.Sesewa, Fisheries Research Officer, pers. comm.).

Detailed information on the subsistence catch will soon be available as a result of a subsistence fisheries survey conducted in 1993 in villages on Viti Levu. It is planned to extend the survey to Vanua Levu and eventually to all areas of Fiji. Previous estimates of the subsistence catch and catch methods was based on a survey conducted in 1979, which involved only 9 per cent of coastal villages. Preliminary results of the recent survey indicate that the use of **duva** (fish poison extracted from the roots of the derris plant), is still widely used to kill or stun reef fish (A.Sesewa, Fisheries Research Officer, pers. comm.).

There have been recent proposals made by entrepreneurs in the export of live reef-fish from Fiji to S.E. Asian markets. The target species are chiefly rock cods and groupers of the genus *Epinephelus* (**donu**), and maori wrasse (*Cheilinus undulatus* - **varivoce**). Given the current concerns about reef food fish stocks, and the negative impacts on reef resources caused by live reef-fish export operations in other South Pacific countries (Richards, 1994), a cautious approach to these proposals would be in order.

1.3.4 Management

Current Legislation/Policy Regarding Exploitation: The Fisheries Regulations list minimum sizes for **nuqa** (20 cm), **ulavi** (25 cm), **kawakawa** and **donu** (25 cm), lethrinids (25, 20 and 15 cm for large, medium and small species), **balagi** (20 cm), **damu** (30 cm). There are no other measures in force other than mesh-size limits for gillnets. Some Council By-Laws prohibit the sale of certain species on the basis of ciguatera risk.

Regulation 8 of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall take, stupefy or kill any fish in any lake, pool, pond, river, stream or in the sea use any of the following substances or plants: (a) any chemical or chemical compound, (b) any substance containing derris, (c) any substance containing the active principal of derris, namely rotenone, (d) any plant or extract of or derivative from any plant, belonging to the genera *Barringtonia, Derris, Euphorbia, Pittosporum* or *Tephrosia* (**duva**) or place any such substances or plants in water for the purpose of taking, stupefying or killing of any fish."

Local bans on the use of gillnets, and SCUBA diving equipment for spearing fish are two of four prohibitions or "chiefly bans" which have been in place since 1989 in the combined **qoliqoli** of the districts of Dreketi, Macuata, Sasa and Mali (Fong, 1994). Gillnets have been banned in the Raviravi/Sowana, Nadogo and Bucaisau areas of Macuata Province and in Burenitu in Bua Province. The latter is a fishing rights area which includes the islands of Lekutu, Galoa, Tavea and Yaqaga, where Indian commercial fishermen have been banned from using gillnets (Fong, 1994).

Recommended Legislation/Policy Regarding Exploitation: Reef fish are still the target species for artisanal fishermen, and as such require sustained protection from over-fishing. In the absence of financial and manpower support for increased government policing of existing regulations, support should be given by the authorities to local resource owners who have successfully rehabilitated local stocks of reef fish by the imposition of bans on gillnets and SCUBA diving equipment.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Lal, P.N. 1984. Environmental implications of coastal development in Fiji. Ambio, Volume 13(5-6). 316-321.

Lewis, A.D. 1984 Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1985b Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Richards, A.H. 1994. Live reef-fish exports to South East Asia from the South Pacific. SPC Fisheries Newsletter No.67, October-December 1993. South Pacific Commission, Noumea, New Caledonia. 34-36.

1.4 EMPERORS

1.4.1 The Resource

Species Present: Emperors are classified as belonging to the Family Lethrinidae, and are commonly called " lethrinids ". Twelve species of lethrinids are known from Fiji waters (Table 4), but three species; spangled emperor (**kawago** - *Lethrinus nebulosus*), yellow-tailed emperor (**sabutu**, cabutu - *L. atkinsoni*) and thumb-print emperor (**kabatia**, **kabatiko** - *L.harak*), comprise about 80 per cent of the total landings of these fish in Fiji (Dalzell *et al.*, 1992).

Distribution: The forty or so species of the Family Lethrinidae are restricted to the Indo-Pacific, except for one species which occurs only in the eastern Atlantic (Randall *et al.*, 1990). The Indo-Pacific distributions for the lethrinids taken in Fiji are described in Table 9.

Biology And Ecology: Lethrinids are bottom-feeding, carnivorous, coastal fishes, ranging primarily on or near reefs and seagrass beds, though their preferred habitat is sandy or rubble substrate. They may be found in clear to turbid water. The reefs which they frequent can be shallow, coralline reefs or deep, rocky reefs. They can be solitary or schooling, and do not appear to be territorial. They often form large aggregations while spawning (Carpenter and Allen, 1989).

Carpenter and Allen (1989) state that lethrinids generally possess large, strong jaws and food preference is correlated with the type of lateral jaw teeth, and also the length and angle of the snout found in a particular species. Diet varies from hard-shell invertebrates, to soft-shell invertebrates, to fishes, with combinations of these food items found in many species. Food items most commonly reported for emperors are polychaetes, crabs, shrimps, gastropods, bivalves, squid, octopus, sea urchins, sand dollars, starfish, brittle stars, and fish. Spangled emperors eat mostly bivalve molluscs, then gastropod molluscs and sand dollars (Walker, 1975 In: Kailola *et al.*, 1993). Feeding in most species is done at night, though many species forage coincidentally or purposefully during the day. Diurnal feeding migrations are reported for some species.

Lethrinids are sequential protogynous hermaphrodites, that is, when sexually mature they are initially females and later in life they change sex. This is why males tend to be generally larger than females and there is usually a sex ratio slightly in favour of females. It is likely that sexual transformation occurs over a wide range of sizes (Carpenter and Allen, 1989; Wright, 1993).

There is very little data on the actual spawning and fecundity in any species of lethrinid. Observations by fishermen in Palau (Johannes, 1981) note that spawning is apparently preceded by local migrations at dusk to particular areas near a reef, either in a lagoon or on the outer edge of a reef. Spawning occurs in large aggregations while swimming in circles near the surface, or at the bottom of reef slopes. This activity is reported to be at a peak around the time of the new moon. Spangled emperors are reported to spawn between May and October in Australian waters, peaking in June-July (Williams and Russ, in press; McPherson *et al.*, in press; Walker, 1975 In: Kailola *et al.*, 1993).

Table 9. Lethrinid species occurring in Fiji waters, with Indo-Pacific distribution patterns. (Sources: Lewis, 1984; Dalzell *et al.*, 1992; Carlson, 1975; Carpenter and Allen, 1989). [Previously used scientific names are shown in parenthesis]

Common Name	Scientific Name	Fijian Name	Indo-Pacific Distribution
spangled emperor	Lethrinus nebulosus	kawago	Red Sea and Arabian Gulf, East Africa to southern Japan and Samoa.
slender emperor	L. xanthochilus	kacika, kasika	Red Sea, East Africa, Central Indian Ocean, Indonesia to the Ryukyu Islands, Caroline Islands to the Marquesas, New Caledonia and Vanuatu.
yellow-spotted emperor	L. erythracanthus (kallopterus)	sabutudamu, belenidawa	Western Indian Ocean to the Central Pacific, from East Africa, Seychelles, Chagos and Maldives, to Thailand, Philippines, Ryukyus, Micronesia, North-.East Australia, Samoa, Society Islands and Tuamotus.
long-nosed emperor	L. microdon (elongatus)	dokonivudi, leu	Red Sea, Arabian Gulf, East Africa to Sri Lanka, to the Ryukyu Islands and Papua New Guinea.
yellow-tailed emperor	L. atkinsoni (mahsena)	sabutu, cabutu	Indonesia, northern Australia, Philippines to southern Japan, widespread throughout the Western Pacific to the Tuamotus.
variegated emperor	L. variegatus	kabatianicakau	Red Sea, East Africa to the Ryukyu Islands and New Caledonia.
black-blotch emperor	L. semicinctus	kabatia	Eastern Indian Ocean and Western Pacific, including Sri Lanka, Indonesia, northern Australia, Ryukyu Islands to Marshall Islands and Solomon Islands.
thumb-print emperor	L. harak	kabatia, kabatiko	Indian Ocean and Western Pacific, including the Red Sea.
orange-striped emperor	L. obsoletus (ramak)		Red Sea, East Africa to the Ryukyu Islands, Tonga and Samoa.
yellow-striped emperor	L. ornatus		Eastern Indian Ocean and Western Pacific, from Sri Lanka to the Ryukyu Islands, Papua New Guinea and North-East Australia.
red-eared emperor	L. rubrioperculatus	kabatia	East Africa to southern Japan and the Marquesas.
large-eye bream	Monotaxis grandoculis	bu, mama	Indo-West and Central Pacific from Hawaii and South East Oceania to East Africa and Red Sea and from Australia northwards to Japan.
blue-lined, large-eye bream	Gymnocranius grandoculis (robinsoni)	mama	Indian Ocean, East Africa to South-East Oceania and Australia northward to Japan.

Lethrinid eggs are pelagic, normally ranging in diameter from 0.6 mm to 0.9 mm in diameter. Hatching usually occurs 21 to 40 hours after fertilisation, the newly hatched larvae varying in

length between 1.3-1.7 mm (Carpenter and Allen, 1989). Juvenile lethrinids of all species appear to live in shallow, inshore areas such as seagrass and mangrove areas, the fish movingto deeper water as they age (Williams and Russ, in press; Harris *et al*., in press In: Kailola, 1993).

Lethrinids are relatively long-lived fishes; the average maximum observed age reported for 9 species is 17 years, and the range of maximum observed age is 7 to 27 years. Both scales and otoliths have been used to age emperors, and annual mark formation on these structures are generally distinct (Carpenter and Allen, 1989). In Australian waters, spangled emperors are reported to live up to 25 years, achieve sexual maturity at 28 cm standard length, reach a maximum total length of 86 cm and attain at least 4.4 kg in weight (McPherson *et al*., 1988; Walker, 1975; Harris *et al*., in press In: Kailola *et al*., 1993).

Population dynamics of emperors have been studied widely and the von Bertalanffy growth curve parameters $L_?$ (asymptotic length) and K (coefficient of growth) are known for populations of over 15 species. Dalzell *et al*. (1992) provide preliminary estimates of $L_?$ for Fijian emperors, calculated from length-frequency data and estimates of K for these species based on the growth parameters of emperors from elsewhere in the Indo-Pacific. These estimates are presented in Table 10 together with total mortality (Z), natural mortality (M) and fishing mortality (F) estimates for several Fijian emperor stocks.

Table 10. Growth and mortality estimates for Fijian emperor stocks (after Dalzell *et al*., 1992)

Species	Location (Divis'n)	$L_?$ (cm)	K	Z	M	F
L. harak	Central	33.0	0.49	1.60	1.07	0.53
L. harak	Western	34.2	0.45	2.03	1.01	1.02
L. harak	Northern	33.9	0.46	1.52	1.02	0.50
L. atkinsoni	Central	41.3	0.31	1.03	0.75	0.28
L. atkinsoni	Western	41.4	0.31	0.90	0.75	0.15
L. atkinsoni	Northern	42.8	0.29	0.65	0.71	0.0
L. nebulosus	Central	64.6	0.16	0.53	0.43	0.10
L. nebulosus	Western	62.3	0.17	0.51	0.45	0.06
L. nebulosus	Northern	50.2	na	0.55	na	na
L. ornatus	Central	32.7	0.49	2.35	1.09	1.27
L. ornatus	Western	33.1	0.48	1.74	1.07	0.67
L. ornatus	Northern	30.9	0.55	2.34	1.19	1.16
L. semicinctus	Central	30.0	0.59	2.69	1.25	1.44
L. semicinctus	Western	26.4	0.76	1.93	1.53	0.40
L. xanthochilus	Central	62.2	0.14	0.35	0.39	0.0
L. xanthochilus	Western	64.0	0.17	0.73	0.45	0.28
L. xanthochilus	Northern	53.9	0.18	na	0.49	na

1.4.2 The Fishery

Utilisation: Emperors are caught in Fiji for subsistence and commercial use. **Kawago** is one of the most highly prized food fishes in Fiji, and it is keenly targeted by commercial fishermen. Dalzell *et al*. (1992) report that the fishing gears used to capture lethrinids in Fiji are gill nets, seine nets and hand lines.

Production And Marketing: Emperors form an important part of the marine fish production from Fijian waters. In 1986, lethrinids were the single most important family in the inshore commercial catch, with 867 mt marketed, valued at approximately FJD2 million. Since then there has been a gradual decline in emperor catch compared with the other main groups (Table 11). In 1992, 584 mt of emperors were marketed, with a value of FJD1.89 million.

Table 11. Production (mt) and value (FJD'000) of emperors (mt) in the artisanal fishery, 1986-1992 (Source: Fisheries Division Annual Reports, 1986-1992).

Year	Catch Weight (mt)	Market Value (FJD'000)	Average Market Value (FJD/kg)
1986	867	2,012	2.32
1987	864	2,418	2.80
1988	882	2,598	2.95
1989	739	2,547	3.45
1990	682	2,821	4.14
1991	512	2,030	3.96
1992	584	1,886	3.23

1.4.3 Stock Status

Dalzell *et al*. (1992) used length-frequency data collected from 1982 to 1987, to make some preliminary estimates of population parameters of Fijian lethrinid stocks, based on comparative studies. Exploitation ratios calculated from these parameters showed that, in the late 1980s, stocks may still have been approaching the point of optimal exploitation. However, the gradual decline in catches since then may indicate that stocks are presently over-exploited.

1.4.4 Management

Legislation/Policy Regarding Exploitation: The Sixth Schedule of the Fisheries Act (Regulation 18) lists minimum lengths for several lethrinid species as follows:

Common Name	Fijian Name	Min. Length (mm)
spangled and long-nosed emperors	**kawago**, **dokonivudi**, **musubi**	250
black-blotch, thumb-print and red-eared emperors	**kabatia**, **kake**	150
yellow-tailed emperor	**sabutu**	200

Local bans on the use of gillnets, and SCUBA diving equipment for spearing fish are two of four prohibitions or "chiefly bans" which have been in place since 1989 in the combined **qoliqoli** of the districts of Dreketi, Macuata, Sasa and Mali (Fong, 1994). Gillnets have been banned in the Raviravi/Sowana, Nadogo and Bucaisau areas of Macuata Province and in Burenitu in Bua Province. The latter is a fishing rights area which includes the islands of Lekutu, Galoa, Tavea and Yaqaga, where Indian commercial fishermen have been banned from using gillnets (Fong, 1994).

Recommended Legislation/Policy Regarding Exploitation: Difficulties in setting optimum mesh sizes for nets and introducing minimum permissible sizes to control a fishery where a large range of different sized fishes are caught, are discussed in Dalzell *et al*. (1992). As a follow-up to the study conducted by Dalzell *et al*. (1992), a detailed investigation of the status of exploited lethrinid stocks should be carried out.

In the meantime, support should be given by the authorities to local resource owners who have successfully rehabilitated local stocks of reef fish by the imposition of bans on gillnets and SCUBA diving equipment.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Carlson, B.A. 1975. A preliminary check-list of the fishes of Fiji: based on specimens in the Marine Reference Collection of the University of the South Pacific, Suva, Fiji. 94p.

Carpenter, K.E. and G.R.Allen. 1989. FAO Species Catalogue Vol.9. Emperor fishes and large-eye breams of the world (family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. *FAO Fisheries Synopsis*. No.125, Volume 9. Rome, FAO. 1989. 118p.

Dalzell, P., S.Sharma and G.Nath. 1992. Estimation of exploitation rates in a multi-species emperor (Pisces: Lethrinidae) fishery in Fiji based on length frequency data. In: Dalzell, P. (ed.). Papers on fisheries science from the Pacific Islands: Volume 1. 43-50.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Johannes, R.E. 1981. *Words of the lagoon.* Univ. California Press, Berkeley, 245p.

Kailola, P.J., M.J.Williams, P.C.Stewart, R.E.Reichelt, A.McNee and C.Grieve (eds.). 1993. *Australian Fisheries Resources*. Bureau of Resources Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation, Canberra, Australia. 422p.

Lewis, A.D. 1984. Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

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.

Wright, A. 1993. Shallow water reef-associated finfish. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. South Pacific Forum Fisheries Agency, Honiara: Institute of Pacific Studies, Suva. 203-284.

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". Sharma and Adams (1990) list the seven species groups which dominate the baitfish catch in Fiji, which are:

1. Sprats - blue sprats (*Spratelloides delicatulus*), with smaller quantities of silver sprats (*S. gracilis*).
2. Sardines - spotted sardine (*Amblygaster sirm*), with a small percentage of blue sardine (*S. clupeoides*).
3. Herring - gold-spot herring (*Herklotsichthys quadrimaculatus*).
4. Hardyheads - Two species, *Atherinomorus lacunosus*, still widely known as *Pranesus pinguis*, and the more desirable *Hypoatherina ovalaua.*
5. Mackerels - *Rastrelliger kanagurta* predominates, with the more estuarine *R. brachysoma* contributing in some areas. *R. faughni* also occurs.
6. Cardinals - *Rhabdamia gracilis*, with smaller amounts of *R. cypselurus.*
7. Anchovies - Various species dominate this grouping in different areas at different times, including *Stolephorus heterolobus, S. devisi, S. indicus, S. bataviensis* and *Thryssa baelama*.

Other species, notably fusiliers (Caesionidae), weak herring (*Dussumieria* spp.), and scads (*Selar, Decapterus*) also make occasional contributions to the catch. In 1992, the predominant species group was the anchovies (Engraulidae) which provided 30.6 per cent of the catch. The sardine *A. sirm* made up a further 20.7 per cent with the sprats (*S. delicatulus* and *S. gracilis*) 14.4 per cent, and cardinal fish (Apogonidae) 12.6 per cent being the other major components (Anon., 1993c).

Distribution: The definition of baitfish assemblages is controlled by presence of shallow water on the north-west side of Viti Levu and Vanua Levu, and the numerous rivers and streams on the larger islands which empty into the sea throughout the year. Although over 100 defined baiting areas are used from time to time by pole-and-line vessels, probably less than half of these are regularly visited. Catch data for this large number of sites have been grouped into 8 zones (Table 12) which reflect some administrative boundaries as well as some internal consistency in habitat type (Sharma and Adams, 1990).

A comparison between the two major zones: "mainland" (north and south Vanua Levu, Central Viti Levu) and "island" (Ovalau, Lomaiviti and Northern Lau) showed anchovies and mackerel to be more abundant at "mainland" sites, and sprats and cardinal fish at "island" sites, with sardines and herrings showing little variation (Sharma and Adams, 1990).

In 1992, the majority of the baitfish catch was made from Vanuabalavu (45.7 per cent). The other important baitfishing sites were the islands off western Viti Levu (10.6), Kia Islands (8.0), Gau Island (7.5), Beqa Island (7.6), Ovalau Island (4.3) and Kadavu Island (2.7). The remainder was caught at many different locations within Fiji, but effort at each site was low (Anon., 1993c).

Table 12. Characteristics of the major baitfishing zones (After Sharma and Adams, 1990).

Zone	Characteristics	Important sites
Levuka	Deep lagoon within fringing reef with cannery nearby.	Levuka, Rukuruku, Navosa
Lomaiviti	Sheltered lagoon anchorages on lee side of islands.	Sawaike, Nawaikama (Gau), Nabuna (Koro), Namena, Makogai
Central	Mainland bays, plus the extensive Beqa lagoon.	Lami Bay, Serua, Deuba Vaga Bay, Malumu Bay
Kadavu	Large sheltered harbours in south. Lee shore in north.	Galoa, Soso, Yaruva, Namara, Kavala
Southern Vanua Levu	Deep mainland bays.	Kabulau, Naisonisoni, Savarekareka, Vatulele, Valaga Bay (Savu Savu)
Northern Vanua Levu	A large area inside the Great Sea Reef and amongst various islands.	Kia, Bekana Harbour, Mali Is. Harbour, Sausau Bay, Cukuni Is., Udu Point, Mali Is.
Eastern Vanua Levu	Sheltered waters in lee of islands and reefs.	Qamea, Kio, Viani Bay
Northern Lau	Vanua Balavu lagoon and smaller island lagoons.	Qilaqila, Vanuabalavu, Qelelevu, Wailagilala
Southern Lau	Island lagoons	Moala, Yagasa, Ogea, Matuku, Oneata
Western Viti Levu	Shallow bays in Viti Levu's lee	Nawala Point (Nadi), Momi Bay
Western Vanua Levu	As for Northern Vanua Levu, but access difficult	Rukuruku Bay

Biology And Ecology: The majority of baitfish species are planktivores, although scads, mackerels and the larger anchovies will feed on small fishes (Dalzell, 1993a). They occupy a range of habitats from estuarine waters, coral reefs and lagoons to the open ocean.

Tropical small pelagic fishes may be separated into three groups, based on life history parameters (Conand, 1986; Lewis, 1990 In: Dalzell, 1993), as shown in Table 13. Lewis *et al.*(1983a) describe biological characteristics of the two major species of the baitfishery; *H. quadrimaculatus* and *S. delicatulus*. However, very little data on the age, growth and mortality of these species is available. Dalzell *et al.*, (1987) found that *H. quadrimaculatus* and *R. gracilis* are annual species that live for 10-12 months, while *S. delicatulus* lives for only 6 months. With a short life span and high natural mortality, many of these fish will die before completing their growth. It would therefore pay to fish these species relatively hard so as to catch them before they die of natural causes (Gulland, 1983 In: Dalzell, 1993a). In common with other apogonids, *R. gracilis* is a mouth brooder, and as such is likely to have a low fecundity. Further removal of adults would have a direct effect on recruitment, since survival of adults is necessary for protection of newly hatched larvae.

Table 13. Summary of the biological characteristics of tropical small pelagic fishes (Source: Dalzell, 1993a)

	Length of life cycle	Maximum Length (cm)	Time to achieve sexual maturity	Period of spawning	Batch fecundity (number of oocytes/g of fish)	Species
Type 1	short (< 1 year)	7-10	3-4 months	Extended	500 - 1,000	stolephorid anchovies - Encrasicholina heteroloba, E. devisi, E. punctifer sprats - Spratelloides gracilis, S. delicatulus, S. lewisi silverside - Hypoatherina ovalau
Type 2	annual (some surviving to 2 years)	10-24	Towards end of 1st year	Restricted and seasonal	300 - 500	herrings and sardines - Herklotsichthys spp., Amblygaster spp., Sardinella spp. larger anchovies - Thrissina sp., Stolephorus spp. sharp nosed sprats - Dussumieria spp.
Type 3	2-5 years	20-35		Restricted and seasonal	400 - 600 flying fish: 50 - 100	round scads - Decapterus spp. big eye scads - Selar spp. small mackerels - Rastrelliger spp. flying fish and half beaks - Exocoetidae and Hemiramphidae

Williams and Clarke (1983) recorded *H. quadrimaculatus* (**daniva**) only in shallow water during the day, with both juveniles and adults moving into deeper waters at night where feeding occurs. In Fiji it approaches a maximum length of 13 cm. In New Caledonia waters, it is recorded as having a single spawning peak from October to November. It is sometimes toxic to humans in the form of clupeotoxism (see Profile 1.1).

Little is known of the biology of *S. delicatulus* in Fiji. Known locally as **caru** or **caca** in some areas, blue sprats occur in small schools, usually in clear, deep lagoon waters. The species attains 7 cm in length and its maximum life expectancy is about 6 months (Sharma and Adams, 1990). Lewis *et al.* (1983a) suggest this species has a protracted spawning period between October and June, and possibly throughout the year.

1.5.2 The Fishery

Utilisation: The many species of Fiji's baitfish resources are variously utilised by subsistence, artisanal and commercial fisheries. Pole-and-line tuna vessels, which undertake the vast

majority of commercial skipjack tuna (*Katsuwonus pelamis*) fishing in Fiji, rely on adequate supplies of live bait to stimulate the feeding behaviour which results in tuna biting hooks. Species such as *Rastrelliger* spp. are important in the artisanal fishery (see Profile 1.5), while several species are utilised by traditional fisheries. It should also be noted that many of the baitfish species do not have Fijian names and are not utilised on a subsistence basis (Sharma and Adams, 1990).

In the commercial fishery, the bait is usually captured at night in shallow coastal waters using the *bouke-ami* method. The catch consists mainly of very small fish with large numbers of juveniles. The baitfish are attracted to the vicinity of the boat by submerged and overhead lights. Bait is scooped from the nets in a bucket and transferred alive to a bait tank, ready for use in fishing. Most vessels prefer to catch bait at night, to begin tuna fishing at dawn, due to the high rate of baitfish mortality in bait tanks (Sharma and Adams, 1990).

Production And Marketing: The subsistence catch of baitfish is unknown at present. However, a recently completed subsistence fishing survey in 2,553 households on Viti Levu, conducted by Fisheries Division, is expected to provide information on this subject.

A summary of the baitfish catch and effort by pole-and-line vessels for the years 1976 to 1990 is provided in Sharma and Adams (1990), and reproduced in Table 14 together with data from 1990-1992.

1.5.3 Stock Status

Sharma and Adams (1990) reported that catch rates remained fairly stable over the period 1976-1990 and an average of 38 buckets of bait are caught per set. Analysis of the catch data shows that baitfishing effort to date has shown that baitfishing effort has not yet been sufficiently hard to create a leveling off of catches at higher effort levels. With many suitable areas in Fiji as yet unfished, they were of the opinion that there was probably scope to increase existing catches by moving into new areas. The 1992 catch made by the 11 different boats in the fishery (97 boat-months of operation) was the highest recorded since the commencement of the fishery in 1976 (Anon., 1993c).

Table 14. Summary of baitfish catch and effort by locally operating pole-and-line boats, 1976-1992 (Source: Sharma and Adams, 1990) .

Year	Catch (bkts)	Nights	Sets	Sets/Night	Buckets/Set
1976	41,249	436	681	1.56	60.57
1977	60,116	840	1,259	1.50	47.49
1978	46,987	755	1,041	1.38	45.14
1979	29,302	1,005	1,231	1.23	23.80
1980	54,302	1,068	1,314	1.38	41.30
1981	80,485	1,777	2,482	1.32	32.42
1982	78,901	1,741	2,294	1.30	34.39
1983	57,947	1,363	1,837	1.40	32.00
1984	54,988	890	1,210	1.50	45.00
1985	33,305	735	1,068	1.40	31.00
1986	25,679	570	799	1.40	32.00

1987	42,261	800	1,122	1.40	38.00
1988	43,836	566	799	1.40	55.00
1989	32,281	398	574	1.40	56.00
1990	65,881	1,030	1,634	1.58	40.30
1991	59,154	838	1,310	1.56	45.10
1992	123,815	1,764	3,057	1.73	40.50

1.5.4 Management

Current Legislation/Policy Regarding Exploitation: The rational management of Fiji's baitfish resources, which lie almost entirely within customary fishing areas and are the mainstay of the Fiji pole-and-line tuna fishing fleet, is one of the priority tasks of Fisheries Division. Since the bait requirements of pole-and-line fishing occasionally come into conflict with local interpretations of customary fishing rights, the concept of "goodwill" payments for use of customary fishing grounds is gradually becoming an accepted practice (See A.4.2).

In early 1992, a royalty payment system was initiated to compensate traditional fishing right owners for the removal of baitfish and the operation of commercial pole-and-line vessels within their areas. An interim rate of FJD10.00 per night per vessel was set, until such time as the results of the Baitfish Research Project are available. From records supplied to Fisheries Division by the commercial vessels, it has been possible to assess how many nights of baitfishing has occurred at different fishing rights areas during the course of a year. This has facilitated the allocation of royalty payments to the rightful owners, using boundaries supplied by the Native Lands Trust Board.

During 1992, a total of FJD17,290 was collected from pole-and-line fishing companies to cover royalty payments due to the fifty-six customary fishing rights areas where baitfishing took place. This amount was transferred to the Central Fijian Treasury (Anon., 1993c). Despite these measures, many of the preferred baiting grounds in the Lau group have recently been closed to commercial operations by the traditional resource owners, who require further compensation for the taking of baitfish.

Recommended Legislation/Policy Regarding Exploitation: The results of the Baitfish Research Project, which commenced in 1991 to address concerns from resource owners about the effects of commercial baitfishing operations on fish stocks in baiting areas, will play a major part in framing updated recommendations for this fishery. Project field-work in 1992 sought to gather information towards:

- identifying the areas within Fiji where baitfishing effort is presently low, but might offer potential for the commercial capture of baitfish.
- identifying fish species which are predators of the major species caught in the baitfishery in order to assess interactions between the commercial baitfishery and the subsistence fishery.
- assessing the level of fishing effort and the major fishing activities with the subsistence fishery.

House-to-house questionnaire surveys were carried out during 1993 in order to assess fishing activities within the subsistence fishery. Areas covered include Beqa Island, Gau Island, Kia Island, Vanua Balavu, Waya Island and Yasawa Island. It is hoped to extend the survey to Vanua Levu and the Lau group in 1994.

References

Anon. 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Dalzell, P.J. 1993a. Small pelagic fishes. In: Wright, A. and L.Hill (eds.). Nearshore marine resources of the South Pacific. Forum FisheriesAgency, Honiara and Institute of Pacific Studies, Suva. 97-133.

Dalzell, P., S.Sharma and J. Prakash. 1987. Preliminary estimates of the growth and mortality of three tuna baitfish species *Herklotsichthys quadrimaculatus*, *Spratelloides delicatulus* (Clupeidae), and *Rhabdamia gracilis* (Apogonidae) from Fijian waters. Technical report No.20, South Pacific Commission, Noumea, New Caledonia. 15p.

Lewis, A.D., S.Sharma, J. Prakash and B. Tikomainiusiladi. 1983a. The Fiji baitfishery 1981-82, with notes on the biology of the gold-spot herring *Herklotsichthys quadrimaculatus* (Clupeidae), and the blue sprat *Spratelloides delicatulus* (Dussumieriidae). Technical Report No.6, June 1983, Fisheries Division, Fiji. 50p.

Sharma, S.P and T.J.H.Adams. 1990. The Fiji tuna baitfishery. In: Blaber, S.J.M. and Copland, J.W. (ed.). 1990. Tuna baitfish in the Indo-Pacific region: proceedings of a workshop, Honiara, Solomon Islands, 11-13 December 1989. ACIAR Proceedings No.30, 211p.

Williams. V.R. and T.A.Clarke. 1983. Reproduction, growth and other aspects of the biology of the gold spot herring, *Herklotsichthys quadrimaculatus* (Clupeidae), a recent introduction to Hawaii. *Fish. Bull*. 81(3), 587-597.

1.6 CHUB MACKEREL [salala]

1.6.1 The Resource

Species Present: Three species of mackerel occur in Fiji waters; the chub mackerel (*Rastrelliger faughni*), the slender chub mackerel (*R. kanagurta*) and the stout chub mackerel (*R. brachysoma*). The latter two species are sufficiently abundant to be important to fisheries (Sharma and Adams, 1990).

Distribution: Chub mackerel are distributed widely in the Indo-Pacific Region. In Fiji, *R. kanagurta* is generally more common in clearer reef waters than *R. brachysoma*, which is found closer to the shore (Lewis, 1985a). Both species occur within customary fishing right areas.

Biology And Ecology: Both species are eaters of phytoplankton and zooplankton, straining the surrounding waters with well-developed feathery gill rakers borne by the gill arches (Bal and Rao, 1984 In: Dalzell, 1993a). They form schools which are often seen rippling at the surface in sheltered waters. The mackerels are relatively small species, growing quickly to a size of approximately 30 cm fork length and a weight of 500 g. In New Caledonia, *R. kanagurta* is reported to have an $L_?$ of 23.7 cm and K of 3.0 (Conand, 1988 In: Dalzell, 1993a).

These small mackerels spawn in their second year of life, during the summer months. In New Caledonia, *R. kanagurta* has been observed spawning in September (Conand, 1988 In: Dalzell, 1993a). *R. kanagurta* appears to reach maturity at a larger size than *R. brachysoma*. Mackerel are an important source of food for predatory fish such as Spanish mackerel (**walu** - *Scomberomorus commerson*) and trevallies (**saqa** - *Caranx* spp.) (Lewis, 1985a).

1.6.2 The Fishery

Utilisation: Most individuals of both *Rastrelliger* species are caught in the 15-25 cm length range. Gears for the capture of *Rastrelliger* throughout its Indo-Pacific range make use of its schooling habit and attraction to lights. They include a variety of purse seines, surround gillnets, lift nets and fish traps. In Fiji, gillnets are used to surround schools of **salala** sighted at the surface, a procedure generally requiring moderately calm water. **Salala** are also taken incidentally in set gill nets, and in the Western Division, sizeable quantities are taken by the illegal use of dynamite. In Fiji these two species are generally consumed fresh with small quantities hot-smoked (Lewis, 1985a).

Production and Marketing: The flesh of **salala** is quite dark and oily, and is marketed fresh, frozen, smoked, salted, dried and canned. Volume of sales of **salala** through municipal and non-municipal markets for the years 1985-1992 are presented in Table 15.

The two **salala** species are not distinguished in the records. Northern Division now provides most of the catch sold through non-municipal markets. The catch is seasonal, with the May-September period producing most of the artisanal catch. Total sales have declined appreciably in recent years, with 1992 sales in both municipal markets and non-market outlets dropping to half of the 1991 figures. Nominal annual small pelagic fisheries production for the period 1976-1986, gives an average figure of 1,349 mt for landings of mackerel in Fiji (FAO, 1990 In: Dalzell, 1993a). The average price per kilogram of **salala** in recent years has ranged from approximately FJD2.00-3.00 (Fiji Fisheries Division).

Table 15. Sales of **salala** (mt) in municipal markets and non-market outlets, 1985-1992 (Source: Lewis, 1985a; Fiji Fisheries Division Annual Reports, 1986-1992).

Year	Municipal markets (mt)	Outlets (mt)	Total Sales (mt)
1985	134.93	410.17	545.10
1986	91.46	195.97	287.43
1987	47.94	203.16	251.10
1988	58.78	162.66	221.44
1989	82.14	322.14	404.28
1990	64.99	299.33	364.32
1991	34.36	218.54	252.90
1992	16.74	110.12	126.86

Small quantities of juvenile **salala** (estimated 5-20 mt) are caught by the tuna pole-and-line boats during the course of baiting operations. They are not a preferred bait species and are not targeted upon (Lewis, 1985a).

1.6.3 Stock Status

The status of Fiji's **salala** stocks is unknown. Decreases in catch from year to year, such as that noted from 1991 to 1992, could be due to many reasons and are not unusual for small pelagic species. The 1993 figures will determine whether the possible causes of the gradual decline in sales since 1989 should be investigated.

Lewis (1985a) states that with the simple gear in use, stocks are not threatened. However, the continued use of dynamite in this fishery may have severely affected the available habitat for these species.

1.6.4 Management

Current Legislation/Policy Regarding Exploitation: The Sixth Schedule of the Fisheries Act (Regulation 18) lists 20 mm as the minimum length for fished **salala**. In November 1991 the section of the Fisheries Act concerning dynamite fishing was amended (*Decree No.46 of 1991, s3*). In effect;

- Fishermen will face fines of up to FJD500 (up from FJD50) and an optional jail term of three months for basic fisheries offences, but fishermen convicted of using explosives or dynamite face a FJD1,000 fine (up from FJD100) and a mandatory six month jail term for a first offence.
- Second-time offenders will face fines of up to FJD2,000 (up from FJD150) and face a mandatory jail term of one year (up from nine months).
- Third-time offenders face fines of up to FJD5,000 (up from FJD200) and a jail term of two years (up from one year).

The previous penalty was a fine of FJD100.

Recommended Legislation/Policy Regarding Exploitation: None required unless more efficient gears are introduced. Customary fishing resource custodians should be encouraged to

enhance the sustainability of this resource through application of the existing legislation relating to gillnet mesh size and the illegal use of explosives. Lewis (1985a) states that **salala** may be a suitable product for pastes and smoked fish, and as a high quality bait for local *sashimi* tuna operations. They are one of the few examples of a "single species" fishery in Fiji, with all the handling and marketing advantages that this confers.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Dalzell, P.J. 1993a. Small pelagic fishes. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 97-133,

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D.(ed.). 1985a. Fishery Resource Profiles: information for development planning. Fiji Fisheries Division, Ministry of Primary Industries, Suva. 90p. (Partially updated in 1988).

Sharma, S.P and T.J.H.Adams. 1990. The Fiji tuna baitfishery. In: Blaber, S.J.M. and Copland, J.W. (ed.). 1990. Tuna baitfish in the Indo-Pacific region: proceedings of a workshop, Honiara, Solomon Islands, 11-13 December 1989. ACIAR Proceedings No.30, 211p.

1.7 AQUARIUM FISH [tivitivi]

1.7.1 The Resource

Species Present: Many species of fish on Fiji's coral reefs have been identified as having commercial value in the aquarium fish trade. Some of these are listed in Table 16. Damsel fish (Pomacentridae), angel fish (Pomacanthidae), butterfly fish (Chaetodontidae), tangs (Acanthuridae), wrasses (Labridae) and a wide range of other species are available in abundance. The variety of species is, however, less than in the central Indo-Pacific. Fiji has very few endemic species which could be of great interest to collectors. Fiji's freshwater fish fauna is limited, and it is unlikely to include any species of interest to the aquarium fish trade (Lewis, 1985a).

Table 16. Some commercially valuable aquarium fish species on Fijian reefs, and their principal collecting depths (Sources: Perino, 1990; Fiji Fisheries Division; Randall *et al*., 1990).

Scientific Name	Common Name	Collecting Depth (m)
*Chrysiptera taupou**	Fiji devil or south-seas demoiselle	2-10
Centropyge bicolor	oriole or bicolor angelfish	10-25
Ce. flavissmus	lemon-peel angelfish	Below 10
Ce. bispinosus	coral beauty or two-spined angelfish	Outer reef drop-off >10
Chaetodon baronessa	triangle or triangular butterflyfish	With *Acropora* coral
Ch. pelewensis	dot-and-dash butterflyfish	To 30
Ch. rafflesi	yellow or latticed butterflyfish	
Ch. mertensii	Merten's butterflyfish	Outer reef slope > 15
Ch. vagabundus	cross-hatch butterflyfish	
Pseudanthias squamipinnus	top-hat or scalefin anthias	
*P. pleurotaenia**	square block or squarespot anthias	Outer reef slope 30-70
Amphiprion perideraion	pink anemonefish	3-20
A. chrysopterus	orange-fin anemonefish	1-20
Odonus niger	queen or redtooth triggerfish	Outer reef slope
Paracanthurus hepatus	palette surgeonfish	Clear outer reef areas
Coris aygula	clown coris	
Co. gaimard	yellowtail coris	

* Indicates higher fish value.

Distribution: The major areas from which wild-caught aquarium fishes are exported are the Philippines, Hawaii, Caribbean Sea, Indonesia, Mexico, Red Sea, Sri Lanka, Mauritius, Kenya, Maldives, Seychelles, Taiwan and the Pacific region. Within the South Pacific, marine aquarium fishes are presently, or have at one time been, collected and exported from Australia, Palau, Cook Islands, FSM, Guam, Kiribati, Marshall Islands, Tonga, Western Samoa, Vanuatu and Fiji (Pyle, 1993). The principal collecting areas near Suva, Fiji are Suva Bay, Beqa, Beqa Reef, Serua Reef and outside Serua Reef (Perino, 1990).

Biology and Ecology: Due to their vast diversity, it is difficult to make generalisations about the biology and ecology of tropical marine aquarium fishes as a whole. They are captured from near the surface to depths of 60-70 m, and may be located in a variety of habitats, depending

on the species. In this respect, clown-fish (*Amphiprion* spp.) are unusual, preferring to inhabit sea anemones.

Feeding strategies for these fishes varies from herbivore (surgeonfishes and tangs) through omnivore (wrasses) to carnivore (hawkfishes), depending on the species. Several of the groupers and basslets are planktivorous (Pyle, 1993).

They either spawn pelagic eggs or brood their larvae. Butterfly Fish (Chaetodontidae) and Wrasse (Labridae) are examples of indiscriminate 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. 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).

After spending sufficient time drifting in sea currents, and upon reaching a suitable habitat, fish larvae settle from the water column to the reef, and shortly afterwards metamorphose into juveniles. The chances of an individual fish surviving after settling onto the reef may depend on several factors, most of which are associated with reef fish community structure (Pyle, 1993).

1.7.2 The Fishery

Utilisation: The major importers of marine aquarium fishes are Europe, Japan and the United States of America. Juveniles are sought after by the trade as they are often more colourful than adults and generally easier to handle. Very few of the desirable aquarium species are juveniles of commercial food fishes. They are generally not more than 6 months old and 10 cm long.

Though some aquarium fish are collected by snorkellers, they are usually collected by divers using SCUBA, small-mesh barrier nets and hand-held scoop nets. The divers work between 7 to 70 m and time spent in deeper water is limited because of decompression problems. Companies in the Pacific operate from 1-5 (usually only 1 or 2) medium-sized dive boats (5-8 m), with 3-5 divers on each. Boats may be in use for 2-6 days per week (Pyle, 1993). On board each boat 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.

Barrier nets typically range in length from 2 to 15 m. 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.

Some aquarium fish hide 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 (Passfield and Evans, 1991).

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 a warehouse/holding facility keeps the fish alive until shipped to the wholesaler overseas. Aquarium fish warehouse facilities in the Pacific region vary in size from about 50 to 200 square metres, with an average of about 100 square metres. 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; Pyle, 1993).

Production And Marketing: A local company, Fiji Biomarine Pty.Ltd., commenced collection operations in 1976, as well as operating an aquarium in Suva. Fish were collected primarily from the Suva-Deuba coastal strip using local divers. Production by this company, which enjoyed sole export rights, gradually declined until operations ceased in 1982.

A second company, Aquarium Fish (Fiji) Ltd., commenced operations in August 1984, working out of Pacific Harbour, and collecting fish in the Beqa-Serua areas (Lewis, 1985a). At present there are three companies involved in the collection and export of aquarium fish from Fiji. Numbers of fish exported have risen gradually since 1984, reaching nearly 150,000 in 1991. There was an un-explained drop to less than half this number in 1992. Table 17 summarises aquarium fish exports from Fiji for the years 1989 to 1992.

Table 17. Numbers and value (FJD'000) of aquarium fish exported from Fiji, 1989-1992 (Source: Lewis, 1985a; Fiji Fisheries Division Annual Reports, 1984-1992).

1984		1985		1986	
Number	Value (FJD'000)	Number	Value (FJD'000)	Number	Value (FJD'000)
16,234	29.38	59,404	96.48	71,840	103.33

1987		1988		1989	
Number	Value (FJD'000)	Number	Value (FJD'000)	Number	Value (FJD'000)
83,109	143.73	72,044	329.14	82,409	247.23 (est)

1990		1991		1992	
Number	Value (FJD'000)	Number	Value (FJD'000)	Number	Value (FJD'000)
111,429	259.25	149,750	325.70	60,725	131.80

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. Fish prices ex-Fiji range from FJD0.45-7.00 per fish, with some deep water species achieving higher values. The average export value per fish in recent years has remained steady at just over FJD2.00.

1.7.3 Stock Status

Although catch numbers by species are submitted by the exporting companies each time an application for an export permit is made, recent analyses have not been conducted to determine variations in catch per unit effort for this fishery. It is therefore not possible at present to provide a detailed assessment of the status of the stocks of aquarium fish in Fiji. On the issue of the impact of aquarium fish collection on coral reef fishes, Perino (1990) noted that no noticeable decline in reef fish populations had occurred in Fiji despite six years of collecting activity. However, further study is required on this topic (Pyle, 1993).

The reason why the number of fish exported in 1992 is approximately half of that the numbers exported in 1990 and 1991 should be investigated. It should be kept in mind that Hawaii, with a much smaller reef area than that of Fiji (<10 per cent) and a longer history of aquarium fish collection, exports over 150,000 fish per year on a sustainable basis (Lewis, 1985a).

1.7.4 Management

Current Legislation/Policy Regarding Exploitation: Regulation 26 of the Fisheries Regulations (Cap.158 as amended) provides, in part, that "No person shall export from Fiji - (a) live fish of any kind whatsoever", though Regulation 27 provides that an exemption may be granted by the Permanent Secretary for Agriculture and Fisheries, or any person appointed by him. In effect, this allows as much stringency in the licence conditions for aquarium fish operators as required.

Strict guidelines for the exploitation of the resource were laid down in 1982 because of the:

- emotive nature of the issue.
- large number of enquiries which were being received from overseas interests, many of questionable expertise and experience.
- location of the resource i.e. entirely within customary fishing right areas.

These were later incorporated into the 1984 Cabinet Guidelines:

- Operators exporting live fish should be licensed and limited to a single operator, at least until July 1985, giving the sole operator a 12-month period of grace.
- Future operators should be of a high international repute with a proven record in the trade.
- Involvement of resource custodians in the collection process should be to the maximum extent practicable. (There should be a training component in this process).
- The use of chemicals or poisons for collection to be prohibited.
- Export permits required for each shipment, with quantities and species to be noted.
- Conservation guidelines to be formulated by Fisheries Division in consultation with the operator. A ceiling on the total number of fish exported per year to be set, taking into account the area to be fished.
- Efforts should be made to ensure that collection activities do not conflict with other uses e.g. tourist diving.

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

Recommended Legislation/Policy Regarding Exploitation: With three exporters presently operating, it could be expected that the numbers of fish exported would be increasing rather than decreasing as exports did in 1992. Should 1993 figures continue this decline, further management action may be required in this fishery.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D.(ed.). 1985a. Fishery Resource Profiles: information for development planning. Fiji Fisheries Division, Ministry of Primary Industries, Suva. 90p. (Partially updated in 1988).

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

Perino, L. 1990. Assessment of the feasibility of establishing an aquarium fish industry in Papua New Guinea. FFA Report 90/30. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 35p.

Pyle, R.L. 1993. Marine Aquarium Fish. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 135-176.

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.

2. Outer Reef

2.1 REEF-ASSOCIATED FISHES

2.1.1 The Resource

Species Present: Some of the reef-associated fishes represented in the troll catch from Fiji, and the length in centimetres to which they usually grow, are presented in Table 18.

Table 18. Names of some reef associated fishes in Fiji (Sources: Lewis *et al*., 1983b; Lewis, 1984; Lewis, 1985b, Randall *et al*., 1990).

Common Name	Scientific Name	Fijian Name	Max. Length (cm)
brassy trevally	*Caranx papuensis*		75
bigeye trevally	*C. sexfasciatus*		78
tille trevally	*C. tille*		80
bluefin trevally	*C. melampygus*	**tauta**, **saqanivata**	100
great trevally	*C. ignobilis*	**saqa** (gen.), **saqaleka**	170
golden trevally	*Gnathanodon speciosus*	**vila**, **vala**	110
queenfish	*Scomberoides* spp.		60-120
grey-spot trevally	*Carangoides plagiotaenia*		
finny scad	*Megalaspis cordyla*		80
rainbow runner	*Elagatis bipinnulata*		120
yellow-tail barracuda	*Sphyraena jello*		150
great barracuda	*S. barracuda*	**ogo**, **silasila**	170
dark-finned barracuda	*S. qenie*	**ogo**, **sasanitoga**	
Forster's sea-pike	*S. forsteri*		65
Spanish mackerel	*Scomberomorus commerson*	**walu**	235
dogtooth tuna	*Gymnosarda unicolor*	**yatunitoga**	180
mackerel tuna	*Euthynnus affinis*	**yatu**	100
scad	*Grammatorcynus bicarinatus*	**salalanitoga**	130
frigate tuna	*Auxis thazard*		58
wahoo	*Acanthocybium solandri*		210

Distribution: Spanish mackerel have a wide distribution in the Indo-Pacific, from South Africa to Samoa, Fiji representing the most easterly occurrence of the species in any quantity. Population studies demonstrate that Fiji's Spanish mackerel stock is distinct from those in neighbouring countries and can be treated as a discrete unit for management purposes (Lewis, 1985a). Rainbow runner and wahoo are circum-tropical in distribution.

Information on the micro-distribution within the Fiji Group of several of the species listed in Table 18 is provided by Lewis *et al*. (1983b), which describes trolling surveys which took place from September 1981 - March 1982 in four fishing "zones"; " mainland reef ", " mainland island ", " offshore reef complex " and " offshore island reef ". Lewis *et al*. (1983b)

also includes results of a brief trolling survey which was undertaken in late 1982 at Vanua Balavu in the north of the Lau Group.

During these surveys, **walu** contributed significantly to the catch in two mainland zones and good catches of this species were made in Vanua Balavu. **Ogo** were commonly taken in all zones fished and were the most abundant group overall in terms of both numbers and weight. In the mainland reef zone, *S. qenie* was the dominant species, whereas in the offshore zones, *S. barracuda* predominated.

Among the trevallies (**saqa**), *C. ignobilis* topped the catch by weight in all zones, particularly in the offshore reef complex. *C. papuensis* was common in the mainland zones but was replaced by *C. melampygus* in the offshore zones. *C. plagiotaenia* made a minor contribution to the catch in all areas. *Gymnosarda unicolor* and *Grammatorcynus bicarinatus* assumed some importance in the offshore reef complex and offshore island complex.

Biology and Ecology: In contrast with oceanic species, reef-associated fish appear to maintain long periods of reef residence. **Walu** are often found in waters of low salinity and high turbidity in shallow coastal waters. They are most frequently located on the up-current side of reefs or shoals (McPherson, 1981). They may reach 60 kg in weight, females attaining larger sizes than males, which rarely exceed 17 kg in weight. First maturity in both male and female **walu** is achieved at a size of approximately 70 cm fork length or two years old. Fish appear to aggregate for spawning which occurs during the late October-February period, with a peak in December-January (Lewis *et al*., 1983b).

Trevallies (**saqa**) are powerful mid-water swimmers which frequently occur in large schools that roam for considerable distances. They are common on the edges of reefs, particularly along steep outer reef drop-offs. The great trevally (*C. ignobilis*) grows to 170 cm and may weigh over 35 kg. They are voracious predators that feed on a variety of fishes. Some species such as **vila** (*Gnathanodon speciosus*) eat mainly molluscs and crustaceans. **Saqa** are pelagic spawners that release large numbers of tiny, buoyant eggs. *C. ignobilis* is reported to spawn in pairs within aggregations, around the new and full moon (Johannes, 1981). The larvae may lead a pelagic existence for extended periods. The juveniles of *C. ignobilis* and *C. sexfasciatus* are often found in brackish estuaries or in fresh water (Randall *et al*., 1990).

Barracuda (**ogo**) frequently occur in small to large schools, often on the edge of outer reef drop-offs. However, *Sphyraena barracuda*, the largest species of **ogo**, is often encountered alone (Randall *et al*., 1990). Lewis *et al*. (1983b) reported that the largest specimen of **ogo** taken during their survey in Fiji waters was 135 cm in length, weighing 19.5 kg. Spawning of **ogo** in Fiji waters may occur in summer rather than winter, the mature fish either moving offshore to spawn or becoming unavailable to fishing gear with the onset of maturity (Lewis *et al*., 1983b). The juveniles of *S. barracuda* are found in estuaries throughout the Fiji Group (Lewis, 1985a).

2.1.2 The Fishery

Utilisation: In Fiji waters, **walu** are usually taken by trolling using a variety of artificial lures, and live-bait fishing at night around lights. Smaller quantities, especially juveniles, are caught in gillnets. Seasonal spawning “runs”of this species are well known to local fishermen, who make the major part of their catch at these times. **Walu** flesh is firm and of excellent flavour-often sold fresh or frozen as whole fish or steaks. It is the species of choice for the preparation

of **kokoda**, one of the most popular Fijian seafood dishes. Local markets readily absorb all available catch. Smoked **walu** fillets have considerable potential as an export item and as a high priced local product (Lewis, 1985a).

Lewis *et al*. (1983b) report that large **saqa** may be taken by trolling offshore and night handlining inshore, while smaller individuals are taken by gillnets in estuaries. Night handlining inshore may be successfully used for *Caranx ignobilis*, *C. sexfasciatus* and *C. tille*, but *C. papuensis* is rarely taken by this method.

Ogo are readily taken on trolled lures and baited hooks, smaller individuals of *S. barracuda* being caught on baits intended for larger fish. Juveniles may be taken with gillnets in estuaries. The yellow-tailed barracuda (*S. jello*) has a reputation in Fiji of being ciguatoxic, more so than *S. barracuda* which has this reputation elsewhere (Lewis *et al*., 1983b).

Production And Marketing: From the early to mid-1980s, the total production of **walu** from Fiji's waters was very stable, averaging approximately 200 mt per year. However, from 1989 to 1991 the average annual production more than doubled to 562 mt before dropping to 381 mt in 1992. The annual production of **ogo** and **saqa** for the same period show a similar increase, almost exclusively in the non-market outlets. The weight of **ogo**, **saqa** and **walu,** sold through municipal market outlets and non-municipal market outlets for the years 1986-1992 are presented in Table 19. Figure 1 shows total production for these groups during the same period.

Table 19. Weight (mt) of **ogo**, **saqa** and **walu** sold through municipal markets and outlets for the period 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).

Year	Municipal markets (mt)			Outlets (mt)			Total Sales (mt)		
	ogo	saqa	walu	ogo	saqa	walu	ogo	saqa	walu
1986	61.52	71.43	5.44	106.70	230.52	208.94	168.22	301.95	214.38
1987	62.08	83.72	17.55	89.81	179.59	184.56	151.89	263.31	202.11
1988	57.18	58.51	14.46	151.11	191.41	156.82	208.29	249.92	171.28
1989	58.36	49.97	5.77	162.91	288.59	357.87	221.27	338.56	363.64
1990	65.40	41.72	6.32	370.12	390.70	462.30	435.52	432.42	468.62
1991	74.20	45.18	7.03	212.10	447.45	554.82	286.30	592.63	561.85
1992	70.85	49.07	6.73	452.22	374.30	375.12	523.07	423.37	381.85

In 1986, the market prices for **ogo**, **saqa** and **walu** were approximately the same, at FJD2.00 per kilogram. Since then, the prices for all three have risen steadily, except for 1991 when prices for **ogo** and **saqa** dropped slightly. The 1992 price for **walu** was FJD5.52 per kilogram, more than twice the 1986 price (Figure 2).

2.1.3 Stock Status

Lewis (1985a) interpreted the relative stability of figures for the commercial production of **walu** as meaning that the catch may be finding its own level, and that any increases in commercial production may be the result of diversion of catch from, or at the expense of

subsistence catches. He reasoned that as long as the catch of juvenile **walu** remains small, the fishery may be self-regulating, with fishing effort declining as catches decline.

Figure 1. Total annual production (mt) of **ogo**, **saqa** and **walu** for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).

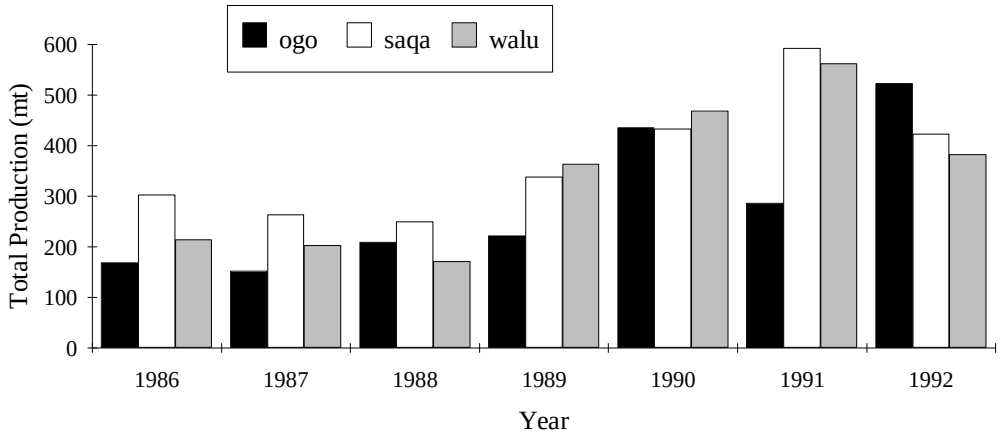
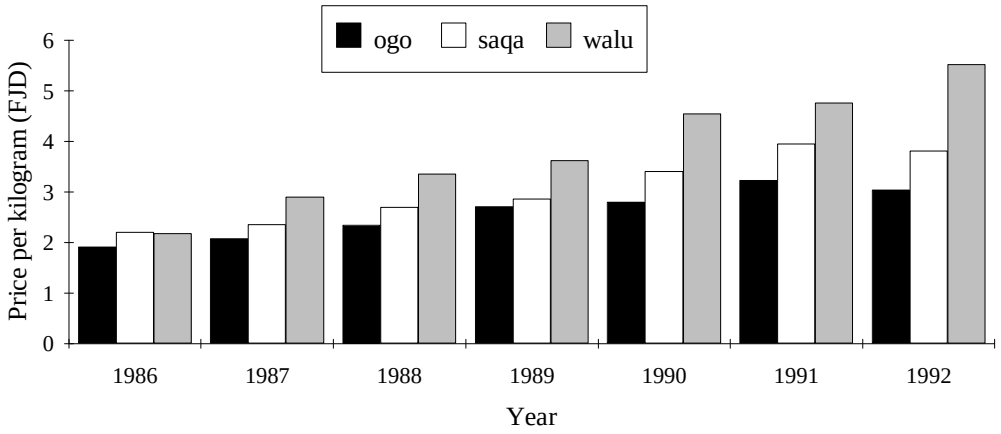


Figure 2. Price per kg (FJD) for **ogo**, **saqa** and **walu** for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).



The doubling of the commercial production of **walu** from the early 1980s to 1991, followed by the subsequent drop in commercial production in 1992, reinforces the call of Lewis (1985a) for a scientific assessment of local **walu** stocks to be undertaken as a matter of urgency. In his opinion, it was unlikely that a large increase in the overall **walu** catch could be sustained.

It is similarly unknown whether observed increases in commercial production of **ogo** and **saqa** can be sustained. At least in the case of these two groups, there are several species in each group to contribute to increased catches, compared to the single species **walu**.

2.1.4 Management

Current Legislation/Policy Regarding Exploitation: The sixth schedule of the Fisheries Act (Regulation 18) lists minimum lengths for **ogo** (300 mm) and **saqa** (300 mm). There is no legislation covering the taking of **walu,** despite earlier proposals to institute a minimum size limit of 70 cm fork length, and increase minimum net mesh size from 6.4 to 7.6 cm to protect juveniles (Lewis, 1985a).

Recommended Legislation/Policy Regarding Exploitation: The recommendations proposed here are identical to those proposed by Lewis (1985a). A scientific assessment of the stock of **walu** should be conducted, the results of which would be used to determine exploitation policy for this species. Large volume exports of unprocessed **walu** should be discouraged until stock assessment results are known. Foreign investment in the fishery should be discouraged as ample local expertise is available.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992a. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Johannes, R.E. 1981. *Words of the lagoon.* Univ. California Press, Berkeley, 245p.

Lewis, A.D., L.B.Chapman and A. Sesewa. 1983b. Biological notes on coastal pelagic fishes in Fiji. Technical Report No.4. Fiji Fisheries Division, Suva, Fiji. 68p.

Lewis, A.D. 1984. Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

McPherson, G.A. 1981. Preliminary report: investigations of Spanish mackerel, *Scomberomorus commerson* in Queensland waters. In: Grant, C.J. and D.G.Walter (eds.) Northern pelagic fish seminar, Darwin, Northern Territory, 20-21 January, 1981. Australian Government Printing Service, Canberra, Australia. 51-58.

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.

3. Deep Bottom [sauloa]

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 Fiji are presented in Table 20.

Table 20. Percentage catch composition by numbers and weight from SPC dropline fishing in Fiji (after Dalzell and Preston, 1992).

Family	Common Name	% by Number	% by Weight
Etelinae/Apsilinae	deep-water snappers	40.8	24.6
Lutjanidae	shallow-water snappers	18.6	11.9
Lethrinidae	emperors	10.0	5.4
Serranidae	groupers	12.6	8.1
Carangidae/Scombridae	trevallies, jacks, tunas and mackerels	7.9	15.1
Gempylidae	oilfish and snake mackerels	1.3	2.7
Sphyraenidae	barracudas and sea-pikes	5.2	5.2
Other teleosts		0.6	1.5
Sharks		3.1	25.6

The etelines in Fiji are mainly red snapper (**laulausevusevu** - *Etelis carbunculus*) and longtail snapper (**reveni**, **onaga** - *E. coruscans*). Other major components of the catch were red jobfish (**sewidri** - *Aphareus rutilans*), large-eye bream (**sabutukula** - *Wattsia mossambica*) and Kusakar's snapper (**bedford**, **uluqa** - *Paracaesio kusakarii*) (Dalzell and Preston, 1992). Also taken are purple-cheek opakapaka (**pakapakaqia** - *Pristipomoides multidens*), red-tailed opakapaka (**pakapakabuidamu** - *P. typus*), blue-lined flower snapper (**canati** - *P. amoenus*), yellow-finned opakapaka (**pakapakabuidromo** - *P. flavipinnis*), flower snapper (**yalayala** - *P. zonatus*), scarlet seaperch (**rosinbogi** - *Lutjanus timorensis*), roundtail seabream (**mamaninubu** - *Gymnocranius lethrinoides*), spotted-fin cod (**kasalaninubu** - *Epinephelus fuscus*), wirenetting cod (**cevaninubu** - *E. chlorostigma*), snakeskin cod (**votocaninubu** - *E. morrhua*), amberjack (**saqavotoqa** - *Seriola rivoliana*), black trevally (**saqaloa** - *Caranx lugubris*) and snake mackerel (**malaka** - *Prometichthys prometheus*) (Lewis, 1984; 1985b).

Distribution: Surveys by Fiji Fisheries Division in 1980-81 and four surveys carried out by SPC master-fishermen around parts of Viti Levu, Vanua Levu, Yasawa Islands, Kadavu, Beqa and Lau Islands, confirmed the presence of stocks of deep-water snappers, groupers, emperors and amberjacks (Dalzell and Preston, 1992).

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, feeding on fish, squid and deep-water shrimp (Smith, 1992). Information on their biology and ecology is available in Moffit (1993).

3.1.2 The Fishery

Utilisation: Deep slope fishes are caught with baited tuna-circle hooks, usually 4-5 per drop, from hand-operated, electric or hydraulic reels. Bottom-set longlines are also used in some areas. The flesh of virtually all species is of excellent quality and is free of ciguatoxin (Lewis, 1985a).

In the mid-1980s, a Japanese survey of Fiji's fishery resources demonstrating the catchability of deep-slope stocks by bottom-set longlining, stimulated local participation in the fishery. A commercial deep-slope fishery commenced in 1985, supplying both the local market and exporting fish by air-freight to the Hawaiian fish market. The fishery was concentrated on nine coastal slope areas and eight sea-mounts around Fiji.

Production And Marketing: Lewis *et al.* (1988a) reported preliminary average catch rates from longlining of 405 kg/set with 200 hooks and average soak times of 11 hours. If this is representative of the CPUE on the virgin stock, then the equilibrium catch rate at MSY would probably be in the region of 200 kg/set for equivalent gear and soak time. Based on the SPC data, catch rates at MSY for dropline fishing would be expected to average about 5.8 kg/line-hr. During 1987, 125 mt of fish were exported, while 35 mt were sold locally (Lewis *et al.*, 1988a). In 1985, local prices ranged up to FJD3.00/kg whole weight, whereas Honolulu auction prices averaged USD6-9/kg.

In 1989, there were at least 22 larger vessels locally involved in the fishery. Some of the commercial fishing areas began to show declines in CPUE during the late 1980s, and this and other economic factors prompted alternative investment by fishermen in longline gear for sashimi tunas and other pelagic species. During the first six months of 1990, only 43.7 mt of deep-slope snappers were exported from Fiji and exports were not expected to exceed 100 mt for the entire year. There are currently two large commercial vessels actively involved in the deep-slope snapper fishery, but several 8.6 m vessels supply deepwater bottom-fish to hotels and other markets. Prices paid for these fish average between FJD3-4 per kilogram. A Japanese OFCF team is currently working with Fisheries Division, Lautoka to survey new deep-slope areas and provide expertise in quality control (A.Sesewa, Fisheries Research Officer, pers.comm.).

3.1.3 Stock Status

Lewis *et al.*(1988a) gave estimates of MSY for Fijian deep slope stocks ranging between 550 and 1,600 mt/year, based on comparative data from elsewhere in the Pacific or on an estimate of 4,900 mt taken from results of a Japanese survey (Anon., 1987b). More recently, an analysis by Nath and Sesewa (1990) of commercial catch data from four sea-mounts and three coastal areas showed that in all instances initial catch rates fell to a level where fishing became uneconomic. The potential yield range at MSY has been estimated at between 409 and 1,230 mt/year (Dalzell and Preston, 1992).

3.1.4 Management

Current Legislation/Policy Regarding Exploitation: In 1987, the Ministry imposed a Guideline prohibiting large vessels from fishing for deep-slope snappers around Vanua Levu and Viti Levu. In 1989, the Ministry (Anon., 1989c) imposed further Guidelines on the issue of

new licences pertaining to vessels over 11 m in length, under discretionary powers enabled by Section 5(1) of the Fisheries Act:

- No new Outside Demarcated Areas (ODA) licences will be issued, pertaining to vessels over 11 m, to fish for deep-water snapper.
- No new ODA licences will be issued, pertaining to vessels over 11 m, which do not have a substantial, and legally verifiable, local financial shareholding.

The reasons behind the Guidelines were:

- it was thought the entire extent of Fiji's fisheries waters was only capable of sustaining a total catch of 1,000 mt of deep-water snapper per year and the existing fleet had the potential to exceed this catch by a factor of two.
- to promote the involvement of small-scale and rural fishermen in the industry.

The 1989 Guidelines were superseded by Legal Notice 25 of 1990 (LN 25/90) which inserted 3 new regulations and 3 new schedules into the Fisheries Act Subsidiary Legislation (Cap.158 as amended), to require a special licence for Fiji fishing vessels catching tuna or deepwater snapper in Fiji waters, and to apply several compliance conditions. These conditions include catch reporting requirements and a requirement to accommodate observers on board licensed vessels. The "Offshore Licence" Regulations allow investment in offshore vessels for tuna longlining, but restrict the potential for overfishing deepwater snapper.

Recommended Legislation/Policy Regarding Exploitation: The current Regulations relating to "Offshore Licences" should be retained.

References

Anon. 1987b. The fisheries resources survey in Fiji and Tuvalu - Figures and Tables. April 1987. Japan International Cooperation Agency, Tokyo, Japan. 126p.

Anon. 1989c. Draft Cabinet Memorandum. The domestic "Sashimi" (Deepwater snapper and tuna) fishery: Including recommendations for its control by addition to the Fisheries Regulations. Fiji Fisheries Division, Suva, Fiji. pag. var.

Dalzell, P. and G. L.Preston. 1992. Deep reef slope fishery resources of the South Pacific: A summary and analysis of the dropline fishing survey data generated by the activities of the SPC Fisheries Programme between 1974 and 1988. Inshore Fisheries Research Project Technical Document No. 2. SPC, Noumea, New Caledonia. 299p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D. 1984. Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D., A.Sesewa and T.J.H.Adams. 1988a. The Fiji deep-water snapper fishery - its development and management requirements. South Pacific Commission Workshop on Inshore Fishery Resources. SPC/Inshore Fishery Resources/BP 67. 14p.

Moffit, R.B. 1993. Deepwater demersal fish. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 73-95.

Nath, G. and A.Sesewa. 1990. Assessment of deepwater bottomfish stocks around the Fijian Republic. In: Polovina, J. R. Shomura (eds.). United States Agency for International Development, and National Marine Fisheries Service - Workshop on tropical fish stock assessment, 5-26 July, 1989. Honolulu, Hawaii. 7-27.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No. 92/17. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

4. Oceanic

4.1 TUNA

4.1.1 The Resource

Species present: The most important commercial tuna species in Fiji waters are yellowfin (*Thunnus albacares*), bigeye (*T. obesus*) and albacore (*T. alalunga*). Other tuna species caught artisanally are skipjack (*Katsuwonus pelamis*) and dog-toothed tuna (*Gymnosarda unicolor*) (Anon., 1993d).

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).

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 epi-pelagic 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: Although tunas are taken for subsistence and artisanal purposes in Fiji, it is the industrial tuna fishery which takes the bulk of the catch. Pole-and-line vessels, of which there were 11 in 1992, catch tuna (90 per cent skipjack tuna) which is landed at Levuka where it is sold to the Pacific Fishing Company (PAFCO) for canning (Anon., 1993d).

The Ministry of Agriculture, Fisheries and Forestry issues licences to local and overseas companies to longline in the waters of Fiji, principally for albacore. The overseas vessels have mainly been from Taiwan and Korea, though the Tongan longliner "Lofa" has also fished in Fiji's waters (Richards, 1993). In 1992, longlining for tuna in Fiji's EEZ was conducted by 23 Korean longline vessels, contracted to PAFCO.

There is also a fleet of domestic joint-venture small longliners which operates within the 12 mile zone. The local longline fleet includes several vessels registered in Korea, Australia, Japan, Taiwan and U.S.A. which are operated by Fijian residents. Twenty-three of these vessels operated in 1992, targeting bigeye and yellowfin tuna, with a substantial albacore tuna by-catch. The proportion of albacore in the catch of these vessels varied from 27 to 44 per cent during this period. The number of vessels active in the fishery (Table 21) has increased

dramatically, since 5 vessels fished in 1989 (Anon., 1993d). The vessel numbers in parenthesis are Korean vessels fishing as part of the local fleet.

Table 21. Catch (mt) by species for the domestic longline fishery, 1989-1992 (Source: Fiji Fisheries Division Annual Reports, 1989-1992).

Year	Vessels active	Vessels covered	Yellowfin	Bigeye	Albacore	Others	Total
1989	5	4	10.1	13.6	3.4	25.5	52.6
1990	10	5+(1)	22.6	27.5	68.5	39.3	157.9
1991	18	6+(3)	106.0	122.7	207.9	135.8	572.4
1992	23	14+(4)	201.3	186.6	243.2	252.1	883.2

Production: The total landing of tuna by the pole-and-line fleet in 1992 was 4,105 mt, a 7 per cent decrease in catch per boat compared with the 1991 figures. Catches for the pole-and-line fleet for the years 1986-1992 are given in Table 22.

Table 22. Total landings of tuna (mt) at the PAFCO cannery by the pole-and-line fleet for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).

	1986	1987	1988	1989	1990	1991	1992
Vessel No.	6	8	11	12	10	11	11
Catch (mt)	3,119	3,885	4,286	5,883	4,029	4,428	4,105
Av.catch/boat	520	486	390	490	403	403	373
% Skipjack	73	89	88	94	87	92	90

In 1992, the chartered Korean longline vessels landed 4,480 mt of tuna, mainly albacore tuna. This represented a 1.5 per cent decrease in catch per boat compared with the 1991 figure of 4,150 mt taken by Taiwanese longliners. Catches for chartered longline vessels for the years 1986-1992 are given in Table 23.

Table 23. Total landings of tuna (mt) at the PAFCO cannery by chartered longline vessels for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).

	1986	1987	1988	1989	1990	1991	1992
Vessel No.	10	15	27	22	21	22	23
Nationality	Taiwan	Taiwan	Taiwan	Taiwan	Taiwan	Taiwan	Korea
Catch (mt)	1,237	2,361	4,887	3,478	3,322	4,150	4,480
Av. catch/boat	124	157	181	158	158	198	195

Catch reports and landings records are collected by Fiji Fisheries Division from domestic longline vessels fishing for *sashimi* grade tuna. In 1992, the fleet caught 883 mt of bigeye, yellowfin and albacore tuna. Catch statistics for the domestic longline fishery for the years 1989-1992 are given in Table 21.

Marketing: PAFCO buys the pole-and-line catch, which with the longline catch and imported tuna from several sources is canned for human consumption, and converted to pet food and fishmeal. Canned tuna production is enumerated in "cartons", each carton containing the equivalent of 48 x 7 oz. cans. The bulk of the canned tuna is exported, though a small quantity is sold locally. Most of the fishmeal produced is sold locally. Information on the quantity and value of canned tuna, pet food and fishmeal produced by PAFCO for the years 1987-1992 is provided in Table 24.

Table 24. Production and exports, and value (FJD million) of canned tuna, pet food and fish meal by PAFCO for the years 1987-1992. The value of exports and local sales is given in parenthesis.

	1987	1988	1989	1990	1991	1992
Cartons canned tuna produced	706,860	888,688	868,049	766,665	884,224	599, 106
Cartons canned tuna exported	669,943 (25.80)	840,688 (46.68)	771,737 (39.70)	780,650 (42.23)	850,156 (46.40)	565,785 (31.60)
Cartons canned tuna sold locally	17,634 (0.37)	48,000 (1.40)	32,963 (1.0)	63,238 (1.6)	38,727 (0.94)	180 (0.001)
Cartons pet food exported	153,000 (n/a)	150,000 (n/a)	126,400 (2.39)	91,200 (1.5)	65,600 (1.15)	25,851 (0.41)
Fishmeal production (mt)	1,118 (0.57)	1,411 (n/a)	1,660 (1.1)	1,285 (0.90)	1,700 (0.91)	1,290 (0.84)

The local longline catch is landed at Levuka and exported, principally to Japan, by Fiji Fish Company Limited. The weights and values of frozen raw tuna exported by PAFCO and other companies for the years 1987-1992 are presented in Table 25.

Table 25. Frozen raw tuna exports (mt) by PAFCO and other companies for the years 1987-1992 . The values of exports (FJD million) are given in parenthesis.

	1987	1988	1989	1990	1991	1992
PAFCO	926(2.95)	n/a (n/a)	763(2.70)	1,152(3.99)	13(0.05)	1,092(4.50)
Others	256(1.17)	72(0.42)	12(0.09)	607(2.72)	624(2.90)	507(2.11)
TOTAL	1,182(4.12)		775(2.79)	1,759(6.71)	637(2.95)	1,599(6.61)

4.1.3 Stock Status

There has been no recent assessment of tuna stocks for Fiji's EEZ, though Cavuilati (1993) states that the maximum sustainable yield for highly migratory species is in the order of 35,000 mt, of which 10-15,000 mt are presently fished. 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 600,000-800,000 mt 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 150,000-200,000 mt 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 relatively 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 for albacore tuna was reported in 1992. There was a slight decrease in catches of albacore trollers during the 1991/92 season (Anon., 1993e).

4.1.4 Management

Current Legislation/Policy Regarding Exploitation: Legal Notice 25 of 1990 (LN 25/90) inserted 3 new regulations and 3 new schedules into the Fisheries Act Subsidiary Legislation (Cap.158 as amended), to require a special licence for Fiji fishing vessels catching tuna or deepwater snapper in Fiji waters, and to apply several compliance conditions. These conditions include catch reporting requirements and a requirement to accommodate observers on board licensed vessels.

No Distant Water Fishing Nations (DWFN) have formal access agreements to fish in Fiji waters, apart from the USA under the Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America. Fiji Fisheries Division licenses foreign fishing vessels to fish in Fiji waters on an individual basis under the Marine Spaces Act, on the condition that they land tuna at a Fiji port and sell to a Fiji company. Catch statistics are collected on standard forms and analysed on a monthly basis. With regard to regional tuna management, Fiji provides data on the tuna catch in Fiji waters to the SPC and liaises closely with FFA, under its UNCLOS obligations to cooperate in the management of highly migratory species (Anon, 1993c).

Recommended Legislation/Policy Regarding Exploitation: No changes to the current policy are recommended at present. Fiji strongly supports regional efforts to introduce multilateral access agreements with Japan and other Asian nations.

References

Anon., 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Anon., 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Anon., 1993e. Status of tuna fisheries in the SPC area during 1992, with annual catches for 1922-1938 and 1952-1992. Working Paper No.2. Sixth Standing Committee on Tuna and Billfish, Pohnpei, Federated States of Micronesia. 16-18 June, 1993.

Cavuilati, S.T. 1993. Managing Fisheries Resources: The Fiji Experience. In G.R.South (ed.). Marine Resources and Development - Ray Parkinson Memorial Lectures 1992. PIMRIS, USP, Suva, Fiji. 37-62.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Hampton, J. 1993. Status of tuna stocks in the SPC area: a summary report for 1993. Working Paper No.3. Sixth Standing Committee on Tuna and Billfish, Pohnpei, Federated States of Micronesia. 16-18 June 1993.

Myers, R.F. 1991. *Micronesian Reef Fishes.* 2nd Ed. Coral Graphics, Guam. 298p.

Richards, A.H. 1993. Historical perspectives and trends of South Pacific albacore fleets. FFA Report #93/18. 11p.

4.2 FLYINGFISH [ikavuka, malolo]

4.2.1 The Resource

Species Present: Though several species of flyingfish (all of the family Exocoetidae) are thought to be common in the oceanic waters of Fiji, only *Cypselurus* sp. is recorded by Lewis (1984; 1985b). Parin (1960 In: Gillett and Ianelli, 1993) estimated that about 41 species of flyingfishes inhabit the western part of the Pacific Ocean, 19 of which occur in the region of Kiribati-Samoa-Fiji-Tonga. According to Gillett and Ianelli (1993) many authors indicate that six genera of flyingfish occur in the Pacific Islands; *Cheilopogon*, *Cypselurus*, *Exocoetus*, *Hirundichthys*, *Parexocoetus* and *Prognichthys*.

Distribution: Flyingfish common in the tropical Pacific have limits of distribution bounded by 40° S and 40° N (Kovalevskaya, 1982 In: Gillett and Ianelli, 1993). However, no accurate data on flyingfish distribution and abundance exist, due to the taxonomic difficulties associated with the family Exocoetidae.

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 (1993) 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, Cook Islands report that both species recognised there breed from October to December. Growth of tropical flyingfish is rapid, in common with many other pelagic species. Dalzell (1993b) describes the growth and mortality of Pacific species of flyingfish.

4.2.2 The Fishery

Utilisation: Gillett and Ianelli (1993) record the techniques used in the Pacific Islands to catch flyingfish, the most widespread of which is the dipnet/torch technique, which is used from Palau to French Polynesia. In many areas of the tropical Pacific, flyingfish are captured for local consumption, being a highly regarded foodfish, and also as prime trolling bait for pelagic or reef-associated gamefish.

Production And Marketing: In August 1991, Fisheries Division cooperated with SPC's Fisheries Development Project and the FAO/UNDP Regional Fishery Support Programme to undertake trial fishing for flying fish outside Suva Harbour entrance. The initial trials yielded approximately 10 fish per hour. An experienced masterfisherman attached to a trial flyingfish operation asserted that higher catch rates could be expected during the period October to March. The trial programme was sufficiently successful to warrant interest from a commercial perspective, but did not result in the establishment of a viable fishery (Walton, 1991 In: Gillett and Ianelli, 1993).

4.2.3 Stock Status

There is no recorded information regarding the status of flyingfish stocks in Fiji.

4.2.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

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

References

Dalzell, P. 1993b. The fisheries biology of flying fishes (Families: Exocoetidae and Hemiramphidae) from the Camotes Sea, Central Philippines. J.Fish Biol. (1993) 43(1). 19-32.

Gillett, R. and J. Ianelli. 1993. Flyingfish. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 177-201.

Lewis, A.D. 1984 Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

4.3 SHARKS [qio]

4.3.1 The Resource

Species Present: The most common species in Fiji waters are the requiem or whaler sharks. Dalzell and Preston (1992) record 2 species of sharks taken as by-catch during SPC dropline fishing surveys in Fiji; white-tip shark (*Carcharinus albimarginatus*) and grey reef shark (*C. amblyrhynchos*). In addition, Carlson (1975) lists the black-tip shark (*C. melanopterus*) and the reef white-tip shark (*Triaenodon obesus*). Also frequently encountered is the lemon shark (*Negaprion acutidens*) (Lewis, 1985a). Sharks responsible for attacks on humans in Fiji are the tiger shark (*Galeocerdo cuvier*) and the freshwater-tolerant bull shark (*G. leucas*).

Offshore, sharks such as silky sharks (*C. falciformis*) and oceanic whitetip sharks (*C. longimanus*) are commonly seen and captured around FADs. Deep-water sharks such as spiny dogfish (*Squalus, Centroscyllium*), and six and seven gilled sharks (*Hexanchus, Heptranchus*) are a by-catch of the deep-water snapper fishery (Lewis, 1985a).

Distribution: *C. albimarginatus* is recorded from the Mamanuca Islands, Kadavu and north and eastern Vanua Levu. *C. amblyrhynchos* is recorded from Qele Levu atoll, Mamanuca Islands, Kadavu and around Vanua Levu. *C. melanopterus* is recorded from Suva, Viti Levu. *T. obesus* is recorded from the Great Astrolabe Reef, Kadavu (Carlson, 1975: Dalzell and Preston, 1992).

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.

4.3.2 The Fishery

Utilisation: While shark meat is well regarded in many countries (e.g. Australia) and supports sizeable fisheries, it is not eaten in many areas of Fiji because of traditional taboos on its use. The exceptions to this case are the Rotuma and Rabi communities where shark is readily accepted. A small quantity of longline-caught shark, mainly mako shark, is exported to Japan. Because of the high urea content of the flesh, which breaks down to produce ammonia, sharks intended for use as meat need to be bled and dressed soon after capture (Lewis, 1985a).

The fins of some species are used to produce a high-priced soup base in S.E.Asian countries, and there is an international trade in dried and frozen shark fins. For this trade, fins need to be removed by curved rather than straight cuts, and not all the fins are used. The skin of many species has been used to produce quality leather, and the teeth of tiger and mako sharks, in

particular, are used for jewelry while the jaws are cured and dried as curios. Sharks such as thresher, mako and great white shark are the target of game-fishermen.

In the last 10 years, interest has grown world-wide in the liver of deep-water sharks as a source of squalene, a fine oil used for medicinal and cosmetic purposes. Between 1985 and 1987, experimental fishing for squalene-rich deep-water sharks was conducted in Fiji waters, under the direction of Fiji Fisheries Division. The trials were suspended principally because of a decline in the squalene price during 1987 (T.Adams, pers. comm.). From 1987 until 1992 in Solomon Islands, and from 1991 until very recently in PNG, commercial fishing ventures targeted deep-water gulper sharks, mainly *Centrophorus* spp., using bottom-set deep-water longlines. The cessation of the Solomon Islands shark fishing venture has been attributed to a weakening in the price of squalene (Richards, *et al.*, 1994)

Production and Marketing: Sharks are caught by gill nets, set lines, ocean longlines and other techniques. In Fiji, most are taken as a by-catch of the pelagic longline fishery, and Fiji has been a significant exporter to S.E Asian markets of dried shark fins. The fins are handled locally by Chinese traders. The weight (mt) and value (FJD'000) of dried shark fin exports for the years 1980 to 1992 are given in Table 26. In 1992, exports increased dramatically to exceed the annual exports recorded in the late 1970s and early 1980s. It is likely that this phenomenon is directly related to the recent resurgence of the local longline fishery.

Table 26. Export weights and values of dried shark-fin from Fiji for the years 1980-1993 (Source: Lewis, 1985a; Fisheries Division Annual Reports, 1986-1992; Fiji Fisheries Division).

Year	Weight (mt)	Value (FJD'000)	Unit Value/kg (FJD)
1980	54.0	(est.) 270.00	(est.) 5.0
1981	41.6	207.72	5.0
1982	40.5	108.80	2.7
1983	7.7	61.62	8.0
1984	8.0	64.00	8.0
1985	10.82	108.20	10.0
1986	8.32	84.36	10.1
1987	6.33	44.33	7.0
1988	not available	not available	-
1989	27.30	not available	-
1990	24.00	192.00	8.0
1991	21.73	173.84	8.0
1992	69.00	552.00	8.0
1993	65.60	524.00	8.0

Although world prices for squalene oil have dropped in recent years, there is some potential for deep-water longline fishing for the sharks that produce this oil. Provided a regular supply of sharks can be obtained, there is some potential for the establishment of cottage industries producing raw or partially processed skins for leather production (Lewis, 1985a).

4.4.3 Stock Status

No information is available on shark stocks in the waters of Fiji, though it is believed they are lightly exploited. Because of the low fecundity and relatively slow growth of sharks, shark stocks are vulnerable to over-fishing (see above).

4.3.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None required at present. Exploitation guidelines may be required should the shark by-catch from commercial longlining become excessive, or a shark target fishery commences.

References

Anon., 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992a. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Carlson, B.A. 1975. A preliminary check-list of the fishes of Fiji: based on specimens in the Marine Reference Collection of the University of the South Pacific, Suva, Fiji. 94p

Dalzell, P. and G.L.Preston. 1992. Deep reef slope fishery resources of the South Pacific: A summary and analysis of the dropline fishing survey data generated by the activities of the SPC Fisheries Programme between 1974 and 1988. Inshore Fisheries Research Project Technical Document No.2. South Pacific Commission, Noumea, New Caledonia. 299p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Nichols, P. V. 1993. Sharks. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 285-327.

Richards, A.H., L.J.Bell and J.D.Bell. 1994. Inshore Fisheries Resources of Solomon Islands. FFA Report #94/1 and ICLARM Contribution #1023. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 11p + figures.

5 Rivers [waindroka]

5.1 FRESHWATER EEL [duna]

5.1.1 The Resource

Species Present: Six species of the genus *Anguilla* are present in the south-west Pacific region - four long-finned species and two short-finned species. Four of these species are recorded from Fiji; the Pacific short-finned eel (*Anguilla obscura*), the giant long-finned eel (**diria** - *A. marmorata*), the short-finned eel (*A. australis*) and the Pacific long-finned eel (*A. megastoma*) (Beumer, 1985).

Distribution: *A. obscura* is widespread in the South Pacific region from Papua New Guinea to the Society Islands and Rapa (Allen, 1991). According to Lewis (1985a), only *A. obscura* and *A. marmorata* are common in Fiji, where they are found in all rivers. Distribution records of *Anguilla* spp. from Fiji are as follows: *A. megastoma* (Viti Levu and Kanacea), *A. marmorata* (Suva, Ovalau, Narokorokoyawa, Kadavu, Nairai and Rewa River, Viti Levu); *A. obscura* (Suva, Kanacea, Rewa River), *A. australis* (Viti Levu); *Anguilla* sp. (Nadi River, Viti Levu) (Beumer, 1985).

Biology And Ecology: When mature, adult eels put on fat, become silvery in colour and migrate down the rivers to spawn in specific localities far out to sea. In this region, there may be several spawning grounds, perhaps located to the north-west and west of Fiji (Beumer, 1985).

The leaf-like larvae drift in regular ocean currents, changing to a more eel-like shape as they approach land. Known as glass eels, they drift with tides into estuaries, gradually becoming pigmented brown elvers which actively migrate upstream into fresh water. There they live and grow for many years and are known as yellow eels. The cycle continues with their maturation and migration downstream as silver eels (Lewis, 1985a).

In Fiji, freshwater eels prefer still-water, marshy habitats. Sampling by Beumer (1985) at several locations on Viti Levu produced *A. marmorata* specimens varying in length from 277 to 620 mm and in weight from 35 to 600 g. This species attains a weight of at least 5 kg in Fiji. Specimens of *A. obscura* varied in length from 225 to 775 mm and in weight from 20 to 1,150 g. In other parts of its range, *A. obscura* is known to occur in small creeks as well as swamps and lakes, growing to a maximum length of approximately 100 cm (Allen, 1991).

5.1.2 The Fishery

Utilisation: World-wide, various stages of the eel life-history are fished commercially. As the upstream migrations of elvers are often predictable and involve large numbers of individuals, elvers and glass eels are caught in special nets at these times and used for stocking eel farms. There is a sizeable world trade in live elvers. Adults are utilised for subsistence purposes as both yellow and silver eels, but the high fat content silver eels are in strong demand for smoking. Eels may also be exported live (Lewis, 1985a).

There is not a strong local preference for freshwater eels and there is no organised fishery for them. They are caught with baited lines, spears, a variety of traditional woven traps, hollow

poles and cane knives. The use of fyke nets would probably increase catches. Electro-fishing is also widely used as a commercial harvesting method in some countries (Lewis, 1985a).

Production And Marketing: Preference in international markets is for the short-finned eels with uniform body colouration. *A. obscura* would probably be acceptable, as would the less common *A. australis.* There is a limited market in S.E. Asia for large (>1.5 kg) eels - the other local species would have some potential there. Negligible quantities of freshwater eels are marketed locally and no separate statistics are kept. Most local consumption is for subsistence purposes (Lewis, 1985a).

Beumer (1985) notes that while commercial eel fisheries based on *Anguilla* spp. exist in Australia and New Zealand, the only current small-scale commercial fishery in the tropical South Pacific is on Mitiaro Island, Cook Islands. Jellyman (1988) reported that only one man regularly visited Lake Te Rotonui on Mitiaro 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).

Although Fiji generally lacks the marshy areas which support large eel populations, there are areas such as the Navua flats which should carry good quantities of eels, in addition to the more dispersed populations inhabiting major rivers. It appears that Fiji has good potential for the intensive farming of eels, though it is probable that farming would be dependent on the importation of elvers or glass eels from elsewhere to support this industry, unless a large local run of elvers can be located (Lewis, 1985a).

5.1.3 Stock Status

Little is known about local eel stocks, although it is suspected they are modest in size. Sampling trials in 1985 indicated that no large runs of glass eels and elvers occur (Lewis, 1985a). Jellyman (1988) used a mark-recapture experiment to estimate the size of the eel population in Lake Te Rotonui on Mitiaro, Cook Islands. Tentative estimates were from 3,960 to 12,540 eels greater than 35.0 cm long, with equivalent standing stocks of 20.7-65.6 kg per ha.

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. Lewis (1985) recommends that if a local fishery for adult eels develops, some restrictions on numbers of fishermen and nets in each production area may be required.

References

Allen, G.R. 1991. *Field guide to the freshwater fishes of New Guinea*. Publication No.9 of the Christensen Research Institute. 268p.

Beumer, J.P. 1985. The eel resources of Fiji. Queensland Department of Primary Industries Study Report QS85010. QDPI, Brisbane, Australia. 33p.

Jellyman, D.J. 1988. A survey of the stock of freshwater eels on Mitiaro, southern Cook Islands. Report to the Ministry of Foreign Affairs and the Cook Islands Government. 37p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

5.2 TILAPIA [maleya]

5.2.1 The Resource

Species Present: The Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*O. niloticus*), " Chitrilada strain " Nile tilapia (*O. niloticus*), " Israeli strain" Nile tilapia (*O. niloticus*), *O. hornorum* and *O. aureus*. None of these fish are native to Fiji, i.e. all were introduced from other countries.

Distribution: The natural distribution of tilapias is limited to Africa and the Near East. Introductions to Fiji of the various species and strains were made from different countries at various times, a summary of which is given in Table 27.

Table 27. Details of introductions of tilapia in Fiji from the late 1940s to 1988 (Source: Anon., 1991b; Gulick, 1990).

Species	Country of origin	Year of introduction to Fiji
O. mossambicus	Not available	Late 1940s
O. mossambicus	Malaysia	Mid-1950s
O. niloticus(Israeli strain)	Malaysia	Late 1960s and 1970s
O. hornorum	Taiwan	Early and mid-1980s
O. aureus	Taiwan	Early and mid-1980s
O. niloticus	Israel	1979
O. niloticus(Chitrilada strain)	Thailand	1988

In the late 1950s and early 1960s, *O. mossambicus* were deliberately released into the Sigatoka, Rewa and Navua Rivers, existing stocks of native freshwater fishes having little nutritional value. This species has also been released into waterways on Vanua Levu. All of the introductions since 1960 have been made with aquaculture of tilapia as the motivation.

Biology and Ecology: Tilapias are of the Family Cichlidae, comprising over 100 species according to some authorities. All tilapia species were considered as belonging to the genus *Tilapia*, but in recent years, mouth-brooding species have been classified into *Oreochromis* or *Sarotherodon*, (Shokita *et al.*,1991).

Just before the breeding season, an *O. niloticus* 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 fertilise the eggs and the female holds the fertilised eggs in her mouth, where they develop. Five to seven days after spawning, hatchlings of 8-9 mm in total length hatch out, but remain in the mother's mouth. About 2 weeks after spawning, juveniles become independent of the mother (Shokita *et al.*, 1991).

5.2.2 The Fishery

Utilisation: Because of the relatively long time *O. mossambica* have been in Fiji, people have become accustomed to their appearance and taste. This has hastened the acceptance of other species of tilapia introduced for pond culture, and no doubt greatly contributed to the growing success of the Rural Aquaculture Programme. Trials at the Nausori and Suva markets with live

fish have shown high acceptance. Fish were purchased by all races, with Indian and Chinese customers preferring plate-sized fish (250-300 g) while no particular size preference was shown by indigenous Fijians (Anon., 1991b). The utilisation of tilapia for aquaculture in Fiji is described in Profile C.1.1.

Production And Marketing: Batches of 200-300 tilapia sell quickly in retail markets for approximately FJD3.00-4.00 per kg, a price comparable or slightly higher than the price paid for several species of reef fish (Anon., 1991b). Prior to 1989, sales of tilapia in municipal markets had not exceeded 6 mt per year, though much of the catch may have been used for subsistence purposes. Since then, the weight of tilapia sold in municipal markets has increased rapidly from 20 mt in 1990 to 72 mt in 1992. There was a slight decline to 63 mt in 1993 (Fiji Fisheries Division).

5.2.3 Stock Status

There is no information available on the current status of tilapia stocks in rivers and natural water bodies.

5.2.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: None required at present

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991b. Tilapia as a cost-effective sustainable protein source for developing countries. Draft proposal for aquaculture development in Fiji for presentation to ACIAR. 7p.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Gulick, C.T. 1990. Aquaculture. In: A.A.J.Jansen, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

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

6. Other Seafood (non-fish)

6.1 TURTLES [vonu]

6.1.1 The Resource

Species Present: Eight species of sea turtles live in the world's oceans, two of which are quite often sighted and captured in Fiji. These are the hawksbill turtle (**taku** - *Eretmochelys imbricata*) and the green turtle (**vonudina** - *Chelonia mydas*). The leatherback turtle is occasionally sighted in offshore waters, and the loggerhead turtle (**tuvonu** - *Caretta caretta*) is sometimes captured, though generally not eaten, because of its musky odour (Lewis, 1985a).

Distribution: Both *E. imbricata* and *C. mydas* are found throughout the tropical regions of the world. In Fiji, they are recorded as being widespread, although not common (UNEP/IUCN, 1988).

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 focused 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. 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 (see 6.1.3). Some long-range movements of South Pacific sea turtles are described by Hirth (1993).

Mating occurs in the vicinity of nesting areas. 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 100 km to their nesting beaches. 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: Turtle meat, particularly that of *C. mydas* with its green-coloured body fat is in heavy demand in Fiji. Quantities of **vonu** are consumed at traditional feasts and for subsistence purposes. It is regarded as a chiefly food, and is offered first to the chief (Lewis, 1985a). With the erosion of traditional values, the use of turtles has become more widespread and this is endangering their existence (Anon., 1988c). Turtle eggs are also collected for food (UNEP/IUCN, 1988).

The shell of *E. imbricata* has long been sought after for ornamental purposes (tortoise shell), and even the less attractive shell of *C. mydas* is used as a receptacle or curio. In 1970, there was reported to be a major shell carving industry, using the shells of both species (Hirth, 1971 In: UNEP/IUCN, 1988).

Because of their habit of nesting on specific beaches, female turtles and their eggs are vulnerable to predation by humans and a variety of animals. They are also caught by spearing, traditional turtle nets, hand capture by divers when the turtles are asleep or cruising, or even the use of sucker fish (**bakewa**) attached to a line (Lewis, 1985a).

Production And Marketing: In Fiji, turtles are marketed live or butchered. The meat, body-fat and intestines are sold, and other organs are all eaten, as is the soft undershell (plastron). Turtle meat sales and average prices for the years 1979 to 1992 are shown in Table 28. The high 1983 figure is attributed to Cyclone Relief collection activities. This may also explain the 1992 figure, given the relatively low tonnages in preceding year. The price per kilogram has risen from around FJD2.00 in the early 1980s to almost FJD4.00 in 1992. The subsistence consumption of turtle meat is estimated to equal or exceed the volume moved through the commercial sector (Swamy, 1991).

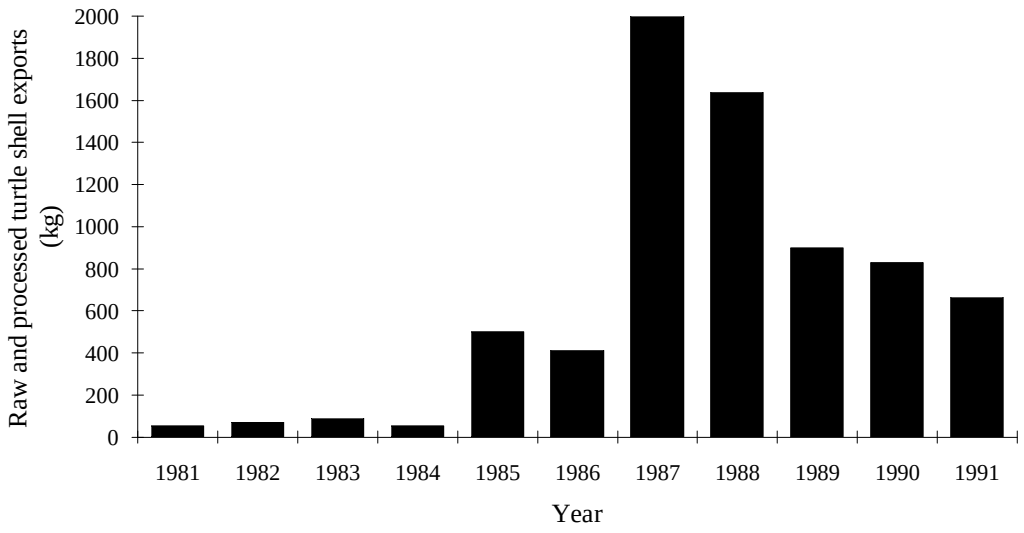
Table 28. Turtle meat sales (mt) and values (FJD'000) for the period 1979-1992 (Source: Fisheries Division Annual Reports; Lewis, 1985a).

1979		1980		1981		1982		1983		1984		1985	
Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value
10	17.4	10.8	na	11.5	na	22.5	na	34.0	na	20.0	47.2	11.1	na

1986		1987		1988		1989		1990		1991		1992	
Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value	Wt.	Value
5.1	11.2	14.0	51.7	4.1	11.1	5.5	17.7	12.9	46.4	1.7	5.3	18.6	74.1

Raw and worked turtle shells have been exported from Fiji for many years, though reliable export data is unavailable. Swamy (1991) provides turtle shell export estimates for the years 1981-1991 (Figure 3). Under present legislation, only processed turtle shells may be exported.

Figure 3. Estimated exports of raw and processed turtle shell (kg) for the years 1981-1991 (Source: Swamy, 1991).



6.1.3 Stock Status

There is very little information available on the stock status of sea turtles in Fiji. Swamy (1991) reported that 4 nesting sites were observed at Makogai Island during the 1990-91 nesting season, while at Namena Island, 18 **taku** nesting sites were located. Anecdotal information from Namena Island suggests that fewer turtles nested there in 1990-91 than in

previous years, and it is now several years since **vonudina** nested there. Easier access to remote nesting islands must have resulted in an increased catch of turtles in recent years.

Because of the vast and complex migratory patterns of sea turtle stocks, it has been suggested that heavy exploitation of turtles and their eggs in one South Pacific country, may have a direct effect on reducing the relative abundance of turtles in neighbouring countries. Turtle exploitation in several areas of Solomon Islands may have had such a deleterious effect on the abundance of turtles in Fiji (Skewes, 1990).

Recent turtle tagging experiments in American Samoa, using satellite-tracked tags, provide direct evidence that **vonudina** migrate between Fiji and American Samoa. After 3 **vonudina** laid their eggs at Rose Atoll, American Samoa in November 1993, they were tagged. Immediately afterwards they migrated 1,600 km to various locations in Fiji, a journey taking 34-45 days to complete at an average swimming speed of 1.8 km per hour. One turtle went to Nateva Bay on Vanua Levu, the second went to Naweni Point, also on Vanua Levu , while the third went to the Lau Group. It is expected that they will remain in those locations for 2-3 years before returning to Rose Atoll to nest again (News Release: 22 March 1994. Department of Marine & Wildlife Resources, Government of American Samoa).

6.1.4 Management

Current Legislation/Policy Regarding Exploitation: Regulation 9 of the Fisheries Regulations (Cap.158 as amended) provides that:

" No person shall harpoon any turtle unless the harpoon is armed with at least one barb, of which the point projects not less than 9.5 mm [3/8 inch] from the surface of the shaft, measured at right angles to the long axis of the shaft."

Regulation 20 of the Fisheries Regulations (Cap.158 as amended) provides that:

"1. No person shall at any time dig up, use, take, sell, offer or expose for sale, or destroy turtle eggs of any species or in any way molest, take, sell offer or expose for sale, or kill any turtle the shell of which is less than 455 mm [18 inches] in length. No person during the months of January, February, November or December in any year shall in any way molest, take, sell, offer or expose for sale, or kill any turtle of any size.

2. No person shall be in possession of, sell, offer, or expose for sale or export any turtle shell the length of which is less than 455 mm [eighteen inches]."

The closed season on the taking of turtles and their eggs spans the main breeding season.

Regulation 26 of the Fisheries Regulations (Cap.158 as amended) provides in part that "No person shall export from Fiji -

? turtle flesh.

? turtle shell unless worked into jewelry or otherwise processed into a form approved by the Permanent Secretary for Primary Industries and Cooperatives."

Recommended Legislation/Policy Regarding Exploitation: The minimum size of 455 mm, as stated in Fisheries Regulation 20, is in fact well below the typical size at first maturity, and should be increased to 750 mm. An assessment of Fiji's turtle stocks should be undertaken. Such a survey may point to the imposition of a ban on the commercial sale of meat and shell.

The consumption of turtle in the traditional context should be allowed to continue, except in the event that stocks appear to be severely depleted.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1988c. Our Marine Resources. Fisheries Division unpublished leaflet. Fiji Fisheries Division, Suva, Fiji. 14p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Hirth, H.F. 1993. Marine Turtles. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 329-370.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

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

Skewes, T. 1990. Marine Resources Profiles: Solomon Islands. FFA Report No.90/61. Forum Fisheries Agency, Honiara, Solomon Islands. 52p.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No.92/17. Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

Swamy, K. 1991. Turtle - country report - Fiji. Fiji Fisheries Division unpublished report. 3p.

UNEP/IUCN, 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

6.2 EDIBLE SEAWEEDS

6.2.1 The Resource

Species Present: South (1993a) notes 7 species of seaweeds in Fiji which are harvested for consumption, or sale for later consumption. These are listed in Table 29. The preferred species in Fiji are *Caulerpa racemosa*, *Hypnea pannosa* and *Gracilaria verrucosam* (South, 1993a).

Table 29. Names of seaweeds commonly harvested in Fiji (Source: Lewis, 1986; South, 1993a).

Family	Fijian name	Common name	Scientific name
Chlorophyta	**nama**, **na**	sea grapes	*Caulerpa racemosa*
(green algae)	**namakeibelo**	sea grapes	*C. racemosa* var. *occidentalis*
	totoyava, **sagati**	codium	*Codium bulbopilum*
Rhodophyta	**lumicevata**, **lumivakalolo**	maidenhair	*Hypnea pannosa*
(red algae)	**lumiyara**, **lumiwawa**	glassweed	*Gracilaria verrucosam*
	lumitamana	goldenweed	*Solieria robusta*
	(not available)	(not available)	*Acanthophora spicifera*

Distribution: Sea grapes are widely distributed in the tropical Pacific (Shokita *et al.*, 1991) and are found throughout Fiji. At Dravuni Island, Fiji, South (1991) recorded three varieties of *C. racemosa* (var. peltata, uvifera and macrophysa), *C. cupressoides* var. lycopodium, *C. serratula*, *C. taxifolia* and *C. urvillianav. Hypnea* and *Gracilaria* are also abundant throughout Fiji (South, 1993a).

Biology And Ecology: *Hypnea* and *Gracilaria* are found in sheltered back-reef areas, protected from the destructive effects of wind and waves (South, 1993a). *Caulerpa* is a purely marine stenohaline alga which will die even in slightly brackish sea-water, so the salinity of the surrounding sea-water should not be lower than 30 parts per thousand (Trono, 1988).

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 2 cm per day, a characteristic which is exploited in cultivation (Shokita *et al.*, 1991).

6.2.2 The Fishery

Utilisation: Throughout the Pacific Islands and S.E.Asia, several species and varieties of seaweed may be utilised as fresh food, mainly through the gathering of natural stocks (Trono, 1988). In Fiji, edible seaweeds form an important part of the diet, and it appears that Fijians have a long tradition in the collection and consumption of seaweeds. However, it is likely that the commercialisation of edible seaweeds is a relatively recent phenomenon, coinciding with the expansion of the cash economy (South, 1993a).

Nama is a subsistence food in Fiji, traditionally eaten fresh as a salad, to accompany other food. It is often prepared by marinating it in lemon juice, then adding grated coconut (**lolo**), some finely chopped chili, and canned fish. **Lumicevata** and **lumiwawa** may be prepared in any of several ways prior to consumption. Plants are cleaned and washed, then mixed with chopped onion, **lolo**, chili and canned fish, and then cooked. The seaweeds add a characteristic flavour and act as a thickening agent (South, 1993a).

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 (1993b) 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: Collecting, marketing and preparing edible seaweed in Fiji is largely an activity of Fijian women and girls. It is community-based, with the work being shared among family and village groups. Seaweed harvested from the lagoon and reef on a weekly basis is stored for eventual sale in markets at the end of the week.

Experienced Fijian **nama** harvesters normally collect only the upright shoots, leaving the stolons to regenerate more shoots. Harvesting strategy includes rotation of collecting areas over at least a 3-4 week cycle, to promote regeneration. Good harvesting sites are protected by the villagers and appear to have been harvested over many generations. **Lumicevata** and **lumiwawa** are harvested by hand and stored in sacks prior to sale, either immersed in seawater or kept damp in the shade. Plants are often entangled with debris, and a considerable amount of time is spent cleaning them before they are marketed (South, 1993a).

Nama shoots are sold in heaps, at prices ranging from FJD0.50-2.00 per heap. Some vendors may exclusively collect and sell **nama**, but normally **nama** sales are combined with those of other seaweeds and non-fish products such as shellfish. A single vendor may sell between 10 and 20 heaps on a market day, earning up to FJD80.00 per week. The greatest sales take place on Fridays and Saturdays at Suva, Nausori, Nadi and Lautoka (South, 1993a). From previous average sales of approximately 10 mt per year for all species recorded, production and sale of edible seaweed in 1991 jumped to 36 mt valued at FJD50,000, falling to 20 mt in 1992. Production figures for the years 1986-1992 are presented in Table 30.

Table 30. Estimated sales (mt) of locally consumed seaweeds in Markets and Outlets for the years 1986-1992 (Source: Fisheries Division Annual Reports).

	1986	1987	1988	1989	1990	1991	1992
nama	4.79	6.16	5.88	6.15	0.36	20.21	9.08
sagati	0.04	0.35	1.02	0.05	0.14	0.10	0.18
lumiwawa	4.54	4.69	5.12	4.88	6.45	16.00	11.10
Total	9.37	11.20	12.02	11.08	6.95	36.31	20.36

Prakash (1990) estimates that at least twice the volume of edible seaweeds sold in markets and outlets are consumed on a subsistence basis.

6.2.3 Stock Status

There is no information available to indicate stock status of the various species of edible seaweeds. The recent rapid increase in seaweed collection, sale and consumption may be impacting adversely on stocks, and this is worthy of investigation.

6.2.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None required at present, though given the increasing harvest of edible seaweeds in Fiji and their importance in the cash economy, South (1993a) believes that some indication of the crop's sustainability should be determined.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Prakash, J. 1990. Fiji. In: Adams, T. and R. Foscarini (eds.). Proceedings of the Regional Workshop on Seaweed Culture and Marketing. FAO South Pacific Aquaculture Development Project, Suva, Fiji. 1-9.

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

South, G.R. 1991. Benthic marine algae from Dravuni Island, Astrolabe Islands, Kadavu, Fiji. Marine Studies Programme Technical Report. Series 1991 Number 5.

South, G.R. 1993a. Edible seaweeds - An important source of food and income to indigenous Fijians. NAGA: The ICLARM quarterly, Volume 16, Number 2-3. International Center for Living Aquatic Resources Management, Manila, Philippines. 4-6.

South, G.R. 1993b. Seaweeds. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 683-710.

Trono, G.C. 1988. Manual on Seaweed Culture; 2. Pond Culture of *Caulerpa* and 3. Pond Culture of *Gracilaria.* ASEAN/SF/88/Manual No.3. ASEAN/UNDP/FAO Regional Small-Scale Coastal Fisheries Development Project. Manila, Philippines. 20p.

6.3 SEA URCHINS

6.3.1 The Resource

Species Present: Morton and Raj (1978) list the following sea urchins from Fiji*;* edible sea urchin (**cawaki**, **gwaca** - *Tripneustes gratilla*), long-spined sea urchins (*Diadema setosum, Echinothrix calamaris*), slate-spined sea urchin (*Heterocentrotus mammillatus*), pink sea urchin (*Echinometra mathaei*), *Toxopneustes pileolus* and *Mespilia* sp.

Distribution: The geographic distributions of selected species of sea urchin are listed in Table 31.

Table 31. Geographic distributions of sea urchins found in Fiji (Source: Guille *et al*., 1986).

Scientific Name	Geographic Distribution
T. gratilla	Widely distributed in the Indo-Pacific region
D. setosum	Very widely distributed in the Indo-Pacific, including Fiji and Tahiti
Echinothrix calamaris	Widely distributed in the Indo-Pacific, Red Sea, Australia and Japan
H. mammillatus	Widely distributed in the Indian and South Pacific Oceans
Echinometra mathaei	Very widely distributed the South Pacific and Indian Oceans
To. pileolus	Very widely distributed in the Indo-Pacific, Australia and Japan

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 from mid-tide down at 1-8 m, in dense aggregations under thickets of branching corals or on surfaces of rocks (Shokita *et al.*, 1991). Towards low water and on the outer reef face, *E. mathaei* is accompanied by *H. mamillatus*. *T. gratilla* is commonly found in little exposed areas of the reef in 1-8 m of water, most often in the presence of seaweed. *To. pileolus* is found from 1-15 m deep in lagoonal sheltered moats and rubble flats, whereas *E. calamaris* is found from 5-40 m in the interior of lagoons (Guille *et al*., 1986). 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).

6.3.2 The Fishery

Utilisation: Lewis (1986) lists *T. gratilla* as an aquatic food of Fiji. Sea urchin roe is highly prized as a delicacy by Japanese consumers who eat approximately 50,000 mt (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).

Production And Marketing: Fiji Fisheries Division maintains records of the sales of **cawaki** in municipal markets and outlets in Fiji. These are presented in Table 32 for the years 1986-1992. There was a massive increase in estimated sales in 1990 to 20 mt, from an average of approximately 3 mt per year in the preceding years. In 1991, sales returned to their previous average level, but rose to 7.6 mt in 1992.

Table 32. Estimated sales (mt) of **cawaki** in municipal markets and outlets for the period 1986-1992 (Source: Fiji Fisheries Division Annual Reports).

	1986	1987	1988	1989	1990	1991	1992
Markets	3.58	2.42	3.01	2.47	15.34	1.68	2.13
Outlets	na.	na.	na.	na.	5.46	1.14	5.42
Total	3.58	2.42	3.01	2.47	20.80	2.82	7.55

The mean price of **cawaki** in Fiji's municipal markets has risen from approximately FJD0.90 per kg in the late 1980s to approximately FJD1.80 per kg in 1991-1992 (Fiji Fisheries Division Annual Reports).

6.3.3 Stock Status

There is no information available on the status of sea urchin stocks in Fiji.

6.3.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None required at present, though if production and sales continue to rise, stock assessment surveys of **cawaki** may be necessary. There does not appear to be any potential for the export of sea urchin roe to overseas markets.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Guille, A., P.Laboute and J.L.Menou. 1986. *Handbook of the sea-stars, sea-urchins and related echinoderms of the New Caledonia lagoon.* Éditions de l'ORSTOM, Institut Français de Recherche Scientifique pour le Développement en Coopération. Collection Faune Tropicale n° XXV, Paris, France. 238p.

Lewis, 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

McShane, P. 1992. Sea urchin fisheries of the world: Prospects for development of a kina fishery in New Zealand. In: NZ Professional Fisherman, June 1992. p.27-32.

Morton, J. and U.Raj. 1978. The shore ecology of Suva and Viti Levu; Composite volume. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 183p.

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

6.4 SEA CUCUMBERS

6.4.1 The Resource

Species Present: There are approximately 1,200 species of holothurians (sea cucumbers) distributed world-wide, about 300 of these occurring in the shallow (<20 m deep) tropical seas of the Indian and Western Pacific oceans (Guille *et al*., 1986). Vuki and Viala (1989) state that in Fiji, approximately 15 species of sea cucumber are used in the preparation of bêche-de-mer for export, while several of these are traditionally used for food (Table 33).

Table 33. Names of sea cucumbers present in Fiji of subsistence* and/or commercial✍ importance, and other common species (Source: Lewis, 1986; Vuki and Viala, 1989).

Common name	Fijian name	Scientific name
sandfish	**dairo**, **tero**	*Metriatyla scabra**✍
brown sandfish	**vula**	*Bohadschia vitiensis**
sea cucumber	**mudra**, **midro**	*Stichopus* sp.*
black teatfish	**loaloa**, **lolo**	*Microthele nobilis**✍
surf redfish	**tarase**	*Actinopyga mauritiana**✍
white teatfish	**sucuwalu**	*Microthele fuscogilva**✍
greenfish	**sucudrau**	*Stichopus chloronotus**✍
lollyfish	**loliloli**	*Halodeima atra**✍
blackfish	**driloli**	*Actinopyga miliaris*
deep-surf redfish	**dri tabua**	*Actinopyga echinites*✍
prickly redfish		*Thelenota ananas*✍
elephant's trunkfish		*Holothuria fuscopunctata*✍
curryfish	**laulevu**	*Stichopus variegatus*✍
stonefish		*Actinopyga lecanora*✍

Distribution: Most commercially important species found in the Pacific Islands are also distributed in the waters of Indonesia, Australia, the Philippines, China and southern Japan (Clark and Rowe, 1971 In: Preston, 1993). Many members of the family Holothuridae are found as far west as East Africa and Madagascar. Species diversity decreases in an easterly direction across the Pacific, and few of the commercially exploited holothurian species are found as far east as the Hawaiian Islands (Preston, 1993).

Within Fiji, most commercial species occur in sheltered lagoons and on reef flats, the resource thus lying within areas under traditional ownership. Most supplies of bêche-de-mer for export originate from Lau, Vanua Levu and the Yasawas (Lewis, 1985a). In a survey conducted at Suva Reef, Levuka Reef, Beqa Reef, and North and South Astrolabe Reefs, Gentle (1979) found that **sucuwalu** were most abundant on Suva Reef, while **loaloa** were more numerous on the other four reefs. Preston (1993) reports that *H. fuscopunctata* dominates some inner lagoon areas in northern Fiji.

Biology And Ecology: Relatively little is known about the biology of sea cucumbers, since 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.

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, 1993).

Conand and Chardy (1985), by categorising the New Caledonia lagoon into 16 biotypes, found that holothurian distribution closely reflected the organisation of the reef system and these component biotypes. As a result of the study, several holothurian categories were defined, as follows:

? outer reef slope species, including *S. chloronotus* and *A. mauritiana*;

? pass and inner slope species, including *M. nobilis*, *M. fuscogilva*, *Ho. fuscopunctata*, *T. ananas*, and *T. anax*;

? inner reef-flat species, including *M. scabra*, *A. echinites*, and *A. miliaris*; and

? lagoon species, including *M. scabra* var *versicolor*, and *S. variegatus*.

Preston (1993) states that some species, such as **dairo**, several *Bohadschia* species in the study of Conand and Chardy (1985), and *H. fuscopunctata*, appear to occur in more than one habitat, or across habitat boundaries, and their habitat preferences do not appear to be as well defined as those of other species.

Gentle (1979), in a skin-diving survey of several reefs in Fiji (see above), noted that **sucuwalu** appears to be associated with turtle grass (*Syringodium isoetifolium*), usually in water deeper than 3 m. **Loaloa** were found mainly in sand channels on the inner rim of barrier and patch reefs of living coral, frequently partially hidden under ledges. Two other commercial species, *T. ananas* and **driloli** were found in the same habitat as **loaloa**, but were everywhere less abundant than this species.

Adams (1988) reported that **driloli** is abundant on sandy reef-flats and near mangrove areas, often in water less than 10 cm deep. Larger individuals may be scattered in water greater than 3 m deep.

6.4.2 The Fishery

Utilisation: Sea cucumbers are utilised in a variety of forms. In Fiji, **dairo**, and to a lesser extent **vula**, are the main species eaten by Fijians in large quantities and are important emergency food sources in times of hardship (Adams, 1992). **Dairo** are eaten fresh, marinated in lemon juice and salt, or cooked in coconut milk. Other species are prepared by cooking them in coconut milk for a few hours. **Loliloli** is sometimes fermented for a few days before marination or before it is cooked in coconut milk (Vuki and Viala, 1989).

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).

Harvesting is usually done by hand-collection or free diving. In many situations, sea cucumbers can be harvested by gleaning at low tide. The use of underwater breathing apparatus such as SCUBA and hookah gear has made the task of collecting deeper dwelling sea cucumbers much easier. In Fiji, over 100 hookah units were sold during 1991, most of which will be used by collectors of sea cucumbers and other marine invertebrates. The use of this type of equipment will significantly increase the likelihood of local over-harvesting, while the uncontrolled introduction of hookah to village fishermen puts villagers at considerable personal risk (Preston, 1993).

The processing of sea cucumbers into bêche-de-mer requires the use of boiling containers, smoke-sheds or smoking racks, and large quantities of firewood. Properly processed bêche-de-mer will keep for many months without refrigeration or other forms of preservation. Although apparently simple, the process is critical to the final price obtained, some variations in the processing being specific to certain types of sea cucumbers. An excellent description of the bêche-de-mer processing operation is provided by Preston (1993). The finished product is graded by species, size and quality and bagged for export, principally to S.E.Asian markets.

Production And Marketing: Because sea cucumbers are harvested for both local sale and consumption, and for preparation of bêche-de-mer, some production and marketing details are available for both uses. There are no current estimates for subsistence production of sea cucumbers. Table 34 provides estimates of the amounts of selected species of sea cucumbers sold in markets and outlets for the years 1986-1992. Sales of **dairo**, in particular, have recently dropped sharply from approximately 30 mt per year to less than 10 mt per year.

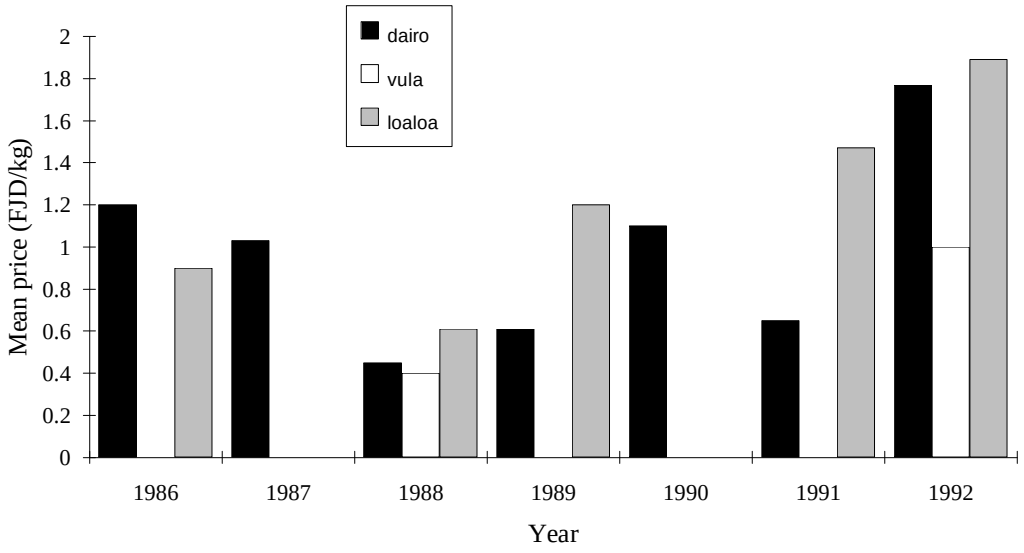
Table 34. Estimates of sales (mt) of selected species of sea cucumbers in markets (M) and outlets (O) for the years 1986-1992 (Source: Fisheries Division Annual Reports).

	1986		1987		1988		1989		1990		1991		1992	
	M	O	M	O	M	O	M	O	M	O	M	O	M	O
dairo	25.5	na	37.2	na	39.7	1.5	27.8	0.2	28.8	2.2	33.6	4.1	6.7	1.7
loaloa	0.7	na	2.8	na	0.3	2.7	nr	0.3	nr	0.9	1.1	0.9	nr	0.1
sucuwalu	0.1	na	2.1	na	0.3	2.2	nr	0.7	0.3	2.1	nr	4.2	nr	nr
vula	nr	na	0.1	na	0.1	0.4	nr	1.1	nr	nr	nr	nr	0.4	nr
sucudrau	nr	na	nr	na	nr	0.9	nr	0.2	nr	0.7	nr	1.7	nr	1.7
Sub-total	26.3	na	42.2	na	40.4	7.7	27.8	2.5	29.1	5.9	34.7	10.9	7.1	3.5
Total	26.3		42.2		48.1		30.3		35.0		45.6		10.6	

[na = not available nr = not recorded]

Figure 4 presents the mean price of three species of sea cucumbers in municipal markets from 1986-1992. Despite considerable fluctuations in prices since 1986, there has been a general upward trend in the prices of **dairo**, **vula** and **loaloa**, undoubtedly reflecting the recent decreased availability of product. The mean price of **dairo** in 1992 was FJD1.77 per kg.

Figure 4. Mean price of **dairo**, **vula** and **loaloa** in municipal markets from 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



Until recently, bêche-de-mer production in Fiji was limited to small quantities of the higher value species, mainly **sucuwalu** and **loaloa,** which were mainly exported to Hong Kong. These deeper-water species, which prefer smaller-island habitats, did not have sufficient export value to warrant their intensive collection (Adams, 1992). 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). Fiji's bêche-de-mer is now mainly exported to Hong Kong, Singapore and Taiwan.

The market opened up very rapidly, and a range of species, even the lower-value species, became relatively valuable. These lower value species were mainly found in shallow, inshore areas around the main islands. Though they were easy to collect in large quantities, they were also easy to over-exploit. From a situation where the level of bêche-de-mer exports had never exceeded 50 mt per year in 100 years, they rapidly increased to over 700 mt in 1988. Adams (1992) states that the real export figure for 1988 was probably nearer 1,000 mt, since much of what was exported as "miscellaneous molluscs" was bêche-de-mer.

Given that sea cucumbers shrink to approximately one-tenth of their fresh weight during processing, it is estimated that some 10,000 mt of sea cucumber was harvested from Fiji reefs in 1988. After the 1988 peak, total bêche-de-mer exports from Fiji have declined to between 300-400 mt per year, a level probably maintained by exploiting new or more distant reefs, and exploiting different and lower value species. In 1988, most of the trade was in **driloli**, but more recently there have been increasing quantities of other species, such as greenfish, redfish and stonefish. There is no series of detailed export figures available to chart the gradual progression of exploitation through the species. Total estimated bêche-de-mer exports from Fiji for the

period 1982-1992 are given in Figure 5. Average export value per kilogram of bêche-de-mer, extrapolated from figures provided by Fiji Customs, are provided in Figure 6.

Figure 5. Estimated bêche-de-mer exports from Fiji for the period 1982-1992 (Sources: Lewis, 1985a; Adams, 1992).

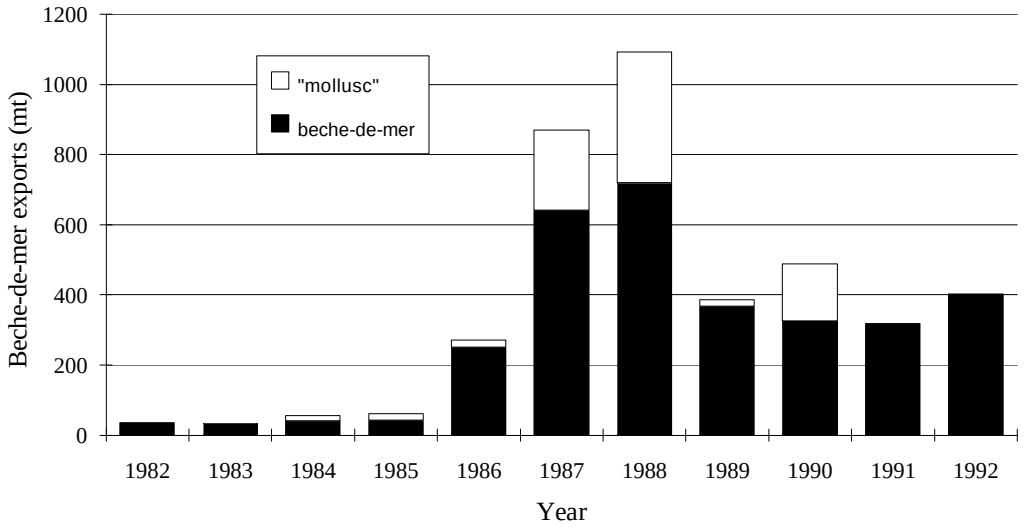
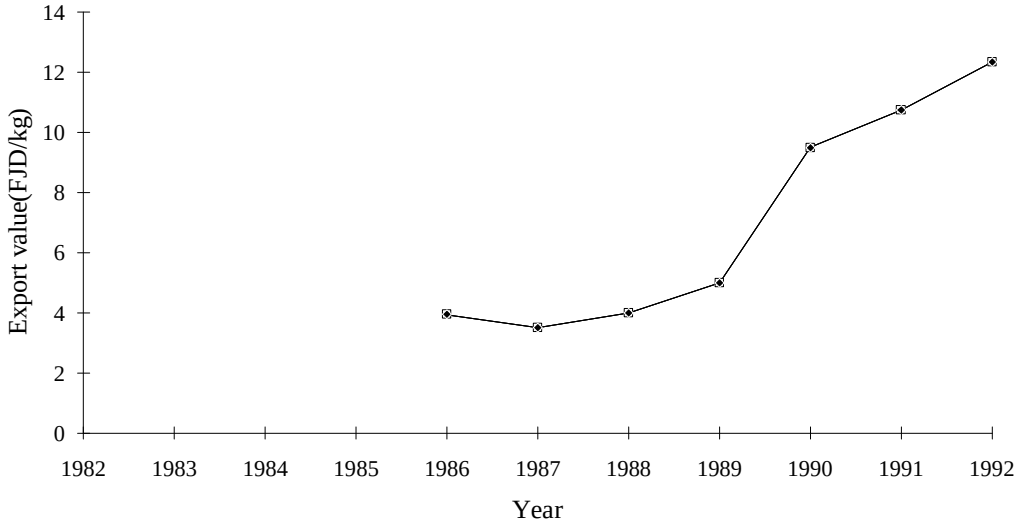


Figure 6. Average export values (FJD/kg) for bêche-de-mer exports from Fiji for the period 1986-1992 (Sources: Adams, 1992; Fisheries Division Annual Reports).



6.4.3 Stock Status

There have been very few assessments made of the stocks of sea cucumbers in Fiji's waters. Gentle (1979) made some assessments of mainly **sucuwalu** on the Suva and Levuka reefs by skin diving. **Sucuwalu** was abundant on these reefs, the average CPUE being 12-20 specimens per man-hour, though at some sites, catches of up to 100 per man-hour were possible. **Loaloa** was generally found in much lower abundance than **sucuwalu**, being taken at up to 10 per man-hour on the reefs of smaller islands.

Though Gentle (1979) expressed abundance in specimens found per man-hour, abundance may also be expressed relatively, in terms of number or biomass of animals per unit area, or absolutely, as the total number or biomass of animals in a given area. Preston *et al*.(1988) recorded a maximum density of 78,900 **driloli** per hectare in northern Fiji. For the same species, Conand (1989) recorded a maximum density of 5,970 per hectare in New Caledonia.

The densities and CPUE figures reported by Gentle (1979) far exceeded those encountered by Stewart (1993) in a survey of sea cucumbers in the Suva and Beqa areas. Free diving near Suva, Stewart (1993) gathered 25 specimens of **dairo** in 34 minutes from an area of 400 m², giving a density of 625 **dairo** per hectare and a recovery rate of 22 animals per man-hour. At Laucala Island, the density of **dairo** was only 63 per hectare and the recovery rate less than 3 animals per man-hour. A 4-day survey of waters surrounding Beqa Island located only one specimen of **driloli**, and villagers there reported that they had ceased gathering **dairo** and **driloli** in 1991, due to insufficient numbers of animals. Anecdotal reports from Bau and Navua indicated to Stewart (1993) that there were few **dairo** left in these two areas.

6.4.4 Management

Current Legislation/Policy Regarding Exploitation: Fiji Fisheries Division recommendations on regulating exploitation in the bêche-de-mer fishery were approved by Cabinet in 1984. The resulting "Bêche-de-mer Exploitation Guidelines" , as listed in Lewis (1985a), are as follows:

? harvesting and processing of product to be restricted to Fiji nationals;

? no size limits are necessary, as prices vary with size, and small individuals are neither collected nor are they commonly seen;

? the use of SCUBA gear for the collection of bêche-de-mer is forbidden.

The second of these Guidelines was reversed in December 1988 when Cabinet legislated to prevent the export of any bêche-de-mer less than 7.6 cm in length (in any form), and banned the export of all **dairo** (in any form) unless a permit is obtained from the Minister for Agriculture, Fisheries and Forestry. Regulation 25B of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall export, either in a natural or processed form, holothurians (beche-de-mer) or the species *Metriatyla scabra* (*Holothuria scabra*) (dairo) (sandfish) or shall take, be in possession of, sell, offer or expose for sale or export holothurians, either in a natural or processed form, of any other species whatsoever of a length less than 7.6 centimetres [3 inches]. The protection for **dairo** reflects the importance of this species as a local and emergency food item (Adams 1993).

The third Guideline banning the use of SCUBA was never given the force of law, though Adams (1993) reports that it was influential in preventing investment in the purchase of SCUBA gear for commercial fishing. However, this Cabinet ban did not apply to hookah

(surface-supplied air), and a new exploitation boom took place, starting in 1991. Cabinet has since legislated to ban the supply and use of hookah gear for the exploitation of bêche-de-mer.

Fong (1994) reports that the Chiefs of the combined area of Dreketi, Sasa, Mali and Macuata Districts banned the commercial taking of bêche-de-mer from the beginning of 1989, for an initial 5 years.

Recommended Legislation/Policy Regarding Exploitation: Adams (1992) suggests that the size restriction currently in force is unlikely to stabilise the fishery at levels of indefinite sustainability, since too much of the original standing stock has already been harvested to sustain full yearly regeneration. It may be more realistic to accept the " boom and bust " cycle of the fishery, maximise export earnings by allowing harvesting to continue for a further period, followed by a complete closure of the fishery for several years to allow full regeneration.

References

Adams, T.J.H. 1988. Status of bêche-de-mer production in Fiji. Unpublished notes: Fiji Fisheries Division, Suva, Fiji. 3p + Appendices.

Adams, T.J.H. 1992. Resource aspects of the Fiji bêche-de-mer industry. Bêche-de-mer Information Bulletin (4), July 1992. South Pacific Commission, Noumea, New Caledonia. 13-16.

Adams, T.J.H. 1993. Management of bêche-de-mer (sea cucumber) fisheries. Bêche-de-mer Information Bulletin (5), August 1993. South Pacific Commission, Noumea, New Caledonia. 15-21.

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Cannon, L.R.G. and H. Silver. 1986. *Sea Cucumbers of Northern Australia.* Queensland Museum, South Brisbane, Australia.

Conand, C. 1989. The fishery resources of Pacific island countries. Part 2. Holothurians. *FAO Fisheries Technical Paper*, No.272.2. Rome, FAO. 1989. 143p.

Conand, C. and P. Chardy. 1985. Are the Aspidochirote holothurians of the New Caledonia lagoon good indicators of the reefal features? *Proc. Vth Int. Coral Reef Congr., Tahiti, 1985*, Vol. 5, 291-296.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Gentle, M.T. 1979. Population ecology of commercial bêche-de-mer (Echinodermata: Holothuroidea) in Fiji. SPC Fisheries Newsletter, (18): 13-15.

Guille, A., P.Laboute and J.L.Menou. 1986. *Handbook of the sea-stars, sea-urchins and related echinoderms of the New Caledonia lagoon.* Éditions de l'ORSTOM, Institut Français de Recherche Scientifique pour le Développement en Coopération. Collection Faune Tropicale n° XXV, Paris, France. 238p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Preston, G.L. 1993. Bêche-de-mer. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 371-407.

Preston, G.L., V. Vakamoce, P. Lokani and F. Viala. 1988. Bêche-de-mer exploitation in Fiji. Report to Chief Fisheries Officer. Mimeo, pag.var.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No.92/17. Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

Stewart, B. 1993. Evidence for a marked decline of bêche-de-mer populations in the Suva and Beqa areas of Fiji, and a preliminary description of a method of identifying bêche-de-mer individuals based on characteristic body wrinkles. Marine Studies Programme Technical Report No.1, The University of the South Pacific, Suva, Fiji. 19p.

Vuki, V.C. and F.Viala. 1989. Shrinkage and weight loss of nine commercial species of holothurians from Fijian waters. South Pacific Commission Fisheries Newsletter 51: 27-29.

6.5 COCONUT CRAB [ugavule]

6.5.1 The Resource

Species Present: Lewis (1986), Wells *et al*., (1983) and Clunie (In: UNEP/IUCN, 1988) note the coconut or robber crab (**ugavule** - *Birgus latro*) as being present in Fiji.

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).

Its distribution in Fiji is probably limited to only a few islands. Clunie (in UNEP/IUCN, 1988) noted the presence of **ugavule** on Qelelevu Atoll in the Ringgold Isles, northern Fiji.

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 7.6-12.7 cm carapace width for crabs on Eniwetok, at an age of four to eight years. Fletcher (1988), working in Vanuatu, estimated a 600 g 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. 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.

6.5.2 The Fishery

Utilisation: The coconut crab is intensively hunted by local inhabitants wherever it occurs, as its flesh is universally regarded as a delicacy. There is no information available on its utilisation in Fiji.

Production And Marketing: There is no information available on the production and marketing of **ugavule** in Fiji. If there is any production, it is at the subsistence level.

6.5.3 Stock Status

The status of **ugavule** stocks in Fiji is unknown, though they are thought to be generally depauperate. **Ugavule** are reported to persist on many of the Northern Lau islands, especially those which have no human populations (T. Adams, pers. comm.).

6.5.4 Management

Current Legislation/Policy Regarding Exploitation: None at present. For several years now, it has been a general policy not to permit applications for export of **uguvale**, due to the depauperate status of stocks.

Recommended Legislation/Policy Regarding Exploitation: Fletcher (1993) states that " ..the rational management of this resource should be of vital importance to the governments of all countries with surviving populations of coconut crabs." Wells (1983) states that " Protection should be afforded to this species in vulnerable areas."

References

Brown, I.W. and D.R.Fielder. 1988. Annotated bibliography of the coconut crab, *Birgus latro* (L). ACIAR Working Paper No.17. ACIAR, Canberra, Australia.

Fletcher, W.J. 1988. Coconut crab ecology in Vanuatu. South Pacific Commission: Workshop on Pacific Inshore Marine Resources, Working Paper #7, Noumea, New Caledonia. 6p.

Fletcher, W. 1993. Coconut crabs. In: A.Wright and L. Hill (eds.) *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 643-681.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No.92/17. Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

UNEP/IUCN, 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

Wells, S.M., R.M.Pyle and N.M.Collins. 1983. *The IUCN Invertebrate Red Data Book.* IUCN, Gland, Switzerland. 632p.

6.6 MANGROVE CRAB [qari, bakera]

6.6.1 The Resource

Species Present: The green mangrove or mud crab (*Scylla serrata*) is listed by Lewis (1986) as present in Fiji.

Distribution: A comprehensive description of the Indo-West Pacific distribution of *S. serrata* is given by Dickinson (in Brown, 1993). Brown (1993) states that any tropical Pacific Island large enough to sustain a fluvial delta with associated mangrove forests, will support a population of mangrove crabs. According to Lewis (1985a), **qari** are found throughout Fiji except on outlying islands where there are no mangrove stands, and occur entirely within customary fishing right areas. The Rewa, and Labasa River deltas, and Bua were noted by Lewis (1985a) to be the main sources of supply to municipal markets and non-market outlets.

Biology And Ecology: Qari are frequently found in areas characterised by a muddy substrate associated with mangrove vegetation, and they are the only portunid crabs characteristically found in mangrove swamps. This type of habitat is typical of sheltered tropical to sub-tropical estuaries, embayments and the lower reaches of rivers and tidal streams (Brown, 1993). In a survey carried out by Lal *et al*. (1983) in Wairiki Creek near Suva, *S. serrata* was the dominant crab species found.

The crabs are sometimes found in the mud amongst mangrove roots, but more often in burrows which extend obliquely down into the mud at an angle of about 30° to the horizontal. Burrows may be up to 2 m in length, and are used as general refuges by sub-adult and adult crabs. *S. serrata* can tolerate a wide range of temperatures and salinities. **Qari** are opportunistic feeders, subsisting primarily on slow-moving or immobile prey organisms. They tend to live in parts of the estuarine system where prey is most abundant, usually remaining buried during daylight hours and feeding at night (Brown, 1993).

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

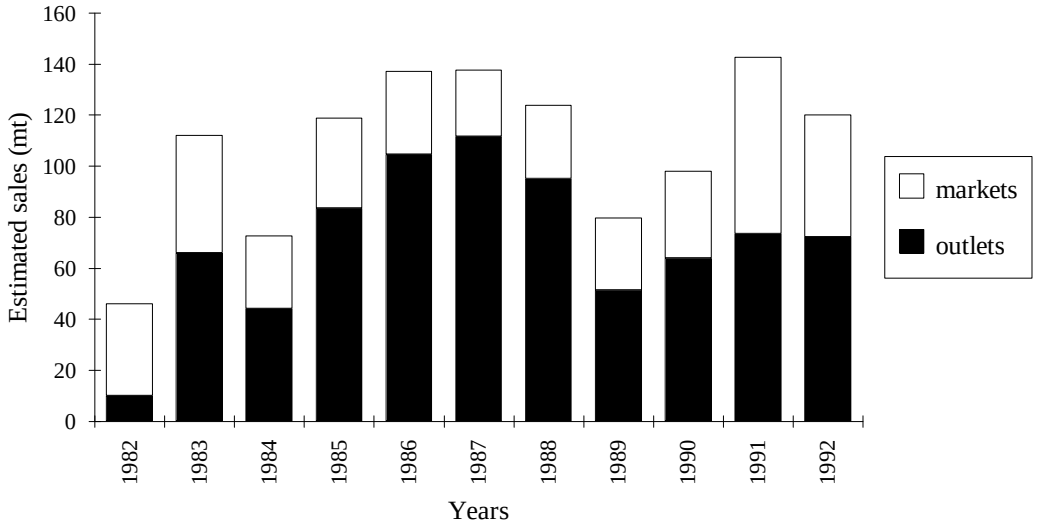
Because **qari**, like other crustaceans, have a rigid exoskeleton, they must periodically shed it (moult) in order to grow. Fielder and Heasman (1978 In Brown, 1993) provide a concise description of this complex process. The rate at which crabs grow depends on the moult frequency and the moult increment, the size difference between the old and new shell. Brown (1993) reports that in sub-tropical climates, mangrove crabs attain a carapace width of between 8 and 10 cm in their first year, and between 13 and 16 cm in their second year. In Australian waters, mangrove crabs can reach a carapace width of 24 cm, but most fall within the 15-20 cm size group. Males have larger, heavier claws and attain weights of 3 kg and more.

6.6.2 The Fishery

Utilisation: Lewis (1985a) states that in Fiji, **qari** are caught by hand, hooked from burrows and taken in baited hoop nets or pots. They are also taken incidentally by gillnet fishermen working near mangroves. Most fishing for **qari** is done by women, who bundle and bind 6-8 live crabs at a time for market. Provided they are kept in moist packing such as mangrove leaves, **qari** can be kept alive for up to a week, though condition is gradually lost. Though males and females differ in shape, claw size and meat return, there is no price differential in local markets, where they are usually sold in strings of mixed sex.

Production And Marketing: Qari are marketed in municipal markets and by direct sales to shops, hotels and restaurants. Small quantities (40-400 kg per year) are also exported. Estimated sales (mt) of **qari** for the years 1982-1992 are given in Figure 7. From total estimated sales of slightly more than 40 mt per year in the early 1980s, total sales have since fluctuated between 70 to 140 mt per year. From 1983 until 1991, direct sales to shops, hotels and restaurants far exceeded sales in municipal markets. However, the municipal market share of the total increased significantly in 1991, only to drop again in 1992.

Figure 7. Estimated sales (mt) of **qari** in municipal markets and outlets for the years 1982-1992. (Source: Lewis, 1985a; Fiji Fisheries Division Annual Reports).



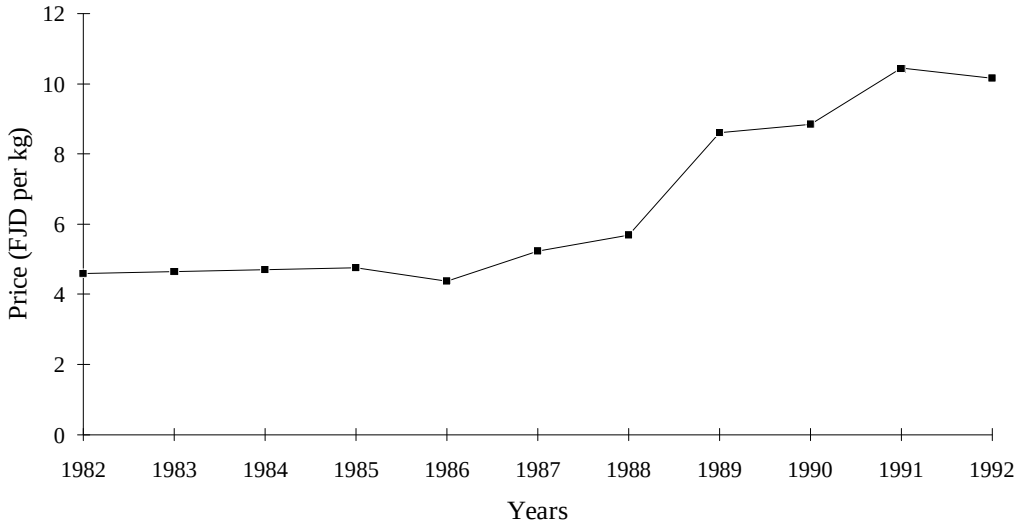
After remaining relatively constant from the early to mid-1980s, prices for **qari** at municipal markets have more than doubled to over FJD10 per kg in 1991-1992 (Figure 8). Prices obtained through other outlets tend to be higher than market prices.

6.6.3 Stock Status

Despite unexplained large dips in production in 1984 and 1989, production of **qari** since 1983 has been consistently high compared with production in the late 1970s to early 1980s. In areas

adjacent to urban centres, the stocks must be experiencing very heavy fishing pressure. Anon. (1988c) noted that large numbers of small **qari** were being sold in markets, which is source of concern for the future of the stocks. Fong (1994) quotes Sasa villagers as saying that **qari** are becoming hard to find. Lewis (1985a) indicated the lack of work undertaken to assess the extent to which overfishing is occurring in particular areas, and the threats to **qari** production from the destruction of their habitat by the clearing and filling of mangrove areas.

Figure 8. Prices (FJD per kg) for **qari** at municipal markets for the period 1982-1992 (Source: Fiji Fisheries Division Annual Reports).



6.6.4 Management

Current Legislation/Policy Regarding Exploitation: Regulation 19 of the Fisheries Regulations (Cap.158 as amended) provides that:

"No person shall kill, take, sell or offer or expose for sale any crab of the species *Scylla serrata* (Swimming Crab or Qari Dina) of less than 125 mm [5 inches] measured across the widest part of the carapace or shell."

Recommended Legislation/Policy Regarding Exploitation: Despite the current size restrictions, it seems that the taking and selling of undersized **qari** is common. Public awareness programmes, particularly focused on the owners of customary fishing rights, could draw attention to the undesirability of killing small crabs before they have had a chance to breed. Large-volume exports of **qari** should not be encouraged.

In terms of the information required for future mangrove crab fishery management, Brown (1993) recommends the collection of a time-series of reliable catch and effort data, including locality information and a realistic measure of fishing effort which can be used to calculate a CPUE or index of population density. He states that "Without such a means of monitoring

changes in the size of the stock in different geographic areas, regular surveys are required, with attendant problems of cost, continuity of personnel, sampling design and fishing technique."

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1988c. Our Marine Resources. Fisheries Division unpublished leaflet. Fiji Fisheries Division, Suva, Fiji. 14p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Brown, I.W. 1993. Mangrove Crabs. In: A.Wright and L. Hill (eds.) *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 609-642.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Lal, P.N., K.Swamy and P.Singh. 1983. Mangroves and secondary productivity: fishes associated with mangroves in Wairiki Creek, Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Division, MAF, Suva, Fiji: 13-31.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Nichols, P.V. 1991. Republic of Palau Marine Resources Profiles. FFA Report No. 91/59. Forum Fisheries Agency, Honiara, Solomon Islands. 124p.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No.92/17. Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

6.7 OTHER CRABS

6.7.1 The Resource

Species Present: The black mangrove crab (**kukaloa**, **kukavulu** - *Metopograpsus messor*), land crab (**lairo** (gen), **tuba** - *Cardisoma carnifex*), red-clawed crab (**kukadamu**, **kukadra** - *Sesarma erythrodactyla*), swimmer crab (**qarivatu** - *Thalamita crenata*), threespot reef crab (**tavutolo**, **kavika** - *Carpilius maculatus*) and redeye crab (**motodi**, **taqalito** - *Eriphia sebana*) (Lewis, 1986).

Distribution: The "South Pacific Island" distribution of many of the crustacean species listed above is described by Yaldwyn (1973). In Fiji, Fulaga is noted by UNEP/IUCN (1988) as a **lairo** breeding area. Lal *et al.* (1983) noted large numbers of burrows of *Sesarma* sp. in the intertidal areas under the mangroves, during a fisheries survey of Wairiki Creek near Suva.

Biology And Ecology: Adult **lairo** 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).

6.7.2 The Fishery

Utilisation: Most utilisation of the wide variety of crabs collected in Fiji waters occurs at the subsistence level, though several of those listed above have commercial importance.

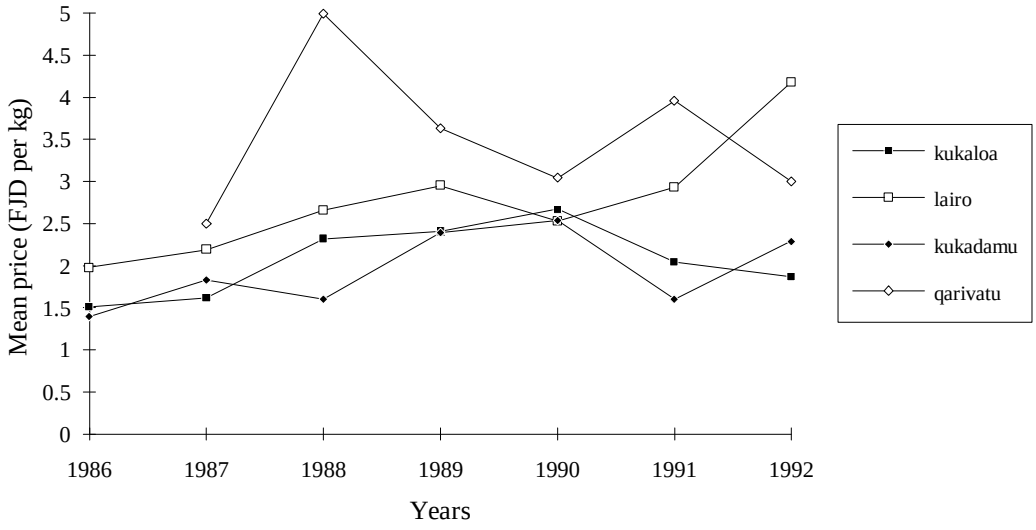
Production And Marketing: Fiji Fisheries Division has been collecting and compiling sales figures and market prices for crustacean species for many years. The estimated volume of sales (mt) of several crustaceans in municipal markets and non-market outlets for the years 1986-1992 are provided in Table 35. Large sales of the major species were recorded in 1991, with subsequent declines in 1992. Sales of **qari** in 1991 and 1992 showed a similar fluctucation (Profile 6.6).

Table 35. Estimated volume of sales (mt) of **kukaloa**, **lairo**, **kukadamu**, **qarivatu** and **tavutolo** in municipal markets (M) and non-market outlets (O) for the years 1986-1992 (Source: Fisheries Division Annual Reports).

	1986		1987		1988		1989		1990		1991		1992	
	O	M	O	M	O	M	O	M	O	M	O	M	O	M
kukaloa	na.	22.1	0.1	11.6	na.	25.7	4.7	12.0	6.5	24.1	11.6	35.6	11.7	18.5
lairo	na	16.8	na.	8.1	na.	11.5	2.1	8.4	1.2	21.3	5.5	52.8	4.2	10.5
kukadamu	na.	5.0	na	0.7	na	3.2	0.6	2.0	0.3	2.6	0.7	23.4	2.3	3.3
qarivatu	na.	0.6	na.	0.1	0.7	1.4	0.0	0.5	0.0	0.6	0.0	1.1	0.0	0.0
tavutolo	na.	na.	na.	na	na.	na.	0.3	na.	0.4	na.	0.0	0.0	0.0	0.0

Prices for the species listed here tend to be well below those for **qari**. Figure 9 gives the prices for **kukaloa** and **lairo** for the years 1986-1992. Prices for **lairo** have shown a consistently upward trend during this period, to the point where **lairo** at FJD4.18 per kg in 1992 is the most expensive of these species.

Figure 9. Prices (FJD per kg) in municipal markets for **kukaloa**, **lairo**, **kukudamu** and **qarivata** for the years 1986-1992 (Source: Fisheries Division Annual Reports).



6.7.3 Stock Status

There is no information on the status of Fiji's stocks of these crustacean species.

6.7.4 Management

Current Legislation/Policy Regarding Exploitation: There is currently no national legislation concerning any of the species of crabs listed in Profile 6.7.

Recommended Legislation/Policy Regarding Exploitation: Public awareness programmes, directed towards the owners of customary fishing rights, should be produced to draw attention to the undesirability of killing small crabs before they have had a chance to breed.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Lal, P.N., K.Swamy and P.Singh. 1983. Mangroves and secondary productivity: fishes associated with mangroves in Wairiki Creek, Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Division, MAF, Suva, Fiji: 13-31.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Nichols, P.V. 1991. Republic of Palau Marine Resources Profiles. FFA Report No. 91/59. Forum Fisheries Agency, Honiara, Solomon Islands. 124p.

UNEP/IUCN, 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

Yaldwyn, J.C. 1973. Decapod crustacea from South Pacific reefs and Islands. *Oceanography of the South Pacific 1972*. Fraser, R. (comp.) New Zealand Commission for UNESCO, Wellington, New Zealand. 503-511

6.8 LOBSTER [urau]

6.8.1 The Resource

Species Present: Lewis (1985a) reports that the most abundant species of rock lobster in Fiji is the golden rock lobster (**uraukula**, **urauvatuvatu** - *Panulirus penicillatus*). Smaller quantities occur of the painted rock lobster (**uraudina** - *P. versicolor*), the whiskered lobster (*P. longipes femoristriga*) and the ornate rock lobster (**urautamata**, **uraubola** - *P. ornatus*). The slipper lobster (**vavaba**, **ivinibila** - *Parribacus caledonicus*), is also found.

Distribution: Geographical distributions, keys to species identification and some biological information about the known marine lobster species are provided in Holthuis (1991). *P. penicillatus* is the most widespread species of spiny lobster, and is found in the Indo-West Pacific and Eastern Pacific regions. Its range extends from the Red Sea, east and south-east Africa to Japan, Hawaii, Samoa and the Tuamotu Archipelago, east to the islands off the west coast of America, and in some localities near the continental coast of Mexico.

P. versicolor is found in the Indo-West Pacific region from the entire Red Sea and east coast of Africa, southern Japan, Micronesia, Melanesia, northern Australia and Polynesia. There are two subspecies of *P. longipes*. In the Indo-West Pacific, the subspecies *P. longipes femoristriga* (called "eastern subspecies"), inhabits waters of Japan, the Molluccas, Papua New Guinea, eastern Australia, New Caledonia and French Polynesia. *P. ornatus* is found in the Indo-West Pacific region from the Red Sea and east Africa to southern Japan, Solomon Islands, Papua New Guinea, Australia, New Caledonia and Fiji. Holthuis (1991) describes the distribution of *Parribacus caledonicus* as being in the Indo-West Pacific region in Queensland, Australia, New Caledonia and Loyalty Islands, Vanuatu, Fiji and Samoa.

In Fiji, **uraukula** is the most abundant of the species present, particularly on the reefs of the eastern groups of islands. **Uraudina** is quite common and is present in the lagoons and sheltered waters of most islands. **Urautamata** is occasionally caught from the reefs of the main and western islands, while *P. longipes femoristriga* is very rare, only a few specimens having been reported (Pitcher, 1993). **Vavaba** is not abundant in Fiji (Lewis, 1985a).

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

P. longipes femoristriga occupies a habitat in clear water just on the lagoon side of active reef edges amongst dense coral growth. *P. ornatus* is found in shallow, sometimes slightly turbid coastal waters from 1-8 m depth. It has been found as deep as 200 m, exposed to oceanic water, outside the Great Barrier Reef (Pitcher, 1993). Its habitat may include sandy and muddy substrates, rocky bottom near the mouths of rivers and coral reefs. *P. versicolor* is found in shallow water, from the sub-littoral down to 15 m depth. Common habitats are coral reef areas, often on seaward edges of the reef plateau, and in clear water also in surf areas (Holthuis, 1991).

Pitcher (1993) states that lobsters are generally regarded as opportunistic and omnivorous scavengers, but they can be somewhat selective, towards food items with higher nutritional and energy value. The range of food items consumed by *Panulirus* species generally includes molluscs (primarily gastropods), crustaceans, echinoderms, seagrass and algae (Phillips *et al*., 1980 In: Pitcher, 1993).

The different species of *Panulirus* have relatively consistent life cycles and breeding behaviour. Sexes are separate and easily distinguished by external characters. Male lobsters, possibly attracted by a sex pheromone, mate with inter-moult females that have developing ovaries. The males deposit an acellular mass containing tubular spermatophores onto the females' sternums. This process, and notes on courtship behaviour are described by Pitcher (1993). Within a few days after mating, the females extrude several hundred thousand eggs into a chamber formed by curving the abdomen over the sternum. The eggs are fertilised as the female releases the sperm by scraping the spermatophore.

The eggs are carried under the tail of the female for about a month before tiny phyllosoma larvae are released. The time of larval release in *P. penicillatus* may be cued to the full moon, and the female may move to areas where currents are stronger and directed to carry the larvae into the oceanic environment. The transparent phyllosoma larvae may remain in the ocean for 4-12 months or more, passing through 10 or more morphological stages and growing to as long as 50 mm, before they moult into the puerulus stage. This stage, when they resemble a colourless miniature adult, may last from a few days to a few months. The pueruli undergo the transition from the oceanic to the benthic environment, where they settle in or near the adult habitat and quickly moult into pigmented juveniles (Phillips and Sastry, 1980 In: Pitcher, 1993). Because of the considerable time and extensive dispersal of the larval stages between mating and puerulus settlement, recruitment may occur from spawning adult populations a considerable distance away.

The size at which lobsters become mature is a basic biological parameter that is also an important consideration for management. Carapace size at sexual maturity for *P. penicillatus* in Palau is 10 cm and in Solomon Islands 7.5-7.9 cm (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 Fiji.

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. The most noticeable difference in patterns of growth is between male and female *P. penicillatus* throughout the Pacific. Females initially may grow slightly faster than males, but then slow substantially, probably as a result of the diversion of energy into egg production with the onset of sexual maturity. In comparison, the males continue to grow relatively quickly. The Pacific average asymptotic carapace length ($L_{?}$) for male *P. penicillatus* is 15.7 cm and for females, 12.2 cm. For *P. ornatus* from Torres Strait, $L_{?}$ for males is 16.4 cm and for females, 14.9 cm. For *P. longipes* from Tonga, $L_{?}$ for males is 13.3 cm and for females, 11.8 cm (Pitcher, 1993).

Estimates of natural, fishing and total mortality for *Panulirus* species in the Pacific are summarised by Pitcher (1993), who also provides information on abundance of lobster

populations. In the Pacific, the absolute abundance of *P. penicillatus* has been estimated in only a few limited areas of reef slope. Figures from Solomon Islands indicate that abundance was between 111-128 lobsters per km of reef slope or 46-57 per ha (Prescott, 1988). Because the area of habitat available for *P. penicillatus* is limited to a 20-25 m wide strip of windward reef slope, stocks of this species are relatively small, and can only be expected to sustain small fisheries.

6.8.2 The Fishery

Utilisation: Traditionally, traps of various kinds were widely used in the Pacific to catch lobsters, but now they are used in only a few fisheries. The traps caught *P. penicillatus* and *P. longipes*, but *P. versicolor* and *P. ornatus* almost never entered traps (Prescott, 1988). As in many of other island countries in the Pacific, *P. penicillatus* in Fiji can be caught by spearing and hand collection on the reef flats at night, either side of a low tide. In the early 1960s, New Zealand lobster pots were trialled without success (Pitcher, 1993).

The product is typically sold as frozen tails, tail weight as a percentage of total weight varying between approximately 40 per cent for females of most sizes to as low as 25 per cent for large males. Lobsters collected locally on a small scale are sold to hotels, shops, municipal markets and wholesalers, though a substantial proportion of the catch is consumed at home or bartered in villages (Pitcher, 1993).

Production And Marketing: The total production in 1984-1985 was estimated at between 70-90 mt, a substantial increase on the < 30 mt per year for the preceding years (Lewis, 1985a). Estimated sales of **uraukula**, **uraudina**, **urautamata** and **vavaba** (mt) in municipal markets and outlets for the years 1986-1992 are presented in Table 36. Total production remained < 40 mt per year for the years 1986-1988, before rising to approximately 90 mt per year in 1990-1991, thus repeating the pattern shown six years previously (Figure 10).

Table 36. Estimated sales of various lobster species (mt) in municipal markets (M) and outlets (O) for the years 1986-1992 (Source: Fisheries Division Annual Reports).

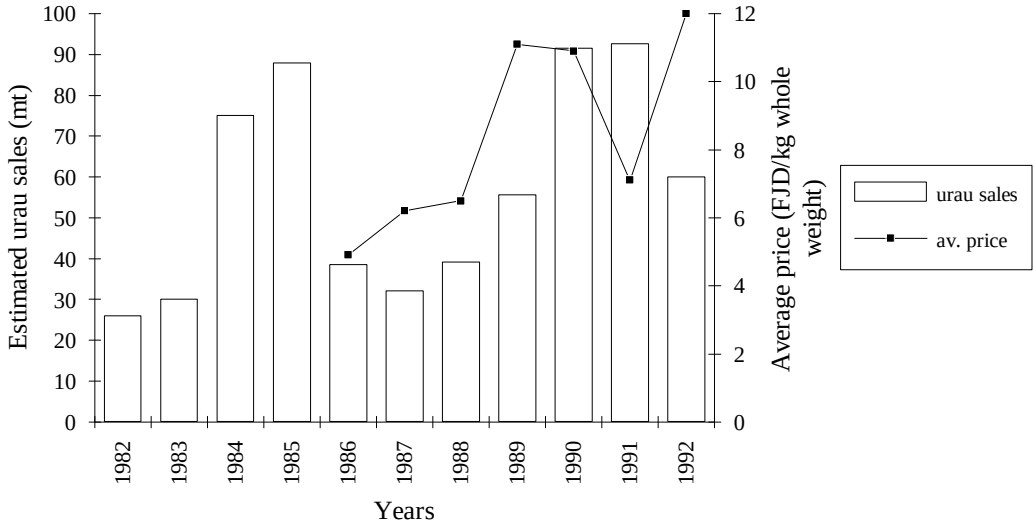
	1986		1987		1988		1989		1990		1991		1992	
	O	M	O	M	O	M	O	M	O	M	O	M	O	M
uraudina	36.8	1.8	30.3	1.8	34.6	3.9	52.3	0.7	87.9	2.2	89.2	1.6	44.0	1.5
uraukula	na	na	na	na	na	na	na	na	na	0.0	0.5	0.8	0.6	0.0
urautamata	na	na	na	na	na	na	na	na	na	0.1	0.0	0.6	3.9	0.0
vavaba	na	na	na	na	0.6	na	2.7	na	0.8	0.6	0.0	0.0	0.0	0.0
Total	36.8	1.8	30.3	1.8	35.2	3.9	55.0	0.7	88.7	2.9	89.7	3.0	58.5	1.5

Prices for **urau** in the early 1980s varied between FJD2.50-7.50 per kg of whole animal, depending on the collection and market circumstances (Lewis, 1985a). Prices for the period 1986-1992 are given in Figure 10. Exports of frozen lobster from Fiji in recent years have not exceeded 70 kg per year (Fisheries Division Annual Reports).

6.8.3 Stock Status

Given the probable wide dispersal of *P. penicillatus* phyllosoma larvae, and the many unexploited reefs which can potentially provide recruitment to exploited reefs, Pitcher (1993) states that it is a reasonable assumption that *P. penicillatus* stocks in the Pacific will be resilient to recruitment overfishing. It is possible that Fiji's reefs may be settled by larvae spawned in neighbouring countries, as well as those spawned in Fiji (Lewis, 1985a). In addition, *P. penicillatus* stocks may enjoy a measure of inbuilt protection because of the animal's exposed seaward reef habitat and reluctance to enter traps.

Figure 10. Estimated total sales (mt) and average prices (FJD per kg whole weight) of **urau** for the years 1982-1992 (Sources: Lewis, 1985a; Fisheries Division Annual Reports).



6.8.4 Management

Current Legislation/Policy Regarding Exploitation: No restrictions are prescribed under the Fisheries Act and Regulations. The harvesting of lobsters is discussed at length under the Cabinet Guidelines approved in 1984, and still in force. They are reproduced here from Lewis (1985a):

? Participation in lobster fishing activities to be restricted to Fiji nationals;

? Fishing activities to be restricted in the first instance to uninhabited islands and reefs and only with the written approval of resource custodians; village fishermen to be involved in fishing operations to the maximum extent practicable;

? A size limit to be imposed on caught lobster. This is to be subsequently incorporated into Fisheries Regulations. (A minimum carapace length of 70 mm has been suggested for the Tongan fishery and would be a useful starting point);

? Provision to be made for Fisheries Division observers to accompany commercial scale operations as deemed necessary;

? It may not be necessary at this stage to implement management regimes. The restriction of the resource to seaward reefs (which will often be inaccessible due to weather) and variation in vulnerability (moon phase, tidal cycle etc.) confers some measure of protection. In addition, optimal fishing methods still need to be developed. The Fisheries Division should be present during the early phase of any development to obtain information relevant to management questions. (The above comment refers to commercial operations. Village and small-scale fishermen will presumably continue as before, but will be subject to any size restrictions);

? Export to be subject to inspection as required, and issue of permit. (It is to be hoped that quality standards will be set for all export items as the industry develops);

? Participation in the fishery on a commercial scale to be restricted where possible to operations with a demonstrated capability to produce a high quality product. (This will maximize the product value and hence returns to fishermen.)

Recommended Legislation/Policy Regarding Exploitation: Because of the resilience of *P. penicillatus* stocks to recruitment overfishing, Pitcher (1993) is of the opinion that there is little current need to be overly concerned about the reproductive capacity of lobster stocks. Consequently, there is little need to protect berried females or to introduce closed seasons, particularly as females tend to breed throughout the year. The main biological concern of management is therefore to maximise yield from the available stock, by carrying out Yield Per Recruit (YPR) research and setting appropriate minimum sizes. A minimum carapace length of 70 mm has been discussed, though Pitcher (1993) suggests that a value in the range 75-80 mm would produce the highest YPR overall.

In discussing strategies for managing Pacific lobster fisheries, Pitcher (1993) makes a case for keeping fishing methods simple to discourage over-capitalisation and its consequences, and taking into account traditional reef-tenure systems for village-based fishermen. He is also in favour of encouraging diving for lobsters in areas where it is currently not practised, since diving provides access to additional productive habitat (the reef slope) and may also improve egg production by shifting effort from female lobsters, which frequent the reef flat, to males.

Lewis (1985a) and Pitcher (1993) stress the concern for quality product, which may be achieved by discouraging spearfishing and encouraging live catching and improved handling. Justification for refusing all overseas applications to exploit the resource is provided in Lewis (1985a). Recent information relevant to this issue is available in Adams and Dalzell (1994).

References

Adams, T.J.H. and P.J.Dalzell. 1994. Pacific islands lobster fisheries: Bonanza or bankruptcy? SPC Fisheries Newsletter No.67, October-December 1993. South Pacific Commission, Noumea, New Caledonia. 28-33.

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Holthuis, L.B. 1991. FAO Species Catalogue. Vol.13. Marine lobsters of the world. An annotated and illustrated catalogue of species of interest to fisheries known to date. *FAO Fish. Synop*. No. 125, Vol.13. Rome, FAO. 292p.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Nichols, P.V. 1991. Republic of Palau Marine Resources Profiles. FFA Report No. 91/59. Forum Fisheries Agency, Honiara, Solomon Islands. 124p.

Passfield, K. 1988. Tropical Spiny Rock Lobsters (Crayfish)[Koura tai]. Cook Islands Fisheries Resource Profile No.4. Cook Islands Ministry of Marine Resources, Rarotonga. 14p.

Pitcher, C.R. 1993. Spiny Lobster. In: A.Wright and L. Hill (eds.) Nearshore Marine Resources of the South Pacific. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 539-607.

Prescott, J. 1988. Tropical Spiny Lobster: An overview of their biology, the fisheries and the economics with particular reference to the double-spined rock lobster *P. penicillatus*. Working Paper No.18, Proceedings of the South Pacific Commission's Workshop on Inshore Fishery Resources. Noumea, New Caledonia, 14-25 March, 1988.

Skewes, T. 1990. Marine Resources Profiles: Solomon Islands. FFA Report No.90/61. Forum Fisheries Agency, Honiara, Solomon Islands. 52p.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No.92/17. Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

6.9 BANDED PRAWN-KILLER [urata]

6.9.1 The Resource

Species present: The banded stomatopod or prawn-killer (**urata** - *Lysiosquilla maculata*), also known as the mantis shrimp (Lewis, 1986).

Distribution: Most mantis shrimps 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 Fiji, **urata** are known from areas where the reef flat is overlain with sand, as noted at Vuda by UNEP/IUCN (1988).

Biology And Ecology: *L. maculata* is known to be the largest species of the Order Stomatopoda. Barnes (1968) 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 225-230 mm, at which size males weighed 125-250 g and females 180-330 g.

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 2-3 cm 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).

6.9.2 The Fishery

Utilisation: The use of **urata** is almost exclusively for subsistence purposes, since volumes of sales of this organism are not listed in the Fiji Fisheries Division Annual Reports.

Production And Marketing: There are no figures available for the production and marketing of **urata** in Fiji.

6.9.3 Stock Status

There are no estimates of stock status of mantis shrimp in Fiji. In a study in the Philippines, Angsinco *et al.* (1986), 57 mantis shrimps were observed from 46 identified burrows in an area of 16 ha, at a density of 3.56 shrimps per ha. In a nearby 10 ha area, the density was 4.2 mantis shrimps per ha.

6.9.4 Management

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

Recommended Legislation/Policy Regarding Exploitation: None required at present. It should be noted that degradation of near-shore habitat, such as dredging or the taking of sand for building purposes, will negatively impact on **urata** stocks.

References

Abelló, P. and P. Martín. 1993. Fishery dynamics of the mantis shrimp *Squilla mantis* (Crustacea: Stomatopoda) population off the Ebro delta (northwestern Mediterranean). Fisheries Research, 16 (1993). 131-145.

Angsinco, L.C., N.C.Mendoza, W.H. Uy, R.E. Acuña and M.M. Tan. 1986. Ecology and biology of giant mantis shrimp, *Lysiosquilla maculata* Fabricus in the Philippines, p. 189-191. In: J.L.Maclean, L.B.Dizon and L.V.Hosillos (eds.) The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.

Barnes, R.D. 1968. *Invertebrate Zoology* Second Edition. W.B.Saunders Company; Philadelphia, London, Toronto. 743p.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

UNEP/IUCN, 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

6.10 FRESHWATER PRAWNS

6.10.1 The Resource

Species present: Lewis (1985a) notes the natural presence in Fiji's freshwaters of at least 13 species of palaemonid prawns; 11 species of the genus *Macrobrachium* (**ura**) and 2 species of the genus *Palaemon* (**moci**). The freshwater prawn (**uradina** - *Macrobrachium lar*), river prawn (**kadikadi, sasakadi** - *M. equidens*) and Koua river prawn (*M. australe*) are specifically mentioned by Lewis (1986). Others believed to be present are the mountain river prawn (*M. latimanus*) (Longhurst, 1970 In: Holthuis, 1980) and the Noumea river prawn (*M. aemulum*), which has been recorded in Cook Islands. Aquaculture of the introduced giant freshwater prawn (*M. rosenbergii*) is discussed in Profile C.1.3.

Distribution: Freshwater or long-armed prawns have an Indo-Pacific distribution from East Africa to the Marquesas (Holthuis, 1980). Within Fiji, these prawns are found in the extensive natural freshwaters and artificial impoundments. Small ghost shrimp or mangrove prawns (**moci**) occur in coastal waters, penetrating upstream to brackish water (Lewis, 1985a).

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.

M. lar can attain 300 g in weight and grow to a maximum total length of 181 mm. As is the case with all *Macrobrachium* species, males attain a much larger size than females, and can be readily distinguished by their larger claws and slimmer bodies. *M. lar* appears to have a 3 year life span, becoming mature towards the end of the first year. Fertilised eggs are carried under the female's abdomen until they hatch. During this time, they change colour from orange to grey as they mature. There is probably a downstream movement for hatching, with planktonic larvae drifting for 4-6 weeks in nearshore waters. Juvenile stages inhabit brackish or salt water. Little is known of the life history of the other species. All are omnivorous bottom scavengers, and are more active at night than during daylight hours (Lewis, 1985a).

6.10.2 The Fishery

Utilisation: Many of Fiji's freshwater **ura** are small, and probably only **uradina**, **kadikadi** and *M. australe* are of any value as food species. No intensive fishery for freshwater **ura** exists in Fiji, though a substantial artisanal/subsistence fishery, usually involving women, employs push nets, hands, fine spears and traps (Lewis, 1985a).

Production And Marketing: Most freshwater **ura** species survive for a considerable period of time out of water, and are often sold live, wrapped in taro leaves. With a lower meat recovery rate and muddy taste compared with penaeid prawns, freshwater **ura** attract a lower price than penaeids in most markets.

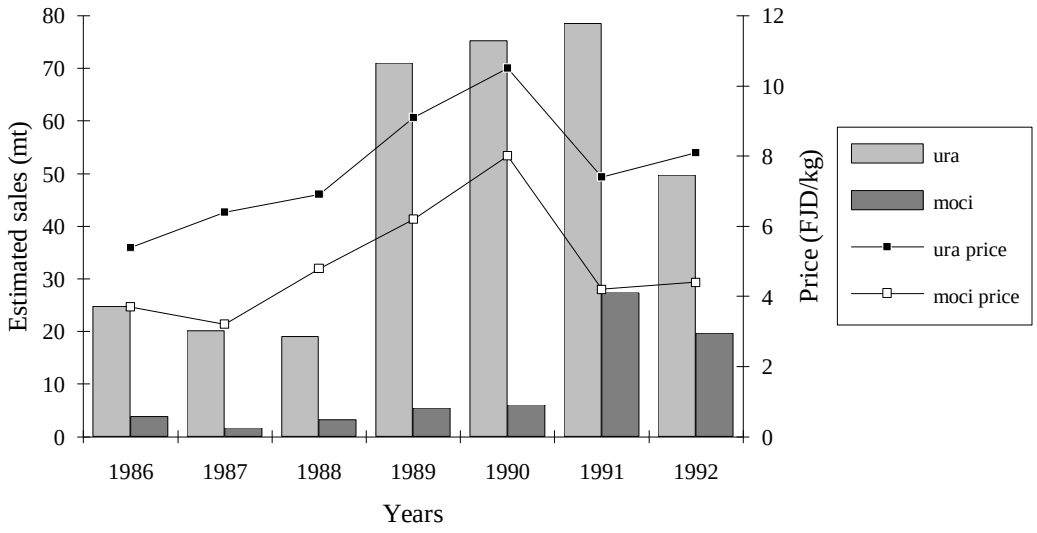
Marine and freshwater prawns are not distinguished in production statistics, though Lewis (1985a) states that *Macrobrachium* are believed to make up the bulk of the catch. Estimated sales (mt) of **ura** and **moci** in municipal markets and non-market outlets for the years 1986-1992 are presented in Table 37. Estimated sales of **ura** and **moce** have increased dramatically

in recent years, particularly the former. There was a sharp drop in sales in 1992. Prices for both have increased similarly. Figure 11 presents total estimated sales of **ura** and **moce**, together with mean prices for both, for the years 1986-1992. The value of **ura** sold in 1990 was approximately FJD790,350, dropping to FJD577,000 in 1991.

Table 37. Estimated sales of **ura** and **moci** in municipal markets (M) and non-market outlets (O) for the years 1986-1992 (Source: Fisheries Division Annual Reports).

	1986		1987		1988		1989		1990		1991		1992	
	O	M	O	M	O	M	O	M	O	M	O	M	O	M
ura	19.4	5.4	17.5	2.6	13.8	5.2	63.4	7.6	65.9	9.3	61.6	16.9	42.2	7.5
moci	0.1	3.7	0.5	1.2	0.3	2.9	2.0	3.4	1.5	4.6	10.7	16.6	11.0	8.6
Total	19.5	9.1	18.0	3.8	14.1	8.1	65.4	11.0	67.4	13.9	72.3	33.5	53.2	16.1

Figure 11. Total estimated sales (mt) of **ura** and **moce**, with prices (FJD/kg), for the years 1986-1992 (Source: Fisheries Division Annual Reports).



6.10.3 Stock Status

The status of local stocks is unknown, though with the vastly increased production from 1989 to 1991, and the sharp drop in production in 1992 (Figure 11), stocks in small streams near major urban centres subject may be severely depleted. Lewis (1985a) reported that the increasing use of chemicals which kill prawns of all species and sizes, was at that time a major source of concern. It is not known whether this illegal method of fishing is still in practise.

6.10.4 Management

Current Legislation/Policy Regarding Exploitation: None at present. The use of poisons to kill prawns is forbidden. Regulation 8 of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall take, stupefy or kill any fish in any lake, pool, pond, river, stream or in the sea by use of any of the following substances or plants:-

(a) any chemical or chemical compound;

(b) any substance containing derris;

(c) any substance containing the active principal of derris, namely, rotenone;

(d) any plant or extract or derivative from any plant, belonging to the genera *Barringtonia*, *Derris*, *Euphorbia*, *Pittosporum* or *Tephrosia*,

or place any of such substances or plants in any water for the purpose of taking, stupefying or killing any fish.

Recommended Legislation/Policy Regarding Exploitation: Given the small size of the prawns and the lengthy spawning season, neither the imposition of minimum size restrictions or restrictions on the sale of berried females would have much value. The ban on the use of poisons to kill prawns in this very valuable fishery should be strictly enforced, so that it can continue to provide income to rural Fijians.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1988c. Our Marine Resources. Fisheries Division unpublished leaflet. Fiji Fisheries Division, Suva, Fiji. 14p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Holthuis, L.B. 1980. FAO species catalogue. Vol. 1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. *FAO Fish. Synop*., (125) Vol. 1: 271p.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

6.11 SHALLOW WATER MARINE PRAWNS[ura]

6.11.1 The Resource

Species Present: Choy (1982) notes the presence of the giant tiger prawn (**urakeirasaqa** - *Penaeus monodon*), witch prawn (**uranicakau** - *P. canaliculatus*), green tiger prawn (*P. semisulcatus*), western king prawn (*P. latisulcatus*) and two species of greasy prawn, *Metapenaeus anchistus* and *M. elegans*. The banana prawn (*P. merguiensis*), which was introduced for prawn culture experiments during the 1970s, has established a localised population. The blue prawn (*P. stylirostris*) which was imported to Raviravi from New Caledonia for farming purposes in 1985/86, probably now exists in the wild (T.Adams, pers. comm.).

Distribution: *P. monodon* and *P. semisulcatus* are widely distributed in the Indo-West Pacific from east and southeast Africa and Pakistan to Japan, the Malay Archipelago, northern Australia, and east as far as Fiji and Tonga (Holthuis, 1980; Braley, 1979 In: Choy, 1982). *P. latisulcatus* is also wide ranging in the Indo-Pacific, from the Red Sea to Malaysia, the Mollucas to Korea, Japan and further east to Australia (Racek and Dall, 1965 In: Choy, 1982) and Fiji (Choy, 1982). *M. elegans* and *M. anchistus* are known from Sri Lanka, Malaysia, Indonesia (Holthuis, 1980) and Fiji (Choy, 1982). *P. canaliculatus* is known from an extensive area of the Indo-West Pacific, reaching from S.E. Africa to Taiwan, the Malay Archipelago, Fiji and Polynesia (Hothuis, 1980).

Choy (1982), in a survey of penaeid prawns around Viti Levu, found *P. merguiensis* only at Raviravi, Ba, in the vicinity of a discontinued FAO/UNDP fish pond project. The other species listed above, with the exception of *P. stylirostris*, were found in the study areas; Laucala Bay near Suva, and the estuaries of the Ba and Navua Rivers, and their adjacent lagoonal areas.

Biology And Ecology: The two divisions of the Natantian decapod crustaceans, Penaeidea and Caridea, contain the most exploited species commonly and interchangably referred to as either shrimps or prawns. The penaeids include the widespread tropical and sub-tropical exploited species of the genus *Penaeus* (King, 1993).

Penaeid prawns generally have an annual life cycle, with adults spawning in deeper nearshore waters. Choy (1982) showed that *P. canaliculatus* spawns in deeper channels of the Laucala Bay lagoon, where the water is of high salinity (>30 ppt). Unlike most prawns, lobsters and crabs, penaeids shed their eggs directly into sea water. The planktonic larvae drift into estuarine areas., where they grow to maturity through a succession of moults. At one month old, with a carapace length (CL) of 4.0 cm, *P. canaliculatus* post-larvae in Laucala Bay become benthic, and settle on the seagrass beds of the intertidal mudflats. Settlement occurs twice a year, in June and November. The post-larvae recruited in June grow in the nursery grounds for approximately 5 months, until they are juveniles measuring 16-20 mm CL. These juveniles are then recruited into the adult stocks offshore, eventually mating and spawning in October-November (Choy, 1982).

Age at first maturity for *P. canaliculatus* was shown by Choy (1982) to be between 5-7 months; the males and females of this age being about 16 mm and 20 mm CL respectively. The number of eggs released at a single spawning ranged from 20,000-100,000 for wild females, the number increasing with the size of the female.

Most species of *Penaeus* favour soft bottoms, where they feed on particulate matter. *P. canaliculatus* were shown by Choy (1982) to be opportunistic omnivores, the gut contents of juveniles and adults containing crustaceans, molluscs, polychaete worms, fish and plant material. Feeding activity was observed to be highest just at onset of darkness, especially when it coincided with high tide.

P. monodon grows to a weight of 250 g, and is easily the largest of the penaeid prawns found in Fiji (Lewis, 1985a). Choy (1982) found that in comparison to other *Penaeus* species, *P. canaliculatus* in Fiji had a relatively slow growth rate and attained a smaller size when adult. Females were larger and heavier than males of the same age.

6.11.2 The Fishery

Utilisation: Penaeid prawns are in demand in local and overseas markets wherever they are fished, including Fiji. The larger marine prawns, particularly *P. monodon* and *P. canaliculatus*, are captured during low tides at night in Fiji along estuary shorelines, using lanterns in conjunction with fine spears and scoops. This method of fishing is known as **cina**.

Other fishing methods for prawns in Laucala Bay involve seining and the use of scissors nets (Choy, 1988). Smaller penaeids and **moci** are captured with small-mesh push nets in estuaries (Lewis, 1985a).

Gravid female *P. monodon* are a potentially valuable resource in their own right, for use in prawn farm hatcheries. At one stage in its development, the Raviravi prawn farm subsisted on post-larvae obtained from wild-caught *P. monodon* (T.Adams, pers. comm.).

Production And Marketing: As mentioned in Profile 6.11, current market statistics do not distinguish between marine and freshwater prawns, production probably being dominated by the latter. Choy (1988) estimated the total penaeid catch from Laucala Bay near Suva to be about 3,000-5,000 kg per annum. Local commercial sales of **ura** underwent a massive increase to between 70-80 mt per year from 1989 to 1991, followed by a drop in 1992. This phenomenon was probably due to aquacultural production of **ura** at Raviravi and Navua, but may also have been influenced by unusually prolific spawning aggregations near Nadi in 1990/1991 (T. Adams, pers. comm.). On local markets, prawns are sold whole and fresh, mostly to wholesale and retail outlets. Lewis (1985a) reported that in 1985, retail prices of locally caught *P. monodon* were approximately FJD10.00 per kg. Current prices of locally caught penaeid prawns are not known.

6.11.3 Stock Status

Lewis (1985a) notes that Fiji's wild stocks of penaeid prawns are probably limited by the relatively small area of soft bottom habitat. Trawl surveys in 1976 and 1983 failed to locate commercial quantities, and encountered problems with rough bottom. It is likely that natural stocks will probably continue to support a small artisanal fishery.

6.11.4 Management

Current Legislation/Policy regarding exploitation: None at present. Choy (1988) noted the imposition of a ban on commercial fishing in Laucala Bay by traditional fishing ground owners.

Recommended Legislation/Policy Regarding Exploitation: None required, given the lack of an organised prawn fishery. With the continuing development of the local prawn farming industry, Lewis (1985a) noted the need for care to be exercised with the importation of exotic species, to prevent the introduction of diseases and parasites. The continuing pollution of nearshore waters from nearby urban areas will adversely affect the habitat of natural stocks of penaeid prawns.

References

Choy, S.C. 1982. The biology of littoral penaeid prawns in Fiji waters with particular reference to *Penaeus* (*Melicertus*) *canaliculatus* Pérez-Farfante. M.Sc. Thesis. The University of the South Pacific, Suva, Fiji. 161p.

Choy, S.C. 1988. The fishery and biology of *Penaeus canaliculatus* (Crustacea: Decapoda: Penaeidae) in Laucala Bay, Republic of Fiji. Fishbyte 6(1). ICLARM, Manila, Philippines. 21-24.

Holthuis, L.B. 1980. FAO species catalogue. Vol. 1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. *FAO Fish. Synop*., (125) Vol. 1: 271p.

King, M.G. 1993. Deepwater shrimp. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 513-538.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

6.12 DEEP WATER MARINE PRAWNS (SHRIMPS)

6.12.1 The Resource

Species Present: The major species found in deepwater trapping surveys in Fiji are pyjama shrimp (*Parapandalus serratifrons*), striped soldier shrimp (*Plesionika edwardsii*), striped gladiator shrimp (*Pl. ensis*), armed nylon shrimp (*Heterocarpus ensifer*), mino nylon shrimp (*H. sibogae*), humpback nylon shrimp (*H. gibbosus*) and smooth nylon shrimp (*H. laevigatus*) (King, 1993).

Distribution: The *Heterocarpus* species listed above have at least an Indo-Pacific distribution. According to King (1993) deepwater shrimps have been found in virtually all Pacific Islands where surveys have been attempted, including Fiji, Vanuatu, Samoa, Tonga, Marshall Islands, Hawaii, French Polynesia, Kiribati and Palau.

Biology And Ecology: The two divisions of the Natantian decapod crustaceans, Penaeidea and Caridea, contain the most exploited species commonly and interchangably referred to as either shrimps or prawns. Carideans include the commercially cold and temperate water shrimps of the genus *Pandalus*. Carideans differ from penaeids in that the pleuron (covering shell) of the second abdominal segment overlaps the pleura of both the first and third segments, and the third pair of walking legs does not have pincers. Unlike penaeids, carideans carry fertilised eggs externally beneath the abdomen (the "tail"), which is often proportionally smaller than that of penaeids (King, 1993).

Deepwater shrimps inhabit the steep outer reef slopes of islands, and the continental slopes of large land masses. Their distribution is relative to depth, with each particular species occupying different but overlapping depth ranges. *P. serratifrons* and *Pl. edwardsii* are widely distributed in shallower water (under 400 m), while medium-sized *Heterocarpus* species predominate in catches over 400 m. *H. sibogae*, which is commonly found in the south-western Pacific, appears to be replaced by *H. ensifer* in the eastern and northern Pacific. One of the largest species found, *H. laevigatus*, is widely distributed in Pacific islands in depths of more than 500 m. There is some evidence that deepwater caridean shrimps move between different depths on the outer reef slopes. *H. gibbosus* in Fiji appears to move between depths of about 450-550 m seasonally (King, 1993).

Tropical deepwater caridean shrimps have separate sexes. Eggs are carried externally on the pleopods of ovigerous females, and the number of eggs carried may exceed 30,000 on the larger *Heterocarpus* species. Female *H. laevigatus* reach sexual maturity between 40-43 mm CL, corresponding to a relative age of 4-4.6 years. The incidence of ovigerous females appears to vary with the time of year. In Fiji, over 50 per cent of female *H. laevigatus* were carrying eggs in April 1979, June and July 1980 and May 1981. Information from the northern hemisphere for the same species indicates that the spawning season of *H. laevigatus* is the winter season of each hemisphere (King, 1993).

The analysis of length-frequency data has been used to estimate the growth of several species of deepwater shrimps in Fiji; *Pl. edwardsii*, *H. sibogae*, *H. gibbosus* and *H. laevigatus*. Growth data for *H. laevigatus* suggest that the largest size groups in the Fiji samples are over 8 years of age, at an L_∞ of 57 mm. Instantaneous natural mortality rates for *H. laevigatus* in Fiji were estimated to be 0.66 yr^{-1} or 48 per cent per year. A combination of slow growth rates with

high natural mortality rates suggests that the biomass of shrimps from a given recruitment is maximised at an early age, after which the available biomass rapidly declines (King, 1993).

6.12.2 The Fishery

Utilisation: Deepwater shrimps in the Pacific islands countries are caught in baited traps. Several different types of traps and baits have been used. In general, baits of oily fish, such as tuna heads or mackerel, provide the highest catch rates. Most traps are made from steel rod frames, covered with galvanised wire or plastic mesh. Traps with side, rather than top entrances appeared most efficient in Fijian surveys (King, 1993).

Commercial fishing trials using a large vessel were carried out in Fiji during 1982. The mean catch rate of small (volume of 0.2-0.3 m^3) traps trialled near Suva in 450-650 m was 1.2 kg per night. In 1991/92, some small-scale trapping of deepwater shrimps was conducted near Suva from an *alia* catamaran. The catch rates achieved at this scale were reported to be sufficient to support a commercially viable operation, but low consumer acceptance of deepwater shrimps, due to sharp shells and associated peeling difficulties, proved to be problematic (T. Adams, pers. comm.).

Larger traps, used by commercial fishermen in Hawaii, are reported to catch at least 5 times more shrimps than small traps (Methot, 1994 In: King, 1993). A commercial fishing vessel, using traps with a volume of 1.84 m^3 in a survey of the Hawaiian Islands during 1983 and 1984, obtained an average catch rate of 12 kg per trap-night (Tagami and Barrows, 1988 In: King, 1993).

Production And Marketing: There are no records of production and marketing of deepwater shrimps in Fiji. King (1993) provides information on research and methods of assessment required to assess the potential for a fishery based on deepwater shrimp resources. In this account, the importance is emphasised of collecting financial information related to potential exploitation, when conducting shrimp trapping surveys.

6.12.3 Stock Status

The status of the stocks of deepwater shrimp in Fiji's waters is unknown.

6.12.4 Management

Current Legislation/Policy regarding exploitation: None at present.

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

References

King, M.G. 1993. Deepwater shrimp. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 513-538.

6.13 MUD LOBSTER [mana, tola]

6.13.1 The Resource

Species present: Yaldwyn (1973) and Lewis (1986) note the presence of the mud lobster (**mana**, **tola** - *Thalassina anomala*).

Distribution: Pillai (1992) states that *T. anomola* is widely distributed in the tropical Indo-West Pacific region, the eastern end of its range probably being demarcated by Fiji. Within Fiji, **mana** is known from those coastal areas which support mangrove vegetation, predominantly in the wetter south-eastern parts of Viti Levu.

Biology And Ecology: The **mana** is a moderately large crustacean, with adult specimens measuring up to 26 cm in length and weighing 250 g. Female **mana** tend to be ovigerous between December and June. The egg-carrying capacity of females is greatly increased by the distension of the ovary to almost the entire length of the animal in gravid individuals. In this condition, the egg-laden posterior extension of the ovary is visible through the arthrodial membranes of the abdominal sterna, as narrow bands of orange colouration (Pillai, 1992).

Mana lead a cryptic, subterranean lifestyle, within the estuarine deposits of the eulittoral and/or supralittoral zones. Yaldwyn (1973) notes that they are nocturnally active. Their presence is usually detected by the presence of their characteristic conical mounds. They rarely venture outside their burrows (Pillai, 1992).

6.13.2 The Fishery

Utilisation: Pillai (1992) notes that **mana** is considered a great delicacy by the Fijian inhabitants of the south-eastern coast of Viti Levu. However, it is seldom utilised as a food by the coastal dwellers of the north and north-west of Viti Levu, perhaps because of the difficulties associated with catching the animal. Though **mana** is regarded as a pest by aquaculturists and agriculturalists because of the harmful effects of its burrowing to such activities, it has a cultural and mythological significance to many Fijians.

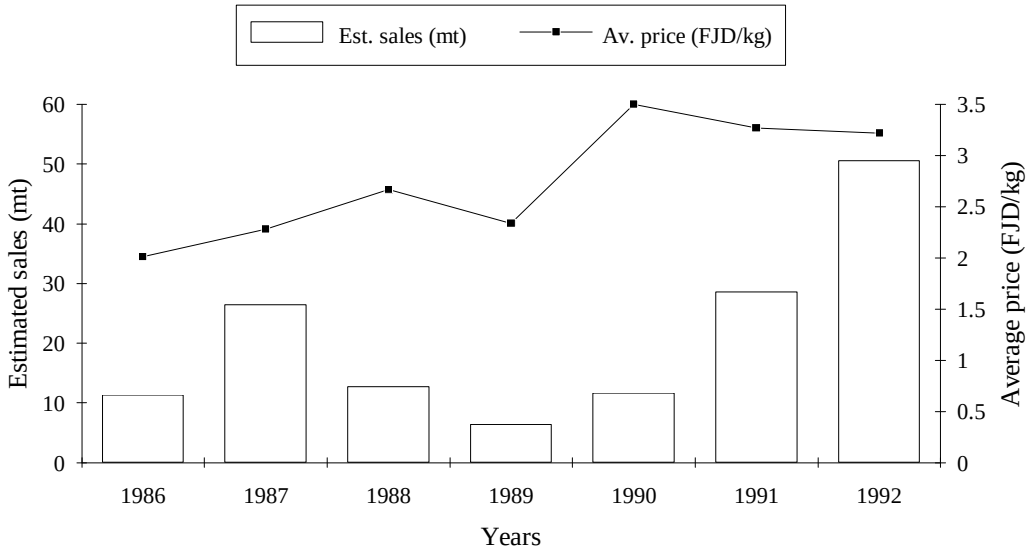
In the Philippines, **mana** are caught using a bamboo trap. However, Fijians have devised two other methods which are described in detail by Pillai (1992). Men usually employ a trapping device, which relies on the adult **mana** tripping a “trigger” to release tension on a bent pole joined to a noose. When the **mana** comes to the entrance of the burrow, it sets off the trigger. As the pole springs up, the noose tightens quickly around the mid-section of the animal’s body, usually resulting in the animal being dragged out of the ground. Skilled trappers can set approximately 10 traps per hour, with a success rate of 80-90 per cent.

A second catching method, known as **kucokuco**, is more commonly used by women, though men may also use it. When one of the several lower accesses to the burrow is located near the base of the mound, the catcher’s foot, or less commonly the hand, is pressed vigorously against it. The disturbance inside the mound created by this action drives the **mana** to the surface, where it is caught in the hands (Pillai, 1992).

Production And Marketing: Most **mana** is produced and sold in the south-east of Viti Levu, usually in bundles of 5-6 individuals tied together, at approximately FJD3.00 per bundle. Estimated sales of **mana** (mt) in markets for the period 1986-1992 are given in Figure 12. Most

of the recent upsurge in sales is due to a marked increase in **mana** sold at non-market outlets. In 1992, approximately 43 per cent of total sales (50.5 mt) were from non-market outlets in the Central Division.

Figure 12. Estimated sales (mt) and prices (FJD/kg) of **mana** in markets and outlets for the period 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).



6.13.3 Stock Status

There is no information regarding the stock status of **mana** in Fiji. Heavy fishing pressure in the south-east of Viti Levu, as witnessed by the rapid increase in estimated sales at markets and outlets, may have a detrimental effect on **mana** stocks. Any further degradation of Fiji's mangroves, and subsequent loss of **mana** habitat, is likely to negatively impact on the stocks of this animal.

6.13.4 Management

Current Legislation/Policy Regarding Exploitation: None at present

Recommended Legislation/Policy Regarding Exploitation: Public awareness programmes, directed towards the owners of customary fishing rights, should be produced to draw attention to the undesirability of taking **mana** before they have had a chance to breed.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1988c. Our Marine Resources. Fisheries Division unpublished leaflet. Fiji Fisheries Division, Suva, Fiji. 14p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Pillai, G. 1992. *Thalassina anomala* fishery in Fiji. Marine Studies Programme Technical Report, Series 1992, No.1. The University of the South Pacific, Suva, Fiji. 5p.

Yaldwyn, J.C. 1973. Decapod crustacea from South Pacific reefs and Islands. *Oceanography of the South Pacific 1972*. Fraser, R. (comp.) New Zealand Commission for UNESCO, Wellington, New Zealand. 503-511.

6.14 TROCHUS [**sici**]

6.14.1 The Resource

Species Present: The turban snail or topshell (**sici, leru** - *Trochus niloticus*). The closely related, white-based topshell (**tovu** - *T. pyramis*) is common in Fiji (Lewis, 1985a).

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 1950s, however, trochus has been successfully introduced into nearly all island groups of Polynesia (Sims, 1988a).

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 0.6-6 m 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, 1988a) 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 7 cm basal diameter producing approximately 500,000 eggs while females of 13 cm basal diameter produce up to 3 million eggs (Sims, 1988a).

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 (1988a) states that trochus attain a basal diameter of 8 cm after about 3 years. Subsequent growth is much slower, 11 cm basal diameter being reached at an age from 5 to 8 years. The maximum size generally attained by *T. niloticus* is about 150-155 mm diameter, though larger specimens (> 163 mm) have been recorded. Longevity is not known, but results of growth studies suggest that *T. niloticus* lives for 10-15 years, and possibly longer (Nash, 1993).

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

6.14.2 The Fishery

Utilisation: Sici is eaten as a subsistence item in Fiji, the shell being boiled to extract the meat which generally comprises 15 per cent of the live weight. It is also collected for the production of quality Mother-Of-Pearl (MOP) buttons and for ornamental purposes. Shells of the 7-10 cm size range are most sought after for commerce. In the manufacture of buttons, blanks are cut from the shell, following the whorls around. The blanks are later buffed and polished, while the residual shell can be further processed to produce MOP chips.

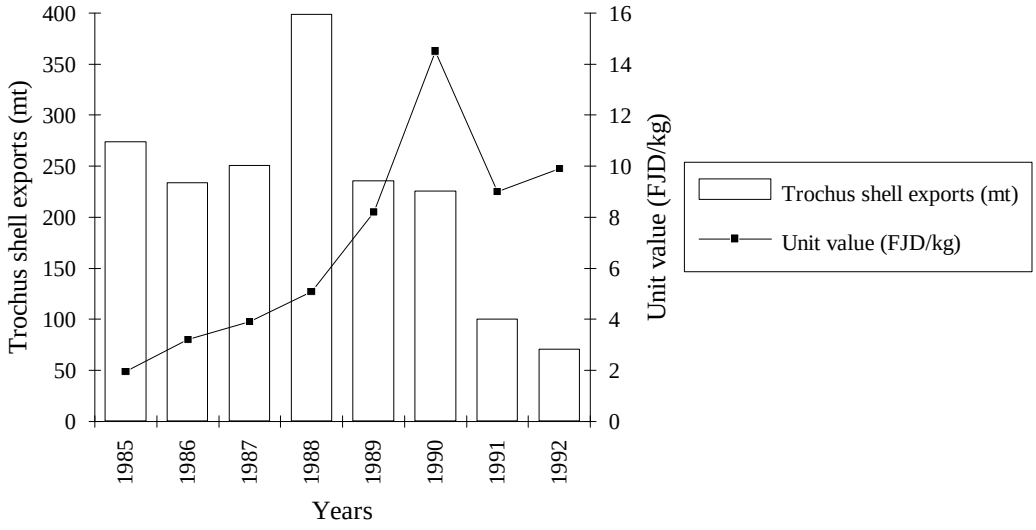
In 1985, two local companies established button-blank factories which between them were anticipated to process 300-350 mt of trochus shell per year, to substitute for exports (Lewis,

1985a). In 1989, Fiji had four button-blank factories, with another one planned, but in 1992 only one was operating at a reduced level (Adams *et al*., 1992).

In S.E.Asia there are markets for fresh, frozen, dried and canned **sici** meat, and markets in the traditional medicine trade for the thin operculum. Collection of **sici** is by hand, usually by walking on the reef flat at low tide, or by free diving (Lewis, 1985a).

Production And Marketing: Production of trochus shell for export fluctuated markedly in Fiji for the period 1969-1985, from a high of 547 mt in 1973 down to 166 mt in 1979. After remaining relatively steady at approximately 250 mt per year for the period 1985-1987, export of trochus shell peaked in 1988 at nearly 400 mt. Fiji Fisheries Division estimated that the total trochus shell harvest in Fiji in 1988 may have exceeded 600 mt (Anon., 1989b). Since then, exports have decreased steadily to an all-time low of 71 mt in 1992. Figure 13 provides trochus shell export weights (mt) and unit values (FJD/kg) for the period 1985-1992. The subsistence production of trochus shell for extraction and consumption of trochus meat is difficult to estimate.

Figure 13. Trochus shell export weights (mt) and unit values (FJD per kg) for the years 1985-1992. Note: Approximately 200-300 mt of trochus shell per year was absorbed by button factories in Fiji during the period 1988-1990, in addition to the amount exported (Source: Fiji Fisheries Division Annual Reports).



Prices paid for dry trochus shell rose steeply from FJD0.60 per kg in 1981 to between FJD1.00-1.40 per kg in 1984. This trend continued until export prices peaked at approximately FJD14.50 per kg in 1990, only to fall to approximately FJD10.00 per kg in 1991-1992 (Figure 13).

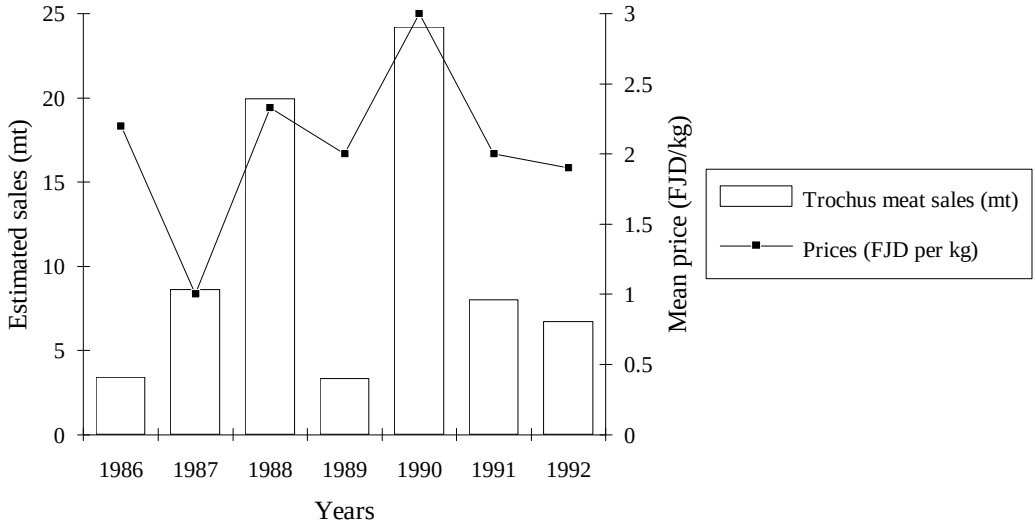
Small quantities of trochus meat are sold through municipal markets, usually in smoked form. Prior to 1984, up to 7 mt per year was sold in this way. Estimated sales of trochus meat (mt) and prices (FJD per kg) in municipal markets and outlets for the years 1986-1992 are presented

in Figure 14. Sales fluctuated between <5-25 mt up until 1990, after which they steadied at slightly more than 5 mt per year. Mean prices during the same period fluctuated between FJD1.00-3.00 per kg.

6.14.3 Stock Status

Lewis (1985a) noted that trochus fisheries in most countries have been characterised by sharp fluctuations in annual production, typically followed by periods of reduced harvest. Trochus are easily collected and thus vulnerable to over-exploitation, which has occurred in many countries. Adams *et al*. (1992) state that the export substitution that was expected to occur with the establishment of button-blank factories in Fiji did take place to some extent. However, with the 1988 peak in raw shell exports and the additional demand from button factories, recruitment overfishing may have occurred on heavily fished reefs, followed by a steady decline in major stocks. There have been no recent stock assessment surveys for trochus shell in Fiji.

Figure 14. Estimated sales (mt) and prices (FJD per kg) of trochus meat municipal markets and outlets for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



6.14.4 Management

Current Legislation/Policy regarding exploitation: Regulation 21(a) of the Fisheries Regulations (Cap.158 as amended) provides that " No person shall take, be in possession of, sell, or expose for sale or export any shell of the species *Trochus niloticus* [**sici**] (trocas shell) measuring less than 90 mm [3.5 inches] across the whorl." Exporters of trochus shell are required to be licensed and are subject to inspection.

Recommended Legislation/Policy Regarding Exploitation: A maximum size limit of 12 cm measured across the widest part of the shell should be imposed, as mentioned in Lewis (1985a). Oversize trochus are of no use for button manufacture but produce many eggs. Closed seasons,

covering the summer spawning season, and the establishment of reserves and sanctuaries where no collection is allowed, should be considered. Because trochus occur within fishing rights areas, fishing rights owners should be targeted for fisheries awareness campaigns, to enhance the prospects of co-management of this valuable resource.

References

Adams, T.J.H., J.Leqata, P.Ramohia, M.Amos and P. Lokani. 1992. Pilot survey of the status of trochus and bêche-de-mer resources in the Western Province of Solomon Islands, with options for management. South Pacific Commission, Noumea, New Caledonia. SPC Inshore Fisheries Research Project Technical Report to the Government of Solomon Islands. pag.var.

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Bour, W. 1990. The Fishery Resources of Pacific Island Countries. Part 3: Trochus. *FAO Fisheries Technical Paper* No.272.3. FAO, Rome.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988)

Nash, W.J. 1993. Trochus. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 451-495.

Sims, N. A. 1988a. Trochus. Cook Islands Fisheries Resource Profile No.3. Cook Islands Ministry of Marine Resources, Rarotonga. 10p.

6.15 BLACK-LIP PEARL OYSTER [civa]

6.15.1 The Resource

Species Present: The black-lip pearl oyster (**civa** - *Pinctada margaritifera*). Based on 1992 survey results and interviews with shell dealers in Fiji, Murray (1992) concluded that there are now no stocks of gold-lip pearl oyster (**civa** - *Pinctada maxima*) in Fiji.

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.

Biology And Ecology: *P. margaritifera* occurs in lagoons, bays and sheltered reef areas to around 40 m depth, but is most abundant just below low-water. Strong byssal threads attach the oyster to rocks or other oysters. In Fiji, Murray (1992) notes that there are two main habitat types for black-lip pearl oysters; shallow lagoons similar to those found in French Polynesia and the Cook Islands, and inshore reef systems where the reef-tops are accessible at low spring tides.

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, 1988b; 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-dependent 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 $L_? = 155$ mm for cultured *P. margaritifera.* The rapid initial growth results in shell diameters of between 100-120 mm 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 natural mortality (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).

6.15.2 The Fishery

Utilisation: Natural pearls are rarely found in *P. margaritifera* and the fisheries are based on the value of the Mother-of-Pearl (MOP) or pearl-shell itself which is used in the manufacture of buttons, in-lay and other jewelry 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 has excellent flavour and texture (Sims, 1988b), and it is listed by Lewis (1986) as an aquatic food of Fiji.

Free-diving and reef gleaning are still the main methods used in most Pacific fisheries for black-lip pearl shell, including Fiji. Murray (1992), in interviews with village divers, found that shells are taken by free diving to 2.5 m and by reef gleaning on reef tops and reef edges an average of 2-4 days per week, depending on tides. Informants told Murray (1992) that in the 1960s to 1970s, a village person could collect 30-50 **civa** per day, falling to 20-30 per day in the 1970s to late 1980s. Presently, villagers report that the average number of **civa** collected is from 1-4 per person per day, though exceptionally, 1-10 **civa** are taken per person per day.

Sims (1993) states that hard-hat and hookah diving machines were once widely used, but their use is now generally proscribed. In Fiji, the rapid increase in the use of hookah appears to be directly related to the rate at which pearl shell resource depletion occurred. Murray (1992) noted that in the 6 months prior to February 1992, 2 Suva-based companies had sold 200 hookah diving machines for commercial fishing purposes, with further orders for 85 more units. Murray (1992) estimated that there were approximately 300-350 hookah units currently in operation in Fiji.

Production And Marketing: Sims (1993) states that notable quantities of black-lip pearl shell are produced in Fiji, in comparison with other countries in the Pacific. Prior to 1960, fishing for *P. margaritifera* and *P. maxima* in Fiji was practised at an artisanal level, with mainly a local trade in shell (Murray, 1992). From 1975 to 1985, Fiji's annual MOP shell exports fluctuated between 9-30 mt per year, with an average of 18.6 mt per year (Fiji Fisheries Division). Exports peaked in 1988 at 57.5 mt, followed by a drop to mid-1970s export levels in 1991-1992. MOP shell exports (mt) for the years 1986-1992 are presented in Figure 15, together with export values (FJD per kg).

The peak in exports in 1988 is thought to have been caused by several factors. Economic necessity within villages, combined with increased access to bank finance permitted many divers and fishermen to acquire fishing boats and equipment. This enabled them to search previously inaccessible areas of reef. Gleaning of reef tops for edible shellfish maintained the fishing pressure on shell stocks. Both buyers and sellers were encouraged by newly opened trade opportunities and increasing world market prices for MOP, from approximately FJD4.00 per kg in 1986 to FJD14.00 per kg in 1990 (Murray, 1992).

Civa is also sold in municipal markets and non-market outlets. Estimated sales (mt) and prices (FJD per kg) of **civa** for the years 1986-1992 are provided in Figure 16. High local sales in 1988 and 1990 were followed by very low or zero sales in subsequent years.

Figure 15. Weights (mt) and values (FJD per kg) of MOP shell exported from Fiji for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).

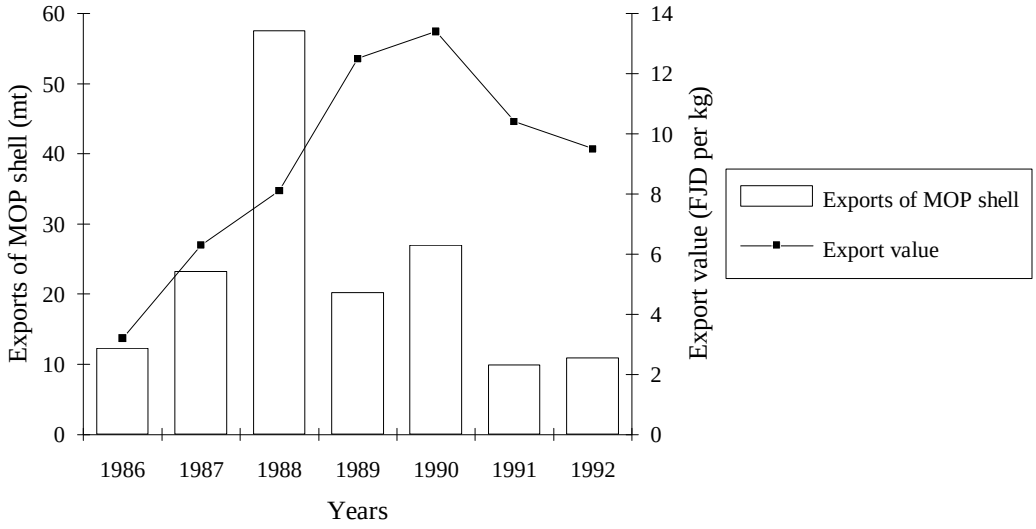
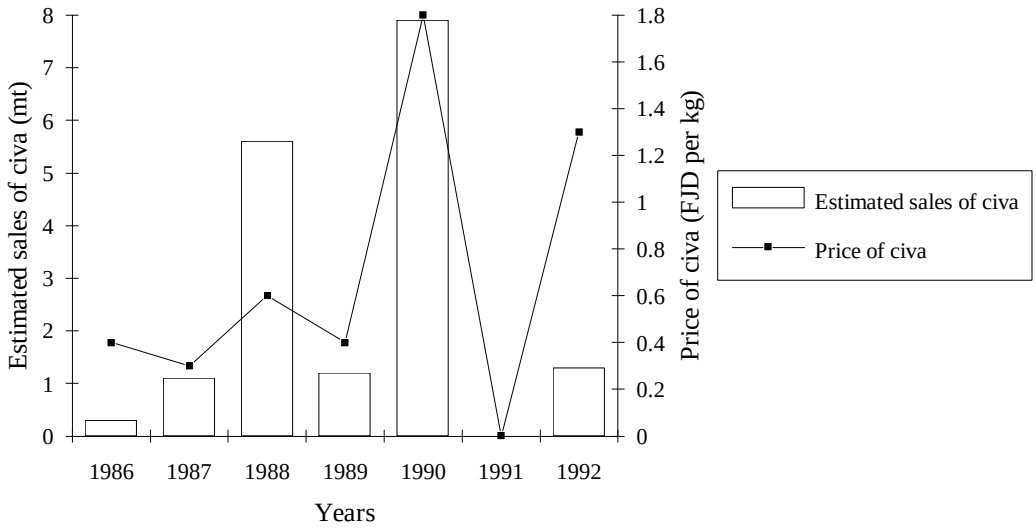


Figure 16. Estimated sales (mt) and prices (FJD per kg) of **civa** for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



6.15.3 Stock Status

Murray (1992), following an extensive **civa** survey, concluded that Fiji's **civa** stocks were very depleted, and in some areas, exhausted. He ascribed the poor condition of the stocks to heavy fishing pressure and in some locations, environmental stress caused by water-borne agricultural chemicals and general pollution of inshore areas land-derived effluent. Of the areas surveyed, Murray (1992) stated that the reefs surrounding Raviravi had the most abundant MOP resources, and estimated that the standing stock of **civa** in west Vanua Levu was between 50,000-70,000 shells.

6.15.4 Management

Current Legislation/Policy Regarding Exploitation: Regulation 21(b) of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall take, be in possession of, sell, offer or expose for sale or export any shell of the species *Pinctada margaritifera* [**civa**](pearl oyster shell) of which the nacre or mother-of-pearl measures less than 100 mm [4 inches] from the butt or hinge to the opposite edge or lip."

Recommended Legislation/Policy Regarding Exploitation: The state of **civa** stocks in Fiji appears to be serious enough to warrant a moratorium on their collection and sale. Should the introduction of a moratorium not be feasible, the following measures are recommended:

? existing regulations should be rigorously applied to all sales of **civa**, not just commercial sales;

? older, thicker shells should be left on the reef to promote the production of spat;

? the use of hookah diving equipment in the harvesting of **civa** should be banned and;

? because **civa** occur within fishing rights areas, fishing rights owners should be targeted for fisheries awareness campaigns, to enhance the prospects of co-management of this resource.

It should be noted that unless strenuous efforts are made to reduce water-borne pollution entering Fiji's coastal zone, efforts to enhance the recovery of **civa** stocks will be rendered ineffectual.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Murray, P. 1992. Report to the government of Fiji on a survey of black lip (*Pinctada margaritifera*) and gold lip (*P. maxima*) pearl shell, with comments on the prospects for pearl farming in Fiji. Fiji Fisheries Division, Suva, Fiji. 47p.

Sims, N.A. 1988b. Pearls and Pearl Oysters (Poe e Parau). Cook Islands Fisheries Profile No.2. Cook Islands Ministry of Marine Resources, Rarotonga. 12p. plus appendices.

Sims, N.A. 1993. Pearl Oyster. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 409-430.

6.16 GIANT CLAMS [vasua]

6.16.1 The Resource

Species Present: There are four species which occur naturally in Fiji; rugose giant clam (**katavatu**, **kativatu** - *Tridacna maxima*), the fluted giant clam (**cega** - *T. squamosa*), the smooth giant clam (**vasuadina**, **matau** - *T. derasa*, and the recently described devil clam (*T. tevoroa*). The giant clam (*T. gigas*) is recently extinct in Fiji, and the horse's hoof clam (*Hippopus hippopus*) was present in pre-historic times (Lewis, 1985a). The latter two species are now present as juveniles which have been imported and quarantined at the Giant Clam Hatchery and Mariculture Research Facility at Makogai Island in Lomaiviti.

Distribution: 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). *T. derasa* (up to 62 cm in length) is only found in clean, full-salinity seawater on sandy areas of the inner reef slope close to living coral. It can live in a range of depths down to 25 m.

The geographic range of *T. squamosa* extends from the western Indian Ocean to Polynesia (Lucas, 1988). *T. squamosa* (up to 40 cm) is usually found closer to shore than *T. derasa*, on rubble and in reef cracks.

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. In Fiji, *T. maxima* (up to 30 cm) is most often found on reef tops, firmly attached or burrowed into the coral to withstand the battering of the surf.

T. tevoroa is reported to occur in the eastern Lau group of Fiji, the northern Vava'u and Ha'apai islands of Tonga (Lucas *et al.*, 1991), and has recently been found around Tongatapu Island in Tonga (Lui Bell, pers.comm.). It inhabits relatively deep water (20+ m) compared to other giant clam species and is apparently intolerant of shallow conditions (Lucas *et al.*, 1991).

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 6 cm, with 50 per cent of individuals fully mature (male and female) at 10-11 cm and 100 per cent fully mature at 14 cm 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 the growth of *T. maxima* throughout its range is relatively slow. Though not confirmed for *T. maxima* from Fiji, it can be assumed they take 5 years to reach 10 cm in length (when 50 per cent are fully mature), 8-10 years to reach 15 cm and 15-20 years to reach 20 cm.

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 (10 cm) 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).

6.16.2 The Fishery

Utilisation: Giant clams are harvested for subsistence purposes throughout Fiji, being taken almost exclusively for their meat. The heavy shell is not commonly utilised. The meat comprises 15-20 per cent of the total weight and is composed of a tough mantle (60 per cent flesh weight) and the tender muscle (15 per cent of flesh weight/22 per cent of total weight). Meat weight varies between 12-20 per cent of total weight, the percentage decreasing with increasing size. The gonad is frequently retained but the dark-coloured kidney is discarded (Lewis, 1985a; 1987).

T. derasa is the species most commonly collected, since it is of large size and easily spotted lying on the sandy sea-bed. However, it is not easily collected from the depths of 7-15 m where it is most common (Lewis, 1985a).

Production And Marketing: From 1978 to 1984, the annual harvest of giant clam flesh brought to market for urban consumption was about 10 mt per year. It was estimated that with purely local artisanal fishing, the total harvest of giant clam meat in 1984 was approximately 50 mt; comprising 20 mt collected for export, 10 mt collected for sale in local commercial markets and 20 mt collected for subsistence purposes. For various reasons, the 1984 estimate of local consumption of giant clam meat has since been revised downwards (T. Adams, pers. comm.). There were three companies involved in the export of giant clams from Fiji in 1985 (Lewis, 1985a). Sales of giant clam flesh, by species, at municipal and non-municipal markets for the period 1985-1992 are shown in Table 38.

In 1985, prices paid to harvesters on landing ranged from FJD6.00-11.00 per kilogram for muscle and FJD0.60-1.50 per kilogram for mantle. Whole flesh prices varied between FJD1 and FJD3 per kilogram (Lewis, 1985a). In 1992, the price of **vasua dina** in municipal markets averaged FJD3.70 (up from FJD2.36 in 1991) and the price of **katavatu** averaged FJD3.17 (up from FJD2.48 in 1991) (Anon., 1993d).

Table 38. Sales of giant clam flesh (mt) at municipal and non-municipal markets for the period 1986 - 1992 (Source: Fiji Fisheries Division Annual Reports).

Year	*T. derasa* [**vasua dina**]	*T. maxima* [**katavatu**]	Clam [**vasua**]	Total (mt)
1986	12.36	1.38	5.32	19.06
1987	22.86	3.97	n/a	26.83
1988	14.81	7.29	n/a	22.10
1989	4.26	9.75	n/a	14.01
1990	2.09	9.27	n/a	11.36
1991	5.15	25.36	n/a	30.51
1992	5.86	3.85	n/a	9.71

6.16.3 Stock Status

Because giant clams are sedentary, large and easily collected, the resource is very vulnerable to exploitation. Giant clams are comparatively fast growing, there appears to be low recruitment of juveniles to the fishery. Fiji's stocks of *T. gigas*, the largest species, have been wiped out, and stocks of *T. derasa* are depauperate. Lewis (1985a) states that due to low level but continuous artisanal harvesting of *T. derasa* over hundreds of years, and estuarine influences creating unsuitable habitats, this species is scarce around the larger inhabited islands. " In the Eastern Division, poaching and commercial harvesting have decimated the stocks on some reefs. These may recover, but *T. derasa* takes at least four years to reach reproductive capability, and perhaps seven years to reach average size, so it will take at least five years of non-exploitation before these reefs again become fishable." Lewis *et al*. (1988) provide detailed information on the status of giant clam stocks in Fiji.

6.16.4 Management

Current Legislation/Policy Regarding Exploitation: Because of the vulnerability of the resource, exploitation guidelines were drawn up in 1984 and approved by Cabinet as follows:

- Harvest and marketing of the resource is to be restricted to Fiji nationals.
- Harvesting is to be carried out at the written invitation of traditional custodians and only on uninhabited islands and reefs in the first instance. Village fisherman are to be involved in (commercial) fishing operations to the maximum extent possible.
- Size limits for the (then) three species are to be established and strictly observed by harvesters; these size limits are to be subsequently incorporated into the Fisheries regulations.
- Provision is to be made for Fisheries Division observers to accompany collecting vessels as deemed necessary.
- Notice is to be given in writing by collection vessels of islands/reefs to be visited, together with the written approval of the custodian.

- ✍ Details of catches are to be supplied on a per-reef basis or as directed by Fisheries Division.
- ✍ Management regimes for particular areas are to be determined by consultation between collectors and Fisheries Division. Possible options include quota (wet weight), selective harvesting (as is done with tree thinning, for example) and reserved sectors where no harvesting would be allowed.
- ✍ All exports are to be subject to optional inspection and compulsory licence. A list of approved exporters is to be drawn up.
- ✍ Processing of material prior to export is to be strongly encouraged and preference on issue of export licences given to persons processing product.
- ✍ The export of *muscle only* is to be discouraged, unless markets can be found for the remainder of the edible portion.
- ✍ Consideration is to be given to the utilisation of the shell itself, which is currently discarded.
- ✍ Although it remains essentially a matter between the collector and resource custodians, Fisheries Division should do all it can to ensure a fair price be paid, and that harvesting itself is done by them.

The Guidelines were designed mainly to put the decision to exploit the resource or not into the hands of the local custodians of the fishing rights, under whose jurisdiction all the clam stocks of Fiji lie, and to enable Fisheries Division to keep track of harvesting so that management advice can be given. Many of the Guidelines were superseded in December 1988 when Cabinet passed a new regulation banning the export of giant clam meat. Regulation 25A of the Fisheries Regulations (Cap.158 as amended) provides that, "No person shall export from Fiji tridacnid clam (giant clam) (vasua) flesh, including adductor muscle or mantle tissue of the following species:- (a) *Tridacna derasa* (vasua dina), (b) *Tridaca squamosa* (cega), (c) *Tridacna maxima* (katavatu)."

A giant clam quarantine facility was built with financial assistance from the Australian Centre for International Agricultural Research (ACIAR) on Makogai Island in Lomaiviti in 1986. A hatchery facility was later added in 1988 as an extension of the quarantine unit. By 1991, over 100,000 seed clams per year were being produced (Ledua, 1992). More information on the operations of this facility are given in Profile C.1.5.

Recommended Legislation/Policy Regarding Exploitation: An assessment survey should be conducted to ascertain the present state of the wild stocks of giant clams in Fiji. Because of the intensive surveys of natural giant clam stocks conducted in Fiji from 1984-1988 under the auspices of the ACIAR International Giant Clam Project, there is an excellent set of baseline data from which to make comparisons.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Ledua, E. (1992). Status of aquaculture development in Fiji. Fiji Country Statement prepared for the Aquaculture Seminar, August 1992, Tokyo, Japan. 34p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1987. Aitutaki Giant Clams (Pa'ua). Resource Profile No. 1. FAO/UNDP Regional Fishery Support Programme, Suva. RAS/87/002. 10p plus appendices.

Lewis, A.D., T.J.H.Adams and E. Ledua. 1988b. Fiji's giant clam stocks- A review of their distribution, abundance, exploitation and management. In: Copland, J.W. and Lucas J.S. (eds.). 1988. Giant Clams in Asia and the Pacific. ACIAR Monograph No.9: 66-77.

Lucas, J.S. 1988. Giant Clams: Description, Distribution and Life History. In: Copland, J.W. and Lucas J.S. (eds.). 1988. Giant Clams in Asia and the Pacific. ACIAR Monograph No.9: 21-32.

Lucas, J.S., E. Ledua and R.D.Braley. 1991. *Tridacna tevoroa* Lucas, Ledua and Braley: a recently described species of giant clam (Bivalvia: Tridacnidae) from Fiji and Tonga. The Nautilus, 105(3): 92-103.

Munro, J.L. 1993. Giant Clams. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 431-449.

6.17 FRESHWATER CLAM [kai]

6.17.1 The Resource

Species present: The freshwater mussel (**kai** - *Batissa violacea*). It has three ecomorphs; **kai buli**, **kai bukivula** and **kai dina**, which belong to a single species (Anon., 1975).

Distribution: *B. violacea* is reported as occurring in S.E.Asia, Australia, Indonesia and Fiji. Within Fiji, it is common in the following rivers; Rewa, Navua, Sigatoka, Nadi, Ba, Labasa, Waikoro, Dreketi and various Tailevu rivers (Lewis, 1985a).

Biology And Ecology: Kai is found on the sandy or muddy beds of rivers, restricted to the lower freshwater reaches of rivers, between the upper limit of tidal influence and the upper limit of saltwater penetration (Lewis, 1985a). The clam is free living, burrowing to 10 cm in river beds and capable of substantial movement.

Spawning in **kai** occurs in March to May, with a peak in April. The larvae are partially incubated within the shell, and are capable of only limited movement, so the influence of floods and tides on settlement is critical. Growth rates are in the order of 2 cm per year, larger specimens growing to 8-9 cm (300 g) (Lewis, 1985a; Anon., 1975).

Between 20-75 per cent of a river bed may be occupied by **kai**, the location of productive beds being influenced by river flow rates and sediment deposition patterns. In the Rewa River, Anon.(1975) reports that the average biomass of the clam is 503 $g.m^{-2}$ of the river bed.

6.17.2 The Fishery

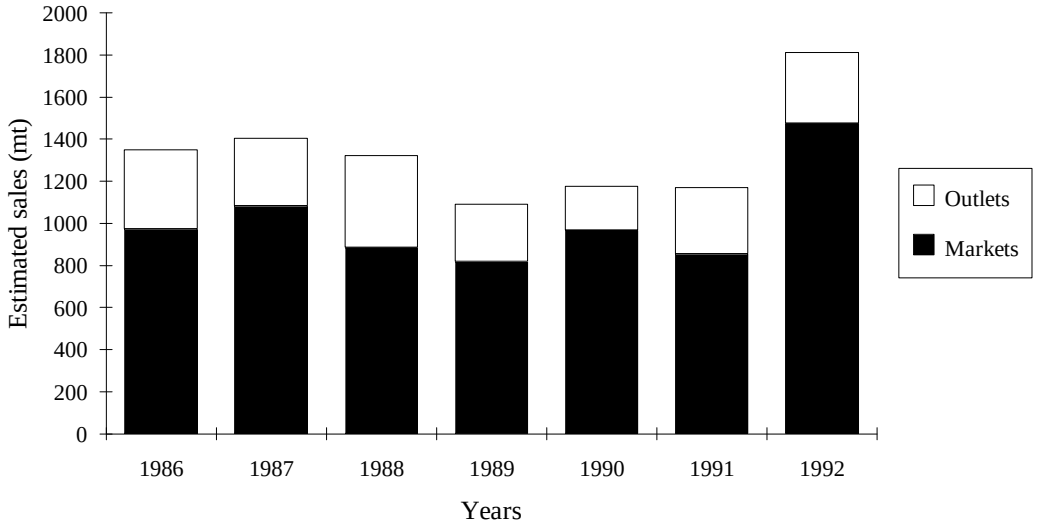
Utilisation: Kai is very important as a subsistence food in Fiji, and has traditionally been used for bartering and as a gift for friends (Anon., 1975). It forms the basis of a fishery that is operated almost entirely by women. Clams are located in shallow parts of the river bed using hands and feet. Diving, using diving glasses, is also practised but Lewis (1985a) notes that deeper parts of the rivers are generally not fished. **Kai** fisherwomen, usually mature women assisted by younger women, routinely spend a day (2-4 hours) harvesting and the next day selling. At a rate of 10 kg per hour, a day's harvest of **kai** may vary between 20-80 kg (Anon., 1975). Bibi (1991) reports that a fisherwoman can earn up to FJD30.00 from the sale of a days's harvest of **kai**.

The clams are invariably sold live, in traditional baskets, either in markets or to middlemen who visit **kai** producing villages on a weekly basis. Providing they are kept wet, **kai** can be kept alive in bags for up to a week, and up to two weeks in regularly changed water. There is considerable water loss but little meat loss during such storage, so **kai** may be extensively transported around the larger islands. Though much of the **kai** from the Toga and Rewa Rivers is sold in the Suva, Nausori and Davuilevu **kai**-selling centres, the market has been extended to the islands of Lomaiviti, particularly Koro Island (Lewis, 1985a; Bibi, 1991).

The raw meat recovery from **kai** is approximately 20 per cent and roughly 650 g of cooked meat can be recovered from 5 kg of **kai** (Lewis, 1985a). The clam is prepared in several ways for consumption; boiled with salt, boiled with coconut cream (**vakalolo**), curried, deep fried or made into soup. The shells are not currently utilised commercially.

Production And Marketing: The **kai** fishery is one of the most valuable village-level fisheries in Fiji, and **kai** forms the major component (by weight) of non-fish products sold in municipal markets and non-market outlets throughout the country. Prior to 1985, approximately 1,300 mt was marketed annually, mainly through municipal markets, though this does not include the substantial subsistence production (Lewis, 1985a). There was a sudden, unexplained increase in total sales to over 1,800 mt in 1992, due mainly to an increase in market sales. Estimated sales (mt) of **kai** in markets and non-market outlets for the years 1986-1992 are provided in Figure 17.

Figure 17. Sales of **kai** (mt) in markets and outlets for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



Since 1986, the mean market price of **kai** has increased gradually from FJD0.26 per kg to FJD0.53 per kg in 1992, a doubling of the price in 7 years. The value of the recorded **kai** harvest in 1992 was FJD960,837, much of which would have provided income direct to village communities.

6.17.3 Stock Status

Lewis (1985a) stated that despite concerns about possible damage to **kai** habitat by dredging, pollution and overfishing, **kai** stocks at that time appeared to be in good condition. Though there have been no **kai** stock assessment surveys, the stability of market sales tends to confirm that this is still the case. Individuals in deeper water constitute a relatively unexploited buffer stock in the large rivers, and increased siltation has probably expanded the area of suitable habitat.

6.17.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: Because of its importance as an affordable source of protein for low income earners and provider of direct income to villagers, every effort should be made to conserve **kai** stocks. Regular market surveys should be conducted to monitor the size-frequency of **kai**, and measures taken to minimise damage to **kai** habitat from water-borne pollution and uncontrolled dredging. A proposed study on the **kai** fishery should be conducted as soon as practicable, and baseline data collected on areas near Ba which have been ear-marked for dredging.

References

Anon. 1975. Notes on “kai”. Unpublished report. Fiji Fisheries Division, Suva, Fiji. 4p.

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Bibi, H. 1991. Women and the kai fishery. Prepared for *Qitawa*, Fiji Fisheries Division Newsletter.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

6.18 ARK SHELL [kaikoso]

6.18.1 The Resource

Species Present: The ark shell (**kaikoso**, **qeqe** - *Anadara cornea*).

Distribution: Ark shells (Family Arcidae) are distributed widely in the tropical Indo-Pacific from Africa to Japan, Malaysia, Australia, Fiji, Tonga and French Polynesia. In Fiji, **kaikoso** are common wherever conditions are suitable (Squires *et al*., 1973).

Biology And Ecology: Butler (1983) in a study of **kaikoso** from Laucala Bay near Suva, found that they were patchily distributed from low water mark downwards, mostly in turtlegrass (*Zostera* sp.). Density of **kaikoso** varied from 0.2 ± 0.8 to 2.2 ± 3.1 individuals per m^2 of substrate. Large **kaikoso** were usually on their own; if a few were together, they were usually small. In a separate study in Laucala Bay, smaller **kaikoso** were more abundant near the shore, whilst larger animals were more abundant in deeper water. Abundance was greater where there was both sand and mud present, but large specimens were found in muddy areas (Chand, 1980 In: Butler, 1983). From this information, Butler (1983) concluded that **kaikoso** is a species which recruits into sand/seagrass areas, though it can live in mud when older. It lives in areas where the sediment is dynamic, due to floods and other causes.

In a survey at Wailoaloa Beach near Nadi, Squires *et al*.(1973) found that the **kaikoso** beds extended along the beach just offshore from low water mark, to approximately 65 m from shore. **Kaikoso** were not uniformly distributed, but aggregated in groups of varying number. The number per m^2 ranged from 0-46, with an average of 7.2. The average weight of the **kaikoso** specimens sampled was 25 g.

Kaikoso from Laucala Bay may grow from settlement to a length of 20 mm in less than a year, and from 20-40 mm in 8 months or less, though another 4 years may be required for the shells to reach 60 mm (Butler, 1983). Because *A. antiquata* are reported to reach 90 mm in length (Cernohorsky, 1972 In: Butler, 1983), Butler (1983) suggests that none of the animals in his samples were more than two-thirds of their maximum length, which could be explained by the continuous collection by people throughout the Suva area. Farmed *A. granosa* in Thailand are harvested after 18 months, when they have reached approximately 40 mm in length and 24 g in weight (Tookwinas, 1983).

Butler (1993) surmised that **kaikoso** from Laucala Bay recruit several times a year, but discontinuously and at fluctuating densities. Animals above about 20 mm in length had visible gonads at all times. In India, *A. granosa* spawns throughout the year, and can have 2-4 reproductive cycles per year. First maturity is attained at 20 mm for males and 24 mm for females (Narasimham, 1988).

6.18.2 The Fishery

Utilisation: Kaikoso is an important food item in Fiji, being taken by subsistence fishermen, sold in markets or exchanged for agricultural produce in rural areas (Squires *et al*., 1973). This species is recorded by Lewis (1986) as one of the "Aquatic foods of Fiji".

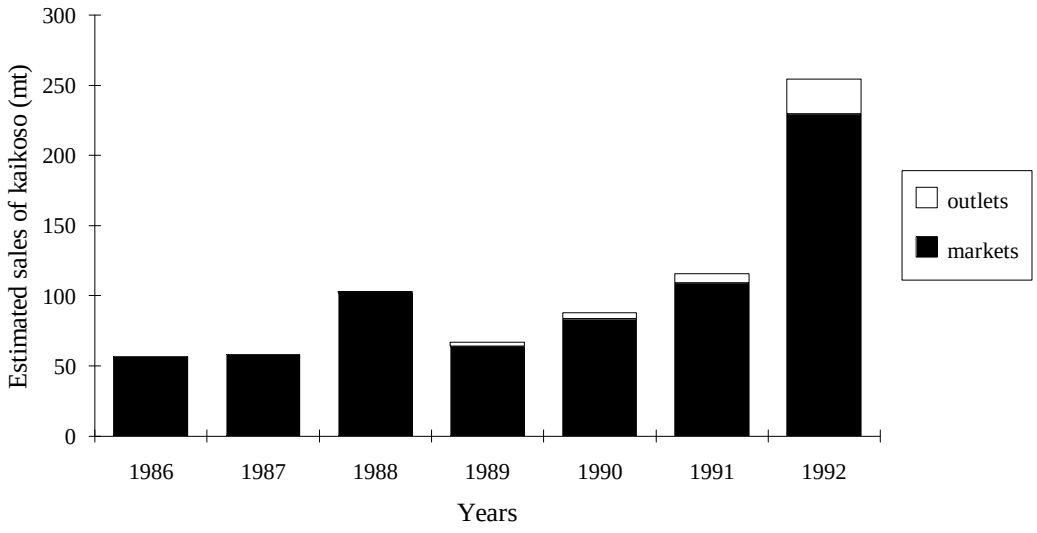
There are several ways in which Fijians collect **kaikoso**, including "dabbling" with the feet and raking with the fingers. Another method is to look for the shell gape at the water's edge on a

rising tide, while another is to walk where mud is exposed at low water, spotting half-covered animals (Butler, 1983).

During observations of **kaikoso** fishing at Wailoaloa Beach near Nadi, Squires *et al*. (1973) recorded that a group of fisherwomen waded out from the beach, feeling with their toes for shells in the muddy sand. The women fished as far out as they could stand with their heads above water, at about 1.5 m depth. Since the outer edge of the **kaikoso** bed is approximately 2.5 m deep at a distance of 60 m from the shore, only part of the bed was fished. Though there was some variation in the time spent fishing, the average catch was approximately 2 kg of **kaikoso** per fisherwoman per day.

Production And Marketing: After **kai**, **kaikoso** forms the next most important component (by weight) of non-fish products sold in municipal markets and non-market outlets throughout the country. Estimated sales of **kaikoso** (mt) in municipal markets and non-market outlets for the years 1986-1992 are presented in Figure 18. From annual sales of < 110 mt per year for the period 1986-1991, the sales of **kaikoso** in 1992 exceeded 250 mt. After years of negligible sales of **kaikoso** in non-market outlets, approximately 10 per cent of total **kaikoso** sales were made through outlets in 1992.

Figure 18. Estimated sales of **kaikoso** (mt) in markets and outlets for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



The mean price of **kaikoso** in municipal markets rose gradually from FJD0.28 per kg in 1986 to FJD0.57 per kg in 1991, before falling to FJD0.43 per kg in 1992. The approximate value of the fishery in 1992, excluding subsistence catches, was FJD109,302. Many village communities would have benefited directly from the income derived from these sales.

6.18.3 Stock Status

There is no information available regarding the status of **kaikoso** stocks in Fiji. It is likely that a substantial proportion of its habitat is in deep water which is out of reach of traditional

harvesting methods. Consideration should be given to re-surveying the previously surveyed sites at Laucala Bay and Wailoaloa Beach, to determine the present abundance of **kaikoso** in these areas.

6.18.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: None required at present. Measures should be taken to minimise damage to **kaikoso** habitat from water-borne pollution and uncontrolled removal of beach sand.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Butler, A.J. 1983. A preliminary examination of populations of the kai-koso, *Anadara cornea* (Reeve) near Suva, Fiji. A report to the Institute of Marine Resources, University of the South Pacific, Suva, Fiji. 28p + appendices.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Narasimham, K.A. 1988. Biology of the blood clam *Anadara granosa* (Linnaeus) in Kakinada Bay. J.mar.biol. Ass. India, 1988, 30 (1&2): 137-150.

Squires, H.J., B.Carlson, T.P.Ritchie and N.Gundermann. 1973. Shellfish on nearshore fishing grounds at Wailoaloa Beach, Nadi, 1973. Fiji Agricultural Journal (1973) 35, 71-74.

Tookwinas, S. 1983. Commercial cockle farming in southern Thailand. Translated by E.W.McCoy (1985). ICLARM Translations 7, 13p. In: E.W.McCoy and T. Chongpeepien (eds.). Bivalve mollusc culture research in Thailand. ICLARM Technical Reports 19.170p.

6.19 OTHER EDIBLE MOLLUSCS

6.19.1 The Resource

Species Present: There are several species of gastropod and bivalve molluscs listed by Lewis (1986) (Table 39).

Table 39. Molluscs listed by Lewis (1986) as "Aquatic foods of Fiji"

Common Name	Fijian Name	Scientific Name
turban shell	**lasawa**	*Turbo chrysostomus*
top shell	**tovu**	*Tectus pyramis*
spider shell	**yaga**, **ega**	*Lambis lambis*
red-lipped stromb	**tivikea**, **gwerativi**	*Strombus luhuanus*
stromb	**golea**, **gerra**	*S. gibberulus*
horn shell	**siciyarayara**, **durulevu**	*Cerithium nodulosum*
polished nerite	**madrali**	*Nerita polita*
moon snail	**drevula**	*Polinices flemingiana*
jewel-box shell	**bu**, **su**, **sobu**	*Chama* sp.
hardshell clam	**kaidawa**, **kaibakoko**	*Periglypta puerpera*
venus shell	**kaitakadiri**, **qaqa**	*Gafrarium tumidum*
littleneck clam	**kaivadra**	*Tapes literata*
coconutscraper cockle	**kaininiu**, **sakaro**	*Vasticardium* sp.
surf clam	**sigawale**, **silawale**	*Atactodea striata*
mangrove mussel	**kuku**, **boro**	*Modiolus agripetus*
mangrove oyster	**dioniveitiri**	*Crassostrea mordax*
thorny oyster	**kolakola**, **saulaki**	*Spondylus ducalis*
pigmy pearlshell	**civaciva**, **civare**	*Pinctada martensi*

Distribution: Most of the edible molluscs listed in Table 39 have a wide distribution in the tropical Indo-Pacific. *Strombus luhuanus* is known from Indonesia to Papua New Guinea and Fiji (Hinton, 1972). Paulay (1987) states that *Chama pacifica* is known to occur from Australia and Borneo in the west to the Tuamotu Islands in the east.

Biology and Ecology: Many of these species are found in the lagoon, on the reef ridge and some in deeper waters. *Te. pyramis* and *Tu.chrysostomus* graze or browse on coralline or small succulent algae below the coral line, their wide radulas being well adapted to scouring and sweeping. *Te. pyramis* is usally found in concavities and under ledges near the reef margin, or beneath coral boulders. *Tu chrysostomus* is common near the reef edge (Morton and Raj, 1978).

Species such as *Spondylus ducalis* and *Crassostrea mordax* are cemented to the substrate, with entire loss of the byssus. Paulay (1987) states that *Chama pacifica*, a cemented sessile heterodont, appears to be restricted to larger lagoonal habitats. They attach by deeply conical right valve, with the smaller left valve forming a lid on top. *Cerithium nodulosum* is found

principally in muddy flats and mangrove areas, where it burrows into the substrate. Shells of the family Strombidae, such as *Lambis lambis*, *Strombus luhuanus* and *S. gibberulus* are mostly confined to the soft expanses of rubble-flats (Morton and Raj, 1978).

6.19.2 The Fishery

Utilisation: Lewis (1986) lists the molluscs in Table 39 as being utilised for subsistence purposes by Fijians. These are also listed in Fiji Fisheries Division Annual Reports as being sold in municipal markets and non-market outlets.

Production And Marketing: Apart from **kai** (Profile 6.17) and **kaikoso** (Profile 6.18) there are several species of molluscs are sold in small amounts in municipal markets and non-market outlets. Estimated sales (mt) of these molluscs for the years 1986-1992 are listed in Table 40.

Table 40. Estimated sales (mt) of various species of edible molluscs in markets and outlets for the years 1986-1992 (Source: Fiji Fisheries Division Annual Reports).

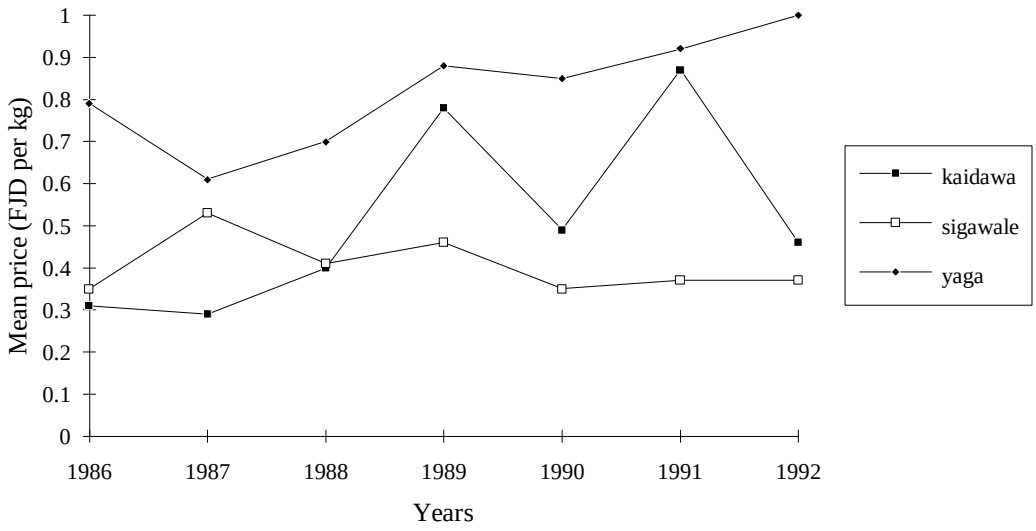
	1986	1987	1988	1989	1990	1991	1992
kaidawa	3.89	4.34	15.47	11.55	10.40	19.14	10.79
qaqa	0.02	1.02	2.41	0.90	0.19	1.33	11.78
sigawale	0.95	2.24	2.43	3.83	2.40	5.32	5.95
kuku	4.4	6.0	6.72	3.40	2.68	0.60	0.22
civaciva	0.18	2.69	0.29	0.64	na.	0.02	na.
bu	0.3	0.13	0.35	0.23	0.23	0.13	1.18
yaga	4.04	6.86	6.78	7.85	14.04	14.69	5.66
tivikea	0.4	0.02	9.78	0.96	0.16	0.38	0.04
golea	2.48	5.08	5.42	5.60	8.66	1.68	3.48
tovu	1.95	1.70	2.41	0.39	1.71	2.28	2.72
madrali	2.99	3.14	0.52	0.37	1.05	0.29	0.07
kaivadra	na.	0.12	0.80	0.34	na.	1.71	3.47
kalokalo	na.	na.	0.12	0.06	0.19	0.06	na.
lasawa	na.	na.	1.45	na.	na.	na.	na.

Market prices for the various molluscs have risen very gradually or remained constant over the period 1986-1992, generally selling at less than FJD1.00 per kg. Price information (FJD per kg) for **kaidawa**, **sigawale** and **yaga** for this period is shown in Figure 19.

6.19.3 Stock Status

There is no information on the status of the stocks of these molluscs in Fiji. From estimated sales figures (Table 40), sales of **kuku** and **madrali** have suffered distinct declines from 1986-1992, while sales of **qaqa** and **kaivadra** have dramatically increased from previous levels. Other species, such as **kaidawa** and **sigawale** have had relatively constant sales over the same period. Fong (1994) reports that, due to over-exploitation mainly for subsistence and big feasts, Sasa villagers (Macuata Province) have said that **yaga** are hard to find.

Figure 19. Mean prices (FJD per kg) for **kaidawa**, **sigawale** and **yaga** for the period 1986-1992 (Source: Fiji Fisheries Division Annual Reports, 1986-1992).



6.19.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

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

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Hinton, A. 1972. *Shells of New Guinea and the Central Indo-Pacific*. The Jacaranda Press. 94p.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Morton, J. and U.Raj. 1978. The shore ecology of Suva and Viti Levu, Composite Volume, Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 183p.

Paulay, G. 1987. Biology of Cook Islands' bivalves, Part I. Heterodont families. Atoll Research Bulletin No.298. The Smithsonian Institution, Washington, D.C., U.S.A. 31p.

6.20 COLLECTORS SHELLS [qani vivili]

6.20.1 The Resource

Species present: Fiji has over 800 species of shells that are of interest to collectors, and several endemic or unique shells. These shells are from the classes Gastropoda (sea shells), Pelecypoda (bivalves), Scaphopoda (tusk shells) and Cephalopoda (nautilus) (Lewis, 1985a). Fiji is particularly rich in cone shells (*Conus* spp.), cowrie shells (*Cypraea* spp.), mitre shells (*Mitra* spp.) and auger shells (*Terebra* spp.). The Fiji area supports a large number of other shell families which have market potential, such as olive shells (*Oliva* spp.), cerith shells (*Cerithium* spp.), stromb shells (*Strombus* spp.) and murex shells (*Murex* spp.) (Parkinson, 1982). Table 41 lists the distribution of species recorded in Fiji during a survey undertaken in 1981.

Table 41. Distribution of species recorded in Fiji by family or family grouping (Source: Parkinson, 1982).

Group	Number of species found
Cones (F. Conidae)	28
Augers (F. Terebridae)	26
Mitres (F. Mitridae/Costellariidae)	22
Olives (F. Olividae)	11
Cowries (F. Cypraeidae)	11
Dog whelks (F. Nassariidae)	8
Ceriths or horn shells (F. Cerithiidae)	8
Strombs (F. Strombidae)	4
Turrids (F. Turridae)	2
Murexes (F. Muricidae)	1
Tritons (C. Cymatiidae)	1
Turbans (F. Turbinidae)	1
Total	113

Distribution: Shells occur in all of the world's seas, but their centre of distribution, and maximum diversity, is generally considered to be the area of ocean bordered by Indonesia, Papua New Guinea and the Philippines. In terms of shell distribution, Fiji is at the eastern margin of the rather flexible and vague boundaries of the "Central Indo-Pacific" - Japan southwards to northern Australia, and from south-east Asia and the islands of Indonesia eastwards towards Fiji (Hinton, 1972). Although collector's shells are found throughout Fiji, particularly good records are available for Suva Harbour, Suva-Sigatoka coastal strip and Yasawa Islands, which were surveyed by a team of divers in 1981 (Parkinson, 1982).

Biology And Ecology: Shells can be found in every type of marine habitat, from coral reefs to volcanic sand and silt or mud. Most shells are habitat specific, and there are many examples of specialisation of habitat. Terebra shells and Olive shells are seldom, if ever, found away from sand, and some species of these are confined to black volcanic sand while others prefer white coral sand. Stromb shells and Cassid shells are generally most prolific in shallow waters,

though some Cassids have been found in very deep water. Some species of Muricid are found on intertidal mangrove roots, while others are taken in depths of over 180 m. Mitrids occur in colonies on shallow patches of sand and on intertidal coral reefs (Hinton, 1972).

Some shells are herbivorous, such as Strombs, or carnivorous, such as *Murex* spp., which prey on other molluscs. Cone shells are also carnivorous, and may be divided into three groups, according to their food preference - piscivorous (kill and eat fish), molluscivorous (eat molluscs including other cone shells) and vermivorous (eat small marine worms) (Hinton, 1972).

6.20.2 The Fishery

Utilisation: Shells are collected by a variety of methods, the most common being by hand on areas of sand and coral at low tide. Shells in deeper water can be collected by free diving, or by trained divers using SCUBA or hookah diving equipment. Optimum results are usually obtained at night by the use of torches, as this is when the shells are most active, and when they often leave their cover. Care should be taken to collect only perfect shells without breaks, scars or blemishes, as imperfect shells have a greatly reduced value (Lewis, 1985a). Parkinson (1982;1987) gives detailed descriptions of specimen shell collection methods.

Larger shells, except for cowries (F. Cypraeidae), can be boiled to extract the meat, but smaller species should either be buried in sand where they will decompose, or preserved in methylated spirits. Once they have been properly cleaned, shells are easily stored and transported. They are a readily marketable commodity for villagers in remote islands who may have few other sources of revenue (Lewis, 1985a).

Production And Marketing: Most of the shells marketed in Fiji are sold through the many stalls and shops that cater to the tourist industry. Shells are also sold at the municipal markets throughout Fiji and at handicraft centres in the major towns. Large ornamental shells such as *Murex ramosus*, *Lambis chiragra* and the larger cowries may be sold directly to tourists by villagers, especially in the Mamanuca and Yasawa Island Groups, Western and Northern Viti Levu and on Taveuni. It is not possible to estimate exactly how many shells are sold each year, or what the total value of these shells would be, but a conservative estimate would be several hundreds of thousands of dollars per annum (Parkinson, 1982; Lewis, 1985a). The collecting and marketing of shells worldwide is of major importance. Markets for shells can be found in most of the countries of Europe, Japan, the United States, Australia, New Zealand and many others.

Prices for **qani vivili** are determined by supply and demand. Prices range from as low as FJD0.10 for some of the more common cowries, strombs, cones and olives, to as high as FJD9,000 for some of the exceptionally rare shells (Parkinson, 1987). Parkinson (1987) provides a catalogue of sea shells of the Pacific region, together with prices quoted by shell dealers as of December 1986. Current information on prices is available from reputable shell dealers.

6.20.3 Stock Status

Lewis (1985a) stated that good stocks of most species of shells exist in Fiji, and at the time, no species in the country was in danger of extinction. Only perfect shells should be collected, so that a breeding nucleus always remains to perpetuate the species. Every effort should be made

to conserve the nearshore environment, the habitat of many species of shells, as the destruction of this habitat will adversely affect the present shell stocks.

6.20.4 Management

Current Legislation/Policy Regarding Exploitation: Regulation 22 of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall take, sell or offer or expose for sale or export any shell of the species *Charonia tritonis* (davui). Regulation 23 of the Fisheries Regulations (Cap.158 as amended) provides that "No person shall take, sell or offer or expose for sale or export any shell of the species *Cassis cornuta* (giant helmet shell)." There are no other laws or regulations in Fiji pertaining to or restricting the collection of marine shells.

Recommended Legislation/Policy Regarding Exploitation: No changes to current legislation recommended at present.

References

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Hinton, A. 1972. *Shells of New Guinea and the Central Indo-Pacific*. The Jacaranda Press. 94p.

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Parkinson, B.J. 1982. The specimen shell resources of Fiji. Report prepared for the South Pacific Commission and the Government of Fiji. South Pacific Commission, Noumea, New Caledonia. 53p.

Parkinson, B.J. 1987. Collection and sale of specimen shells. FFA Report No. 87/34. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 15p + appendices.

6.21 CEPHALOPOD MOLLUSCS

6.21.1 The Resource

Species present: Lewis (1986) includes octopus (**kuita**, **sulua** - *Octopus* sp.) and bigfin reef squid (**kuitanu**, **suluanu** - *Sepioteuthis lessoniana*) in the "Aquatic foods of Fiji". An oceanic squid is also recorded from Fiji's waters, the purple-back flying squid (*Symplectoteuthis oualaniensis*).

Distribution: *Se. lessoniana* is distributed in the Indo-Pacific from the Red and Arabian Seas to 160º E, northern Australia and north to central Japan, eastward to the Hawaiian Islands (Roper *et al*., 1984). It is found throughout Fiji. *Sy. oualaniensis* is widely distributed in the warm waters of the Indo-Pacific region. In Fiji, it has been taken during surveys at several sites; south of Cape Washington, south-east of Kadavu and east-south east of Qelelevu (Brown, 1979).

Biology and ecology: Most octopuses are benthic animals, usually having cryptic habits, hiding in crevices, empty mollusc shells and seagrass beds during the day and hunting at night. Many species lay relatively large eggs which are brooded by the female during a prolonged incubation period. Most brooding species have a direct development and hatchlings almost immediately adopt the benthic life of the adults (Roper *et al*., 1984)

Se. lessoniana is a neritic species occurring from the surface down to at least 100 m depth. The spawning season depends on prevailing hydrographical conditions, and can be quite extended. Finger-shaped egg capsules containing 3-7 eggs are attached in clusters to seaweeds, twigs, stones and corals in coastal waters. Males attain sexual maturity at 10-14 months and females at 12-17 months. **Kuitanu** typically live for 2.5 years. Maximum dorsal mantle length (ML) is 36 cm, corresponding to a weight of 1.8 kg. Males outnumber females in the upper size classes. This species preys primarily on prawns and fishes, and occasionally on stomatopods and crabs (Roper *et al*., 1984).

Sy. oualaniensis is an oceanic species occurring from the surface to probably 1,000 m depth. It is known to carry out diurnal vertical movements between the surface at night and deeper layers during the day, though it may inhabit the surface sea layers during the day as well as the night (Roper *et al*., 1984). This species is characterised by a yellow patch (photophore) on the antero-dorsal surface of the mantle. The females mature at 20-24 cm ML and have a life-span of slightly more than one year. It is a quick and powerful swimmer, capable of propelling itself out of the water and "gliding" above the surface for a considerable distance (Brown, 1979).

6.21.2 The Fishery

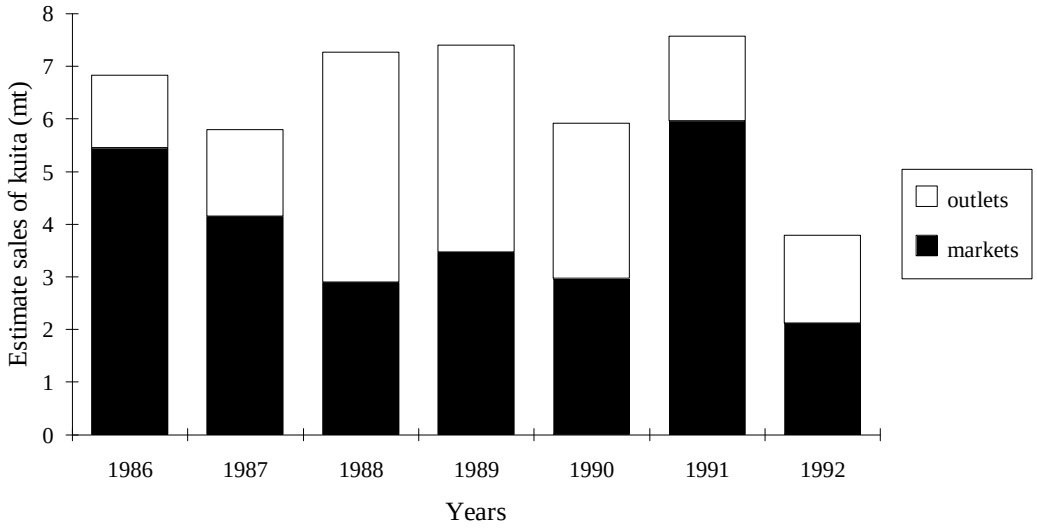
Utilisation: Kuita are an important subsistence food for Fijians, as are **kuitanu** (Lewis, 1986). Both species are taken by reef gleaning. **Kuita** holes are often identified by shell litter at the opening. Spears and sticks are used mainly by women and children while reef gleaning to evict **kuita** from their holes at low tide. **Kuitanu** has been successfully reared in aquaculture experiments (Choe, 1966 In: Roper et al., 1984).

Sy. oualaniensis is reported to be fished commercially in Okinawa and Taiwan. This species may be taken by automatic squid-jigging machines, though often only the tentacles are landed as the body breaks off during the fishing operation. The edible quality and size consistency of

Sy. oualaniensis from Fiji was rated "less than optimum" for the Japanese market (Brown, 1979). Surveys of Fiji's flying squid resources conducted in 1979 and 1981, though optimistic about the possibility of commercial exploitation, have not led to the establishment of a commercial fishery (Brown, 1979; Takeda and Hamilton, 1981).

Production and Marketing: Sales of **kuita** in Fiji's municipal and non-municipal markets for the years 1986-1992 are given in Figure 20. From 1986 to 1991, total annual sales have averaged 6.8 mt per year with very little fluctuation. The reasons behind the drop of sales to 3.8 mt in 1992 are worthy of further study.

Figure 20. Sales (mt) of **kuita** in markets and non-market outlets, 1986-1992 (Source: Fiji Fisheries Division Annual Reports).



The weighted mean price for **kuita** in municipal markets during 1992 was FJD3.52 per kg, a slight increase on the price for previous years which has varied between FJD1.62 - 3.08 per kg.

6.21.3 Stock Status

The status of the stocks of **kuita** and **kuitanu** in Fiji is unknown. **Kuita** were reported to be abundant on Fiji's reefs following the cyclone in late 1992/early 1993. It is thought that this was due to the destruction of their holes on the reef by strong wave action generated by the cyclone (Johnson Seeto, pers. comm.). The stocks of *Sy. oualaniensis* are thought to be considerable (Takeda and Hamilton, 1981).

6.21.4 Management

Current Legislation/Policy Regarding Exploitation: None required at present. The amount of suitable habitat on reefs may be a critical factor for the sustainability of octopus stocks.

Recommended Legislation/Policy Regarding Exploitation: Brown (1979) was of the opinion that there could be a considerable demand for squid as bait, particularly in the event of the development of a local bigeye tuna fishery. A potential Fiji squid fishery would probably be limited to a non-capital intensive operation supplying a local market.

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Brown, I.W. 1979. Survey of squid resources in Fiji waters: the cruise of the "Shinei Maru" No.8. 29 May - 4 June, 1979. 14p. Fiji Fisheries Division, Suva, Fiji. 14p.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Roper, C.F.E., M.J.Sweeney and C.E.Nauen. 1984. FAO Species Catalogue. Vol.3. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fish.Synop*., (125) Vol.3:277p.

Takeda, M. and J.E.Hamilton. 1981. Report on the survey of squid resources, particularly flying squid (*Symplectoteuthis oualaniensis*) in Fijian waters. 26 January - 6 March, 1981. 13p plus figures.

6.22 ORNAMENTAL CORAL [lase]

6.22.1 The Resource

Species Present: Fiji has a wide variety of reef-building and soft corals. Viala (1992) reports that according to exporter's returns, 56 species (or species groups) from 11 Scleractinia families and 3 non-Scleractinia families are exploited for the ornamental coral trade (Table 42).

Table 42. Numbers of coral pieces exported from Fiji, by taxa, from 1985-1988 (Source: Viala, 1992).

Species	Trade name	Number of pieces	Species	Trade name	Number of pieces
Acropora arcuata	small branch	17,054	*Millepora dichotoma*	fire	687
A. echinata	pine tree	2,519	*Millepora* spp.	fire	5,148
A. humilis	finger	8,334	*Montipora striata*	montipora	512
A. nobilis	staghorn	8,462	*Montipora* spp.	Bermuda	94
A. palifera	catspaw	5,040	*Pacheseris rugosa*	rugosa	402
A. prostrata	table	17,182	*Pavonia frondifera*	lettuce	1,275
A. subglabra	tree	10,886	*P. lata*	cactus	950
A. vaughani	table	2,711	*Pectinia lactuca*	lettuce	504
Agancia tenuflora	mushroom (?)	342	*Pectinia* spp.	cluster	11,243
Dendrophyllia micranthus	octopus	244	*Pocillopora damicornis*		2,406
Echinopora lamellosa	lettuce/rose	518	*P. eydouxi*	cauliflower	1,443
Euphyllia divisa	divided brain	87	*P. verrucosa*		48
Fungia concinne	mushroom	3,641	*Porites* spp.	porites	134
Galaxea fascicularis	tooth	350	*Sandalolitha* spp.	cup	685
Goniastrea spp.	brain	3,456	*Seriatopora hystrix*	birds nest	9,986
Herpolitha spp.	slipper	2,337	*Stylaster* spp.		68
Leptoria phrygia	closed brain	5,734	*Stylophora pistillata*	elkhorn	7,356
Leptoseris fragilis	glass	29	*Stylophora* spp.	black elkhorn	416
Lobophyllia corymbosa	open brain	1,408	*Tubipora musica*	pipe organ	4,091
Mendusa? *korei*	korei	383	*Turbinaria mollis*	rose/cup	214
M. lakeri	lakeri	258	*Turbinaria* spp.	frond	501
Merulina ampliata	merulina	13,676	*Zoopilus echinatus*	big cup	16
Merulina spp.	star	203		fan coral	55

Distribution: Many of the ornamental corals may be found as part of coral reefs throughout Fiji, though in Fiji waters, blue coral is only known to occur on Rotuma (Lewis, 1985a). Ornamental corals are most abundant in shallow water and should not be confused with semi-precious black coral (**baka**) and precious red and pink corals which occur at much greater depths. There have been several surveys of corals in Fiji, one of the most comprehensive being that of Ryland (1981a).

UNEP/IUCN (1988) mentions various authors in relation to descriptions of reefs at Kabara; Namuka-i-lau, Kabara, Yagasa Cluster and Aiwa; and fringing reefs at Cicia, Katafaga and Tuvuca. Koro Sea Islands such as Wakaya, Makogai, Ovalau, Nairai and Cakau Momo have very complex reef systems (Dunlap and Singh, 1980 In: UNEP/IUCN, 1988). The reefs around Viti Levu are best known and are described in Ryland (1981b).

Biology And Ecology: Corals may be divided into two main types, hermatypic and ahermatypic, depending on whether their tissues contain single-celled symbiotic algae known as zooxanthellae. Hermatypic, or reef-building, corals contain zooxanthellae and ahermatypic corals do not. The zooxanthellae use photosynthesis to convert sunlight energy into their organic food from carbon dioxide, inorganic nutrients and water. Much of the food produced by the zooxanthellae is used as food by the coral polyp, and due to photosynthesis by zooxanthellae, hermatypic corals are able to deposit their limestone skeletons two to three times faster in light than in darkness. This enables reefs to grow faster than they are eroded by the action of the sea and boring organisms (Veron, 1986).

Ahermatypic corals are not restricted to sunlit waters and can grow at any depth, all their nutrition being derived from the capture of plankton. Some ahermatypes, notably *Tubastrea*, *Dendrophyllia* and *Balanophyllia*, are often found in caves or other places where lack of light prevents the more vigorously growing hermatypes from displacing them. Very few ahermatypes are colonial, and those that are have poorly inter-connected, widely spaced tubular polyps. Only the hermatypes have compact, integrated colonies, with well-defined shapes.

The development that has allowed the Sleractinia to exploit algal symbiosis to the fullest extent, in order to build reefs, is their capacity to form complex colonies by asexual multiplication of polyps. By producing colonies composed of hundreds or thousands of individuals, corals can grow to a very great size, achieve great age, produce enormous quantities of larvae, grow fast enough to out-manoeuvre competitors and construct plankton-catching sieves on a very large scale.

Some fast-growing “stag-horn” *Acropora* species can increase their branch lengths by up to 15 cm per year. Other corals produce sturdy colonies able to withstand strong wave action; others produce encrusting colonies, maximising their surface area, and so survive when light is limited. Some *Porites* species may grow only 9 mm per year to produce massive growth forms, rapid growth being sacrificed for long-term endurance and stability. As well as asexual duplication of polyps, all corals devote a substantial part of their available energy to sexual reproduction, using a wide range of methods (Veron, 1986).

6.22.2 The Fishery

Utilisation: In the Fiji operation, collection of corals is performed entirely by local fishermen, within their traditional fishing rights areas, and coral pieces are sold direct to the exporting

company. Collectors use snorkeling gear and a sharpened steel bar to extract corals from the substrate, great care being taken to avoid damage to the specimens. After harvesting, the specimens are laid out to dry for 1-2 days on a bamboo rack or a plastic ground-sheet. This process also assists in bleaching the coral. The specimens are then sorted by species, measured, recorded and wrapped in newspaper before being packed into custom-built crates for export (Viala, 1992).

The Fijian corals most exploited for the period 1985-1988 (Table 42) included branching corals (*Acropora, Seriatopora* and *Pocillopora*), stinging corals (*Millepora*), organpipe corals (*Tubipora*), brain corals (*Goniastrea, Lobophyllia* and *Leptoria*), mushroom corals (*Fungia*), cluster corals (*Pectinia*) and star corals (*Merulina*) (Viala, 1992). In the international trade, a total of 95 species from 51 genera were reported traded from 1985 to 1990. Trade was dominated by branching corals (e.g. brown stem cluster corals *Pocillopora* spp., branch corals *Acropora* spp., birds nest corals *Seriatopora* spp.) and mushroom corals *Fungia* spp. Blue coral *Heliopora coerulea*, used in jewelry making, was also traded in large amounts, as were several genera of massive, or brain corals (e.g. *Platygyra* spp. and *Favia* spp.). Reported trade in most genera declined significantly, following a peak in 1986 or 1987, corresponding with the decline in reported trade from the Philippines (Mulliken and Nash, 1992).

Live coral pieces may be kept in aerated sea-water and exported live. In recent years, with many public aquaria and private enthusiasts have attempted to keep live corals in their tanks along with other invertebrates and fish (Mulliken and Nash, 1992). However the bulk of the stony corals traded internationally are sold for ornamental purposes. Coral pieces, both worked and unworked, are variously used as tabletop decorations, to display jewellery in shop windows, and to provide " natural " surroundings in saltwater aquaria (Lewis, 1985a).

Stony corals have also been traded in very small amounts for surgical use in treating serious fractures and bone cancer. Up until 1992, over 5,000 bone graft operations using coral implants had been performed, using coral pieces cut from large stony corals such as *Goniopora* spp. and *Alveopora* spp. Because corals are not recognized by the human immune system, these implants have lower rejection rates than do implants of human bone tissue (Hodgson, 1989, cited in Mulliken and Nash, 1992).

Production and Marketing: Prior to 1985, production of ornamental corals in Fiji was limited to the small quantities gathered by the tourist market and for private collection. In early 1985, a licence was issued to a local company to extract and export coral, mostly in Bau waters of the Central Province. More recently, extraction began at another site on Ovalau Island (Viala, 1992). The 1985 price paid to collectors per coral piece varied from FJD0.15-0.40, according to size. Table 43 gives the number of pieces of coral exported with associated export values for the years 1984-1989 and the weight of coral exported with associated export values for 1990-1992.

The number of pieces of coral exported from Fiji for the period 1985-1988 is reported by Viala (1992) as being 154,054 while Mulliken and Nash (1993) report only 68,640 pieces as being imported from Fiji by various countries for the same period. There is no known explanation for this discrepancy. All stony corals (Orders Scleractinia and Coenothecalia, families Milleporidae, Stylasteridae and Tubiporidae) are listed in Appendix II of CITES. Though Fiji is not at present a party to CITES, permits for export of stony corals may still have to be issued (Wells *et al*., 1994).

Table 43. Amount of coral (number of pieces 1985-'89/ weight in mt 1990-'92) and value (FJD'000) of exports of ornamental coral from Fiji, 1985-1992. Note: The exported weights for the years 1990-1992 refer to "Corals and all others", including rocks and other materials. Ornamental coral is likely to be only a small portion of this (Sources: Fiji Fisheries Division Annual Reports 1986-1992; Mulliken and Nash, 1993; Viala, 1992).

1985		1986		1987		1988	
Pieces	Value	Pieces	Value	Pieces	Value	Pieces	Value
3,243 (est.)	12.38	30,789 (est.)	117.34	56,186 (est.)	136.36	61,896 (est.)	159.28

1989		1990		1991		1992	
Pieces	Value	Weight	Value	Weight	Value	Weight	Value
101,200 (est.)	253.0 (est.)	1,008.42	1619.1	315.21	238.30	268.7	316.20

6.22.3 Stock Status

Nothing is known of the status of the stock of stony corals in Fiji. More information is required on the distribution and abundance of commercial coral species in Fiji, their rates of regeneration and the current state of the stocks in the coral extraction project area of the Central Province.

6.22.4 Management

Current Legislation/Policy Regarding Exploitation: Since coral, as an "..aquatic animal whether piscine or not..", comes under the definition of "fish" in the Fisheries Act, it is subject to the various restrictions on exploitation of fish listed in the Act. For example, the export of live coral is banned, in the same way that the export of live fish is banned, subject to explicit ministerial exemption (See Profile 1.7). Fiji Fisheries Division has a coral harvesting policy document, which includes provision for a baseline survey before coral collection commences in a new area, with occasional follow-up surveys (T. Adams, pers. comm.). Cabinet Guidelines which have been in place since 1985, make preliminary provision for the exploitation of coral reefs:

- Licensing of commercial collectors is to be restricted. One local collector should be licensed in the first instance to enable more information to be gathered on the resource.
- Export permits are required, and a full listing of species exploited is to be supplied.
- Management requirements for particular areas are to be determined by consultation between the collector and Fisheries Division.
- The resource custodians are to be involved to the maximum extent practicable in the harvest of corals.

At present there is a total ban on coral extraction covering the area of the three Vanuas of Dawasamu, Bureiwai and Nakorotubu, and Kubuna waters, and a Cabinet sub-committee is looking into the industry (Fiji Fisheries Division).

Recommended Legislation/Policy Regarding Exploitation: Lack of information on the resource itself requires that great caution be adopted in regard to requests for expanded exploitation. Attempts have been made in many countries to regulate ornamental coral harvest, in recognition of the increasing usage pressures to which coral reefs are subjected in many areas, and the complexity of the coral reef ecosystem of which they are an integral part. Collecting and exporting reef corals is now prohibited or restricted in some 30 countries worldwide. Countries in the Pacific with legislation which specifically mentions corals include Australia, Federated States of Micronesia, Guam, Hawaii, New Caledonia, Philippines, USA, Vanuatu (Wells *et al*., 1994) and Tonga (DC No.1853 of 15 December 1993). Tonga's legislation prohibits the export from Tonga of reef corals of the Orders Scleractinia, Coenothecalia, Athecata and Stolonifera. This is probably the only feasible way of preventing excessive damage to reefs when sustainable exploitation figures are not available.

Some countries have imposed quotas, prohibition on use of SCUBA gear for collection, restriction of species to be collected, and zonation of the areas for collection. Details of these measures are provided by Wells *et al*. (1994). Some of these have been imposed on the single operation in Fiji, e.g. collectors have been advised to move operations to fringing reefs and inner lagoon reefs, rather than inshore reefs, as the latter are affected by freshwater run-off, and are likely to be slow to regenerate (Viala, 1992).

References

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Anon. 1993f. CITES annual report data provided by the World Conservation Monitoring Centre, Cambridge, UK.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Mulliken, T.A. and S.V.Nash. 1993. The recent trade in Philippine corals. In: TRAFFIC Bulletin Volume 13(3). April/May 1993. TRAFFIC International, Cambridge, UK. 97-105.

Ryland, J.S. 1981a. Introduction to coral reefs of Fiji. *South Pacific Journal of Natural Science 2:* 44-51.

Ryland, J.S. 1981b. Reefs of southwest Viti Levu and their tourism potential. In: The Reef and Man. Proceedings of the Fourth International Coral Reef Symposium. Volume 1: 293-298.

UNEP/IUCN, 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific.* UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

Veron, J.E.N. 1986. *Corals of Australia and the Indo-Pacific*. Angus & Robertson, Sydney, Australia. 644p.

Viala, F. 1992. An assessment of coral exploitation in Fiji. In: Papers on Fisheries Science from the Pacific Islands, Vol.1. Inshore Fisheries Research Project, Technical Document No.1. South Pacific Commission, Noumea, New Caledonia. 33-35.

Wells, S., P. Holthus and J. Maragos. 1994. Environmental guidelines for coral harvesting operations. South Pacific Regional Environment Programme, Apia, Western Samoa. 36p.

6.23 BLACK CORAL [baka]

6.23.1 The Resource

Species present: Two species of commercial black coral are found in Fiji, *Antipathes dichotoma* and an undescribed species (Lewis, 1985a).

Distribution: According to Lewis (1985a), black coral is widely, but patchily distributed in Fiji. The undescribed species is found mainly around the larger islands.

Biology And Ecology: Black corals typically occur at depths of 20-100 m, generally in areas of strong current and hard clean sea-bottom. Growth of tree-shaped colonies is very slow, 6 cm per year or less, and large "trees" may be 100 years old. Considerable mortality occurs when boring organisms undermine and topple the tree base (Lewis, 1985a).

6.23.2 The Fishery

Utilisation: Because black coral colonies normally occur at depths of 80-100 m, they are primarily harvested by hand using SCUBA gear. A small-tooth pruning saw or bolt-cutters are used to saw through the black coral "trees" at the base, or to remove branches. The harvested black coral is left in fresh or brackish water to cause death and decomposition of the coral. It is then cleaned and trimmed, and hung or stacked in a well ventilated position to season for 3-12 months. Black coral is processed to produce beads, regularly shaped jewelry components, carved jewelry components such as animal figures, unique articles of jewelry such as bracelets and coral sculptures. Processing is a skilled and labour intensive operation, adding considerable value to the raw product (Lewis, 1985a; Philipson, 1989).

Production And Marketing: There is no current information on the production and marketing of black coral in Fiji. Lewis (1985a) noted that one company in Fiji was at that time producing high quality jewelry from local black coral, for supply to the tourist trade. The retail value of black coral jewelry sold annually in Fiji was estimated by Lewis (1985a) to be as high as FJD250,000.

6.23.3 Stock Status

Lewis (1985a) states that Fiji's stocks of black coral are believed to be limited and vulnerable to over-exploitation. The distribution is patchy and density of colonies low.

6.23.4 Management

Current Legislation/Policy Regarding Exploitation: There are Cabinet Guidelines for the exploitation of black coral in Fiji, which suggest close monitoring of harvest, and prohibition of indiscriminate harvest methods and export of unprocessed product. They are as follows:

? with a single operator, no regulatory action is required, but the situation should be monitored;

? mechanical harvesting or the destructive use of drag nets to be prohibited for commercial harvest and;

? exports of unprocessed product to be prohibited.

Recommended Legislation/Policy Regarding Exploitation: Information on the current status of the black coral industry in Fiji should be obtained, so that the present Cabinet Guidelines can be reviewed. The voluntary practices of the operator relating to harvesting restrictions and "replanting" of coral pieces noted by Lewis (1985a) should be monitored. As the resource is limited and very vulnerable to over-exploitation, local harvesters should be limited in number.

References

Lewis, A.D. (ed.) 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Philipson, P.W. 1989. *The marketing of marine products from the South Pacific*. Institute of Pacific Studies, University of the South Pacific, Suva, Fiji. 307p.

6.24 MANGROVES

6.24.1 The Resource

Species Present: The term "mangrove" is now applied to angiosperm (flowering plant) trees which are restricted to the inter-tidal zone. The term "mangal" is employed to denote the community of plants in the mangrove habitat, from algae to angiosperms. Globally, there are some 60 species of mangrove trees and shrubs which are found exclusively in the mangrove habitat. (Saenger *et al.*, 1983 In: Pillai, 1990).

Fiji's mangrove vegetation is dominated by three species and a putative hybrid of the family Rhizophoraceae: *Bruguiera gymnorrhiza* (**dogo**) , *Rhizophora stylosa* (**tiri**), *R. samoensis* (**tiri**) and *R.* x. *selala* (**selala**) (putative hybrid of *R. samoensis* and *R. stylosa*). The other principal species are *Xylocarpus granatum* (**dabi**), *Lumnitzera littorea* (**sagali**), *Exoecaria agallocha* (**sinu gaga**) and *Heritiera littoralis* (**kedra ivi na yalewa kalou**) . Also recorded are 41 common, non-exclusive mangrove species and 32 less common, non-exclusive mangrove species (Watling, 1985).

Distribution: Mangroves are essentially pan-tropical plants, but they extend to 31?N (Southern Japan) and 38? 45' S (Victoria, Australia) of the equator. The main concentrations of mangrove species in the world are found in the Indian Ocean and Malaysia-Indonesia archipelago. The distribution of mangrove flora in the Indo-West Pacific region is characterised by a species gradient which diminishes eastward and westward.

The most luxuriant mangrove flora in Fiji is found on the southern and south-eastern shores of Viti Levu and Vanua Levu and also in the estuaries of the Ba and Labasa Rivers. As the seaward advancement of the coast has generally been much greater along the north-facing coasts of Viti Levu, Vanua Levu and Kadavu than along the south-facing coasts, wide mangrove belts occur on the northern rather than southern shores. Also, the compression of Viti Levu along its southern margin has resulted in narrow belts of mangal on these shores (Pillai, 1990).

Biology and Ecology: Mangroves are termed "facultative halophytes", since some species can grow well in fresh water, while others grow best in high salinities or at salinities which lie between fresh water and sea water. They follow the silting-up of inshore areas rather than preceding it. Once established, mangroves contribute to coastal accretion by trapping debris and sediment.

The mangrove habitat is colonised by a very diverse resident fauna ranging from sponges to invertebrates. It may also be frequented by an array of animals such as insects, crabs, fish, amphibians, reptiles, birds and mammals, including bats, mongoose and man. The activities of many of these animals, coupled with enhanced sediment accumulation, lead to the gradual transition to a terrestrial environment. For example, the burrowing activities of the mangrove lobster (**mana** - *Thalassina anomala*) leads to the formation of large mounds (Pillai, 1992).

6.24.2 The Fishery

Utilisation: The majority of indigenous Fijians are coastal dwellers and a large proportion of these have access to and utilise mangrove. Such communities have a profound utilitarian

knowledge and dependence on the direct and indirect benefits of the mangrove ecosystem. Extensive traditional use of the mangrove vegetation has been recorded by Pillai (1987).

Some mangrove fauna have an important traditional and mythical status. One such animal is the mud lobster, *T. anomala*, which is of great traditional significance to the people of the Rewa delta. The red prawn, *Parahippolyte uveae* found in a few mangrove-fringed anchialine habitats of Fiji constitute the subject of very interesting magico-religious taboos (Choy, 1984).

Approximately 308 ha of mangrove habitat was impoldered and cleared in the early 1970s at Raviravi, Ba and about half of the area is destined for aquaculture of penaeid prawns. This venture was subject to many difficulties, including soil acidity and cyclonic damage. It is unlikely that major aquaculture development will be considered for Fiji's mangroves, and specifically not for artisanal aquaculture (Watling, 1985).

Production and Marketing: In the past, mangroves were of major importance as a source of fuelwood. In 1952, over 50,000 m^3 was harvested and processed by the Forestry Department, which initiated working plans based on sound management principles of sustained yield for the industry. However, due to the availability and convenience of imported fuel oil, demand for fuelwood declined drastically through the 1950s to 1960s. It stabilised at approximately 5,000 m^3 per year after 1967 and virtually ceased as a managed fuelwood industry (Watling, 1987).

Whilst domestic use of mangrove in urban areas almost certainly declined in parallel with the national trend, and is today the only major use of the wood, the volume of wood taken is far greater than the Forestry Department figures. This is because illegal felling is commonplace and unchecked (Swarup, 1983).

Lal *et al.*(1983) found that 83 per cent of 87 fish species caught at one mangrove site were utilised by local people as a source of food, while at least two-thirds are of commercial importance. Watling (1985) calculated that the mangrove-associated fishery for 1983 was worth approximately FJD21 million.

6.24.3 Stock Status

Watling (1985) estimated that the area covered by mangroves in Fiji is 38,543 ha. This accounts for a fraction over 2 per cent of Fiji's total land area. Watling's estimate, however, does not include the mangroves of the whole of the Lau Group, Yadua, Vatulele and Taveuni (Pillai, 1990).

The National Trust for Fiji has the responsibility of implementing the country's National Parks and Reserves Plan. It is envisaged that during the implementation of the plan, certain mangrove areas will be declared as national parks and reserves, for conservation and preservation of unique (flora and fauna) species and those being depleted and in danger of extinction. One such reserve has been declared at Rewa (Anon., 1991c). The objective of creating mangrove reserves is to provide full protection for the areas. Further information on the status of Fiji's mangrove resources is available in Watling and Chape (1992).

6.24.4 Management

Current Legislation/Policy Regarding Exploitation: A national policy statement concerning Fiji's mangroves has been endorsed by the Fijian Government: "Mangroves are an important national asset:

primarily as a resource base for capture fisheries and secondarily as a renewable source of products which contribute significantly to the quality of life of associated coastal communities.

Recognising this:

The natural processes of the ecosystem should be preserved wherever possible, thereby allowing the sustained harvesting of its renewable products and the preservation of future development options. Conversion activities should be minimised and permitted only in the national interest and after a detailed socio-economic comparison with the expected loss to the capture fisheries and other renewable uses."

The Lands and Surveys Ministry chairs a Mangrove Management Committee, which advises the Ministry on all matters concerning mangroves. This committee considers all applications, either for reclamation or other (sustainable) activities, on individual merits, in the context of the National Mangrove Management Plan. The committee has no power of veto, as it is merely an advisory body.

Recommended Legislation/Policy Regarding Exploitation: In terms of their value to fisheries resources as habitat, conservation and management of existing mangrove stands in Fiji are worthy of receiving top priority from the Ministry of Agriculture, Fisheries and Forests.

References

Anon., 1991c. The Rewa mangrove reserve. *Forestry Quarterly* 42: 10-11.

Choy, S.C. 1984. On the freshwater palaemonid prawns from the Fiji Islands (Decapoda, Caridea). *Crustaceana* 47 (3): 269-277.

Lal, P.N., K.Swamy and P.Singh. 1983. Mangroves and secondary productivity: fishes associated with mangroves in Wairiki Creek, Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Division, MAF, Suva, Fiji: 13-31.

Pillai, G. 1987. Mangroves of Fiji: their uses and management. In: C.D.Field and A.J.Dartnall (eds.). Mangrove ecosystems of Asia and the Pacific. Proceedings of the research for development seminar, Australian Institute of Marine Science, Cape Ferguson, Australia, 18-25 May, 1985. 150-160.

Pillai, G. 1990. Mangroves of Fiji. University of the South Pacific, Suva, Fiji. 31p.

Pillai, G. 1992. *Thalassina anomala* fishery in Fiji. Marine Studies Programme Technical Report, Series 1992, No.1. The University of the South Pacific, Suva, Fiji. 5p.

Swarup, R. 1983. Mangroves as a forestry resource and its possible silviculture in Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Divison, MAF, Suva, Fiji: 6-10.

Watling, D. 1985. A mangrove management plan for Fiji: 1. zonation requirements and a plan for the mangroves of Ba, Labasa and Rewa deltas. South Pacific Commission, Fiji. 67p.

Watling, D. 1987. Mangrove state of the art report: Fiji. 29p plus appendices.

Watling, D. and S.Chape (eds.). 1992. Environment Fiji: The National State of the Environment Report. International Union for the Conservation of Nature, Gland Switzerland. 154p.

C. AQUACULTURE RESOURCES PROFILES

Introduction

Though milkfish (*Chanos chanos*) may have been traditionally cultured by people in certain areas of the Lau Islands and the Rewa Delta (Uwate and Kunatuba, 1983 In: Gulick, 1990), aquaculture in Fiji using introduced organisms may have commenced in the 1880s, when oysters are reported to have been introduced from Australia. In the succeeding 100 years, native and exotic plants and animals, including fish, crustaceans, molluscs and turtles have been cultured (Gulick, 1990).

One of the first was tilapia (*Oreochromis mossambicus*), which was introduced in the 1940s. Since then, there have been further introductions of *O. mossambicus* and of several other tilapia species, and introductions of an array of other organisms. Table 44 lists some of the organisms either cultured in Fiji using native stock, or introduced to Fiji for purposes of aquaculture. This list does not include species such as brown trout (*Salmo trutta*) or smallmouth bass (*Micropterus dolomieus*), which were introduced principally for stocking into rivers.

Table 44. Some organisms native to Fiji used for aquaculture, and those introduced to Fiji for purposes of aquaculture (Source: Gulick, 1990).

Common name	Scientific name	Country of origin	Year of introduction or first culture in Fiji
fresh-water prawns	*Macrobrachium rosenbergii*	Hawaii French Polynesia	1980 1981
marine prawns	*Penaeus monodon*	French Polynesia	1981
large-mouth (black) bass	*Micropterus salmoides*	New Caledonia	1983
grass carp	*Ctenopharyngodon idella*	Malaysia	1968
silver carp	*Hypophthalmiothys molitrix*	Malaysia	1968
big-head carp	*Aristichthys nobilis*	Malaysia China	1968 1982
tawes	*Puntius gonionotus*	Malaysia	1968
Pacific oysters	*Crassostrea gigas*	Japan	1968
	Saccostrea commercialis	Australia	1968
mangrove oyster	*Saccostrea glomerata*	New Zealand Fiji	1970
Philippine oyster	*Crassostrea iredalei*	Philippines	1975
	Crassostrea mordax	Fiji	1971
	Ostrea edulis	USA?	1977
Manila clam	*Tapes semidecussata*	USA	1971
blacklip pearl oyster	*Pinctada*	Fiji	1966

	margaritifera		
winged oyster	*Pteria penguin*	Fiji	1966
giant clams	*Tridacna gigas*	Australia	1987
green mussel	*Perna viridis*	Philippines	1975
		Philippines	1976
		French Polynesia	1980
		French Polynesia	1984
commercial red seaweed	*Eucheuma* spp.	?	1976
		Philippines via Tonga	1984
hawksbill turtle	*Eretmochelis imbricata*	Fiji	1974
Mozambique tilapia	*Oreochromis mossambicus*	Not available	1940s
		Malaysia	mid-1950s
Nile tilapia	*Oreochromis niloticus* (Israeli strain)	Malaysia	late-1960s-early1970s
Nile tilapia	*O. niloticus*	Israel	1979
Nile tilapia	*O. niloticus* (Chitrilada strain)	Thailand	1988
	O. hornorum	Taiwan	Early and mid-1980s
	O. aureus	Taiwan	Early and mid-1980s
red tilapia	hybrid		1985
common carp	*Cyprinus carpio*	New Zealand	1937
		Malaysia	1968
milkfish	*Chanos chanos*	Fiji	Traditional - revived in 1947
rabbitfish	*Siganus* spp.	Fiji	Early 1970s
mullet	*Mugil* spp.	Fiji	Early 1970s
molly	*Poecilia mexicana*	Western Samoa	1982

Most of the commercial ventures based on these introduced organisms have been unsuccessful. There are many reasons for this, not the least being that the organism and its culture system were simply transplanted from another country, with little thought to marketing. Another fact that was overlooked in many cases of failed aquaculture ventures was that Fiji, along with the rest of the South Pacific countries, does not have a long history of aquaculture.

In contrast to the many failed commercial aquaculture enterprises, the Rural Aquaculture Programme shows great promise. This is because it has been introduced gradually, with consistent, long-term extension back-up, based on the pond culture of *Oreochromis niloticus*, a fish with which Fijians are already familiar, due to previous introductions of *O. mossambicus*. It also occurred at a time when inexpensive, fresh fish was becoming less available to the rural population because of the fishing pressure on inshore marine fin-fish and non-fish species. A similar approach with other organisms may see the eventual development of large-scale aquaculture projects in Fiji.

References

Gulick, C.T. 1990. Aquaculture. In: Jansen, A.A.J, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

1.1 TILAPIA

1.1.1 The Resource

Species present: The Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*O. niloticus*), " Chitrilada strain " Nile tilapia (*O. niloticus*), " Israeli strain" Nile tilapia (*O. niloticus*), *O. hornorum*, *O. aureus* and a hybrid red tilapia (possibly from an *O. mossambicus* and *O. niloticus* cross). None of these fish are native to Fiji, i.e. all were introduced from other countries.

Aquaculture Facilities: Gulick (1990) states that *O. mossambicus* were originally grown in ponds at the Sigatoka Agricultural Station, and in the mid-1950s were stocked into some school ponds in Fiji. In 1968, introduced *O. niloticus* were held in the Fiji Fisheries Research ponds at Lami. Later research work on tilapia, including production of *O. mossambicus* fry for the Rural Aquaculture Programme (RAP), has been conducted at the Naduruloulou Research Station (NRS). An additional hatchery facility for the Northern Division has been developed at Dreketi on Vanua Levu (Anon., 1991b), and towards the end of 1992, a third government hatchery was established at Ba (Anon., 1993d).

Biology and Ecology: See Profile B.5.2, this volume.

1.1.2 Aquaculture Information

Utilisation: *O. mossambicus* was originally introduced to Fiji to be grown in ponds as pig feed. In the early 1950s, it was suggested (Holmes, 1954 In: Gulick, 1990) that tilapia could be used for human food. In the 1970s, tilapia were considered as baitfish for tuna, but behavioural and technical problems negated further investigation of this proposed use (Gulick, 1990).

In 1982, the RAP commenced, based on the monoculture of *O. niloticus*. The RAP, an initiative between the Fiji Government and the US Peace Corps, produces *O. niloticus* fry at the NRS for distribution to private grow-out farms (Anon., 1991b). The initial major objective of the RAP was to improve protein nutrition in inland areas, by encouraging individual subsistence fish farms. In late 1988, the focus of the project changed to income generation from multiple communal fish farms (Anon., 1991b).

Trials with the hybrid red tilapia were first carried out in 1985, it being supposed that they would grow faster and their red colour would make them more marketable. Difficulties with a 20-35 per cent rate of reversion to a black or brown colour and less than expected growth rates, led to a halt to the project in the late 1980's (Gulick, 1990).

Production and Marketing: From 3 fully functional private ponds in the RAP in 1982, the programme grew to 23 operational ponds in 1986, with farmer production of approximately 2 mt ha^{-1} yr^{-1}. Hatchery trials gave production of approximately 6-8 mt ha^{-1} yr^{-1} , the difference in production being ascribed to lack of farmer commitment to feeding the ponds. In 1988, 2.5 mt or fish were harvested, and yields as high as 6.3 mt ha^{-1} yr^{-1} were being achieved by rural farmers. In late 1989, production in the Namosi Province had risen to more than 7 mt ha^{-1} yr^{-1}, though other areas of the country were not generally as productive (Gulick, 1990).

The estimated total tilapia production in 1990 was 14 mt, with projections of 48 mt by the end of 1995 (Anon., 1991b). In fact, (Anon., 1993d) reports that the approximately 229,557 fry

stocked by RAP farmers during 1992 produced 45.9 mt. In the same year, demonstration farms such as Montfort Boys Town and Wainitu produced 26.1 mt, making a total production of 72 mt, compared to 16 mt in 1991.

In 1988, Fiji Fisheries Division recognised that increases in production of tilapia were subject to the genetic improvement of broodstock. Because the hybridised strain of *O. niloticus* consistently reproduced within the 6-monthly production cycle, the hatchery was constantly required to re-stock ponds. Since 1989, stocking of the supposedly pure "Chitrilada" strain of *O. niloticus* was meant to enable fish to breed in ponds after reaching a marketable size. Further work is planned on the genetic improvement of tilapias in Fiji (Gulick, 1990; Anon., 1991b).

The RAP is undoubtedly successful. For example, co-operative groups and individuals have established nearly 70 fish farms in Fiji's Naitasiri Province. Thirty farms are operated by small groups, the rest by individuals, and an average of 5.7 mt valued at FJD17,000 (about USD11,300) is harvested each year (Anon., 1994).

Batches of 200-300 tilapia sell quickly in retail markets for approximately FJD3.00-4.00 per kg, a price comparable or slightly higher than the price paid for several species of reef fish (Anon., 1991b). Using these figures, the 1992 yield of 72 mt was valued at approximately FJD215,000. However, part of this success is due to government subsidies, e.g. *O. niloticus* fingerlings are supplied to farmers free of charge (S.Lal, Aquaculture Officer, pers.comm.).

1.1.3 Status of Farmed Stock

Broodstock of the "Chitrilada" strain of *O. niloticus* are held at the NRS. This strain is generally considered to be preferable for culture in comparison with other strains held there (Anon., 1991b). Broodstock of the hybrid red tilapia is also held at the NRS.

1.1.4 Management

Legislation/Policy Regarding Cultivation: None at present.

Recommended Legislation/Policy Regarding Cultivation: Work on genetic improvement of tilapias in Fiji should continue. It may be useful to conduct a rigorous economic study of the pond culture of tilapia in Fiji, to assist in planning future development work.

References

Anon. 1991b. Tilapia as a cost-effective sustainable protein source for developing countries. Draft proposal for aquaculture development in Fiji for presentation to ACIAR. 7p.

Anon. 1994. The South Seas Digest, Number 5, Volume 14, May 20 1994.

Gulick, C.T. 1990. Aquaculture. In: Jansen, A.A.J, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

1.2 CARP

1.2.1 The Resource

Species present: The carp introduced to Fiji are common carp (*Cyprinus carpio*), grass carp (*Ctenopharyngodon idellus*), bighead carp (*Aristichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*). The tawes or Indonesian carp (*Puntius gonionotus*) is also present. All these species are included in the group known as "Asiatic" carps.

Aquaculture Facilities: In the late 1960s, ponds at Lami were used to hold *Ct. idellus* and other introduced species of carp. Later work with carp was done at the Naduruloulou Research Station (NRS).

Biology and Ecology: Carp are found almost entirely in fresh water, although a few will occasionally go into brackish water. They have no teeth in their jaws, but the jaws may develop a horny cutting edge for scraping algae. One or two pairs of short barbels may be present at the corners of the mouth. Mastication of food, such as insects, plants and detritus, may be achieved by a set of pharyngeal teeth.

The carp-like fishes are all egg layers. Some species lay eggs in shallow water, some in deep water, some attach their eggs to aquatic plants, while yet others release their eggs into the water so that they float downstream with the current while the embryos develop. In tropical countries, the period of embryonic development may be very short, the larvae hatching in only 36 hours (Honders, 1975).

Asiatic carps usually do not breed in captivity, although they attain full maturity in ponds. In their natural habitats, the rivers, several environmental and climatic factors influence their reproduction. In the absence of the required environmental factors, the Asiatic carps fail to reproduce in ponds and require exogenous hormones to stimulate endogenous ovulatory discharge. These hormones are usually obtained from pituitary glands located in the brains of certain fish species, including *Cy. carpio* and *P. gonionotus* (Chaudhuri and Juario, 1983).

From its first introduction to Fiji in 1968, *Ct. idellus* was the subject of research into inducing the fish to spawn, since it would not be economical to continually import fingerlings. It wasn't until 1985 that *Ct. idellus* were first successfully induced to spawn in Fiji.

1.2.2 Aquaculture Information

Utilisation: *Cy. carpio* and *P. gonionotus* were introduced from Malaysia in 1968 for pond culture and as a source of pituitary material. While *P. gonionotus* survived to become part of the weed control programme, the *Cy. carpio* were later destroyed by the government and further introductions of this species were banned. *Ct. idellus*, *A. nobilis* and *H. molitrix* also introduced from Malaysia in 1968, were to be used for pond culture and weed control. In fact, the latter two species are plankton feeders rather than herbivores, and of these three species, only *Ct. idellus* was used for weed control. The other species may have been used for pond culture in the early 1980s, but by the mid-1980s had been phased out in favour of *Oreochromis niloticus* for pond culture (Gulick, 1990).

Production and Marketing: When *Ct. idellus* were eventually induced to spawn in Fiji in 1985, this allowed a far greater number to released into weed-infested rivers on Viti Levu.

Rivers treated included the Rewa (33,887 from 1978-1986), Waidalice (33,000 from 1984-1986), Navua (5,000 in 1986), Korovou (5,000 in 1986) and others. Fish are now released at intervals of 2.5 years compared to the previous 4 year intervals (Gulick, 1990).

The October-November 1992 spawning of *Ct. idellus* produced over 3 million eggs, from which 1.2 million fry developed to be released into ponds and nursed for river release. Only 200,000 of these are expected to reach fingerling size for use in weed control in rivers and other water bodies (Anon., 1993c).

1.2.3 Status of Farmed Stock

Stock of *Ct. idellus* are kept at NSR where they are periodically induced to spawn to provide fingerlings for the weed control programme. *P. gonionotus* spawns naturally at NSR and in rivers.

1.2.4 Management

Legislation/Policy Regarding Cultivation: None at present.

Recommended Legislation/Policy Regarding Cultivation: Given the proven success of the weed control programme using *Ct. idellus*, and the success of the Rural Aquaculture Programme using *O. niloticus*, further importation of carp species would not seem to be appropriate. However, it may be occasionally necessary to introduce new varieties of *Ct. idellus*, to genetically improve the stock.

References

Anon. 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Chaudhuri, H. and J.V.Juario. 1983. Use of hormones in breeding cultivated warm-water fishes with special reference to milkfish, *Chanos chanos* (Forsskal). A compilation of SEAFDEC AQD technical papers on milkfish and other finfishes. Vol.1. Aquaculture Department, SEAFDEC, Iloilo, Philippines. 47-53.

Gulick, C.T. 1990. Aquaculture. In: Jansen, A.A.J, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

Honders, J. 1975. (ed.). *The World of Fish.* Peebles Press, New York. 160p.

.

1.3 MACROBRACHIUM PRAWNS

1.3.1 The Resource

Species present: The freshwater prawn species which have been utilised for aquaculture in Fiji are the giant freshwater prawn (*Macrobrachium rosenbergii*) and the freshwater prawn (**uradina** - *M. lar*), nearly all of the work being done with the former species (Gulick, 1990).

Aquaculture Facilities: The original freshwater prawn hatchery was based at Lami, but after problems with high mortality of post-larvae, a larger facility was opened in late 1983 at Naduruloulou Research Station (NRS). Grow-out trials have been conducted at NRS, Montfort Boys Town and at various private farms (Gulick, 1990).

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). Ideal conditions for larval stages are water salinity of 8-10 ppm, reduced to 3-5 ppm after the first metamorphosis, water temperature of 28° C, water change of 70-80 per cent every 3 days, and feeding 4-5 times per day (Lal, 1987 In: Gulick, 1990).

1.3.2 Aquaculture Information

Utilisation: Freshwater prawn culture was commenced with the intention of providing both dietary protein and cash income for rural people, especially those of the Rewa Delta (Gulick, 1990).

Production and Marketing: From makeshift beginnings in 1983, by 1985 the hatchery at NRS produced in excess of 300,000 *M. rosenbergii* post-larvae, and mass production of post-larvae of this species was found to be technically feasible under Fiji conditions. One million *M. rosenbergii* post-larvae were produced in 1986 at an approximate cost of FJD7.00 per thousand, though by 1988 production had dropped to 90,000. Attempts to rear the larvae of **uradina** were not successful for technical reasons (Bell and Gervis, 1994).

Grow-out trials in 1980-1981 using *M. rosenbergii* post-larvae obtained from Hawaii and French Polynesia, produced encouraging results. In 1982, polyculture with fish was proposed, and the Japanese International Cooperation Agency (JICA) became involved with the project. The best grow-out trial in 1985 yielded 1.2 mt ha^{-1} $year^{-1}$. Ten grow-out trials were conducted in 1986, survival ranging from 4-40 per cent with an average production of 0.7 mt ha^{-1} $year^{-1}$.

Prawn/tilapia polyculture trials commenced at NRS in 1987. Though survival rate ranged from 98 per cent in two trials, to almost zero in six later trials, the two successful trials produced 0.8-1.2 mt $ha.^{-1}$ $year^{-1}$ (Gulick, 1990). Despite vast improvements in rearing techniques over the life of the project, freshwater prawn farming was not taken up as a commercial venture, possibly because of low market price for the prawns, high feed costs and technical constraints. Feed formulation trials at NRS using locally available agricultural by-products continued during 1991 with JICA technical assistance. In 1992, the project was halted due to loss of the remaining *M. rosenbergii* broodstock in a flood (Bell and Gervis, 1994).

1.3.3 Status of Farmed Stock

By mid-1992 there were no surviving broodstock at NRS (Bell and Gervis, 1994).

1.3.4 Management

Legislation/Policy Regarding Cultivation: None at present.

Recommended Legislation/Policy Regarding Cultivation: None required at present. It is unlikely that freshwater prawn farming will be attempted on a large scale in Fiji, unless it can be shown to be economically viable in this country.

References

Bell, L.A.J. and M.H.Gervis. 1994. Aquaculture potential on Niue. FFA Report No.94/15. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 51p + appendices.

Gulick, C.T. 1990. Aquaculture. In: A.A.J.Jansen, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

New, M.B. and S.Singholka. 1982. Freshwater prawn farming. A manual for the culture of *Macrobrachium rosenbergii*. *FAO Fish. Tech. Pap.*, (225): 116p.

1.4 PENAEID PRAWNS

1.4.1 The Resource

Species present: The penaeid prawns used for aquaculture in Fiji include the giant tiger prawn (**urakeirasaqa** - *Penaeus monodon*), kuruma prawn (*P. japonicus*), Indian white prawn (*P. indicus*), banana prawn (*P. merguiensis*) and blue prawn (*P. stylirostris*) (Gulick, 1990).

Aquaculture Facilities: Research on penaeid prawns in Fiji was originally carried out in government owned ponds at Raviravi in the early 1970s. A joint project between the Government of Fiji and France Aquaculture established in 1981 also used ponds at Raviravi, where the hatchery site, on reclaimed mangrove soil, has previously been criticised as being very poor, with higher than permissible bacteria levels (Gulick, 1990).

There are now two private prawn farms in Fiji - a 24 ha (est.) farm at Raviravi which has a hatchery, and a 4 ha (est.) farm at Navua which has no hatchery. Both farms base their operations on the culture of *P. monodon*. Montfort Boys Town is due to commence grow-out of *P. monodon* during 1994 (S.Lal, Aquaculture Officer, pers.comm.).

Biology and Ecology: See Profile B.6.11, this volume.

1.4.2 Aquaculture Information

Utilisation: There is a market for commercially produced penaeid prawns in Fiji. Lewis (1985a) estimated that the demand was 25-30 mt per year, but this has been recently revised upwards to 60-100 mt per year (S.Lal, Aquaculture Officer, pers. comm.).

Production and Marketing: The joint Fiji Government/French project at Raviravi was based on *P. monodon*. Culture of *P. indicus* was also tried, but survival and growth were both poor. Lewis (1985) reported that the farm had a larvae production capacity of 8 million per year, while prawns with an average size of 30 g were harvested after 4 months of growth. The annual production target in 1985 was 2 mt per ha. The species used were fast growing strains of *P. monodon* and the American species, *P. stylirostris*, both of which were introduced.

For a variety of reasons, production targets were not achieved during the life of the project. Major damage from 3 hurricanes in 1985 delayed full operations from resuming for approximately 6 months. A production target of 7.2 million post-larvae was set for 1986, but only 1.8 million were obtained, due to water quality problems. In 1987, a production target of 70 mt was set, but only 7.7 mt were produced. In 1988, 16.8 mt were produced, at production averages of 2.7 mt ha^{-1} $year^{-1}$ (Gulick, 1990). In early 1990, an Australian company named "Barrier Fisheries of Australia", in partnership with the Fiji Development Bank, took over the farm. Due to technical difficulties encountered, the farm suspended operations in 1991.

There is very little information available for the production of the privately operated prawn farms. By 1992, production at the Navua farm was between 4-6 mt ha^{-1} $year^{-1}$ (Ledua, 1992).

1.4.3 Status of Farmed Stock

There are local stocks of *P. monodon* for the provision of broodstock, in addition to those held at the private farms (See Profile 6.11).

1.4.4 Management

Legislation/Policy Regarding Cultivation: None at present.

Recommended Legislation/Policy Regarding Cultivation: As recommended by Lewis (1985a), care should be exercised with the importation of exotic species, to prevent introduction of diseases and parasites.

References

Gulick, C.T. 1990. Aquaculture. In: A.A.J.Jansen, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

Ledua, E. 1992. Status of aquaculture development in Fiji. Report prepared for the aquaculture seminar, August 1992, Tokyo, Japan. 34p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

1.5 GIANT CLAMS

1.5.1 The Resource

Species present: There are four species of giant clam which occur naturally in Fiji; rugose giant clam (**katavatu**, **kativatu** - *Tridacna maxima*), the fluted giant clam (**cega** - *T. squamosa*), the smooth giant clam (**vasuadina**, **matau** - *T. derasa*) and the recently described devil clam (*T. tevoroa*). The giant clam (*T. gigas*) is recently extinct in Fiji, and the horse's hoof clam (*Hippopus hippopus*) was present in pre-historic times (Lewis, 1985a).

T. gigas was successfully re-introduced to Fiji in 1986, 1987 and 1990 as juvenile clams from James Cook University (JCU), Australia. *H. hippopus* was re-introduced from JCU in 1991. *T. derasa* was first spawned locally in 1988, the juveniles being re-stocked on local reefs. This species was also re-introduced in 1985 from the Micronesian Mariculture Demonstration Centre (MMDC), Palau, but the stock died. *T. tevoroa* was re-stocked from Tonga. By mid-1989, juveniles of locally spawned *T.squamosa* were being produced (Gulick, 1990).

Aquaculture Facilities: In Fiji, the aquaculture of giant clams is conducted at Makogai Island in Lomaiviti, where a quarantine facility was established in 1986 to receive 400 juvenile *T. gigas* from Australia. A hatchery facility was constructed at Makogai in 1988 as an extension of the quarantine unit. The establishment is now known as the "Giant Clam Hatchery and Mariculture Research Facility" (Gulick, 1990).

The system at Makogai consists of 6 x 1,000 litre and 2 x 2,000 litre fibreglass tanks in the hatchery, with 7 large splasher pools and 6 shallow concrete raceways in the land-based nursery. Hatchery production is limited due to the present pump size and the configuration of the reticulation system. The hatchery site experiences low winter temperatures, resulting in slightly slower growth rates than those found in other, more equatorial hatcheries (Bell and Gervis, 1994).

Biology and Ecology: See Profile B.6.16, this volume.

1.5.2 Aquaculture Information

Utilisation: Phase 2 of the ACIAR Giant Clam Project (1989-1991) concentrated mainly on developing giant clam aquaculture techniques under Fiji conditions, initiating reef re-seeding trials and exploring the possibilities of commercial clam farming (Anon., 1993c). During this time, approximately 1,000 juvenile clams produced at Makogai were distributed to villages and resorts around Fiji for trial ocean nursery grow-out (Batibasaga, 1993).

Phase 3 of the ACIAR Project (1991-1992) evaluated the options of establishing small clam farms and the re-stocking of reefs, improved the production capability of the hatchery and explored overseas markets for juvenile (5-12 cm) clams for the aquarium trade. These initiatives were set back at the start of 1993 by the devastating effects on ocean nursery stocks of a cyclone (Batibasaga, 1993).

It must be noted here that all species of giant clams are currently listed on Appendix II of CITES. Appendix II includes all species which although not necessarily now threatened with extinction, may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilization incompatible with their survival.

Production and Marketing: The Makogai hatchery produced over 100,000 seed clams per year by 1991, with a further 150,000 being stocked in an ocean nursery directly in front of the hatchery (Ledua, 1992). During 1992, hatchery production reached 130,000 seed clams, of which 10,000 were sold to Western Samoa and the USA for FJD18,000, and 8,000 were used for either the establishment of 4 small clam farms, or reef re-stocking (Anon., 1993c).

1.5.3 Status of Farmed Stock

The 1993 cyclone was responsible for the loss from the ocean nursery of over 200,000 clams between the ages of 1.5-3 years (Batibasaga, 1993). Stocks are being replenished, and currently stand at approximately 215,000, the majority of which are under 1 year old. In order to minimise future catastrophic losses from cyclone damage, clams are being maintained on floating ocean nursery rafts (Bell and Gervis, 1994).

1.5.4 Management

Legislation/Policy Regarding Cultivation: None at present.

Recommended Legislation/Policy Regarding Cultivation: Fiji Fisheries Division has been solely responsible for funding the Giant Clam Project since ACIAR funding ceased in January 1992. Options for further initiatives under the Project are currently being evaluated by the Division.

References

Anon. 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Batibasaga, A. 1993. Country Report: News from Fiji. Clamlines 12, (ICLARM Giant Clam Newsletter). ICLARM Coastal Aquaculture Centre, Honiara, Solomon Islands. 10-11.

Bell, L.A.J. and M.H.Gervis. 1994. Aquaculture potential on Niue. FFA Report No.94/15. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 51p + appendices.

Gulick, C.T. 1990. Aquaculture. In: A.A.J.Jansen, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

Ledua, E. 1992. Status of aquaculture development in Fiji. Report prepared for the aquaculture seminar, August 1992, Tokyo, Japan. 34p.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

1.6 GREEN MUSSEL

1.6.1 The Resource

Species present: The green mussel (*Perna viridis*) was first introduced from the Philippines in 1975 and on several occasions since then, but has not become established. The most recent importation was from Tahiti, French Polynesia, where there is a green mussel hatchery (Hickman, 1987).

Aquaculture Facilities: Naqara in Laucala Bay was the site of the now discontinued experimental work on green mussels.

Biology and Ecology: An ideal culture site for *P. viridis* has low wave and wind action, depth of at least 2 m at low tide, no drastic salinity fluctuations, a low level of population, and temperatures of approximately 28° C (Gulick, 1990). It is technically possible to import *P. viridis* into Fiji from the Philippines or Tahiti with up to 99 per cent survival. Satisfactory growth rates (4-5 mm per month) can be achieved, the mussels reaching 40-60 mm length in 5-6 months and 90 mm in 18 months. There is very little information available on the annual condition index of green mussels grown in Fiji waters, which is a major constraint on predicting the meat yield that might be achieved (Hickman, 1987).

Under ideal feeding conditions, *P. viridis* can rapidly complete its maturation cycle and spawn. This can be as brief as six weeks under certain conditions. Following fertilisation, the free-swimming larva has a 2-3 week pelagic life during which time, in the wild, it can be carried a great distance, depending on currents and circulation patterns. This pelagic phase is also a period of high mortality.

A combination of high larval numbers and some means of concentrating them, such as a partially enclosed gyre or circulation, are probably pre-requisites for dense, commercial scale, spat settlement. Tropical mussels tend to spawn throughout the year and therefore have less pronounced spawning peaks than are generally seen in temperate water species. This tendency will mitigate against the seasonal concentration of larvae that is necessary for successful commercial spat hatching (Hickman, 1987).

1.6.2 Aquaculture Information

Utilisation: Although *P. viridis* grow to a length of more than 120 mm in the Philippines, commercial growers generally harvest their mussels when they are approximately 5 months old. These younger mussels range from 40-60 mm in length, and are considered to be more tender (Ritchie, 1975). There is no data available from which to estimate the meat yield for green mussels grown in Fijian waters. Without this data, in combination with information on growth rates and stocking density, it is not possible to make realistic estimates of potential production from a mussel farm in Fiji (Hickman, 1987).

Production and Marketing: Gulick (1990) reports that 8,000 green mussel spats shipped to Savusavu in 1985 for grow-out were successfully marketed. However, trials conducted in 1987 were disappointing, and Fiji's grow-out trials of green mussels ended unsuccessfully in 1988. Even the pioneer of green mussel culture in the region, French Polynesia, is considering discontinuation of its green mussel hatchery, due to instability of spawning and lack of suitable sites (Tanaka, 1993).

1.6.3 Status of Farmed Stock

There is no information on the status of the stock of *P. viridis* in Fiji waters. It is likely to be extremely small and limited to the area of the grow-out trials.

1.6.4 Management

Legislation/Policy Regarding Cultivation: None at present

Recommended Legislation/Policy Regarding Cultivation: Hickman (1987) states that:

- it is unrealistic to expect to develop green mussel farming in Fiji, based on the catching of wild spat originating from stocks of green mussels imported as seed.
- It is unlikely that farming green mussels in Fiji using hatchery-reared spat would be economically profitable
- Hatchery- reared spat from a fully commercial operation would have a considerably higher unit cost than that charged for the most recent imports of seed from Tahiti.

Definition of the reasons for farming an exotic mussel species in Fiji, and analysis of the economics of growing mussels in Fiji, are necessary to determine the priority of further research and development work on green mussels.

References

Gulick, C.T. 1990. Aquaculture. In: Jansen, A.A.J, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

Hickman, R.W. 1987. Report on green mussel consultancy for Fisheries Division, Ministry of Primary Industries, Fiji. 16p.

Ritchie, T.P. 1975. Experimental introduction of the Philippine oyster (*Crassostrea iredalei*) and Philippine green mussel (*Mytilus smaragdinus*) in Fiji. Working paper presented at the 8th annual South Pacific Commission Fisheries Meeting, Noumea, New Caledonia.

Tanaka, H. 1993. Terminal report of South Pacific Regional Aquaculture Development Project.

1.7 COMMERCIAL SEAWEED

1.7.1 The Resource

Species Present: Species of commercial red seaweed *Eucheuma* sp. introduced to Fiji from the Philippines via Tonga for aquaculture trials included *Eucheuma striatum*, *E. alvarezii*, *E. denticulatum* and *E. spinosum* (Gulick, 1990). The species used for commercial production since 1985 is a "cottonii" type seaweed (*Kappaphyces alvarezii* var *tambalang*).

Aquaculture Facilities: Experiments in seaweed culture commenced at USP in the late 1970's. In 1984, the Commonwealth Fund for Technical Cooperation (CFTC), in conjunction with Coast Biologicals (NZ) Ltd. and Fiji Fisheries Division, carried out trials at Tavua, Rakiraki and Verata in Tailevu. The first commercial scale production started in 1986 at Tavua, Rakiraki and Kaba/Kiuva/Rewa, and by 1987, farms were also established in Moturiki, Ovalau, Bua, Batiki, Vanuabalavu, Fulaga and Ogea (Ram, 1991).

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, 1993b).

The grow-out trials in Fiji showed that *Eucheuma* had two distinct growth patterns, from April to December and December to March. In the cooler season of April to December, *Eucheuma* grows rapidly, reaching harvestable size in 8-10 weeks. From December to March, slower growth extends the harvesting period to 10-12 weeks. It was concluded that *Eucheuma* could be successfully grown for a period of 9 months, from April to December (Prakash, 1990).

1.7.2 Aquaculture Information

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).

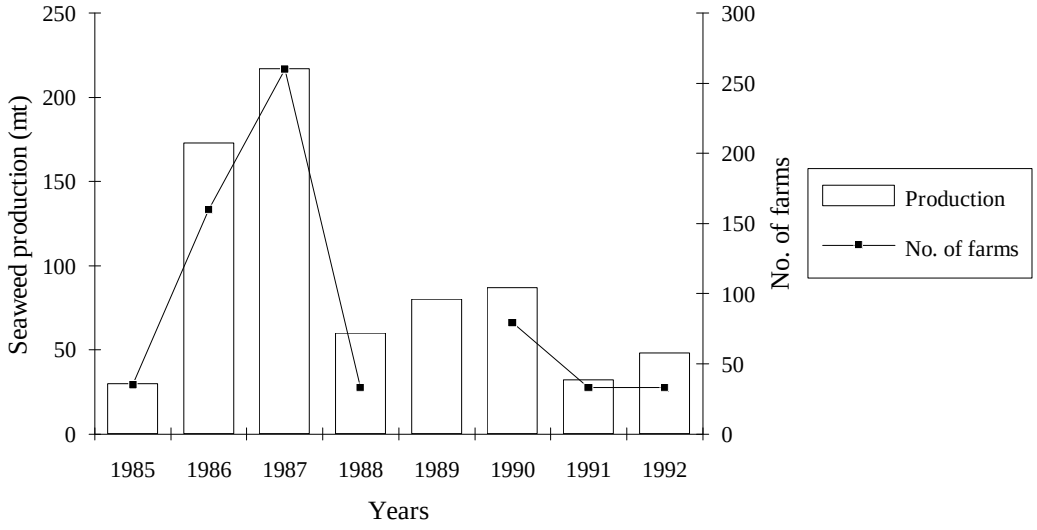
Prakash (1990) provides a description of *Eucheuma* cultivation methods. The method finally used in Fiji involves 25 cuttings being tied on 5-7 m of 3 mm diameter polypropylene rope. Farm sizes are between 0.25 ha (500 lines) and 0.5 ha (1,000 lines). Seaweed is planted in blocks (80-100 lines) and harvested and planted every week. No artificial fertiliser is added to enhance growth. After maturing, the seaweed is sun dried for 3-4 days until moisture is reduced to at least 35 per cent.

Production And Marketing: The major culture areas for *Eucheuma* seaweed for carrageenan extraction are Taiwan, Philippines and Indonesia. Approximately 17,000 mt of carrageenan and 7,000 mt of semi-refined product were produced worldwide in 1989 (Smith, 1992).

In 1985, 35 seaweed farms were established in Western Viti Levu, Fiji with the assistance of loans from Coast Biologicals Co. These farms produced 30 mt of dried seaweed in the first year of operations. A combination of events, including the adverse effects of Cyclone Bola in early 1988 which destroyed approximately 50 per cent of the crop, led to the withdrawal of Coast Biologicals Co. Fiji Fisheries Division took control of the industry from mid-1988 until the end of 1989, seaweed being sold to the National Marketing Authority. From the beginning of 1990, seaweed marketing was conducted by a joint-venture company called Seaweed (South Pacific) (Ram, 1991).

From the end of the first quarter of 1991 until late 1992, a new company, Oceania Trading Co.Ltd. took over the buying and marketing of dried seaweed. This role was taken over by the National Trading Corporation (NATCO) in 1993. However, NATCO will not buy dried seaweed unless it can be sold on the world market. Production figures (mt) and number of farms for the years 1985-1992 are presented in Figure 21. There were only 14 farms still in operation by late 1993 (S.N.Lal, Aquaculture Officer, pers comm.).

Figure 21. Production (mt) of dried seaweed and number of seaweed farms in Fiji for the years 1985-1990 (Source: Ram, 1991; Fiji Fisheries Division Annual Reports 1991-1992.



Since 1988, dried *Eucheuma* seaweed from Fiji has been exported to Denmark. Prices from 1988 have fluctuated between FJD350-500 per mt. The “farm-gate” price in Fiji remained steady at FJD0.40 per kg in 1990 and 1991, but fell to FJD0.35 per kg in 1992, and even further in 1993. High shipping costs from the Pacific to Denmark appear to be responsible for the disadvantaged position of Fiji’s seaweed producers in the world market (S.N.Lal, Aquaculture Officer, pers. comm.).

1.7.3 Status of Farmed Stock

There are 14 farms still in operation in Fiji (S.N.Lal, Aquaculture Officer, pers. comm.).

1.7.4 Management

Current Legislation/Policy Regarding Exploitation: None at present.

Recommended Legislation/Policy Regarding Exploitation: Given the current difficulties in marketing dried seaweed, further planting by smallholders would not be advisable.

References

Anon., 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Gulick, C.T. 1990. Aquaculture. In: Jansen, A.A.J, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

McHugh, D.G. and B.V.Lanier. 1983. The world seaweed industry and trade: developing Asian producers and prospects for greater participation. ADB/FAO INFOFISH Market Studies, Volume 6. INFOFISH, Kuala Lumpur, Malaysia. 30p.

Prakash, J. 1990. Fiji. In: Adams, T. and R. Foscarini (eds.). Proceedings of the Regional Workshop on Seaweed Culture and Marketing. FAO South Pacific Aquaculture Development Project, Suva, Fiji. 1-9.

Ram, V. 1991. The seaweed industry in Fiji with special reference to *Eucheuma* (Rhodophyta). Marine Studies Programme Technical Report No.2, Series 1991. 19p.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No. 92/17. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

South, G.R. 1993b. Seaweeds. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 683-710.

D. REFERENCES

Abelló, P. and P. Martín. 1993. Fishery dynamics of the mantis shrimp *Squilla mantis* (Crustacea: Stomatopoda) population off the Ebro delta (northwestern Mediterranean). Fisheries Research, 16 (1993). 131-145.

Adams, T.J.H. 1988. Status of bêche-de-mer production in Fiji. Unpublished notes: Fiji Fisheries Division, Suva, Fiji. 3p + Appendices.

Adams, T.J.H. 1989. Fiji fisheries aid 1979-1989. Forum Fisheries Agency, Honiara, Solomon Islands. 14p.

Adams, T.J.H. 1992. Resource aspects of the Fiji bêche-de-mer industry. Bêche-de-mer Information Bulletin (4), July 1992. South Pacific Commission, Noumea, New Caledonia. 13-16.

Adams, T.J.H. 1993. Management of bêche-de-mer (sea cucumber) fisheries. Bêche-de-mer Information Bulletin (5), August 1993. South Pacific Commission, Noumea, New Caledonia. 15-21.

Adams, T.J.H., J.Leqata, P.Ramohia, M.Amos and P. Lokani. 1992. Pilot survey of the status of trochus and bêche-de-mer resources in the Western Province of Solomon Islands, with options for management. South Pacific Commission, Noumea, New Caledonia. SPC Inshore Fisheries Research Project Technical Report to the Government of Solomon Islands. pag.var.

Allen, G.R. 1991. *Field guide to the freshwater fishes of New Guinea*. Publication No.9 of the Christensen Research Institute. 268p.

Angsinco, L.C., N.C.Mendoza, W.H. Uy, R.E. Acuña and M.M. Tan. 1986. Ecology and biology of giant mantis shrimp, *Lysiosquilla maculata* Fabricus in the Philippines, p. 189-191. *In* J.L.Maclean, L.B.Dizon and L.V.Hosillos (eds.) The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.

Anon. 1975. Notes on "kai". Unpublished report. Fiji Fisheries Division, Suva, Fiji. 4p.

Anon. 1987a. Fiji Fisheries Division Annual Report 1986. Fisheries Division, Suva. 49p.

Anon. 1987b. The fisheries resources survey in Fiji and Tuvalu - Figures and Tables. April 1987. Japan International Cooperation Agency, Tokyo, Japan. 126p.

Anon. 1988a. Fiji Fisheries Division Annual Report 1987. Fisheries Division, Suva. 33p.

Anon. 1988b. Mullets in Fiji. Internal memorandum. Fiji Fisheries Division, Suva. 1p.

Anon. 1988c. Our Marine Resources. Fisheries Division unpublished leaflet. Fiji Fisheries Division, Suva, Fiji. 14p.

Anon. 1989a. The 1989 Fisheries Division Work Programme. Fiji Fisheries Division, Suva, Fiji. Pag.var.

Anon. 1989b. Fiji Fisheries Division Annual Report 1988. Fisheries Division, Suva. 38p.

Anon. 1989c. Draft Cabinet Memorandum. The domestic "Sashimi" (Deepwater snapper and tuna) fishery: Including recommendations for its control by addition to the Fisheries Regulations. Fiji Fisheries Division, Suva, Fiji. pag. var.

Anon. 1990a. Fiji Ministry of Education Annual Report for 1987.

Anon. 1990b. Fisheries Sector Development Plan for the 1990s. Fiji Fisheries Division, Suva, Fiji. 17p + appendices.

Anon. 1990c. Fiji Fisheries Division Annual Report 1989. Fisheries Division, Suva. 18p + appendices.

Anon. 1991a. Fiji Fisheries Division Annual Report 1990. Fisheries Division, Suva. 18p+ appendices.

Anon. 1991b. Tilapia as a cost-effective sustainable protein source for developing countries. Draft proposal for aquaculture development in Fiji for presentation to ACIAR. 7p.

Anon. 1991c. The Rewa mangrove reserve. *Forestry Quarterly* 42: 10-11.

Anon. 1992. Fiji Fisheries Division Annual Report 1991. Fisheries Division, Suva. 52p.

Anon. 1993a. Current Economic Statistics, October 1992, Bureau of Statistics, Suva. 120p.

Anon. 1993b. Islands Business, November 1993.

Anon. 1993c. Annual Report 1993: Ministry of Agriculture, Fisheries and Forests. Parliamentary Paper No.38 of 1993, Suva, Fiji. 126p.

Anon. 1993d. Fiji Fisheries Division Annual Report 1992. Fisheries Division, Suva. 48p.

Anon. 1993e. Status of tuna fisheries in the SPC area during 1992, with annual catches for 1922-1938 and 1952-1992. Working Paper No.2. Sixth Standing Committee on Tuna and Billfish, Pohnpei, Federated States of Micronesia. 16-18 June, 1993.

Anon. 1993f. CITES annual report data provided by the World Conservation Monitoring Centre, Cambridge, UK.

Anon. 1994. The South Seas Digest, Number 5, Volume 14, May 20 1994.

Banner, A.H. and P.Helfrich. 1964. The distribution of ciguatera in the tropical Pacific. Hawaii Marine Laboratory Technical Report No.3, University of Hawaii, Honolulu, Hawaii. 7p.

Barnes, R.D. 1968. *Invertebrate Zoology* Second Edition. W.B.Saunders Company; Philadelphia, London, Toronto. 743p.

Batibasaga, A. 1993. Country Report: News from Fiji. Clamlines 12, (ICLARM Giant Clam Newsletter). ICLARM Coastal Aquaculture Centre, Honiara, Solomon Islands. 10-11.

Bell, L.A.J. and M.H.Gervis. 1994. Aquaculture potential on Niue. FFA Report No.94/15. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 51p + appendices.

Beumer, J.P. 1985. The eel resources of Fiji. Queensland Department of Primary Industries Study Report QS85010. QDPI, Brisbane, Australia. 33p.

Bibi, H. 1991. Women and the kai fishery. Prepared for *Qitawa*, Fiji Fisheries Division Newsletter.

Bour, W. 1990. The Fishery Resources of Pacific Island Countries. Part 3: Trochus. *FAO Fisheries Technical Paper* No.272.3. FAO, Rome.

Brown, I.W. 1979. Survey of squid resources in Fiji waters: the cruise of the "Shinei Maru" No.8. 29 May - 4 June, 1979. 14p. Fiji Fisheries Division, Suva, Fiji. 14p.

Brown, I.W. 1993. Mangrove Crabs. In: A.Wright and L. Hill (eds.) *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 609-642.

Brown, I.W. and D.R.Fielder. 1988. Annotated bibliography of the coconut crab, *Birgus latro* (L). ACIAR Working Paper No.17. ACIAR, Canberra, Australia.

Bulai, N., V.Ram and G.R.South. 1993. Marine Studies 1993 Programme Handbook. University of the South Pacific, Suva, Fiji. 39p.

Butler, A.J. 1983. A preliminary examination of populations of the kai-koso, *Anadara cornea* (Reeve) near Suva, Fiji. A report to the Institute of Marine Resources, University of the South Pacific, Suva, Fiji. 28p + appendices.

Campbell, B. and M.Lodge (eds.). 1993. Regional compendium of fisheries legislation (Western Pacific Region). Fisheries Management and Law Advisory Programme Vol.III. CP/INT/466/NOR, Field Report 93/31, FL/WPSCS/93/19. South Pacific Forum Fisheries Agency, Honiara/Food and Agriculture Organisation of the United Nations, Rome. 1,708p.

Cannon, L.R.G. and H. Silver. 1986. *Sea Cucumbers of Northern Australia.* Queensland Museum, South Brisbane, Australia.

Carlson, B.A. 1975. A preliminary check-list of the fishes of Fiji: based on specimens in the Marine Reference Collection of the University of the South Pacific, Suva, Fiji. 94p.

Carpenter, K.E. and G.R.Allen. 1989. FAO Species Catalogue Vol.9. Emperor fishes and large-eye breams of the world (family Lethrinidae). An annotated and illustrated catalogue of lethrinid species known to date. *FAO Fisheries Synopsis*. No.125, Volume 9. Rome, FAO. 1989. 118p.

Cavuilati, S.T. 1993. Managing Fisheries Resources: The Fiji Experience. In G.R.South (ed.). Marine Resources and Development - Ray Parkinson Memorial Lectures 1992. PIMRIS, USP, Suva, Fiji. 37-62.

Chaudhuri, H. and J.V.Juario. 1983. Use of hormones in breeding cultivated warm-water fishes with special reference to milkfish, *Chanos chanos* (Forsskal). A compilation of SEAFDEC AQD technical papers on milkfish and other finfishes. Vol.1. Aquaculture Department, SEAFDEC, Iloilo, Philippines. 47-53.

Choy, S.C. 1982. The biology of littoral penaeid prawns in Fiji waters with particular reference to *Penaeus* (*Melicertus*) *canaliculatus* Pérez-Farfante. M.Sc. Thesis. The University of the South Pacific, Suva, Fiji. 161p.

Choy, S.C. 1984. On the freshwater palaemonid prawns from the Fiji Islands (Decapoda, Caridea). *Crustaceana* 47 (3): 269-277.

Choy, S.C. 1988. The fishery and biology of *Penaeus canaliculatus* (Crustacea: Decapoda: Penaeidae) in Laucala Bay, Republic of Fiji. Fishbyte 6(1). ICLARM, Manila, Philippines. 21-24.

Chubb, C.F., I.C.Potter, C.J.Grant, R.C.J.Lenanton and J.Wallace. 1981. Age structure, growth rates and movements of sea mullet, *Mugil cephalus* L., and yellow-eye mullet, *Aldrichetta forsteri* (Valenciennes), in the Swan-Avon River system, Western Australia. Australian Journal of Marine and Freshwater Research **32**: 605-628.

Conand, C. 1989. The fishery resources of Pacific island countries. Part 2. Holothurians. *FAO Fisheries Technical Paper*, No.272.2. Rome, FAO. 1989. 143p.

Conand, C. and P. Chardy. 1985. Are the Aspidochirote holothurians of the New Caledonia lagoon good indicators of the reefal features? *Proc. Vth Int. Coral Reef Congr., Tahiti, 1985*, Vol. 5, 291-296.

Continental Shelf Act (Cap.149) Ed. 1978. Laws of Fiji. Government Printer, Suva, Fiji.

Dalzell, P.J. 1993a. Small pelagic fishes. In: Wright, A. and L.Hill (eds.). Nearshore marine resources of the South Pacific. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 97-133,

Dalzell, P.J. 1993b. The fisheries biology of flying fishes (Families: Exocoetidae and Hemiramphidae) from the Camotes Sea, Central Philippines. J.Fish Biol. (1993) 43(1). 19-32.

Dalzell, P. and G. L.Preston. 1992. Deep reef slope fishery resources of the South Pacific: A summary and analysis of the dropline fishing survey data generated by the activities of the SPC Fisheries Programme between 1974 and 1988. Inshore Fisheries Research Project Technical Document No. 2. SPC, Noumea, New Caledonia. 299p.

Dalzell, P., S.Sharma and G.Nath. 1992. Estimation of exploitation rates in a multi-species emperor (Pisces: Lethrinidae) fishery in Fiji based on length frequency data. In: Dalzell, P. (ed.). Papers on fisheries science from the Pacific Islands: Volume 1. 43-50.

Dalzell, P., S.Sharma and J.Prakash. 1987. Preliminary estimates of the growth and mortality of three tuna baitfish species *Herklotsichthys quadrimaculatus*, *Spratelloides delicatulus* (Clupeidae), and *Rhabdamia gracilis* (Apogonidae) from Fijian waters. Technical report No.20, South Pacific Commission, Noumea, New Caledonia. 15p.

Doyle, B., V.Wichman and P.M.Jimmy. 1993. South Pacific Economies Statistical Summary: SPESS Number 13. South Pacific Commission, Noumea, New Caledonia. 47p.

FAO, 1993. Terminal Report: South Pacific Regional Aquaculture Development Project. FI:GCP/RAS/116/JPN.

Fisheries Act (Cap.158) Ed. 1992. Laws of Fiji. Government Printer, Suva, Fiji.

Fletcher, W.J. 1988. Coconut crab ecology in Vanuatu. South Pacific Commission: Workshop on Pacific Inshore Marine Resources, Working Paper #7, Noumea, New Caledonia.

Fletcher, W. 1993. Coconut crabs. In: A.Wright and L. Hill (eds.) *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 643-681.

Fong, G. Case study of a traditional marine management system: Sasa Village, Macuata Province, Fiji. FAO Field Report. RAS/92/TO5. No. 94/1. Rome, FAO. 1994. 85p.

Gentle, M.T. 1979. Population ecology of commercial bêche-de-mer (Echinodermata: Holothuroidea) in Fiji. SPC Fisheries Newsletter, (18): 13-15.

Gillett, R. and J. Ianelli. 1993. Flyingfish. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 177-201.

Grynberg, R. and D.Forsyth. 1993. Current economic trends in the South Pacific. Pacific Economic Bulletin, Volume 8, Number 2, December 1993. National Centre for Development Studies, Australian National University, Canberra, Australia. 1-21.

Guille, A., P.Laboute and J.L.Menou. 1986. *Handbook of the sea-stars, sea-urchins and related echinoderms of the New Caledonia lagoon.* Éditions de l'ORSTOM, Institut Français de Recherche Scientifique pour le Développement en Coopération. Collection Faune Tropicale n° XXV, Paris, France. 238p.

Gulick, C.T. 1990. Aquaculture. In: A.A.J.Jansen, S.Parkinson and A.F.S.Robinson (eds.). *Food and nutrition in Fiji: a historical review, Volume I*. Department of Nutrition and Dietetics, Fiji School of Medicine/Institute of Pacific Studies, The University of the South Pacific, Suva, Fiji. 393-420.

Hampton, J. 1993. Status of tuna stocks in the SPC area: a summary report for 1993. Working Paper No.3. Sixth Standing Committee on Tuna and Billfish, Pohnpei, Federated States of Micronesia. 16-18 June 1993.

Hickman, R.W. 1987. Report on green mussel consultancy for Fisheries Division, Ministry of Primary Industries, Fiji. 16p.

Hinton, A. 1972. *Shells of New Guinea and the Central Indo-Pacific*. The Jacaranda Press. 94p.

Hirth, H.F. 1993. Marine Turtles. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 329-370.

Holthuis, L.B. 1980. FAO species catalogue. Vol. 1. Shrimps and prawns of the world. An annotated catalogue of species of interest to fisheries. *FAO Fish. Synop*., (125) Vol. 1. Rome, FAO. 271p.

Holthuis, L.B. 1991. FAO Species Catalogue. Vol.13. Marine lobsters of the world. An annotated and illustrated catalogue of species of interest to fisheries known to date. *FAO Fish. Synop*. No. 125, Vol.13. Rome, FAO. 292p.

Honders, J. 1975. (ed.). *The World of Fish.* Peebles Press, New York. 160p.

Jellyman, D.J. 1988. A survey of the stock of freshwater eels on Mitiaro, southern Cook Islands. Report to the Ministry of Foreign Affairs and the Cook Islands Government. 37p.

Johannes, R.E. 1981. *Words of the lagoon.* Univ. California Press, Berkeley, 245p.

Kailola, P.J., M.J.Williams, P.C.Stewart, R.E.Reichelt, A.McNee and C.Grieve (eds.). 1993. *Australian Fisheries Resources*. Bureau of Resources Sciences, Department of Primary Industries and Energy, and the Fisheries Research and Development Corporation, Canberra, Australia. 422p.

Kay, R. 1990. *Fiji, a travel survival kit* (2nd Edition). Lonely Planet Publications, Hawthorn, Australia. 211p.

King, M.G. 1993. Deepwater shrimp. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 513-538.

Lal, P.N. 1984. Environmental implications of coastal development in Fiji. Ambio, Volume 13(5-6). 316-321.

Lal, P.N., K.Swamy and P.Singh. 1983. Mangroves and secondary productivity: fishes associated with mangroves in Wairiki Creek, Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Division, MAF, Suva, Fiji: 13-31.

Langi, S.A., T.F.Latu and S. Tulua. 1992. Preliminary study of the biology of mullets (Pisces: Mugilidae) from Nuku'alofa, Tonga. In: Dalzell, P (ed.). Papers on fisheries science from the Pacific Islands, Vol.1. Inshore Fisheries Research Project, Technical Document No.1. South Pacific Commission, Noumea, New Caledonia. 37-42.

Ledua, E. 1992. Status of aquaculture development in Fiji. Report prepared for the aquaculture seminar, August 1992, Tokyo, Japan. 34p.

Lewis, A.D. 1984 Food fishes of Fiji. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. (ed.). 1985a. Fishery resource profiles: information for development planning. Fisheries Division, Ministry of Primary Industries, Suva, Fiji: 90p. (Partially updated in 1988).

Lewis, A.D. 1985b. Food fishes of Fiji-II. Fisheries Division, Suva: 1 poster: col.; 99 x 69cm.

Lewis, A.D. 1986. Aquatic Foods of Fiji. Fisheries Division, Suva: 1 poster: colour; 99 x 69 cm.

Lewis, A.D. 1987. Aitutaki Giant Clams (Pa'ua). Resource Profile No. 1. FAO/UNDP Regional Fishery Support Programme, Suva. RAS/87/002. 10p plus appendices.

Lewis, A.D., S.Sharma, J.Prakash and B.Tikomainiusiladi. 1983a. The Fiji baitfishery 1981-82, with notes on the biology of the gold-spot herring *Herklotsichthys quadrimaculatus* (Clupeidae), and the blue sprat *Spratelloides delicatulus* (Dussumieriidae). Technical Report No.6, June 1983, Fisheries Division, Fiji. 50p.

Lewis, A.D., L.B.Chapman and A. Sesewa. 1983b. Biological notes on coastal pelagic fishes in Fiji. Technical Report No.4. Fiji Fisheries Division, Suva, Fiji. 68p.

Lewis, A.D., A.Sesewa and T.J.H.Adams. 1988a. The Fiji deep-water snapper fishery - its development and management requirements. South Pacific Commission Workshop on Inshore Fishery Resources. SPC/Inshore Fishery Resources/BP 67. 14p.

Lewis, A.D., T.J.H.Adams and E. Ledua. 1988b. Fiji's giant clam stocks- A review of their distribution, abundance, exploitation and management. In: Copland, J.W. and Lucas J.S. (eds.). 1988. Giant Clams in Asia and the Pacific. ACIAR Monograph No.9: 66-77.

Lucas, J.S. 1988. Giant Clams: Description, Distribution and Life History. In: Copland, J.W. and Lucas J.S. (eds.). 1988. Giant Clams in Asia and the Pacific. ACIAR Monograph No.9: 21-32.

Lucas, J.S., E. Ledua and R.D.Braley. 1991. *Tridacna tevoroa* Lucas, Ledua and Braley: a recently described species of giant clam (Bivalvia: Tridacnidae) from Fiji and Tonga. The Nautilus, 105(3): 92-103.

Marine Spaces Act (Cap.158A) Ed. 1978. Laws of Fiji. Government Printer, Suva, Fiji.

McDowell, R., R. Rao, L. Kumar and N.Gounder. 1993. Fiji Fisheries Bibliography. PIMRIS, The University of the South Pacific. 191p.

McHugh, D.G. and B.V.Lanier. 1983. The world seaweed industry and trade: developing Asian producers and prospects for greater participation. ADB/FAO INFOFISH Market Studies, Volume 6. INFOFISH, Kuala Lumpur, Malaysia. 30p.

McPherson, G.A. 1981. Preliminary report: investigations of Spanish mackerel, Scomberomorus commerson in Queensland waters. In: Grant, C.J. and D.G.Walter (eds.) Northern pelagic fish seminar, Darwin, Northern Territory, 20-21 January, 1981. Australian Government Printing Service, Canberra, Australia. 51-58.

McShane, P. 1992. Sea urchin fisheries of the world: Prospects for development of a kina fishery in New Zealand. In: NZ Professional Fisherman, June 1992. p.27-32.

Moffit, R.B. 1993. Deepwater demersal fish. In: Wright, A. and L.Hill (eds.). *Nearshore marine resources of the South Pacific*. Forum Fisheries Agency, Honiara and Institute of Pacific Studies, Suva. 73-95.

Morton, J. and U.Raj. 1978. The shore ecology of Suva and Viti Levu; Composite volume. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 183p.

Mulliken, T.A. and S.V.Nash. 1993. The recent trade in Philippine corals. In: TRAFFIC Bulletin Volume 13(3). April/May 1993. TRAFFIC International, Cambridge, UK. 97-105.

Munro, J.L. 1993. Giant Clams. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 431-449.

Murray, P. 1992. Report to the government of Fiji on a survey of black lip (*Pinctada margaritifera*) and gold lip (*P. maxima*) pearl shell, with comments on the prospects for pearl farming in Fiji. Fiji Fisheries Division, Suva, Fiji. 47p.

Myers, R.F. 1991. *Micronesian Reef Fishes.* 2nd Ed. Coral Graphics, Guam. 298p.

Narasimham, K.A. 1988. Biology of the blood clam *Anadara granosa* (Linnaeus) in Kakinada Bay. J.mar.biol. Ass. India, 1988, 30 (1&2): 137-150.

Nash, W.J. 1993. Trochus. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 451-495.

Nath, G. and A.Sesewa. 1990. Assessment of deepwater bottomfish stocks around the Fijian Republic. In: Polovina, J. R. Shomura (eds.). United States Agency for International Development, and National Marine Fisheries Service - Workshop on tropical fish stock assessment, 5-26 July, 1989. Honolulu, Hawaii. 7-27.

New, M.B. and S.Singholka. 1982. Freshwater prawn farming. A manual for the culture of *Macrobrachium rosenbergii*. *FAO Fish. Tech. Pap.*, (225): 116p.

Nichols, P.V. 1991. Republic of Palau Marine Resources Profiles. FFA Report No. 91/59. Forum Fisheries Agency, Honiara, Solomon Islands. 124p.

Nichols, P. V. 1993. Sharks. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 285-327.

Passfield, K. 1988. Tropical Spiny Rock Lobsters (Crayfish)[Koura tai]. Cook Islands Fisheries Resource Profile No.4. Cook Islands Ministry of Marine Resources, Rarotonga. 14p.

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

Parkinson, B.J. 1982. The specimen shell resources of Fiji. Report prepared for the South Pacific Commission and the Government of Fiji. South Pacific Commission, Noumea, New Caledonia. 53p.

Parkinson, B.J. 1987. Collection and sale of specimen shells. FFA Report No. 87/34. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 15p + appendices.

Paulay, G. 1987. Biology of Cook Islands' bivalves, Part I. Heterodont families. Atoll Research Bulletin No.298. The Smithsonian Institution, Washington, D.C., U.S.A. 31p.

Perino, L. 1990. Assessment of the feasibility of establishing an aquarium fish industry in Papua New Guinea. FFA Report 90/30. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 35p.

Philipson, P.W. 1989. *The marketing of marine products from the South Pacific*. Institute of Pacific Studies, University of the South Pacific, Suva, Fiji. 307p.

Pillai, G. 1987. Mangroves of Fiji: their uses and management. In: C.D.Field and A.J.Dartnall (eds.). Mangrove ecosystems of Asia and the Pacific. Proceedings of the research for development seminar, Australian Institute of Marine Science, Cape Ferguson, Australia, 18-25 May, 1985. 150-160.

Pillai, G. 1990. Mangroves of Fiji. University of the South Pacific, Suva, Fiji. 31p.

Pillai, G. 1992. *Thalassina anomala* fishery in Fiji. Marine Studies Programme Technical Report, Series 1992, No.1. The University of the South Pacific, Suva, Fiji. 5p.

Pitcher, C.R. 1993. Spiny Lobster. In: A.Wright and L. Hill (eds.) Nearshore Marine Resources of the South Pacific. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 539-607.

Prakash, J. 1990. Fiji. In: Adams, T. and R. Foscarini (eds.). Proceedings of the Regional Workshop on Seaweed Culture and Marketing. FAO South Pacific Aquaculture Development Project, Suva, Fiji. 1-9.

Prescott, J. 1988. Tropical Spiny Lobster: An overview of their biology, the fisheries and the economics with particular reference to the double-spined rock lobster *P. penicillatus*. Working Paper No.18, Proceedings of the South Pacific Commission's Workshop on Inshore Fishery Resources. Noumea, New Caledonia, 14-25 March, 1988.

Preston, G.L. 1993. Bêche-de-mer. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 371-407.

Preston, G.L., V. Vakamoce, P. Lokani and F. Viala. 1988. Bêche-de-mer exploitation in Fiji. Report to Chief Fisheries Officer. Mimeo, pag.var.

Pyle, R.L. 1993. Marine Aquarium Fish. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 135-176.

Qitawa: The Fisheries Newsletter. 1992. March/April issue. Volume 7(2). Fisheries Division, Suva.

Ram, V. 1991. The seaweed industry in Fiji with special reference to *Eucheuma* (Rhodophyta). Marine Studies Programme Technical Report No.2, Series 1991. 19p.

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.

Richards, A.H. 1993. Historical perspectives and trends of South Pacific albacore fleets. FFA Report #93/18. 11p.

Richards, A.H. 1994. Live reef-fish exports to South East Asia from the South Pacific. SPC Fisheries Newsletter No.67, October-December 1993. South Pacific Commission, Noumea, New Caledonia. 34-36.

Richards, A.H., L.J.Bell and J.D.Bell. 1994. Inshore Fisheries Resources of Solomon Islands. FFA Report #94/1 and ICLARM Contribution #1023. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 11p + figures.

Ritchie, T.P. 1975. Experimental introduction of the Philippine oyster (*Crassostrea iredalei*) and Philippine green mussel (*Mytilus smaragdinus*) in Fiji. Working paper presented at the 8th annual South Pacific Commission Fisheries Meeting, Noumea, New Caledonia.

Roper, C.F.E., M.J.Sweeney and C.E.Nauen. 1984. FAO Species Catalogue. Vol.3. Cephalopods of the world. An annotated and illustrated catalogue of species of interest to fisheries. *FAO Fish.Synop*., (125) Vol.3:277p.

Ryland, J.S. 1981a. Introduction to coral reefs of Fiji. *South Pacific Journal of Natural Science 2:* 44-51.

Ryland, J.S. 1981b. Reefs of southwest Viti Levu and their tourism potential. In: The Reef and Man. Proceedings of the Fourth International Coral Reef Symposium. Volume 1: 293-298.

Sharma, S.P and T.J.H.Adams. 1990. The Fiji tuna baitfishery. In: Blaber, S.J.M. and Copland, J.W. (eds.). 1990. Tuna baitfish in the Indo-Pacific region: proceedings of a workshop, Honiara, Solomon Islands, 11-13 December 1989. ACIAR Proceedings No.30, 211p.

Shireman, J.V. and C.R.Smith. 1983. Synopsis of biological data on the grass carp, *Ctenopharyngodon idella* (Cuvier and Valenciennes, 1844), *FAO Fish. Synop*., (135) :86p.

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

Sims, N. A. 1988a. Trochus. Cook Islands Fisheries Resource Profile No.3. Cook Islands Ministry of Marine Resources, Rarotonga. 10p.

Sims, N.A. 1988b. Pearls and Pearl Oysters (Poe e Parau). Cook Islands Fisheries Profile No.2. Cook Islands Ministry of Marine Resources, Rarotonga. 12p. plus appendices.

Sims, N.A. 1993. Pearl Oyster. In: *Nearshore Marine Resources of the South Pacific*. A.Wright and L. Hill (eds.). Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 409-430.

Siwatibau, S. 1993. Macroeconomic management in the small open economies of the Pacific. In: R.V.Cole and S.Tambunlertchai (eds.). *The future of Asia-Pacific economies: Pacific Islands at the crossroads?* Asian and Pacific Development Centre/National Centre for Development Studies, Canberra, Australia. p135-186.

Skewes, T. 1990. Marine Resources Profiles: Solomon Islands. FFA Report No.90/61. Forum Fisheries Agency, Honiara, Solomon Islands. 52p.

Smith, A.J. 1992. Federated States of Micronesia Marine Resources Profiles. FFA Report No. 92/17. South Pacific Forum Fisheries Agency, Honiara, Solomon Islands. 108p.

Sorokin, M. 1975. Ciguatera poisoning in north-west Viti Levu, Fiji Islands. Hawaii Medical Journal, Vol.34, No.6. 207-210.

South, G.R. 1991. Benthic marine algae from Dravuni Island, Astrolabe Islands, Kadavu, Fiji. Marine Studies Programme Technical Report. Series 1991 Number 5.

South, G.R. 1993a. Edible seaweeds - An important source of food and income to indigenous Fijians. NAGA: The ICLARM quarterly, Volume 16, Number 2-3. International Center for Living Aquatic Resources Management, Manila, Philippines. 4-6.

South, G.R. 1993b. Seaweeds. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific.* Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 683-710.

Squires, H.J., B.Carlson, T.P.Ritchie and N.Gundermann. 1973. Shellfish on nearshore fishing grounds at Wailoaloa Beach, Nadi, 1973. Fiji Agricultural Journal (1973) 35, 71-74.

Stewart, B. 1993. Evidence for a marked decline of bêche-de-mer populations in the Suva and Beqa areas of Fiji, and a preliminary description of a method of identifying bêche-de-mer individuals based on characteristic body wrinkles. Marine Studies Programme Technical Report No.1, The University of the South Pacific, Suva, Fiji. 19p.

Sutherland, P.H., S.T. Cavuilati, A.C.Robertson and G.R.South. 1991.Human Resource Development and Planning in the Pacific Islands Fisheries Sector. South Pacific Commission, Noumea, New Caledonia. pag.var.

Swamy, K. 1991. Turtle - country report - Fiji. Fiji Fisheries Division unpublished report. 3p.

Swarup, R. 1983. Mangroves as a forestry resource and its possible silviculture in Fiji. In: Lal, P.N. (ed.) Mangrove Resource Management. Fisheries Division, MAF, Suva, Fiji: 6-10.

Takeda, M. and J.E.Hamilton. 1981. Report on the survey of squid resources, particularly flying squid (*Symplectoteuthis oualaniensis*) in Fijian waters. 26 January - 6 March, 1981. 13p plus figures.

Tanaka, H. 1993. Terminal report of South Pacific Regional Aquaculture Development Project.

Tauvoli, M. 1993. Education in Fiji. In: Tok Blong SPPF: A quarterly of news and views on the Pacific Islands. August 1993 #44. Victoria, B.C. Canada. 10-11.

Tookwinas, S. 1983. Commercial cockle farming in southern Thailand. Translated by E.W.McCoy (1985). ICLARM Translations 7, 13p. In: E.W.McCoy and T. Chongpeepien (eds.). Bivalve mollusc culture research in Thailand. ICLARM Technical Reports 19.170p.

Trono, G.C. 1988. Manual on Seaweed Culture; 2. Pond Culture of *Caulerpa* and 3. Pond Culture of *Gracilaria*. ASEAN/SF/88/Manual No.3. ASEAN/UNDP/FAO Regional Small-Scale Coastal Fisheries Development Project. Manila, Philippines. 20p.

UNEP/IUCN. 1988. *Coral Reefs of the World Volume 3: Central and Western Pacific*. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, U.K./UNEP, Nairobi, Kenya. xlix + 329 pp., 30 maps.

Veron, J.E.N. 1986. *Corals of Australia and the Indo-Pacific*. Angus & Robertson, Sydney, Australia. 644p.

Viala, F. 1992. An assessment of coral exploitation in Fiji. In: Papers on Fisheries Science from the Pacific Islands, Vol.1. Inshore Fisheries Research Project, Technical Document No.1. South Pacific Commission, Noumea, New Caledonia. 33-35.

Vuki, V.C. 1991. A fish consumption survey of Dravuni Islanders, Great Astrolabe Reef, Fiji. Marine Studies Programme Technical Report, Series 1991, Number 1. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 7p.

Vuki, V.C. and F.Viala. 1989. Shrinkage and weight loss of nine commercial species of holothurians from Fijian waters. South Pacific Commission Fisheries Newsletter 51: 27-29.

Vuki, V., C.Tisdell and L.Tacconi. 1991. Socio-economic aspects of giant clams in the Lau Group, Fiji, and farming prospects: Results of field research. Research reports or papers in economics of giant clam mariculture, No.23. Department of Economics, University of Queensland, Australia. 41p.

Walton, H. 1991. Progress and planning in Fiji's artisanal fishery: a review of past activity and future options in the rural fisheries development programme. FAO/UNDP Regional Fishery Support Programme, Suva. 80p + appendices.

Watling, D. 1985. A mangrove management plan for Fiji: 1. zonation requirements and a plan for the mangroves of Ba, Labasa and Rewa deltas. South Pacific Commission, Fiji. 67p.

Watling, D. 1987. Mangrove state of the art report: Fiji. 29p + appendices.

Watling, D. and S.Chape (eds.). 1992. Environment Fiji: The National State of the Environment Report. International Union for the Conservation of Nature, Gland Switzerland. 154p.

Wells, S.M., R.M.Pyle and N.M.Collins. 1983. *The IUCN Invertebrate Red Data Book.* IUCN, Gland, Switzerland. 632p.

Wells, S., P. Holthus and J. Maragos. 1994. Environmental guidelines for coral harvesting operations. South Pacific Regional Environment Programme, Apia, Western Samoa. 36p.

Williams. V.R. and T.A.Clarke. 1983. Reproduction, growth and other aspects of the biology of the gold spot herring, *Herklotsichthys quadrimaculatus* (Clupeidae), a recent introduction to Hawaii. *Fish. Bull*. 81(3), 587-597.

Wright, A. 1993. Shallow water reef-associated finfish. In: A.Wright and L.Hill (eds.). *Nearshore Marine Resources of the South Pacific*. Forum Fisheries Agency, Honiara/Institute of Pacific Studies, Suva. 203-284.

Yaldwyn, J.C. 1973. Decapod crustacea from South Pacific reefs and Islands. *Oceanography of the South Pacific 1972*. Fraser, R. (comp.) New Zealand Commission for UNESCO, Wellington, New Zealand. 503-511.

Zann, L.P. 1981. Fiji's artisanal fisheries and fishing vessels: recommendations in development and training. USP/IMR Misc.Rep.83/1. Institute of Marine Resources, The University of the South Pacific, Suva, Fiji. 35p + appendices.