Fisheries Resources Profiles

Kingdom of Tonga

Prepared by
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FFA Report 94/05

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PREFACE

The Government of Tonga requested the South Pacific Forum Fisheries Agency (FFA) for assistance in the compilation of a set of fisheries resources profiles. These profiles were to document available information on various aspects of the important fisheries resources in Tonga.

The Terms of Reference adopted were those used for profiles already completed, which are as follows:

1. With the assistance from national fisheries staff, examine all files pertaining to fisheries resource matters in the Kingdom of Tonga, held at the Ministry of Fisheries;
2. Assess, collate and compile written matter, data, etc., which provide information relating to resource abundance, distribution, exploitation, etc., in Tonga;
3. Examine existing legislation controlling the exploitation of living marine resources in the kingdom, and advise on appropriate regulations for controlling the existing fisheries for those resources currently not protected;
4. Based on the information examined, produce a comprehensive set of fisheries profiles for the marine resources of Tonga in a similar format to the profiles that have been produced for other FFA member countries.

This report was prepared during and after a three-week visit by FFA's Assistant Research Coordinator to the Kingdom of Tonga in October, 1993. It provides an overview of those major fisheries resources identified by the Ministry of Fisheries as important to the commercial, artisanal and subsistence fisheries sectors within the kingdom.

Following the format used in the profiles already completed for some FFA countries, each fishery resource is divided into four major areas: (i) a brief description of the resource (species present, their distribution, biology and ecology); (ii) an overview of the existing fishery (utilization, production and marketing); (iii) the status of the stocks; and (iv) management concerns (current legislation and policies regarding exploitation and recommended management options). Most of the resources described in these profiles involve more than one species. In cases where aquaculture trials have been conducted, an extra section on this has been added either under the fishery or stock status sections of a particular resource.

A comprehensive bibliography, listing fisheries and fisheries related references, has been compiled for the Kingdom of Tonga by Gillett, *et al*. (1988) under the FAO/UNDP Regional Fishery Support Programme. This has been revised by Gillett (1994). It was not possible to locate some of the references listed in the bibliography, during the compilation of these profiles. However, most of these are listed by specific resources and are attached as Attachment 1.

The preparation and documentation of this report was funded by the International Centre for Ocean Development (ICOD) under the FFA Research Coordination Unit project. The assistance provided by Mr Sione T. Mangisi, Secretary of the Ministry of Fisheries, as well as his staff, is greatly appreciated. The Japan International Cooperation Agency (JICA) team at the Ministry of Fisheries provided information and data on aquaculture activities, as well as shellfish landing data in Nuku'alofa. The authors also greatly appreciate the comments, corrections, review and suggestions provided by the following people; Dr Robert Gillett (FAO Fisheries Adviser, Ministry of Fisheries, Tonga), Mr Kazuo Udagawa (Resource Economist, JICA, Ministry of Fisheries, Tonga), Mr. Viliami Langi (PIMAR Project, Tonga), Mr Andrew Richards (Research Coordinator, FFA) and Mr. Noel Omeri (Fisheries Development Officer, FFA).

The authors assume full responsibility for the contents of this report. Opinions, where expressed, are theirs alone and in no way reflect the policy of FFA, Ministry of Fisheries or the Government of Tonga.

LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR	Australian Centre for International Agriculture Research
BLPO	Black lip pearl oyster
CCOP/SOPAC	Cooperative Committee for Offshore Prospecting in the South Pacific
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CL	Carapace length (used in lobster length measurement)
CPUE	Catch per unit effort
DP5	Fifth National Development Plan
DP6	Sixth National Development Plan
DPS	Developing or partially spent stage (used in staging gonad development in shellfish)
DVM	Dorso-ventral measurement (used in length measurement for pearl oysters)
DWFN	Distant water fishing nation
EEZ	Exclusive Economic Zone
FAD	Fish aggregating device
FAO	Food and Agriculture Organization of the United Nations
FFA	South Pacific Forum Fisheries Agency
FSM	Federated States of Micronesia
GDP	Gross domestic product
GSI	gonadalsomatic indices
GSIDW	gonadalsomatic indices dry weight
GSITW	gonadalsomatic indices total weight
GT	Gross tonnage
ICLARM	International Centre for Living Aquatic Resource Management
ICS	Inactive or completely spent stage (used in staging gonad development in shellfish)
IUCN	International Union for the Conservation of Nature
JAMARC	Japan Marine Fishery Resources Research Centre
JICA	Japan International Cooperation Agency
JPO	Japanese pearl oyster
MPO	Mabe pearl oyster
NGO	Non-governmental organization
PFO	Principal Fisheries Officer
PIDP	Pacific Islands Development Program
PIMAR	Pacific Islands Marine Resource Project
R	Ripe stage (used in staging gonad development in shellfish)
SCUBA	Self Contained Underwater Breathing Apparatus
SPADP	South Pacific Aquaculture Development Programme
SPC	South Pacific Commission
SPREP	South Pacific Regional Environmental Programme
TCP	Technical Cooperation Programme
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
USA	United States of America
USAID	United States Agency for International Development
UVC	Underwater Visual Census
WLPO	White lip pearl oyster
YPR	Yield per recruit

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SUMMARY

The Kingdom of Tonga consists of 170 scattered islands of which 36 are inhabited. There are three main groups of islands and the estimated total land area is 747 km^2. The islands are mainly elevated coral reefs with some having volcanic origin. The coralline and limestone islands, consisting of those in the Tongatapu, Ha'apai and Vava'u groups, are immediately west of the Tonga Trench, while further west is a line of small volcanic islands some of which are still active. The area of the inshore fishing grounds of Tongatapu has been estimated to be 947 km^2, of which reefs and mangroves make up 11.2 and 0.36 per cent respectively, with the remaining consisting of shallow and deep lagoon with an outer shelf less than 160 m deep. The potential Exclusive Economic Zone of Tonga covers an area of approximately 700,000 km^2 as compared to about 395,000 km^2 under the 1887 Royal Proclamation. The total human population recorded in 1976 was 90,098 and 94,649 in 1986. This represented an intercensal growth rate of 5.0 per cent or an annual increase of 0.5 per cent. The projected 1996 population for Tonga is 101,107.

The control, development and management of the fisheries resources in Tonga are the responsibility of the Ministry of Fisheries. However, the Ministry of Lands, Survey and Natural Resources coordinates policy making regarding land, natural resources and the environment. It has divisions responsible for environmental planning, mineral resources and energy planning as well as the management of parks and reserves.

The overall development theme during the Kingdom's Fifth Development Plan period (1985-1990) was geared towards identifying options to enhance the basic subsistence living. Thus the emphasis was placed on the development of the commercial private sector, especially in the areas of industry and manufacturing, commerce, trade and tourism, agriculture and forestry as well as fisheries. The Sixth Development Plan (1991-1995) aims at achieving sustainable economic growth conducive to a higher per capita income with special emphasis placed on export and tourism sectors. Fisheries have been identified as one of the sectors demonstrating the highest growth potential.

Fishing has always been an important subsistence activity in Tonga, with the shallow-water reefs and lagoons surrounding the islands providing a vital source of protein for the local population. With the change from a barter to a cash economy, these resources have been subjected to increasing pressures.

Commercial lobster fishing in Tonga was started in the late 1960's by a company which operated a mobile lobster fishery from as far north as the Ha'apai Group, and as far south as the Minerva reefs. Annual lobster landings by the company at that time were estimated at 36 mt a year. However, there has been a general decrease in landings and exports in this fishery. Recent estimates for the Nuku'alofa artisanal fishery indicate that annual lobster landings at Vuna and Faua is about 12 mt.

The fin-fish resources from the shallow-water reefs have been a major source of protein both in the subsistence and the artisanal fisheries in Tonga. Estimates, in 1993, of fish landings at two landing sites, Vuna and Faua, in Nuku'alofa indicate that fish species classified as shallow-water reef fishes in these profiles make up almost 70 per cent (200 mt) of the total artisanal finfish landings there. The main fish family recorded was parrotfishes. In 1987, the shallow-water reef fish landing in the Tongatapu artisanal fishery was estimated to be 333 mt (including 140 mt of mullet) of which emperors were the main family.

Catches of mullet are known to have been decreasing since the 1970's. This trend has been attributed to one of the effects of introducing highly effective fishing methods, such as fish fences made from chicken wire. One of the mullet species, *Mugil cephalus*, which formed about 70 per cent of the commercial mullet landings in Tonga in the 1980's, is believed to be on the verge of becoming locally extinct. Annual mullet landing in the Tongatapu artisanal inshore reef fishery in the late

1980's was estimated to be 140 mt accounting for 17 per cent of the total finfish landing. In 1993, the estimated Tongatapu mullet landing was only 3.2 mt, accounting for less than 1 per cent of the finfish landing in the Tongatapu artisanal fishery.

Most of the mollusc resources seem to be harvested on a sustainable level at this stage. These resources have been an important seafood component in both the subsistence and artisanal levels of utilization. However, giant clams have been subjected to heavy exploitation leading to very low populations in certain areas. The estimated shellfish (including giant clams) landing at Vuna and Faua in 1993 is 118 mt, with *Anadara* making up 34 per cent and giant clams 33 per cent. The development of the aquarium fish trade in Tonga has led to the exploitation, not only of the small colourful reef fishes, but also juvenile giant clams, other shellfish species, corals and sea anemones. Export data submitted by the main aquarium fish exporter indicate that, in terms of the number of pieces exported during 1993, corals made up about 60 per cent of the total exports during the year.

Harvesting of sea cucumber for consumption on the subsistence level has always been low. This resource forms only a small portion in the artisanal fishery. However, the commercial production of bêche-de-mer for export has been a major development within the last few years. Some limited processing was reported in the 1980's but the industry boomed starting in 1990 when markets were established for a species currently known in Tonga as the sandfish, *Holothuria scabra*. This sea cucumber species is abundant in shallow lagoons and fetches higher prices than the teatfish sea cucumber species.

One of the major fishery developments in Tonga is the establishment of the offshore bottomfish fishery, which started in 1980 after successful results of surveys conducted by UNDP/FAO and the South Pacific Commission. The development was initially aimed at lessening pressure on the shallow-water reef fisheries resources and to increase production to meet the local demand. However, in recent years the establishment of overseas markets for the more valuable bottomfish species, has changed the nature of the fishery, with most boats targeting the deep-water snappers and groupers for export. Associated developments include fishing vessel construction, harbour and on-shore market and cool storage facilities. The highest landing, 633 mt, was recorded for the demersal fishery in 1987, while the 1991 estimate was 323 mt. Annual yields of 200 to 300 mt are regarded as a sustainable level of exploitation for the deep-water snappers (depths of more than 200 m) while a preliminary estimate of 400-700 mt may be taken from the whole demersal fishery (depth of 40 to 400 m).

Prior to the recognition of the 200 nautical mile EEZ worldwide, commercial long-lining for albacore in Tongan waters by distant fishing nations started around the late 1950's when the tuna fishery based in American Samoa began. Approximations of tuna catches by Japanese, Korean and Taiwanese longliners within Tonga's estimated EEZ were 776.6, 146.3, 27.0, 75.4 and 762.9 mt for 1972, 1973, 1974, 1975 and 1976 respectively. Commercial longlining by the Tongan Government, in Tongan waters, started on an experimental basis in 1967, when the government received its first longliner ("Ekiaki") from Japan. A second longliner ("Tavake") was donated by the Government of Japan in 1976 with the third one ("Lofa") arriving in 1982. Annual catches by each of the first two longliners were about 100 mt for the first few years. However, the "Lofa" annual catches have been mostly above 300 mt. Most of these catches were exported. Very little fishing by pole-and-line has been conducted in Tonga waters and assessment results of the local baitfish resource indicate it as a limiting factor to this type of fishing. Catches by trolling from small boats form an important component in the landings for the local markets. The tuna resource in Tonga offers a great potential for further development.

Several oyster species, both edible and pearl oysters, have been introduced into Tonga for mariculture grow-out experiments. All of the trials on edible oyster species failed due to high mortalities, slow growth rates attained and low market value. The culture of the winged Mabe pearl oyster is showing some success for the production of half pearls. The Philippine green mussel, *Perna viridis*, was also introduced for culture trials. These experiment were unsuccessful. Farming of red Euchema seaweed, introduced from Fiji in 1982, was initially successful. However, the project eventually ceased in 1986 due to low prices, rabbitfish grazing, 'ice ice' disease and unfavourable environmental conditions such as, cold weather and cyclones. Lake Ano on Vava'u was stocked with about 10,000 *M. cephalus* fry imported from Hawaii in 1990. This exercise has been considered successful, considering the good growth rates attained. Under the JICA Aquaculture and Development Project at the Ministry of Fisheries, experiments on pen culture of the native mullet species in Fanga'uta Lagoon have been initiated and this is one of the major current aquaculture activities. Two giant clam species, *Tridacna gigas* and *Hippopus hippopus*, were re-introduced into Tonga in 1990 and 1991. Both species are believed to have become locally extinct. The giant clam project started in Tonga with the creation of clam circles in 1986, in an attempt to revitalize the stocks of these animals. Several community giant clam sanctuaries were initiated. Due to faster growth rates, the current giant clam project is concentrating on the production of *T. derasa* and *T. tevoroa* and the establishment of community-owned ocean nurseries. Two hundred and fifty live trochus, *Trochus niloticus*, were introduced from Fiji in 1992 and released in the wild on a reef west of Tapana Island, Vava'u. Fifty mature green snails, *Turbo marmoratus*, were introduced from the Republic of Vanuatu in 1993. Twenty of these green snails were released in the wild at Hufangalupe but 23 were kept in baskets at the Ministry of Fisheries' giant clam ocean nursery in Sopu.

Landing and export data from individual fish operators are lacking.

The requirement under Section 28 of the Fisheries Act 1989 has been poorly observed by fish operators in Tonga. This section requires that anyone engaged in fishing, fish processing, fish marketing, or the export of fish or fish products shall provide to the Registrar (defined as the Principal Fisheries Officer or such other person designated by the Minister) such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed.

Three sets of Fisheries Regulations have been proposed and are currently under review. It is hoped that these will be finalized and passed in 1994, as they are vital to the development and management of Tonga's marine resources.

A. BACKGROUND

1. THE COUNTRY

The Kingdom of Tonga consists of three main scattered groups of islands; Tongatapu, Ha'apai and Vava'u, which are located within latitudes 15°-23.5°S and longitudes 173°-177°W. The minor group, the Niuas, consists of three small islands, Niuafo'ou, Tafahi and Niuatoputapu, which are the northernmost islands, and quite isolated from the main groups of islands. Niuatoputapu is about 300 km north of the nearest Tongan island group, Vava'u. There are 170 islands in the whole Kingdom of which 36 are inhabited. The Tonga ridge supports all of the islands except Niuafo'ou. The Tonga Trench (6,000 m deep) lies immediately east of this ridge while the Lau Basin (2,000 m deep) lies to the west (Dye, 1983). The islands lie within the south Pacific equatorial drift and the dominant current runs south-west. The total land area has been estimated by Zann (1981) to be 668 km^2 and by Latu and Tulua (1992) and Koloa (1993) to be 747 km^2.

The islands are mainly elevated coral reefs which cap the peaks of two parallel submarine ridges, with some having volcanic origin. The coralline and limestone islands, consisting of those in the Tongatapu, Ha'apai and Vava'u groups, are immediately west of the Tonga Trench, while further west is a line of small volcanic islands some of which are still active (George, 1972). Some of the coralline and limestone islands reach 46-204 m and are gentle sloping while the volcanic islands rise more steeply, e.g. 'Eua rises to about 305 m. Latu and Tulua (1992) describe the islands in the Tongatapu and most of the Ha'apai groups as low coral islands and those in Vava'u as raised coral islands. The region was described by Zann (1981) as geologically active, lying where the Asia-Australian plate is moving past the Pacific plate. Earthquakes occasionally cause damage and volcanic eruptions have caused some islands to be abandoned in recent times. Volcanic eruptions on Tofua and Niuafo'ou about 10-20,000 years B.C. covered the limestone islands with volcanic ash, the origin of their present rich soils (Zann, cited above). The islands' vegetation was originally dominated by sub-tropical rainforest because of the high rainfall and rich soils. However, most has been cleared for agriculture.

The climate is mild to warm with temperatures averaging from 23°C (ranging from 15°C to 27°C) in the south to 26°C in the north. George (1972) reported the average temperature in the Niuas as 28°C. As is the case with temperatures, rainfall increases from Tongatapu in the south (1,702-1,733 mm) to the Niuas in the north (2,972 mm). The south-east trades are the prevailing winds but during the warmer months (October to March) tropical cyclones may form over the waters to the north and move southwards where they may cause considerable damage (Zann, 1981).

The territorial waters of Tonga encompass an area of 363,500 km^2 (Zann, 1981). The Royal Proclamation of August 24, 1887 established the Kingdom of Tonga as all islands, reefs, foreshores and waters lying between 15° and 23°30' South and 173° and 177° West (Campell and Lodge, 1993). This proclamation covers an area (land and sea) of about 395,000 km^2. The Royal Proclamation of June 15, 1972 confirmed the rights of the Kingdom of Tonga to the islands of Teleki Tokelau and Teleki Tonga (the Minerva Reefs) and all islands, rocks, reefs, foreshores and water lying within a radius of 12 miles thereof. An estimate of Tonga's 200 nmi Exclusive Economic Zone (EEZ) has been made to be approximately 700,000 km^2. However, the Territorial Sea and Exclusive Economic Zone Act 1978, which establishes these boundaries, is not in force.

2. THE PEOPLE

The Tongan people are Polynesian in origin. The latest population census in 1986 revealed that the vast majority (95.5 per cent) of persons enumerated were ethnic Tongans. An additional 2.8 per cent were part-Tongan while the remaining 1.7 per cent were made up of mostly Europeans followed by other Pacific Islanders and Asians (Statistics Department, June 1991). The national language is Tongan. However, the first Europeans to reach Niuatoputapu, in 1616, recorded that the language there then was Samoic with Tongic elements. Tongan imperialism that began in the 16th century culminated in the official Tongan annexation of Niuatoputapu in June, 1862 during the reign of King George Tupou I (Dye, 1983). Tongan is now the spoken language there.

The population in Tonga as recorded in the 1986 population census was 94,649, which is equivalent to an annual increase of only 0.5 per cent since the previous census in 1976. Statistics from the two censuses are presented in Table 1.1.

Table 1.1: Population Statistics for the Kingdom of Tonga. (Sources: Statistics Department, June, 1991; Statistics Department, November, 1991; Statistics Department, 1993).

	1966	1976	1986	1996 (med-projection)
TOTAL POPULATION	77,429	90,098	94,649	101,107
By Sex				
Males		46,036	47,611	
Females		44,049	47,038	
By Age Groups				
0-4		12,536	13,916	
5-14		27,502	24,526	
15-24		18,061	21,341	
25-34		10,296	11,156	
35-44		8,519	7,961	
45-54		6,336	6,818	
55 and over		6,804	8,858	
Not stated		31	73	
By Ethnic Groups				
Tongans			90,390	
Part-Tongans			2,650	
Other			1,609	
By Island Group				
Tongatapu		57,411	63,794	
Vava'u		15,068	15,175	
Ha'apai		10,792	8,919	
'Eua		4,486	4,393	
Niuas		2,328	2,368	

Approximate growth rates obtained per thousand population for the 1976-1986 period were as follows:

Rate	per thousand population
Birth rate	30.0
Death rate	6.5
Rate of Natural Increase	23.5
Intercensal Rate of Growth	5.0
Net Migration Rate	18.5

Mean annual internal migrations between 1976 and 1986 indicated that only Tongatapu had a positive net growth. This is mostly to Nuku'alofa. Migration to greater Nuku'alofa between 1976 and 1986 is shown in Table 1.2 as given in Statistics Department (November, 1991).

Table 1.2: Migration to greater Nuku'alofa, 1976-1986. (Source: Statistics Department, November, 1991).

Place of Origin	Migrants to Nuku'alofa	Migrants from Nuku'alofa	Net Migrants to Nuku'alofa
Rural Tongatapu	1,104	792	+312
Vava'u	912	674	+238
Ha'apai	1,028	489	+539
'Eua	338	240	+98
Niuas	161	79	+82

TOTAL	3,543	2,274	+1269

3. THE GOVERNMENT

"The Kingdom of Tonga became an independent monarchy in 1970, having been a British protected state from 1900 to 1970 under the provisions of the Anglo-German Agreement of 14 November 1899" (Campell and Lodge, 1993). It is governed by the King, the Privy Council, Cabinet, an elected Legislative Assembly and a Judiciary.

The Head of State is the hereditary head of the royal family, presently HM King Taufa'ahau Tupou IV. Under the Constitution of 1875, bills passed by the Legislative Assembly are referred to the King for approval and become law when assented to by him. Executive government is the prerogative of the King, who appoints the Prime Minister and Ministers to a Cabinet which sits with him as the Privy Council (Campell and Lodge, 1993). The Legislative Assembly is composed of the Privy Councilors and Cabinet ministers, who sit as nobles, nine representatives of the nobles elected by the nobles, and nine representatives of the people elected by the people. The King appoints the speaker of the Assembly. The judicial power is vested in the Court of Appeal, the Supreme Court, the Magistrate's Court and the Land Court. The Court of Appeal consists of the Chief Justice and judges appointed by the King. The same applies to the Supreme Court.

4. THE ECONOMY

The economy of Tonga is based on agriculture. However, other sectors including fisheries contribute significantly to the exports.

Based on the results to the question on the main activity during the week preceding the population census in 1986, only 43.2 per cent of the population aged 15 and over was estimated to be economically active. (The 43.2 per cent was made up of 37.3 per cent employed and 5.6 per cent unemployed). The main economic activity of the employed population was recorded for 1986 as follows:

Economic Activity	Total number	Percentage
Paid employment	10,788	49.9
On leave	141	0.7
Family business	1,165	5.4
Agriculture		
- subsistence	7,961	36.8
- for cash	1,549	7.2
TOTAL EMPLOYED	**17,558**	**100.0**

"Tonga has largely an agrarian economy and as a consequence a high proportion of its economically active population is engaged in farming, fishing and the raising of livestock. The majority of these farmers produce for subsistence only, although relatively large numbers also sell some of their produce" (Statistics Department, June, 1991). Sectoral contribution to the gross domestic product (GDP) at factor cost (in percentage) is presented in Table 1.3 for some years from 1974 to 1989.

Table 1.3: Contribution to GDP at factor cost. (Source: Central Planning Department, 1991).

Sector	1974-1975	1982-1983	1988-1989
Agriculture, forestry and fisheries	50.2	32.3	31.5
Mining & quarrying	-	0.1	0.5
Manufacturing	5.3	3.6	4.8
Electricity & water	0.9	0.8	1.3
Construction	3.6	9.8	6.8
Trade, restaurants & hotels	13.4	10.8	11.0
Transport & communications	3.7	6.7	6.7
Finance & business services	7.3	5.5	6.3
Community & personal services	15.6	13.0	12.2

Ownership of dwellings	-	20.1	22.6
less: imputed bank service charges	-	2.5	3.7

Annual overseas trade for the country has been generally increasing negatively from about minus T$27 m in 1982 to over minus T$60 m in 1992 as summarized in Table 1.4 for the export/import area. Domestic exports have always been dominated by agriculture products and fish under the food and live animal category. Table 1.5 summarizes import values by broad categories as given in several references while Table 1.6 gives the summaries of the exports from Tonga, also in broad categories. Detailed breakdown of items in these tables are reported in Statistical Abstracts published by the Statistics Department, Government of Tonga.

Table 1.4: Balance of Export/Import Trade for Tonga from 1982 to 1993. All figures are in T$x1,000 and on fob basis except 1992 and 1993. The 1993 figure is up to June only. (Sources: Reserve Bank, quoted in World Bank, 1993; Statistics Department, 1992 & 1993).

Year	Imports (1)	Export (2)	Re-exports (3)	Balance (2+3-1)
1981/82	34,778	7,140		-27,638
1982/82	39,983	3,754		-36,229
1983/84	36,847	7,942		-28,905
1984/85	40,900	9,849		-31,051
1985/86	46,232	8,397		-37,835
1986/87	52,841	10,655		-42,188
1987/88	60,440	8,844		-51,596
1988/89	61,600	10,700		-50,900
1989/90	64,198	11,664		-52,534
1990/91	65,452	13,472		-51,980
1992*	84,270.5	16,575.6	833.0	-66,861.9
1993* (Jan-June	38,087.0	3,492.2	509.4	-35,085.5

* Imports are on CIF basis while Export and Re-exports are on fob basis.

Table 1.5: Imports by Section of SITC. All values in T$x1,000. The figures for 1993 are only for the first 6 months, from January to June. (Source: Statistics Abstracts, 1989; Statistics Department, 1993).

Section	1985	1986	1987	1988	1989	1990	1991	1992	1993 (Jan-Jun
Food & Live Animals	13,265.5	13,565.8	14,755.3	17,740.7	16,513.6			18,171.9	(8,217.8)
Beverages & Tobacco	3,101.1	3,475.6	3,639.5	3,202.7	3,243.5			3,247.7	(1,792.2)
Crude Materials	3,095.7	2,084.6	3,213.1	2,635.1	2,871.5			4,032.8	(1,484.5)
Mineral Fuels & Lubricants	7,598.2	7,340.4	6,952.0	6,853.3	7,410.7			10,755.8	(6,320.90)
Animal & Vegetable Oils & Fats	144.8	127.1	123.2	178.9	165.7			195.7	(93.40)
Chemicals	3,854.4	5,186.1	4,475.8	4,604.0	4,306.3			5,203.9	(2,863.9)
Manufactured Goods	10,849.2	13,904.4	12,511.3	13,453.8	13,310.7			19,162.6	(6,727.1)
Machinery & Transport Equip.	11,246.8	9,135.9	16,175.0	15,472.0	13,668.5			16,229.6	(7,211.9)
Misc. Manufactured Articles	5,476.9	4,679.4	6,355.0	6,028.6	6,520.4			6,951.3	(3,203.0)
Not Classified	297.3	116.9	260.0	519.8	323.3			319.4	(172.3)
GRAND TOTAL	58,929.5	59,616.2	68,460.1	70,688.9	68,334.2			84,270.5	(38,087.0)

Table 1.6: Value of Exports by Major Commodities between 1984 to 1990. All figures are in T$x1,000. (Source: DPVI).

Export commodity	1984-85	1985-86	1986-87	1987-88	1988-89	1989-90
Vanilla	1,126	1,182	1,418	1,191	2,504	829
Bananas	768	1,041	1,859	797	517	185
Watermelon	438	195	2	16	6	15
Root crops	422	280	353	544	865	1,823
Fish	256	649	1,249	1,292	2,048	1,445
Manufac. (including coconut prod.	6,998	4,039	4,353	3,693	4,582	4,252
TOTAL	10,247	7,524	9,372	8,060	10,923	10,798
COMPOSITION (%)						
Agriculture	29	38	40	38	39	47
Others	71	62	60	62	61	53

The performance of fisheries during the DP5 period has been described as adequate. However, the potential exists to increase the level of exports. Likewise, tourism has become a major segment of the economy and was estimated to have greater significant potential than manufacturing industry.

5. INSTITUTIONS/AGENCIES

Ministry of Fisheries: Development objectives for the fisheries sector during the DP6 period as listed include efforts to:

* create an environment conducive to the development of private sector involvement in fisheries;
* encourage commercial production of quality fish and marine products for both domestic consumption and exportation;
* encourage alternative fishing habits to prevent over-exploitation of traditional fishing grounds;
* encourage technology transfer to increase the productivity and profitability of fishing activities;
* encourage the development of market outlets, both locally and overseas, for fish and other marine products; improve the existing marketing systems;
* develop aquaculture;
* develop the Fisheries Department's scientific and technical services to support the development of the sector.

Ministry of Lands, Survey and Natural Resources: DP6 recognizes that natural resources are affected by all governmental activities. It further urges that all government departments maintain environmental considerations and that sectoral policies should contribute to sustainable development. Policy coordination regarding land, natural resources and the environment is vested in the Ministry of Lands, Survey and Natural Resources which has divisions responsible for land registry, land surveying, town and country planning, valuation of land, environmental planning, mineral resources and energy planning, and parks and reserves management (Central Planning, 1991). Broad objectives concerning the natural resources were listed as:

* to improve the pattern of land allocation among competing uses or activities such as settlement, agriculture, mineral resources exploitation, industry and tourism;
* to safeguard the natural resources and heritage of the Kingdom, preserve the social and cultural functions that relate to the environment, and enhance the contribution of natural resources to economic and social progress;
* to improve the management of natural resources in order to attain optimum levels of exploitation, and allow sustainable development.

One of the most important component in the development strategy suggested for the protection of the natural resources is community participation and public awareness. Specifically, DP6 notes that Government will:

* promote community participation, particularly through NGOs, youth and women's groups, in environmental planning and conservation, as well as resources management, including parks management;
* devise and implement a parks and reserves policy that will encourage community participation in sites selection and related research and protection; educational material for public awareness of community parks and reserves will be developed.
* establish district-based fishing committees to monitor marine life and reef areas, and with Fisheries and Lands representatives, decide on sustainable fishing levels;

* introduce environmental information of local relevance into the education curricula, and develop skills that can serve the objectives of long-term environmental sustainability.

6. MARINE RESOURCES LEGISLATION

Royal Proclamation 1887: The proclamation defines the extent and boundaries of the Kingdom of Tonga within the latitudes 15°S and 23.5°S and longitudes 173°W and 177° W from the Meridian of Greenwich.

Royal Proclamation 1972: This proclamation defines the islands of Teleki Tokelau (North Minerva Reef) and Teleki Tonga (south Minerva Reef) and all islands, rocks, reefs, foreshores and waters lying within a radius of twelve miles thereof as part of the Kingdom of Tonga.

The Continental Shelf Act of 1970 [CAP. 63]: The Act provides for the protection, exploration and exploitation of the continental shelf, the prevention of pollution in consequence of works in connection with the shelf, and for matters connected with those purposes. It empowers the King, by Order-in-Council, to delineate the boundaries of the Continental Shelf. No order has been made in exercise of this power (Campell and Lodge, 1993).

The Territorial Sea and Exclusive Economic Zone Act 1978: This Act is not in force. But if it will be, it would establish a twelve nautical mile territorial sea and a 200 nautical mile exclusive economic zone (Campell and Lodge, 1993). The total area of the EEZ would be about 700,000 km^2 as compared to approximately 400,000 km^2 covered by the Royal Proclamation 1887.

The Fisheries Act 1989: The basic fisheries law in Tonga is the Fisheries Act 1989 (Campell and Lodge, cited above). The Act provides for the management and development of fisheries in Tonga and other matters incidental thereto and repeals the Fisheries Regulation Act, 1923, the Fisheries Protection Act, 1973, and the Whaling Industry Act, 1935.

Section 2 of the Act defines fisheries waters as the territorial waters of the Kingdom, internal waters, including lagoons, and such other waters over which the Kingdom of Tonga claims sovereign rights or jurisdiction with respect to the marine living resources by legislative enactment or by Royal Proclamation.

Part II of the Act deals with Fisheries Conservation, Management and Development. Section 3 requires the Director (now Secretary) of Fisheries to progressively prepare and keep under review plans for the conservation, management and development of the fisheries in the fisheries waters of Tonga. The Director is required to consult with local government authority and local fishermen concerned in the preparation and review of each fishery plan. The Minister approves these plans. The same part of the Act includes sections on:

- Registration of Local Fishing Vessels
- Local Fishing Vessel Licenses
- Local Committees
- Commercial Sports Fishing
- Foreign Investment in Fisheries.

Part III: Foreign Fishing, and includes sections on:

- Foreign Fishing Vessel Licenses
- Other Agreements and Arrangements
- Stowage of Fishing Gear
- Marine Scientific Research Operations

Part V: General Provisions, including:

- Prohibited Fishing Methods
- Reserved Fishing Areas
- Fish Processing Establishments
- Leasing of Land for Aquaculture
- Import and Export of Live Fish
- Controls over the Export of Fish and Fish Products
- Statistics

Under Section 59 of the same Act the Minister may make regulations not inconsistent with the Act for the implementation of its purposes and provisions.

Parks and Reserves Act 1988: The following five Parks and Reserves have been established under this Act:

- Hakaumama'o Reef
- Pangaimotu Reef Reserve
- Monuafe Island Park and Reef Reserve
- Ha'atafu Beach Reserve
- Malinoa Island Park and Reef Reserve.

Fisheries Regulations: Three separate sets of Fisheries Regulations have been proposed by the Ministry of Fisheries and are currently under review. The three sets are:

The Fisheries (Conservation and Management) Regulations.

The Fisheries (Foreign Fishing) Regulations.

The Fisheries (Local Fishing) Regulations.

7. MANAGEMENT OF THE FISHERIES RESOURCES

The Ministry of Fisheries is responsible for the control, development and management of the fisheries resources in the Kingdom of Tonga under the Fisheries Act 1989.

8. DEVELOPMENT PLANS

The Fifth Development Plan (1985-1990): development was defined to recognize that subsistence living limits an individual's choices and options for improving his standards and conditions of living. Thus development was geared towards alleviating the basic subsistence living and hence identifying a range of options for the individual allowing him to have greater control over his future. Accordingly, policy statements for that period were summarized to include an emphasis on commercial private sector development, including:

- industry and manufacturing
- commerce, trade and tourism
- agriculture and forestry
- fisheries

with the Government acting as a catalyst through;

- Tonga Development Bank and the banking system
- investment incentives
- foreign investment and development assistance
- the provision, where necessary, of supporting infrastructure and services and
- the expansion of existing markets and the procurement of additional markets where appropriate.

The emphasis of the Sixth Development Plan (1991-1995) is reflected by its predominant objective, which is to achieve sustainable economic growth conducive to a higher per capita income. The national development objectives were to:

* achieve sustainable economic growth conducive to a higher per capita income;
* achieve a more equitable distribution of incomes and a more equitable access to goods and services between regional community groups and between income groups;
* generate more employment opportunities;
* restore and control external financial balances;
* enhance the quality of life by raising health standards, maintaining national security and continuing to promote the cultural heritage of the Kingdom;
* develop beneficial relations with other nations; and
* ensure the continued protection and management of natural resources for sustainable development.

The economic development strategy to attain the above objectives is aimed at generating economic growth and employment opportunities with special emphasis on the export and tourism sectors. Special incentives would be given to support private entrepreneurs.

DP6 recognizes the importance of fisheries in its development strategies and places it among sectors demonstrating the highest growth potential. Key issues and constraints encountered in the fisheries sector during DP5 include:

- unequal distribution of the fishing effort due to poor transport facilities and the lack of ice plants and supporting infrastructure for fishermen, especially in the outer islands;
- over-exploitation of resources because of prolonged fishing pressures;
- the limited/absence of legislation in the old Fisheries Act to allow proper monitoring of fishing activities;
- lack of major components of infrastructural support to fishermen;
- lack of effort to develop fish processing;
- insufficient data base to allow meaningful analysis on any sector of fisheries; and
- failure to organize fishermen into a cohesive force.

Development strategies were adopted under several categories for the period taking into account the potential resources especially the pelagic resources which is believed to be large enough to sustain accelerated development. The categories with their respective strategies were given as follows:

<u>Project and development planning</u>

- formulate, evaluate and monitor development projects;
- carry out financial analysis of Government's commercial ventures and recommend measures allowing economic viability;
- conduct periodic evaluation of sectoral performance;
- conduct analysis of access fee levels;
- seek foreign market outlets though contacts with regional organizations;
- set out a manpower development programme;
- administer aid programmes;
- develop a system of fisheries data collection and analysis.

Policy management

- establish an appropriate licensing scheme for fishermen, domestic and foreign vessels;
- authorize village elders to assist as "wardens" in resources management;
- devolve authority and responsibilities in inshore fisheries management on the Tongan Fishermen Association;
- organize a surveillance programme for Tonga's Exclusive Economic Zone.

Fisheries extension

- establish closer links between Extension and Research services on gear development and alternative fisheries;
- expand and improve fishermen's training in gear technology and fish business management;
- allow interaction between fishermen and Extension through frequent exchanges of information;
- develop a fisheries information service;
- strengthen the Women's Development in small-scale fisheries unit.

Support services

- offer vessel maintenance and repair support to fishermen;
- develop preventive maintenance on vessels and in ice plants;
- provide training for local boat builders.

Research

- implement resource surveys in liaison with regional organizations;
- study alternative fishing modes;
- develop links between Research and Management services;
- develop data forms for research purposes;
- train local observers to accompany foreign research vessel teams.

Aquaculture

- experiment species that have commercial potential;
- liaise with the Research Section on technical aspects of the culture systems;
- implement reef re-seeding programmes;
- strengthen the manpower's capacity in regard to the various culture systems;
- exchange information on aquaculture with other South Pacific countries.

9. TONGA FISHERIES BIBLIOGRAPHY

The fisheries bibliography, updating and enhancing the existing list of reports on aspects of fisheries in Tonga, was completed in 1988 under the FAO/UNDP Regional Fishery Support Programme (Gillett, *et al*., 1988). This document has been up-dated by Gillett (1994).

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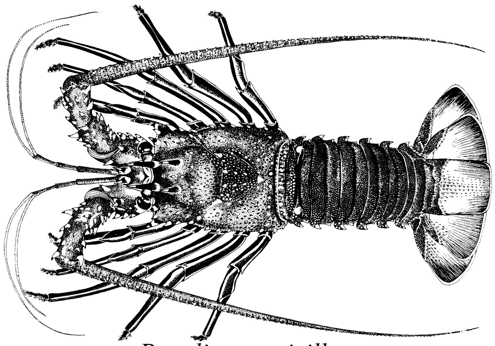
B. FISHERIES PROFILES

1. CRUSTACEANS

1.1 Lobsters - *'Uo*

1.1.1 The Resource



Panulirus penicillatus

Species present: Spiny lobster species found in Tonga include; *Panulirus penicillatus* (double-spined or pronghorn spiny lobster), *P. longipes femoristriga* (long-legged spiny lobster), and *P. versicolor* (painted spiny lobster). Zann (1984) reported unconfirmed occurrence of *P. ornatus* (the ornate spiny lobster). Prescott (1990) reported two species of Scyllarid (slipper) lobsters, *S. squammosus* and *Parribacus caledonicus* (the slipper or Caledonian mitten lobster). Zann (cited above) noted that *Arctides* sp. and *Scyllarides* sp. may be present. A single specimen of *Arctiides regalis* was captured at Leka Leka during a night dive (Prescott, cited above).

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

P. penicillatus - this is the most widespread species of spiny lobsters and is found in the Indo-West Pacific and eastern Pacific regions, from the Red Sea, east and south east Africa to Japan, Hawaii, Samoa and the Tuamotu Archipelago and east to the islands off the west coast of America and in some localities near the continental coast of Mexico.

P. versicolor - this species is found in the Indo-West Pacific region from the entire Red Sea and east coast of Africa, southern Japan, Micronesia, Melanesia, northern Australia and Polynesia.

P. longipes femoristriga - in the Indo-West Pacific, this subspecies (called eastern subspecies) inhabits waters of Japan, the Molluccas, Papua New Guinea, eastern Australia, New Caledonia and French Polynesia.

Pa. caledonicus - in the Indo-West Pacific region in Queensland, Australia, New Caledonia and Loyalty islands, Vanuatu, Fiji and Samoa.

Lobsters are generally found throughout the Tonga group of islands. However, Ha'apai has favourable lobster habitat with large populations of lobsters (Prescott, 1990).

Biology and ecology: Most of the following summary of the biology of the spiny lobsters is taken from Pitcher (1993). Spiny lobsters are considered opportunistic and omnivorous scavengers living mainly on gastropods, crustaceans, echinoderms, seagrass and algae (Phillips *et al*., 1980, quoted in Pitcher 1993). All of the three main lobster species found in Tonga are nocturnal and not gregarious (Holthuis, 1991). After mating, the female carries eggs under its tail for about 1 month before the tiny phyllosoma larvae are released (Pitcher, 1993). The larvae remain in the ocean for 4-12 months before moulting into the puerulus stage, about 50 mm long, which resembles a colourless miniature adult lobster. At this stage it "undertakes the transition from the oceanic to the benthic environment, where they settle in or near the adult habitat and quickly moult into pigmented juveniles" (Phillips and Sastry, 1980, quoted in Pitcher, 1993).

Prescott (1990) recorded sex ratio of lobster species from data collected in Ha'apai and Tongatapu as follows, together with the number of specimens used. Zann (1984) calculated sex ratios for *P. penicillatus* separately for Vava'u and Tongatapu specimens.

Species	Females:Males	Number
P. penicillatus	1:1.16	328
	1:1.52	2,329 (Ha'apai, Zann, 1984)
	1:1.59	70 (Tongatapu, Zann, 1984)
P. longipes	1:1.11	133
P. versicolor	1:1	22
Pa. caledonicus	1:0.38	11

The calculated predicted tail widths for carapace lengths of 75, 85 and 95 mm for each sex for *P. penicillatus* and *P. longipes* were given by Prescott (1990) and are attached as Appendix 1. During the survey in May, 1990, *P. penicillatus* and *P. longipes* were the only lobster species found which were reproductively active. Breeding cycles for species found in Tonga have not yet been determined, although Zann (1984) used the period data from December to February in an effort to determine the age at first sexual maturity. The same author suggested that maturity for *P. penicillatus* commences between 48 mm and 56 mm carapace length (CL) and is completed at about 60 mm. Prescott (cited above) estimated the size at maturity as 65 mm CL. Fecundity was estimated to be 125,000 eggs and 338,000 eggs per spawning for 70 mm CL and 100 mm CL individuals respectively (Zann, 1984). Munro (1988) estimated the growth and mortality rate parameters for both *P. penicillatus* and *P. longipes* for Tonga (Tongatapu and Ha'apai) as follows:

	CL_∞	W_∞	K	M	M/K
P. penicillatus					
Male	179	3,718	0.27 (Tongatapu)	0.284	1.05
Female	128	1,467	0.32 (Tongatapu)	0.244	0.76
P. longipes					
Male	133	1,884	0.31 (Tongatapu)		0.73
Female	118	1,356	0.42 (Tongatapu)		0.55

Note: CL_∞=asymptotic carapace length (mm), W_∞=Asymptotic weight (grams), M=natural mortality.

Prescott (1990) considered the natural mortality for *P. penicillatus* calculated by Munro (1987) as too low, and suggested 0.4 as closer to actual mortality rate for lobsters in Tonga.

Recruitment parameters as calculated (or reported from other sources) by Munro (1988) are as follows:

Species/Area	Sex	Z	Lc	L'	F	E
<u>P. penicillatus</u>						
Tongatapu	Male	1.66	77	82.5	1.38	0.83
	Female	1.33	62	72.5	1.09	0.82
Ha'apai	Male	0.75	70	82.5	0.47	0.62
	Female	0.88	67	77.5	0.64	0.72
<u>P. longipes</u>						
Tongatapu	Male	1.19	41	47.5	0.96	0.81
	Female	1.41	42	47.5	1.18	0.84
Ha'apai	Male	0.61	52	57.5	0.38	0.62
	Female	0.89	49	52.5	0.66	0.74

Z=Total mortality, Lc=Mean size at first capture, L'=length at full recruitment, F= Fishing mortality.

Zann (1984) examined gut contents of ten *P. penicillatus* from Tongatapu and Vava'u and found them to contain the following; gastropods (about 40 per cent of total contents), particles of coralline algae, coral sand and crushed coral (about 40 per cent but up to 80 per cent in some), crustaceans (10-20 per cent), sponge spicules, algal cell walls (5 per cent) and fish scales and vertebrates, polychaete bristles, bryozoan skeletons, echinoderm spines were present in small quantities in certain individuals. The same author examined gut contents of several *P. longipes* and found them to contain a large component of gastropod shells but organic detritus of algal origin was very common.

1.1.2 The Fishery

Utilization: The trapping of lobsters using a beehive shaped pot (***funaki***) made of vines with a single opening at the top was traditionally practiced by a few fishermen at Ha'ano Island in the Ha'apai group (George, 1972). Crushed chitons and sea urchins were successfully used as bait. Other traditional methods include spearing and catching by hand at night during high tide on dark nights. It seems that traditionally, lobster consumption was reserved for feasting times. However, lobster fishing has always played an important part in subsistence level activities within the kingdom.

With the change from subsistence to a cash-based economy, exploitation levels and methods have changed accordingly. Zann (1984) describes, in some detail, the different methods of fishing for lobsters in Tonga, which include capturing at night by reef gleaners with lanterns, underwater spearing with underwater flash lights, and the use of tangle nets. Currently, diving at night using a spear and under-water torch is almost exclusively the method used. Commercial lobster fishing seems to have started in the late 1960's. The Tonga Government Development Plan (1970-1975) mentioned that the only true commercial fishing at that time was the export of frozen crayfish by Australian interests. The commercial operations have centred in Ha'apai where there is a lower human population density, and favourable lobster habitat with a large population of lobsters (Prescott, 1990). Details pertaining to the history of commercial lobster fishery in Ha'apai is given in Zann (1984) and Prescott (1990).

Production and marketing: No data is available on the consumption of lobsters on the subsistence level. Estimates available have been erratic in both the artisanal and commercial fisheries in Tonga.

George (1972) reported lobster production by one company which operated a mobile lobster fishery as far north as the Ha'apai Group, and as far south as Minerva Reef in the late 1960's to be in the order of 1,016 kg of tails per month. Zann (1984) calculated that this was equal to 3,000 kg of whole animals (6,000 individuals) per month or 36,000 kg (72,000 individuals) per year. Most of these were exported to Fiji and American Samoa at US$ 0.15 per 0.45 kg to fishermen.

A decline in lobster catches was reported for 1974 due to a lessening in interest by the only commercially operated lobster company, and the departure of some of their experienced lobster divers (Anon, 1974). Lobsters sold via the company that year weighed 17,332 pounds (7.86 mt) worth a mere T$3,120.76 to the fishermen. Kelsen (1977, quoted in Carleton, 1982) estimated that crayfish, crabs and other crustaceans make up 2 per cent of the domestic marine resources landings in Tonga.

Estimates of fish landings by districts in Tonga for September and October in 1975 were given in JICA (1977). The figures were given in pounds but have been converted to kg and presented in the following table. The "Others" category includes all fishes, shellfish, turtles, crabs and sea cucumber.

	Eastern District	Western District	Fanga'uta	'Atata	Nuku'alofa	Ha'apai
Lobsters						
September	43.09				1,232.41	
October	45.36			389.64	310.71	
Others						
September	2,145.49	2,036.17		5,489.82	16,560.64	
October	5,049.39	3,596.98	2,218.06	7,595.40	17,681.02	3,200.09

Thomas (1978) estimated that 5 mt of lobster tails (~8 mt whole lobsters) can be produced mainly from Ha'apai and outer-islands reef area, for export. At that time the value of 5 mt lobster tails was estimated to be worth US$82,500 (US$16.50/kg).

Lobster landing records obtained by Zann (1984) from two Ha'apai processors are given in Table 1.1.1.

Table 1.1.1: Records of lobsters obtained from processors on Ha'apai. (Source: Zann, 1984). The figures are in kg.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Pacific Fisheries Co., Pangai												
1980												1,411
1981	860	1,043	750	104	255	577			1,234	970	1,932	812
1982	no	records										
1983							300	150	100	461	800	600
1984	1,535											
Tonga Sea Foods, 'Uiha												
1983										500	414	484
1984	380	1,507										

Averaging these landings, Zann (1984) estimated the total lobster landings at these outlets at 15,000 kg per year. He then went on to assume that the other fishermen landed 5,000 kg p.a. thus making the total lobster landing for Ha'apai 20,000 kg.

On 'Eua, lobsters, parrotfish and groupers are caught by spear fishing, representing 12 per cent of the estimated annual catch for the 1980-1981 period (Schuh, 1982).

Zann (1984) estimated the lobster landing for Tongatapu from preliminary surveys at Vuna fish market to be approximately 3,500 kg sold per year. Landings from Vava'u or 'Eua were considered of minor importance. The same author reported the 1984 lobster landings at the Tonga Cooperative in Vava'u to be 3.7 mt whole weight. Collecting data for the commercial and artisanal lobster fishery in Tongatapu has been difficult because fishermen sell them "directly to the public, restaurants, hotels, and small retailers, and in the past, exporters".

Prescott (1990) presented records of lobster purchases by companies in Ha'apai and storage records passing through the Ministry of Agriculture, Forestry and Fisheries freezers at Haafeva, Nomuka and Pangai by year and month, which is reproduced in Table 1.1.2. (Note: blank records are not directly indicative of zero catches; figures are in kg, and where tails only were purchased, they were converted by a factor of 2.86 to estimate whole weight. Annual totals are only shown for those years which were considered complete or almost complete).

Table 1.1.2: Lobster purchases by companies in Ha'apai and storage records by the Ministry of Agriculture, Forestry and Fisheries at Ha'afeva, Nomuka and Pangai. (Source: Prescott, 1990).

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1981	860	1,043	750	104	255	577			1,234	970	1,932	812	**8,537**
1983						300	150	100	461	800	600	2,711	
1983										500	414	484	
1984	1,535	1,388	206	487	111	511	471	130	346	132	163	48	**5,528**
1984	380	1,507											
1985	27	161	390	140		144	52	91	75	135	254	160	
1986	444	80	2,098	183	253	135	190	58	58	18		18	**3,536**
1987		233	364	26			29	31	110	58	571	91	**1,515**
				107	63	30	4	100	166	359	635	1,782	**3,215**
1988	174	375	410	497	60	89	46	24	29	63	36		**1,803**
	175	167		14	240	142	87	153	180	236	410	720	
	36	114	8	3	102	249	190	393		77	191	353	**1,788**
1989	40	112	16	62	6		206		6				
	193	16	55	35	221	13	107	376	165		85	23	**1,027**
	115	34	428	66	329		150	140		24	124	2	**1,412**

Lobster purchases by FIMCO and the Vava'u Fish Market were recorded in Prescott (1990) as follows:

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1985			308	157	145	102	40	211	134	211	90	368	
1986	45	312	399	126	16	61	50	7	108	52	162	17	**1,355**
1987	11	152	38	35	5	9	12		6	7	3	1	
1988	2	143	11	52							15		
1989	11	4	18	8					54				

A one-week survey conducted by the Ministry of Fisheries at Vuna and Faua landing sites in Nuku'alofa in April, 1992 indicated that lobsters make up 77 per cent of the total weekly crustaceans landing of 261 kg (Udagawa and Tulua, 1992). An extrapolation of this figure for a 50-week year, resulted in an estimated annual landing for crustaceans at the two sites of 13.05 mt. This corresponds to a lobster landing of 10.05 mt at the two sites.

The Inshore Fish Landing Survey, conducted by the Ministry of Fisheries at the same sites in Nuku'alofa, under a JICA project, recorded lobster landings from March to December 1993, as summarized in Table 1.1.3. Lobster catches were made almost exclusively by night diving.

Table 1.1.3: Monthly lobster landings at Vuna and Faua during 1993. (Source: Data for the March-June period was provided by Udagawa of JICA, while that for July-December was extracted from weekly data in the Ministry of Fisheries Inshore Fisheries main database).

1993	March	April	May	June	July	Aug	Sep	Oct	Nov	Dec	TOTAL (10 months)
Lobster weight (kg)	346.34	91.07	1,918.78	59.28	250.9	2,203.90	2,842.00	1,724.80	553.90	18.0	**10,006.97**

Using the total lobster landing of 10 mt for the 10 months, the annual landing at the two sites is estimated to be about 12 mt. It has been estimated that shallow-reef fisheries landings at these sites account for about 75 per cent of the whole Tongatapu landing. This gives an estimated annual lobster landing on Tongatapu of about 16 mt.

Export of lobsters from Tonga as recorded by the Statistics Department, DP6 and Fisheries Annual Report, 1989, are recorded in Tables 1.1.4 (a) and (b).

Table 1.1.4 (a): Export values of lobsters from Tonga. (source: Statistics Office, 1972).

	1967	1968	1969	1970	1971	1972	1973	1974
Lobster bodies (T$)	-	-	79	891	9,827	1,799	8,200	-
Lobster tails (T$)	-	-	5,896	793	-	-	-	-

Table 1.1.4 (b): Exports of lobsters from Tonga. (Source: Statistics Department Data, 1993; DP6,1991; and Fisheries Annual Report, 1989).

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Weight kg)	833.0	2,872.0	2,952.0	2,916.0	5,791.0	869.0	2,855.0	3,421.0	3,844.0	641.0	10.0	1,192.0	1,454.0
Value (T$)	3,389	15,284	12,806	17,493	46,999	6,940	13,058	30,351	38,552	3,815	50	13,405	13,110

Note: Lobsters are grouped together with crustaceans and sometimes giant clams but indications are that these other species are insignificant. Both the Fisheries Annual Report, 1989 and the DP6 list the same figures for 1985 to 1989 as been made up of lobsters only.

1.1.3 Stocks Status

No information could be located on any study that attempts to estimate standing stocks of lobsters in Tonga.

George (1972) reported that six people would catch twenty lobsters in about two hours (probably in Ha'apai). Zann (1984) recorded some catch per unit effort data obtained for various sites in Ha'apai in

1984, from dives made mostly by the Fisheries Division Team, as follows:

Place (date)	CPUE (kg/man/hr)	Place (date)	CPUE (kg/man/hr)	Place (date)	CPUE (kg/man/hr)
N. Ha'ano (14/2)	3.9	S. Foa (31/1)	4.1	N. Lifuka (2/2)	2.9
C. Ha'ano (9/2)	4.3	S.Foa (10/2)	3.3	C. Lifuka (1/2)	2.7
C. Ha'ano (9/2)	6.2			C. Lifuka (3/2)	2.2
S. Ha'ano (13/2)	6.2			C. Lifuka (7/2)	2.7
Average	5.15	Average	3.70	C. Lifuka (11/2)	4.7
				C. Lifuka (2/2)	2.3
				C. Lifuka (3/2)	3.3
				Average	2.81

Prescott (1990) gave the following table of average catches by fisherman for the period 1984-1989 at 'Uiha and at Pangai from 1989 to 1990:

'Uiha	**1984**	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**
Catch per trip	7.9	4.8	11.6	11.7	6.5	7.2	
Number of catches	701	343	306	129	278	62	
Pangai							
Catch per trip						12.8	7.0
Number of catches						80	52

The author noted that the lowest catches per fisherman followed the year in which the highest total catch was taken, and suggested that it could have been the effect of a depleted stock or more limited access to the best habitat, as a result of bad weather resulting in lower catch per unit effort per trip.

Munro (1988), from Yield Per Recruit (YPR) computations for male *P. penicillatus*, indicated that the Tongatapu fishery was being subjected to growth overfishing. He also calculated that raising the size at first capture (Lc) to 127.5 mm CL would substantially increase the harvest and that larger or similar harvest could be taken by half the effort at that time. In addition, any increase in effort at Ha'apai would result in decreased landings. Substantial increase in size at first capture as well as a decrease in fishing effort for females would result in benefits for the fishery. Optimum Lc was about 95 mm CL and that harvests in Ha'apai would decrease with an increase in effort. For *P. longipes*, harvests for males could be doubled by increasing Lc to 100 mm CL. However, halving the fishing effort would not have any effect on yield/recruit if Lc is 100 mm but would increase harvests substantially at Lc = 41 mm (current situation). This situation is the same for females but optimum Lc is 95 mm.

1.1.4 Management

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

Current legislation/policy regarding exploitation: Section 27 of the Fisheries Act 1989 authorizes the Minister, with the consent of Cabinet, to make regulations prohibiting or restricting the export from Tonga of any prescribed species, type or size of fish, or other aquatic organisms to protect the supply of fish to the domestic markets of Tonga or in the interest of the proper management of a fishery.

Recommended legislation/policy regarding exploitation: Based on local knowledge and accepting and rejecting some of the advice given by visiting consultants after conducting analyses on the lobster fishery in Tonga, the proposed Fisheries Regulations include the following prohibitions concerning the lobster fishery exploitation:

- lobsters carrying eggs;
- lobsters with carapace length less than 7.5 cm;
- lobsters with tail width less than 4.5 cm;
- destructive techniques to dig lobsters from their burrows;
- removal of eggs and sale of lobsters from which eggs have been removed.

The same prohibitions apply to slipper lobsters, except that the minimum size limit is 15 cm in length measured from the front edge of the carapace to the rear of the telson.

On management options, Prescott (1990) notes that due to the nature of the fishery (without large commercial operations) there is really only one option, introduction of a minimum size limit, with several variations. He recommended against the imposition of a minimum tail width because of its impracticality and the fact that conversion factors normally use means. In addition, the use of two different parameters for size limits on the same animal can cause unnecessary complication in enforcement.

An alternative option, to avoid the use of size limits on more than one parameter on the same organism, is to ban sales and purchases of lobsters without heads, and prior to processing, if lobster tails is the form required by certain markets.

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

King and Bell (1990) noted that the introduction of a minimum size regulation presents practical difficulties, which include policing a large number of isolated fishermen, and the use of catching methods in which lobsters may be speared in crevices, where it is virtually impossible to estimate size before capture. "Although imposing regulations on the catching sector is the most direct method of applying size limit regulations, practical considerations mitigate against it". The recommended compromise offered by the same authors is the introduction of regulations preventing the sale and purchase of lobsters below a legal minimum size.

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

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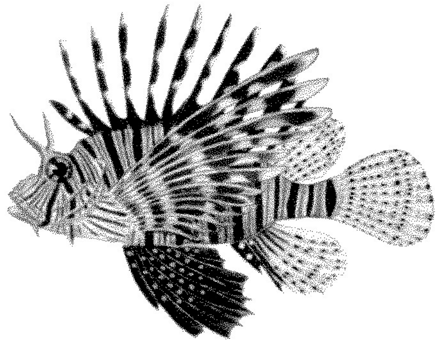
Appendix 1. Predicted tail widths for carapace lengths of 75, 85 and 95 mm as given in Prescott (1990).

Species	Sex	Carapace length	Predicted Mean Tail Width	Lower 95% Confidence limit
P. penicillatus	m	75	45.56	43.84
P. penicillatus	f	75	47.34	45.60
P. penicillatus	m	85	50.02	48.30
P. penicillatus	f	85	52.45	50.71
P. penicillatus	m	95	54.45	52.63
P. penicillatus	f	95	57.44	55.70
P. longipes	m	75	46.08	44.30
P. longipes	f	75	48.38	46.63
P. longipes	m	85	50.54	47.67
P. longipes	f	85	53.80	52.05
P. longipes	m	95	54.86	51.97
P. longipes	f	95	59.13	57.38

2. FIN-FISHES

2.1 Aquarium fish

2.1.1 The Resource



Pterois volitans

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

Packing lists submitted by the current aquarium fish trade operators in Tonga indicate that the non-finfish marine species have become increasingly important in this trade. In particular, increases in species composition have been noted for corals (including soft corals), giant clams and anemones. However, discussion in this section is limited to fin-fish, as the other organisms are treated separately in their respective profiles, except for a comparative composition made in the production section.

Distribution: Fish exploited for the aquarium trade in Tonga, as is done in other South Pacific islands are all wild-caught marine species mostly from the shallow-water coral reefs surrounding the islands. However, in some countries and for certain species, depths where collection take place can be very deep. For example, in Cook Islands, habitat depths for most of the commercially valuable aquarium fish species on Rarotongan reefs range from about 8 to 30 m (Passfield and Evans, 1991, quoted in Richards, 1993).

No information is available on aquarium fish collecting sites in Tonga. However, all of the current operations are concentrated around Tongatapu.

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

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

No study has been conducted in Tonga on any aspect of the fin-fish species exported in the aquarium fish trade.

2.1.2 The Fishery

Utilization: Available information indicates that one of the current aquarium fish export companies started its operation in 1989. Two other new companies started in 1993, mostly on an experimental basis. Recent information from the Ministry of Fisheries indicates that there are now five locally-based companies actively operating in the aquarium-fish industry in the kingdom.

Collection has mostly been limited to workers employed by the concerned companies, with no participation from villagers. Thus the villagers adjacent to the fishing (collecting) sites have not benefited from these undertakings.

Fish are caught using hand-scoop nets and a fence-net. Fish are carefully herded towards the fence-net then collected using the hand-scoop net. A very strong, sharp knife is used to cut off live coral colonies, whereas a thick rectangular iron bar is used to clear off anemones and giant clams from dead corals. Fishing is usually done by skin-diving. However, in most cases, hookah is used, even in shallow water from surface to depths of 7m, as the exercise requires a great deal of patience, as well as skill and a knowledge of fish behaviour.

The fish are transferred from the collection area in aerated bins to onshore storage, where their health is carefully monitored for 4 to 5 days before exporting to overseas markets. At this stage, cupramine (buffers active copper) is sometimes used to cure any viral infected fish. The fish are not fed prior to packing, to reduce excretory waste build-up during air shipment.

Fish are exported in double-walled plastics bags half filled with fresh sea water, then provided with oxygen prior to sealing, and carefully packed in standard size boxes. An authorisation to export is required for each shipment, in which details of catch by species are supplied.

Production and marketing: The first company to become involved in this enterprise, Walt Smith International, commenced collection and export of aquarium marine products from Tonga in 1989. Its operation is now established and is conducted at a professional level. According to the company, mortalities as low as 5 per cent or less during shipment, have been attained.

The second company, Intra - Pacific Co. Ltd, commenced operations in June, 1993. The company was still conducting exports on a trial basis and so export quantity has been limited. The third company, Sea of Color, commenced in July, 1993 but made only 2 trial shipments during the year. No information is available on the other new companies.

The actual records of number of fish, invertebrates and corals were made available to the Ministry of Fisheries on packing lists submitted by the companies prior to every shipment. However, these records have not been adequately or completely compiled. Due to numerous species involved, general (family) categories have been used to summarize the export figures available. Tables 2.1.1 (a) and 2.1.1 (b) record monthly exports (number of pieces) of various organisms from available data for 1992 and 1993 respectively, including total number and percentage composition for the indicated periods, for the major aquarium fish operator. These figures have been summarized from files from the Ministry of Fisheries, and they do not constitute complete annual export figures.

Table 2.1.1 (a): Monthly exports in 1992, for months indicated, from data from the Ministry of Fisheries for the main aquarium fish exporter. These include two shipments dated for 1991.

Species family	Feb-April	April	May	June	July	August	September	October	TOTAL	%
Anemone	1,575		371	522	118	70	69	62	**2,787**	**13.00**
Anemonefishes	675	283	249	190	203	107	5	50	**1,762**	**8.24**
Angelfishes	157	128	396	3319	188	324	128	193	**1,833**	**8.57**
Bannerfishes	26	9	1	3	2	0	0	0	**41**	**0.19**
Basslets	0	0	0	0	0	136	0	216	**352**	**1.65**
Blennies	1,101	137	207	360	100	81	11	140	**2,137**	**9.99**
Butterflyfishes	127	132	190	195	282	152	46	36	**1,160**	**5.42**
Soft Corals	213	0	11	22	0	4	66	89	**405**	**1.89**
Hard Corals	697	285	249	110	96	173	448	0	**2,058**	**9.62**
Cowries	77	0	11	0	2	0	5	3	**98**	**0.46**
Dartfishes	0	14	8	10	0	0	0	1	**33**	**0.15**
Dascyllus	187	160	425	245	160	26	10	0	**1,213**	**5.67**
Demoiselle	1,640	725	932	858	485	520	131	515	**5,806**	**27.1**
Filefishes	24	0	66	5	26	26	2	26	**175**	**0.82**
Jellyfishes	3	0	0	0	0	0	0	0	**3**	**0.01**
Hawkfishes	0	0	2	0	0	45	55	49	**151**	**0.71**
Hermit crab	0	0	0	0	0	1	0	0	**1**	
Lionfishes	13	0	8	3	0	5	0	1	**30**	**0.14**
Moorish idol	13	0	2	13	0	0	0	0	**28**	**0.13**
Moss on coral	0	0	0	0	0	0	0	4	**4**	**0.02**
Nudibranch	100	0	0	2	0	0	3	0	**105**	**0.49**
Pufferfishes	0	0	4	2	0	0	0	8	**14**	**0.07**
Sergeantfishes	0	123	0	0	0	0	0	0	**123**	**0.57**
Sea fan	0	0	0	0	0	0	0	1	**1**	
Sea urchin	10	0	0	0	0	0	0	0	**10**	**0.05**
Starfishes	173	0	0	0	0	0	0	0	**173**	**0.81**
Sweetlips	0	3	0	6	0	0	0	0	**9**	**0.04**
Tang	62	77	111	130	57	46	5	13	**501**	**2.34**
Triggerfishes	1	2	2	1	0	0	0	0	**6**	**0.03**
Trunkfishes	0	0	1	0	0	0	0	0	**1**	
Wrasses	149	91	10	15	28	63	14	2	**372**	**1.74**

Table 2.1.1 (b): Monthly exports for 1993 for those months which data were available. For the item Bio-rock, the figures are in kg but are taken to equal one piece in the calculations.

Species/family	August	September	October	November	December	TOTAL	%
Anemone	0	1,791	850	1,230	57	**3,928**	**10.74**
Anemonefishes	67	236	365	207	58	**933**	**2.55**
Angelfish	144	354	498	267	123	**1,386**	**3.79**
Bannerfish	0	0	0	0	0	**0**	**0.00**
Basslet	9	32	12	0	0	**53**	**0.14**
Blennies	44	178	132	100	78	**532**	**1.46**
Butterflyfishes	40	13	23	55	0	**131**	**0.36**
Soft Corals	989	2,457	1,659	1,930	302	**7,337**	**20.07**
Bio-rock-corals (kg)	0	1,667	0	2,788.3	0	**4455**	**12.18**
Corals	3,631	2,947	2,116	1,728	267	**10,689**	**29.23**
Cowry	81	0	0	0	0	**81**	**0.22**
Dartfishes							
Dascyllus	32	0	0	153	0	**185**	**0.51**
Demoiselle	762	1,048	931	813	476	**4,030**	**11.02**
Filefishes	0	23	0	0	0	**23**	**0.06**
Giant clams	0	591	350	778	295	**2,014**	**5.51**
Gobies	0	20	27	20	0	**67**	**0.18**
Jellyfishes							
Hawkfishes	100	128	108	139	45	**520**	**1.42**
Hermit crabs							
Lionfishes	0	13	0	3	0	**16**	**0.04**
Moorish idol							
Nudibranch							
Pufferfish	0	54	13	2	0	**69**	**0.19**
Sweetlips							
Tangs	0	17	24	53	0	**94**	**0.26**
Triggerfishes	0	1	0	0	0	**1**	
Trunkfishes							
Wrasses	0	19	0	0	0	**19**	**0.05**

Table 2.1.1 (c) gives species composition of the same organisms using broader organism categories for the same period.

Table 2.1.1 (c): Summaries of exports by the main aquarium fish exporter for the 1992-1993 period using broader organism categories.

Species category	1992 Pieces	1993 Pieces	1992 Percentage	1993 Percentage
Algae	4	0	0.02	0.00
Anemone	2,787	3,928	13.03	10.74
Corals	2,463	22,481	11.51	61.49
Crustaceans	1	0	0.00	0.00
Echinoderms	183	0	0.86	0.00
Fin-fish	15,747	8,059	73.61	22.04
Giant clams	0	2,014	0.00	5.51
Invertebrates	109	0.00	0.51	0.00
Shellfish	98	81	0.46	0.22

Relative composition of each species, separated to fin-fish and invertebrate categories, are given in the following table for August-December, 1993 data presented in Table 2.1.1 (b) above.

FINFISH		INVERTEBRATES	
Species	**%**	**Species**	**%**
Anemonefish	11.58	Anemone	13.78
Angelfish	17.20	Coral - bio-live	15.63
Basslet	0.66	Hard Coral	37.50
Blenny	6.60	Coral-soft	0.28
Butterflyfish	1.63	Cowry	7.07
Dascyllus	2.30	Giant clams	25.74
Demoiselle	50.01		
Filefish	0.29		
Goby	0.83		
Hawkfish	6.45		
Lionfish	0.20		
Pufferfish	0.86		
Tang	1.17		
Triggerfish	0.01		
Wrasse	0.24		

Table 2.1.2 (a) records the exports made by one of the new companies now involved with aquarium fish trade as provided to the Ministry of Fisheries. Two of the sets of data were not dated. Again these do not seem to constitute the complete export listing made by the company. The unit for "Live rock" was given in kg but is being used in the table percentage column as pieces.

Using more general categories for data in Table 2.1.2 (a) results in the information presented in Table 2.1.2 (b), summarized as the total number of pieces and percentage composition, by category, for the same period. The unit for "Live rocks" were given as kg but is being added as pieces to the "corals" category.

It has not been possible to obtain complete actual value figures for the exported aquarium species since the initiation of the operations. However, the limited value-data available from the main exporter are given in Table 2.1.3, for shipments for which they were recorded and submitted.

Table 2.1.2 (a): Monthly aquarium fish exports made by one of the new companies involved in the industry in 1993.

	Undated 1	Undated 2	September	October	November	December	TOTAL	%
Abalone		10		13	3	25	51	0.68
Anemone		30	12	155	67	37	301	4.01
Anemonefishes	15		24	95	90	58	282	3.76
Angelfish	213		84	257	145	441	1,140	15.18
Basslets			25	28	24	32	109	1.45
Blennies/Gobies	9			44	88	93	234	3.12
Butterflyfishes	81		46	66	83	117	393	5.23
Cardinalfishes						5	5	0.07
Hard Corals		233		282	285	129	929	12.37
Soft Corals					100	17	117	1.56
Live rocks (kg)					332	254	586	7.81
Coris			2				2	0.03
Cowries				1	8		9	0.12
Crabs					6		6	0.08
Damselfishes	55			44	247	693	1,039	13.84
Demoiselle			128				128	1.70
Eels						3	3	0.04
Flounders						1	1	0.01
Giant clams		76	7	143	354	241	821	10.94
Groupers	1			3	6	4	14	0.19
Hawkfishes	36		7	16	99	137	295	3.93
Hermit crabs		20		13	15		48	0.64
Lionfishes	1		10	12	7		30	0.40
Moorish idol			16	6		6	28	0.37
Nudibranch			7	1	5		13	0.17
Octopus					1		1	0.01
Oyster					1		1	0.01
Filefishes					3	8	11	0.15
Pufferfishes	9		17	43	51	12	132	1.76
Scallops		2			1		3	0.04
Sea urchins		4		13	29		46	0.61
Snail				14	16	3	33	0.44
Snapper				1			1	0.01
Spondylus					4		4	0.05
Starfishes		3			9		12	0.16
Squirrelfishes						2	2	0.03
Tangs	50		4	42	15	52	163	2.17
Triggerfishes	2		7	7	5	2	23	0.31
Triton				1	1		2	0.03
Unicornfishes	2		1	5	44	1	53	0.71
Wrasses	32		60	175	97	46	410	5.46
Other				3	20	4	27	0.36
TOTAL # PIECES	**506**	**378**	**457**	**1,483**	**1,929**	**2,169**	**7508**	
TOTAL VALUE (t$)	**1,367.40**	**978**	**1,120.8**	**3,242.10**	**6,953.40**	**5,523.00**	**19,184.70**	

Table 2.1.2 (b): Aquarium fish exports made by one of the new companies in about six months in 1993, as recorded in Table 2.1.2(a) classified here under more general categories.

Category	# Pieces	Percentage
Bivalve	8	0.11
Coral	1,632	21.74
Crustaceans	54	0.72
Fin-fish	4,498	59.91
Giant clams	821	10.94
Other Invertebrates	400	5.33
Shellfish	95	1.27
TOTAL # PIECES	**6,022**	
TOTAL VALUE	**19,184.70**	

Table 2.1.3: Some export figures of aquarium fish given with their estimated value. The values are in US$.

Date	Market	Live fish	Invertebrates	Scleractina	Total
27 April, 92	Tropical Fish??	1,896	0	0	1,896
Value		2,368.55			2,368.55
8 May, 92	Universal Marine	839	371	202	1,412
Value		1,192	1,193	747	3,132
11 May, 92	Universal Marine	1,196	13	0	1,209
Value		1,754.35	51.00	0	1,805.35
25 May, 91	Universal Marine	320	0	96	416
Value		554.75	0	466.50	1,021.25
25 May, 91	Guaranteed Hawaii Fish	250	0	0	250
Value		433.00	0	0	433.00
29 June, 92	Arugumbay Aq.	286	100	53	439
Value		283.50	300.00	263.50	847.00
29 June, 92	Universal Marine	945	396	91	1,432
Value		1,520.50	1,188.00	442.50	3,151.00
June, 92	Guaranteed Hawaii Fish	358	0	0	358
Value		665.00	0	0	665.00
4 Oct, 92	Clayton Emporium	93	16	38	147
Value		277.25	56.00	122.00	455.25
4 Oct, 92	Universal Marine	371	30	180	581
Value		927.00	93.00	534.00	1,554.00
19 Oct, 92	Arumbay Aq.	334	68		
Value		650.00	224.00	405	1,279
19 Oct, 92	Sealife Imports	456	5	157	618
Value		905.50	25.00	707.50	1,638.00

Values for individual organisms as indicated by one of the current exporters are listed in Appendix 2.1.1.

Comparison of available export figures for 1992 and 1993 shows a significant increase in the number of hard and soft corals exported. The 1993 invertebrate export figures indicate that anemones and giant clams (mainly *Tridacna maxima*) form major portions, and both contribute significantly to the overall export figure. For fin-fishes, the most important families are the damselfishes, blennies, butterflyfishes, wrasses, tangs and surgeonfishes, angelfishes and hawkfishes. The demoiselle, *Chryspteria taupou* (Fiji damsel) has been the main finfish species exported.

2.1.3 Stocks Status

Collection of marine organisms (fish and invertebrates including corals) in Tonga for the aquarium trade occurs only on coral reefs around Tongatapu island. There has been no study conducted to assess the stocks of any of the targeted species in the aquarium fish trade nor has there been a study undertaken to detect any significant human-induced disturbance of the fish communities as a result of aquarium fish operation. Some reef disturbances are apparent as a result of natural factors such as cyclones, crown-of-thorns starfish infestation and blast fishing.

Even though the trade has been operating for several years in Tonga now, the collection, compilation and analysis of data have not been done, and thus the development has been proceeding without any monitoring. The Ministry will need to closely monitor the development of this undertaking, through a more active involvement in inspection of the collecting and packing operations by the companies. Detailed data collection and proper compilation of data will be necessary before any analysis can be conducted on the fishery. A sample form for collecting data during fishing operations is attached as Appendix 2.1.2.

2.1.4 Management

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

Current legislation/policy regarding exploitation: Section 21 of the Fisheries Act 1989 prohibits the use of explosive, poison or other noxious substances for the purpose of killing, stunning, disabling or catching of fish, or any way rendering fish more easily caught. Penalties for offences under this section are a fine of $T1,000 or imprisonment for a period not exceeding 2 years or both. Section 26 prohibits the import or export or attempt to import or export, of any live fish (including corals) into or from Tonga without the permission in writing of the Director (now Secretary). Offences under this section are punishable by a fine not exceeding T$10,000.

Section 22 authorizes the Minister to declare by Order any area of the fisheries waters to be a reserved fishing area for subsistence fishing operations.

Section 27 of the same Act also authorizes the Minister for Fisheries, with the consent of Cabinet, to make regulations prohibiting or restricting the export from Tonga of any prescribed species, type or size of fish or other aquatic organism, where, in his opinion, such action is required to protect the supply of fish to the domestic markets of Tonga or in the interests of the proper management of a fishery.

Section 28 of the Act requires that anyone engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar (defined as the Principal Fisheries Officer) such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed.

The taking of hard coral for export and the use of damaging techniques for extracting fish have been the major concerns of the Ministry of Fisheries and the fisheries industry. As a result a recommendation was made and approved by His Majesty's Cabinet, DC No 1853 on 15 December 1993 as follows:

a. The export from Tonga of reef corals (orders Scleractinia, Coenothecalia, Athecata, and Stolonifera) be prohibited. This ban is not applicable to processed precious/semi - precious corals.

b. Ministry of Fisheries to also consider restriction of export of live fish.

A policy statement submitted to Cabinet by the Ministry of Fisheries concerning the aquarium fish industry in Tonga includes the following controls on the industry:

> In view of the value to Tonga of the aquarium fish industry and in recognition of potential problems, the Ministry of Fisheries believes that several measures should be taken.

Requirement for authorisation from the Ministry of Fisheries for shipments of aquarium fish: The Fisheries Act 1989 states "No person shall import or export or attempt to import or export,
any live fish into or from Tonga without the permission in writing from the Director" (recently upgraded to Secretary). The Ministry shall continue requiring the authorisation for each and every shipment of aquarium fish.

Ban on the export of certain species: Cabinet decisions in December 1993 prohibit the export from Tonga of reef corals (orders Scleractinia, Coenothecalia, Athecata, and Stolonifera) and of giant clams. Although this will affect the operations of the aquarium fish exporters, the consultation with industry indicated it was something that they "could live with".

Restriction on the number of operators: Although there is no evidence of over-exploitation of aquarium fish in Tongatapu lagoon at present, a conservative approach to management should be taken. No new companies with foreign participation should be allowed to operate around Tongatapu. Recognising the desirability of development in other areas of the country, companies with foreign participation shall be restricted to non-Tongatapu areas. Applications from wholly Tongan owned/operated companies for collecting and exporting Tongatapu fish shall be considered if they can demonstrate substantial industry experience and reputation which is thought to be the single most important factor in the use of responsible collecting techniques.

Requirement for collection of statistics: In order to carry out stock assessment on the various species involved, detailed catch/effort data must be supplied by the operators. This is to include date of collection, specific site of collection, number of divers, collecting time, and catch by species. The Inshore Fisheries Research Assessment Programme of the South Pacific Commission should be able to assist in designing appropriate forms and subsequent analysis of data. The industry has mentioned the supply of such data may be cumbersome, and they have limited control over the accuracy of the data supplied by their divers. The Ministry, however, should be adamant on the provision of accurate, detailed data. Operators shall assume full responsibility for any non-reporting or inaccurate reporting by their divers and non-authorisation of shipments by the Ministry shall be the penalty for not complying.

On-board requirements: The suggestion by the Ministry that metal bars or hammers which could be used to pry or crush coral shall be banned from collecting boats, has been readily endorsed by the industry. To enable monitoring of fishing activities, there should be the requirement for each collecting vessel to have an identification number displayed in 50 cm black characters on a white background in such a manner as to be visible from the surface as well as from aircraft. Non-authorisation of shipments by the Ministry shall be the penalty for not complying.

Observation: There should be a standing offer by all operators for personnel of the Ministry of Fisheries to accompany collection trips and observe packing activities.

Transfer of technology: The complex and capital intensive nature of the aquarium fish industry has resulted in a high degree of foreign participation. This is not necessarily undesirable at present, but increased Tongan participation should be advocated and factors which limit the transfer of technology should be discouraged. Although outside the jurisdiction of the Ministry of Fisheries, it should be noted that some aquarium fish operators have contractual arrangements with their employees which stipulate that the employee cannot legally work for another operator for a certain period of time after the current employment terminates. The Ministry of Fisheries is of the opinion that this has an inhibiting effect on the transfer of technology to Tongans.

Collectors should be employees of the exporting company: To assure that the operators have control over the collection process and be responsible for the type of collection techniques used, all fish bought by an exporting company must be collected by their divers; no buying of aquarium fish from outside divers should be allowed.

Recommended legislation/policy regarding exploitation: The policy statement as submitted by the Ministry of Fisheries is only a step towards closer monitoring of the industry. However some consideration may be given for the following in view of the headings given in the policy statement:

* observation during collection expedition, especially during the packing process, be a standard requirement instead of a standing offer;
* it would probably be necessary to limit the number of aquarium fish operators around the Tongatapu area to the current number (but not necessarily with the same ownership arrangement) until a proper assessment of the industry and resource has been conducted;
* submission of statistics is required for both the catching operations as well for those actually shipped out (from packing list). For ease of databasing by the Ministry of Fisheries, recording of statistics by species on packing list forms should be made under separate headings such as, fin-fish, corals, soft corals, crustacean, bivalves, echinoderms etc). Fin-fish can be broken down to further subheadings to account for the different families;
* in order to increase the spread of the benefits to local people and improve the chance for local operators in this industry, a training component in all aspects of the industry would be necessary.

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

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

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

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

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

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

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

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

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

It was not possible to estimate annual value generated from the export of aquarium marine organisms, due to the absence of complete relevant data. Prior to the compilation of these profiles, no attempt had been made to properly collect, keep and compile catch and export figures. It is recommended that a system and a computer database be developed to accommodate consistent recording of detailed information of the operations, catch and export statistics. A sample form for the recording of fishing statistics by the operators is attached as Appendix 2.1.2.

Corals exported should be labeled as corals, not as "rocks" as is presently the case.

References

Lewis, A. (1985). Fishery Resource Profiles: Information for Development Planning. Fisheries Division, Ministry of Primary Industries. Suva, Fiji.

Pyle, R.L. (1993) Marine Aquarium Fish. In: Wright, A. and Hill, L. (eds.). *Nearshore Marine Resources of the South Pacific. Information for Fisheries Development and Management*. Forum Fisheries Agency (Honiara)/Institute of Pacific Studies (Suva)/International Centre for Ocean Development (Canada). Chapter 6, pp. 135-176.

Richards, A. (1993). Cook Islands Fisheries Resources Profiles. Forum Fisheries Agency, FFA Report 93/25.

Appendix 2.1.1: Unit prices of most of the marine organisms exported from Tonga, for the aquarium trade, to North America, as given by one exporter based in Nuku'alofa.

FINFISHES

ORGANISM	Unit Price	ORGANISM	Unit Price	ORGANISM	Unit Price	ORGANISM	Unit Price
Angelfishes		Anemonefishes		Pufferfishes		Wrasses cont.	
Bi-color	2.50	Red clown	2.00	Blue spotted	2.00	Blue line	2.00
Coral beauty	2.50	Blue stripe	2.50	Valentini	1.00	Painted parrot	2.50
Black tip	3.50	Skunk	2.50	Dog face (grey)	2.00	Cleaner	1.00
Flame angel	8.50			Dog face (gold)	8.00	Bi-color cleaner	2.50
Lemon peel	5.00	Damselfishes		Dog face (orange)	4.00	Six line	1.50
Imperator (small)	10.00	Two stripe	0.25	Coranata	2.00	Harwicke(f)	2.00
Imperator (medium)	15.00	Three stripe	0.25	Box fish	2.00	Harwicke (m)	4.00
Imperator (adult)	25.00	Domino	0.35			Jensen	2.00
Flagfin	6.00	Chromis	0.25	Tangs & unicornfishes		Leopard (s)	1.00
Regal	6.00	Starcki	3.50	Naso (s)	1.50	Leopard (m)	1.50
		Tonga devil	1.00	Naso (m)	3.00	Samoan neon	2.00
Basslets (anthias)		Lemon head	1.00	Naso (l)	4.50	Bicolor parrot	4.00
Pictilis (male)	16.00	Yellow	0.50	Sail fin	3.00	Lunare (f)	2.50
Pictilis (female)	12.00	Black and white	1.00	Yellow mimic	4.00	Lunare (m)	4.00
Squanipinis (m)	2.50			Blue	3.00	Banana (s)	1.50
Squanipinnis (f)	2.00	Gobies/Blennies		Powder brown	3.50	Banana (f)	3.00
Square block (m)	5.00	Yellow S. Pacific	3.00	Clown (s)	2.50	Banana (m)	5.00
Square block (f)	3.00	South Pacific	1.50	Clown (m/l)	4.00	Buffalo head	2.00
		Yellow canary	1.50	Scopaz	1.00	Green metallic	2.00
Butterflyfishes		Eyelash	1.25	Convict	2.00		
Auriga (s/m)	1.50	Clown goby	1.00	Blue eye	1.00	Pipefish	1.50
Auriga (l)	3.00	Watchman goby	1.50			Sea horse	1.50
Melanotus	2.00	Scissor tail goby	2.00	Triggerfishes		Moorish idol	1.50
Lineolatus	3.00			Clown	25.00	Yellow dash goatfish	2.00
Flavirostria	3.50	Groupers		Humuhumu (s)	1.50	Bi-color goatfish	1.50
Blue spot	1.50	Asst.	1.00	Humuhumu (m)	2.50	Moray eel	1.50
Ulietensis	3.50	V-tail	1.75	Humuhumu (l)	5.00	Picus sweetlip	5.00
Raccoon (s/m)	3.50	Red louti	5.00	Niger	2.50	Yellow scolopsis	3.00
Raccoon (l)	5.00			Valentini	2.00	Catfish	0.25
Pelewensis	2.50	Hawkfishes				Cardinalfishes	0.40
Vagabundus (s/m)	1.50	Spotted	1.50	Wrasses		Black canary blenny	2.50
Vagabundus (l)	3.00	Flame	6.50	China (f)	2.50	Spotted sweet lips	2.00
Tear drop	2.50	Arc eyed	1.50	China (m)	5.00		
Saddleback	2.50			Twisti	2.50		
Rafflessi	2.50	Lionfishes		Velvet rare	5.00		
Klieni	1.50	Antenata	2.50	Common velvet	1.00		
Reticulatus	3.00	Volitan	4.00	Twin spot	5.00		
Long nose	2.50	Radiata	6.50	Red coris juv.	1.50		
Black and white	4.50	Dwarf (zebra) - s/m	1.50	Red coris adult	3.00		
Brown and white	3.00	Dwarf (zebra) - l	2.50	Basket	1.50		
Varius	3.00			Brown bird (f)	1.50		
Mertensi	2.50			Green bird (m)	6.00		
				Christmas	1.00		

INVERTEBRATES

ORGANISM	Unit Price	ORGANISM	Unit Price	ORGANISM	Unit Price	ORGANISM	Unit Price
Anemones		**Corals**		Crustaceans		Soft corals	
Bubble	2.00	Acropora nana	3.50	Anemone shrimp	1.00	Green yellow (s/m)	2.00
Rose (s)	3.00	Closed brain (s/m)	2.00	Banded coral	1.00	" " (l)	3.50
Rose (m)	5.00	Closed brain (l)	4.00	Anemone hermit crab	1.00	Grey (s/m)	1.50
Rose (l)	7.00	Worm brain (s/m)	2.00	Shameface crab	1.00	" (l)	2.50
Seabae	3.50	" " (l)	4.00			Sinularia (s/m)	1.50
Purple seabae (s)	4.00	Cup tubinaria (s/m)	2.00	**Nudibranch**		" (l)	2.50
Purple seabae (m/l)	6.00	" " (l)	4.00	Asst.	1.50	Cauliflower	3.00
Ritteri	3.50	Bubble (s/m)	2.00	Spanish dancer	2.00	Grey soft leather (s/m)	1.50
Carpet	3.00	Bubble (l)	4.00			" " " (l)	2.50
		Grape (s/m)	2.00	Starfish		Green soft leather (s/m)	2.00
Giant clams		" (l)	4.00	Orange	1.50	" " " (l)	3.50
Tridacna derasa 4"	2.00	Galaxea star (s/m)	2.00	Brittle	1.00		
" " 4-6"	3.75	" " (l)	4.00	Red	1.00	Mollusc	
" " 6-8"	5.00	Goniopora (s/m)	2.00	Blue	1.00	Tiger cowry	2.00
" " 8-10"	7.50	" (l)	4.00	Kenya	2.50	Asst. cowry	1.00
" " 10" +	10.00	Hammer (s/m)	2.00	Pillow	2.50	Spondylus	1.00
T. squamosa 4"	3.75	" (l)	4.00			Hermit crab	0.40
" " 4-6"	5.00	All coral species		Sea urchins		Live rock	1.00
" " 6-8"	8.50	(s/m)	2.00	Asst.	1.00		
" " 8-10"	12.50	(l)	4.00	Diadema	1.00		
" " 10"+	20.00	Pipe organ	2.00	Flower	2.00		
T. maxima (regular) 4"	3.50	Mushrooms					
" " 4-6"	5.00	Asst. (m)	2.50	Worms			
" " 6-8"	7.00	" (l)	5.00	Tube	0.75		
" " 8-10"	10.00	Purple (s)	2.00	Christmas tree	3.50-6.00		
" " 10"+	12.50	" (m)	3.50				
T. maxima (coloured) 4"	5.00	" (l)	6.00				
" " 4-6"	7.00	Red (s)	2.00				
" " 6-8"	10.00	" (m)	3.50				
" " 8-10"	15.00	" (l)	6.00				
" " 10"+	20.00						

Appendix 2.1.2: Suggested form used for the collection of aquarium fish catch data.

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

FIN-FISH		INVERTEBRATES		INVERTEBRATES	
Species	Total #	Species	Total #	Species	Total #

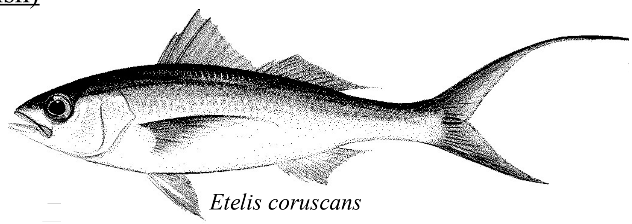
Name of person filling the form (signature and date):

Fisheries Officer receiving the form (signature and date):

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

2.2 Deep-water snappers and groupers (bottomfish)

2.2.1 The Resource



Etelis coruscans

Species present: The most important bottomfish species landed in Tonga include; *Aphareus rutilans* (rusty jobfish - ***palu polosi***), *Aprion virescens* (green jobfish - ***utu***), Carangidae (trevallies and jacks - ***lupo***), *Etelis carbunculus* (short-tailed red snapper - ***palu malau***), *Et. coruscans* (longtail snapper - ***palu tavake***), *Epinethelus morrhua* (comet grouper - ***ngatala***), *Ep. septemfasciatus* (convict grouper - ***mohuafi***), *Pristipomoides filamentosus* (crimson jobfish - ***palu hina***), *Pr. flavipinnis* (golden eye jobfish - ***palu sio'ata***), *Pr. argyrogrammicus* (Ornate jobfish), *Lethrinus chrysostomus* (sweetlip emperor - ***manga***), and *Gymnocranius radiosus.*

Other species include; *Aph. furcatus* (small-toothed jobfish), *Et. oculatus* (Queen snapper), Gempylidae (snake mackerel), *Le. miniatus* (long nosed emperor - ***ngutu kao***), *Le. variegatus* (variegated emperor), *Lutjanus bohar* (two-spot red snapper - ***fangamea***), *Lu. gibbus* (paddletail seaperch), *Lu. kasmira* (blue-line snapper - ***havani***), Sparidae (sea bream), *Paracaesio xanthurus* (sea carp queen snapper), *Pa. kusakarii* (Kusakar's snapper), *Pr. sordidus* (blue snapper), *Pr. zonatus* (flower snapper), *Ruvettus pretiosus* (castor oil fish), and *Seriola purpurescens* (amberjack). Comprehensive listings for bottomfish species caught in Tonga are given in Mead (1987) and Langi and Langi (1988).

Overall species composition by percentage weight for the Tonga deep slope snapper fishery from 1986 to 1990 is given in Latu and Tulua (1991) and is reproduced in the following table in order of decreasing percentage.

Species	Weight Percentage
E. coruscans	22.2
P. filamentosus	20.2
E. septemfasciatus	20.2
Others	15.6
L. chrysostomus	6.3
E. carbunculus	5.8
P. flavipinnis	4.3
E. morrhua	3.2
G. japonicus	1.1
L. operculatus	0.7
L. truncatus	0.4

Annual principal species composition (percentage weight) between 1986 and 1992 are listed below, in descending order of overall percentage means, for the Tonga deep slope fishery as recorded, in most cases, by Latu and Tulua (1992):

Species	1986	1987	1988	1989	1990	1991	1992	Mean
E. coruscans	8.59	15.98	15.76	27.46	54.08	40.67	15.51	25.44
P. filamentosus	28.54	26.72	20.36	21.14	9.47	14.22	35.98	22.35
Others	11.85	12.77	32.70	24.74	10.23	11.47	27.96	18.82
E. septemfasciatus	27.36	21.42	5.92	9.30	14.58	17.79	1.50	13.98
E. carbunculus	3.17	8.74	3.56	2.80	4.69	6.16	13.38	6.07
L. chrysostomus	0.02	6.40	14.40	8.55	4.47	6.35	0.00	5.74
P. flavipinnis	10.15	4.67	4.99	3.83	1.56	2.08	0.00	3.90
E. morrhua	10.31	3.32	2.32	2.17	0.92	1.27	5.67	3.71

Distribution: Throughout the South Pacific, the most important fish catch components of the deep-water fishery, in terms of total landing and value, comprise snappers and groupers. Most of the species in these two families are "widely distributed throughout the central, western and South Pacific although species richness tends to decline with distance from the Indo-Pacific faunal centre, leaving areas like Hawaii with somewhat fewer species" (Moffitt, 1993). Allen (1985) gives an overall general distribution pattern by subfamilies in the family Lutjanidae as well as the known distribution and identification of individual species. He also writes that "the family is divisible into four discrete geographical faunas: eastern Pacific, Indo-West Pacific, eastern Atlantic and western Atlantic" with no species found in more than a single region. Furthermore, "many species, particularly members of *Aphareus, Aprion, Etelis, Lutjanus, Macolor, Paracaesio, Pinjalo* and *Pristipomoides* have broad distributions encompassing wide areas of the Indo-West Pacific region. Some of these species such as *Lutjanus bohar, L. gibbus, L. kasmira, L. monostigma,* and *L. rivulatus*, as well as species of *Etelis*, *Paracaesio* and *Pristipomoides* are frequently associated with oceanic insular localities. Relatively few species have greatly restricted distribution and some of these may be more widespread, but because of their relatively deep habitat, they are seldom collected".

Moffitt (1993) notes that even though most of these species are wide ranging, their relative composition in catches varies considerably with location.

Even though studies of the deep-water bottomfish resources in Tonga have used the length of the 200 m isobath as an estimate of the habitat of the export species, bottom fishing occurs in depths ranging from 50 to 450 m. The total length of the 200 m isobath has been estimated to be 930 nautical miles around the different seamounts and islands of the Tongan Archipelago (Langi and Langi, 1988), of which 294 nm are for all the seamounts (Latu and Tulua, 1991 and Langi *et al*., 1992). However, the habitat length could be more, as charts are incomplete. Langi and Langi (1988) and King (1992) refer to the overall demersal fishery as those fishes caught at depths from 40 m to 400 m. Species depth distribution of the demersal catch in Tonga was divided by King (1992) and is given in the following table. However, these distributions are estimated using only two depth ranges.

Depth > 200 m	Depths < 200 m
E. coruscans	*L. chrysosomus*
E. carbunculus	*P. filamentosus*
E. septemfasciatus	*P. flavipinnis*
E. morrhua	Other species

The only other species depth range distribution estimated for the Tonga bottomfish species was that by Thomas (1978) during the FAO/UNDP Marine Resources Development Project from 1975 to 1977 and is summarized below:

Species	Depth (fathoms)	Area
Shark (*Chondrichthys* sp)	all depths	found throughout the Kingdom but mostly bottom.
Lutjanus bohar	15-40	Akkumanes & banks of northern Ha'apai /Vava'u, seldom south of Nomuka bank
Lethrinus lentjan	10-80	entire Kingdom, concentrations in banks north of Nomuka
L. miniatus	20-40	entire Kingdom
L. variegatus	10-40	entire Kingdom, predominant Nomuka and North Banks
Pristipomoides typus	20-50	entire Kingdom, predominant south of Nomuka
Aprion virescens	10-40	entire Kingdom, more predominant Nomuka to Vava'u off bottom
Lutjanus gibbus	20-50	northern waters
L. johni	15-40	entire Kingdom
Aphareus sp.	40-100	entire Kingdom, concentrations in depth of middle & northern banks & Hunga crater
Serranidae	10-60	entire Kingdom, predominant middle group and southern group
Carangidae	10-50	predominant southern banks

The main target deep-water bottomfish species for exports are those found on the offshore seamounts at depths of 200 m and more, except *P. filamentosus*, the second most important export species in Tonga, which is normally caught at shallower depths. Fish species from the shallower banks are for the domestic market with only less than 10 per cent used for export. Analysis of species catch from the different areas indicated that *L. chrysostomus* forms the main component of the bank (shallow) fishery while the five export species, *P. filamentosus*, *E. coruscans*, *E. carbunculus*, *E. morrhua* and *E. septemfasciatus*, were almost exclusively found on the seamounts (Latu and Tulua, 1992).

Biology and ecology: It has been established that benthic fish and crustaceans form an important dietary component for deep-water snappers and groupers, and that pelagic urochordates are important prey items for many *Pristipomoides* species (Moffitt, 1993). Deep-water snappers are serial spawners, able to spawn several times over a prolonged breeding season. Reproduction takes place in the summer, May to September in the North Pacific and November to May in the South Pacific. Fecundity increases with size and for some species it has been estimated to be between 300,000 and 2,000,000 eggs. Groupers on the other hand are protogynous hermaphrodites with an abbreviated breeding season peaking for 1-2 months. Groupers aggregate in large numbers during spawning and they usually become susceptible to fishing during this period. Fecundity has not been determined. Both snappers and groupers are long lived and slow growing. For natural mortality (M), Ralston (quoted in Moffitt, 1993) found the relationship M=0.0189+2.06K for snappers and groupers.

The Ministry of Fisheries has been collecting data on the deep-water bottomfish fishery since 1986. Several analyses have been conducted for biological parameters of species in this fishery and results have been published. Table 2.1 records the annual sustainable yield estimates for the Tonga deep-water snapper fishery most of which is reported in King (1992).

Table 2.2.1: Various estimates of annual yields of bottomfish in Tonga.

Estimated Sustainable Yield	Species/depth	Analysis method used	Reference
71-222 mt	all	depletion studies using Allen's model for biomass	Latu and Tulua (1991)
169-773 mt	for all seamount species	using Allen's model; results depend on input value for natural mortality.	Latu and Tulua (1991)
200-300 mt	depths > 200 m	based on Schaefer and Fox models applied to partitioned catch and effort	King (1992)
400-560 mt	all species/40-400 m	based on Schaefer and Fox models applied to unadjusted catch and effort; model has poor fit.	King (1992)
225 mt maximum	*E. coruscans* only	based on length-based Thompson and Bell analysis	King (1992)
216.7 mt	294 nmi of 200 m isobath of seamounts (six major species making about 80% of seamount landing).	based on Allen's model	Langi *et al* (1992)
356 mt	deep-water snapper (five export species from seamounts)	Schaefer model	Latu and Tulua (1992)
412 mt	as above	Fox model	Latu and Tulua (1992)
214 mt	*P. filamentosus* and *E. coruscans*	Schaefer and Fox models	Latu and Tulua (1992)

Length/weight relationships of the main seven deep-water bottomfish species in Tonga have been estimated as presented in the following table. N is the sample size, a and b are constants of the equation $W = aL^b$ where W is weight in kg and L is the caudal fork length in cms.

Species	N	a	b
E. coruscans	646	0.00007485	2.62
E. carbunculus	241	0.00001940	2.98
P. filamentosus	896	0.00013914	2.49
P. flavipinnis	1,118	0.00007120	2.67
E. morrhua	450	0.00003167	2.83
E. septemfasciatus	141	0.00022713	2.45
L. chrysostomus	295	0.00005119	2.72

Source: Langi and Langi (1987).

Using K and L_∞ values of 0.17 and 97 cm respectively obtained in Hawaii and Marianas, King (1992), estimated the largest individuals of *E. coruscans* found in Tonga to be approximately 20 years old. Because of the absence of growth information, the determination of natural mortality for native species has not been possible. King (quoted above) suggests that instantaneous rates of about 0.3 $year^{-1}$ (26 per cent per year) appears reasonable for *E. coruscans*. Langi *et al*. (1992) estimated q (catchability coefficient) and R (recruitment in number of fish) using Allen's model for six of the major species caught in the seamount fishery on three seamounts in Tonga. These are reproduced below: (an estimate of M (natural mortality) = 0.04/month was used).

Seamount	Length of 200 m contour	q	q/nm	R/month	R/nm/year	R^2
901	6.8	0.0009	0.006	131	231	0.88
1001	7.4	0.0002	0.0015	568	921	0.98
1004	1.2	0.0020	0.0024	92.6	926	0.90

Average q/nm=0.0033 Average R/nm/year=693

Latu and Tulua (1992) list some biological parameters concerning the major deep-water bottomfish species in Tonga as compared to those estimated for other countries as presented in the following table:

Species	Country	M	K	L∞ (mm)	Z/K	Reference
P. filamentosus	Tonga		0.16	772	4.10	Langi & Langi (1987)
	Tonga			800	2.80	Latu & Tulua (1991)
	Marianas	0.57	0.23	673		Polovina & Ralston (1986)
	Vanuatu	0.25	0.15	780		Brouard and Grandperrin (1984)
E. coruscans	Tonga		0.13	993	3.33	Langi & Langi (1987)
	Tonga			116	5.92	Latu & Tulua (1991)
	Marianas	0.38	0.17	976		Polovina & Ralston (1986)
	Vanuatu	0.12	0.13			Brouard & Grandperrin (1984)
E. carbunculus	Tonga			120	2.08	Latu & Tulua (1991)
	Marianas	1.55	0.18	691		Polovina and Ralston (1986)
	Vanuatu	0.08	0.07	120		Brouard & Grandperrin (1984)
P. flavipinnis	Tonga		0.19	575	11.50	Langi & Langi (1987)
	Tonga			570	4.69	Latu & Tulua (1991)
	Vanuatu	0.83	0.36			Brouard & Grandperrin (1984)
E. morrhua	Tonga		0.16	742	1.33	Langi & Langi (1987)
	Tonga			920	3.77	Latu & Tulua (1991)
E. septemfasciatus	Tonga			1,980	4.52	Latu & Tulua (1991)

2.2.2 The Fishery

Utilization: Fishing outside the reef for the deep-water species was not a tradition in Tonga. Prior to the development of the deep-water fishery in the kingdom, commercial fishing was "carried out around Nuku'alofa by part- or full-time fishermen whose main fishing method is handlining in the shallow water (up to 60 m) within the lagoons" (Mead, 1987). These commercial handliners used small skiffs powered by outboard motors or sails which were suitable only for short fishing trips in sheltered areas before 1970 (Halapua, 1982). He estimated that in 1976 there were sixty-two households involved with commercial handlining in Nuku'alofa. Thomas (1978) estimated that 10 per cent of the estimated 1,000 tons/year of bottom-fish was exploited by the local fishermen of the outer islands along the fringes of the banks.

The UNDP/FAO Marine Resources Development project to investigate the skipjack tuna and deep-water demersal fishery resources of Tonga was initiated in mid-1975 for a two-year period (Fisheries Division, 1975). Specific objectives involving the bottomfish fishery include, determining the more promising fishing areas for snapper and other deep-water species in the reef areas and determining the effective fishing methods in the deep water areas including trolling for surface and deep water (Thomas, 1978). The South Pacific Commission (SPC) conducted exploratory fishing trials for the deep-water snappers and groupers in 1978, 1979 and 1980-1981. The objective was to encourage bottom fishing especially in the unexploited deep water along the outer reef slope and on sea mounts through the introduction of new gear and techniques successfully used in other South Pacific countries (Mead, 1979).

The successful results obtained during the SPC surveys together with the desire to lessen the pressure on the coastal reefs and lagoon resources prompted the government in 1980 to promote the development to exploit the snapper and grouper resources on the outer reef resources which were subjected to virtually no fishing pressure at the time. Associated developments are listed in Ratcliffe (1983) as reproduced below with their status at the time:

Project Title	Planned Level	Location	Remarks
UNCDF Artisanal Fisheries Development (US$850,000)	2 boatyards 40 boats	Vava'u Ha'apai	Personnel, funding and materials available
Japanese Grant Aid-Artisanal Development (¥ 200 million)	engines, fishing gear equipment and spares for 60 boats	Tongatapu Vava'u	Installation to boats underway
FAO/UNDP Fish Vessel construction (Phase II) US$626,000	Select design, train and supply boatbuilders for 60 boats	Tongatapu Ha'apai Vava'u	
FSP Fisheries Development Project-US$413,000	3 advisers, cool storage equipment demonstration boats	Tongatapu Ha'apai Vava'u	1978-1984
ADB Fish Marketing and Process complex-US$215,000	construct complex	Vava'u	Complex to provide essential infrastructure to Vava'u fisheries development
EEC Faua Fisheries harbour T$2.8 million	harbour and market facilities	Tongatapu	Infrastructure to cater for artisanal fleet development

Thomas (1978) suggested that export of snappers as frozen fillet was possible if production were to increase. Two hundred mt of snapper fillet per year, from 500 mt of wet fish, was estimated as a possibility in Tonga.

The development of the bottom-fish fishery was initially geared towards lessening the pressure on the inshore fisheries resources, and to increase production to meet the local demand. However, the establishment of overseas markets in recent years for the more valuable species has changed the nature of the fishery (King, 1993). By 1988 the export market for the more valuable deep-water species was well established and most of the offshore bottom-fish boats target the deep-water snappers for export. The 40 vessels constructed under the FAO/UNCDF project were completed by the same year. In addition, privately-built fishing boats joined the fleet making a total of 44 boats. Ten additional vessels were planned to be built under the UNCDF project but a moratorium was established after the completion of 43 vessels. Due to the lack of consistent maintenance and attention to safety, the number of fishing boats decreased, so that by 1992 only 19 boats were estimated to be active. At the beginning of 1993, nine 28 ft vessels were reported to be actively fishing for export fish on Tongatapu, in addition to three 35-45 ft vessels and one 50 footer. The fishing fleet on Vava'u currently consists of ten 28 ft and one 40 ft boats while that in Ha'apai consists of three, of which two fish as part of the Nuku'alofa fleet while one mainly collects fish from Ha'apai fishermen and transports them to Nuku'alofa. There are currently five exporters of bottomfish in Tonga.

Production and marketing: Thomas (1978) estimated that the outer reef areas of Tonga offer a potential yield of 1,000 mt a year and at that time only about 20 per cent was being taken by local fishermen.

During the SPC Deep Sea Fisheries Development project in Tonga from 3 June to 20 September, 1978, a total of 11 trips, involving a total of 555 hours of sea time, caught 2,081 kg of bottomfish

(Mead, 1979). The catch figure excludes *L. bohar* which was also caught. Catch composition from those trips was given by the same author as listed in Table 2.2.2.

Table 2.2.2: Catch composition during the SPC exploratory deep-sea fishing in Tonga involving 11 fishing trips and 555 hours at sea in 1978. (Source: Mead, 1979).

Species	**Number caught**	**Total weight (kg)**	**% by numbers**	**% by weight**	**Mean wt per fish (kg)**
A. furcatus	38	144	3.8	6.9	3.8
A. virescens	33	95	3.3	4.6	2.9
Carangidae	5	100	0.5	4.8	20.0
Epinephelinae	73	271	7.2	13.0	3.7
E. carbunculus	17	110	1.7	5.3	6.5
E. oculatus	35	164	3.5	7.9	4.7
Gempylidae	4	28	0.4	1.3	7.0
L. miniatus	9	25	0.9	1.2	2.8
L. variegatus	384	501	37.9	24.1	1.3
L. gibbus	1	1	0.1		1.0
L. kasmira	12	5	1.2	0.2	0.4
Sparidae	35	36	3.5	1.7	1.0
P. xanthurus	16	108	16.5	5.2	0.6
Pristipomoides sp.	188	340	18.6	16.3	1.8
R. pretiosus	6	140	0.6	6.7	23.3
S. purpurascens	1	10	0.1	0.5	10.0
P. zonatus	3	2	0.3	0.1	0.7
P. argyrogrammicus	2	1	0.2		0.5
TOTAL	**1,013**	**2,081**			

A total of 19 fishing trips were conducted by SPC during the 1980-1981 period, when evaluating the suitability and effectiveness of several prototype sailing and motor-sailing boats produced by a joint FAO/UNDP/Tonga Government boatbuilding project. At the same time, assessment and demonstration of several fishing methods and provision of training were also conducted (Mead, 1987). The total catch and CPUE by method used is presented in Table 2.2.3(a) while Table 2.2.3(b) records the catch by family and method, as reported by the same author.

Table 2.2.3(a): Catch statistics by fishing method during the 1980-1981 SPC assessment and demonstration project in Tonga.

Fishing Method	**Total Fishing hours**	**Catch (kg)**		**Effort**	**CPUE**
Handline	82.0	535.3	233.0	2.3	
Handreel	44.0	370.5	114.0	3.3	
Longline (bottom)	39.8	281.5	267.5	1.0	
Trap	2.0	8.5	5.0	1.7	

(Note: Effort for handline and handreel is the number of lines x fishing hours, for bottom longlining it is the number of hooks/10 x number of hours, and for traps, number of traps x number hours fished).

Table 2.2.3(b): Catch statistics by fish family and fishing method during the 1980-1981 SPC assessment and demonstration project in Tonga. (Figures in kg).

Family/sub-family	**Handreel**	**Handline**	**Bottom longline**		**Trap**	
Lutjanidae						
sub-family Eteline (deep-water snappers)	93.5	88.2	118.5		0	
sub-family Apsilinae (fusilier)	62.3	6.8	0		0	
sub-family Lutjaninae (other snappers)	53.3	48.4	0		0.5	
Lethrinidae (emperors)		49.0	160.5	10.0		0
Serranidae (groupers, cods)	55.0	59.9	66.0		0	
Carangidae (trevallies, jacks)	16.1	7.9	20.0		-	
Sphyranidae (barracudas, seapikes)	4.0	14.1	0		0	
Gempylidae (snake mackerels)	4.8	7.1	0		0	
Muraenidae (mooray eels)	1.0	1.5	3.0			
Muraenesocidae (pike eels)		5.5				
Haemulidae (sweetlips)		2.8				
Tetraodontodae (puffer fishes)		3.0				
Echeneidae (remoras)			2.0			
Holocentride (squirrel fishes)		2.2	2.0			
Mullidae (goatfishes)		1.5				
Balistidae (trigger fishes)	1.5	0.5				
Chaetodontidae (butterfly fishes)					1.2	
Acanthuridae (surgeon fishes)					0.8	
Scaridae (parrot fishes)					6.0	
Carcharhinidae (whaler sharks)	24.0	21.0	42.0			

Hexanchidae (six-gill shark)		17.7	
Mustelidae (smooth hounds)		15.5	9.0
Squalidae (spiny dogfish)	6.0		9.0

Table 2.2.4 gives the estimated annual bottomfish landing for Tonga as extracted from various sources for several years. Species are given in most cases. Because of discrepancies in data given by different sources for the same species or categories for the same year in most cases, all figures are recorded but are separated, according to the source, by the number of asterisks (*) after each species or category. [Thus, species with one asterisk (*) represent figures according to King (1993), (**) are those according to Latu and Tulua (1991 & 1992), (***) according to King (1992), (****) according to Langi *et al*. (1992) and (*****) according to the Ministry of Fisheries (1991)].

Table 2.2.4: Estimated annual bottomfish landings in Tonga (landing in mt.) from several sources.

Species	1986	1987	1988	1989	1990	1991	1992	Sources
P. filamentosus*		137.34	91.95	85.24	20.29	36.48		King, 1993
P. filamentosus**	60.09	145.08	98.45	89.72	22.07		41.50	Latu & Tulua, 1991 & 1992
P. filamentosus*****						40.10		Ministry of Fisheries, 1991
E. coruscans	*		82.13	71.17	110.75	115.81	10.35	King, 1993
E. coruscans	**	18.08	89.49	76.42	118.45	155.09		17.89 Latu & Tulua, 1991 & 1992
E. coruscans*****						116.18		Ministry of Fisheries, 1991
E. carbunculus*		44.92	16.05	11.29	10.04	15.80		King, 1993
E. carbunculus**	6.68	56.15	23.75	18.09	14.58		15.43	Latu & Tulua, 1991 & 1992
E. carbunculus*****						17.05		Ministry of Fisheries, 1991
E. septemfasciatus*		110.09	26.72	37.51	31.22	45.65		King, 1993
E. septemfasciatus**	57.62	186.41	47.35	74.07	51.57		1.73	Latu & Tulua, 1991 & 1992
E. septemfasciatus*****						76.50		Ministry of Fisheries, 1991
E. morrhua*		17.04	10.47	8.76	1.98	3.25		King, 1993
E. morrhua**	21.71	19.56	12.08	9.97	2.06		6.54	Latu & Tulua, 1991 & 1992
E. morrhua*****						3.70		Ministry of Fisheries, 1991
L. chry*		32.88	65.01	34.49	9.58	16.30		King, 1993
L. chry**	0.04	12.17	67.92	39.89	10.23		0.00	Latu & Tulua, 1991 & 1992
L. chrysostomus*****						11.23		Ministry of Fisheries, 1991
P. flavippinis*		24.00	22.53	15.44	3.33	5.33		King, 1993
P. flavipinnis**	21.38	24.37	22.71	15.92	3.20		0.00	Latu & Tulua, 1991 & 1992
P. flavippinus*****						5.93		Ministry of Fisheries, 1991
L. truncatus**	2.14	1.68	2.53	2.04	0.08			Latu & Tulua, 1991
L. operculatus**	0	0.37	7.06	5.47	1.02			Latu & Tulua, 1991
Gymno. japonicus**	0	2.5	8.96	9.44	1.95			Latu & Tulua, 1991
Other species*		65.63	147.64	99.78	21.91	29.43		King, 1993
Others**	22.82	95.23	117.45	67.00	19.77		32.25	Latu & Tulua, 1991 & 1992
Other*****						52.75		Ministry of Fisheries, 1991
Total Export species* (first five)		391.52	216.36	253.55	179.34	205.51		King, 1993
TOTAL*		514.04	451.55	403.26	214.16	256.58		King, 1993
TOTAL**	210.57	633.00	484.66	450.07	281.61		115.34	Latu & Tulua, 1991 & 1992
EFFORT (reel hours)	15,764	103,562	80,189	65,048	36,089	44,688	41,821	Latu & Tulua, 1992
TOTAL DEEP-WATER***	210.6	633.0	484.7	450.1	281.6	323.5		King, 1992
EFFORT (reel hours)	15,786	122,775	91,020	86,202	59,340	75,713		King, 1992
TOTAL ****(Seamounts)		343	363.5 (first six months)					Langi *et al*, 1992
TOTAL *****						536.91		Ministry of Fisheries, 1991

There is a vast difference between the totals for 1991 given in other references, as compared to that given in the Ministry of Fisheries 1991 Annual Report.

Fish sold locally at the Fish Market by individual fishermen between 1991 and 1993 are presented in the following table. Note that the sales for 1993 are only up to September and that the fish market Manager estimated these totals to be about 60 per cent bottomfish and the rest shallow-water reef fish with a few tunas and other offshore pelagics. (Source: Fish Market Data).

Year	1991	1992	1993
Weight (kg)	58,764.31	61,123.30	48,778.00

The average price of fish sold at the market in 1991 was T$2.20/kg but increased to T$3.00/kg in 1992 and 1993. Prices of fillet of some local bottomfish species in 1993 were: small snapper-T$10.75/kg, large snapper-T$10.20/kg, and grouper-T$10.00/kg.

Fish landed at the Fish Market in Nuku'alofa as reported by the Ministry of Fisheries (1989) and extracted from Fish Market records for the 1991-1993 period, are as follows:

Market	1985	1986	1987	1988	1989	1990	1991 (Dec. only)	1992	1993 (Jan to Sept only)
Export (mt)	325	276	341	271	256		7.834	109.70	38.515
Local (mt)	45	27	14	48	44		6.409	102.08	32.155
Total	**370**	**203**	**355**	**319**	**300**		**14.243**	**211.76**	**70.670**

The catch for all *Etelis* and *Epinephelus* sp., considered as the deep-water catch from depths of more than 200 m, were recorded by King (1992) for the 1986-1991 period as follows:

	1986	1987	1988	1989	1990	1991
Catch (t)	104.1	351.6	159.6	220.6	223.3	213.5
Effort (rh)	4,761	40,999	17,112	29,050	38,868	48,141

Between 1985 and 1989, fresh, chilled or frozen fish (both tunas and bottomfish) made up more than 90 per cent of the total marine animal exports from Tonga. These export figures were reported in Ministry of Fisheries Annual Report (1989) as recorded in Table 2.2.5, comparing the various marine resources.

Table 2.2.5: Export of marine animals from Tonga between 1985 and 1989 by various category. (Source: Ministry of Fisheries Annual Report, 1989).

Category/(Value)	1985	1986	1987	1988	1989
Fish (frozen/chilled) (mt) Value (T$)	320.30 727,221	331.01 749,977	1,144.07 1,193,062	452.36 2,295,046	373.69 1,100,392
Lobster (mt) Value (T$)	0.87 6,940	2.86 13,058	3.42 30,351	3.84 38,522	0.64 3,815
Giant clams & others (mt) Value (T$)	0.03 80	0.27 1,030	1.34 5,106	0.80 3,005	0.06 245
Octopus (mt) Value (T$)	0.15 650	0.14 700	0.18 480	0.05 200	0.43 1,360
Preserved fish (mt) Value (T$)	0.12 210	0.30 440	3.11 14,595	5.61 20,903	2.22 8,818
Crustaceans & molluscs (mt) Value (T$)	0 0.00	4.82 18,755	0.66 4,500	0.24 230	0.40 1,990
Total weight (mt) **Total value (T$)**	**321.47** **735,101**	**339.39** **783,960**	**1,152.77** **1,248,094**	**462.90** **2,357,906**	**377.43** **1,116,620**

The value figures for the 1988 and 1989 for the Fish (frozen/chilled) category seem high for the volume of fish recorded.

Export figures for fish from 1980 to 1992, as recorded by the Statistics Department, are given in Table 2.2.6. The figures also include those for tunas, and may be incomplete.

Table 2.2.6: Fish exports from Tonga for the 1980 -1992 period. (Sources: Statistics Department)

	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Weight (kg)	859.4	47.8	10.0	1,098.0	40,432.0	320,300.0	331,013.0	1,144,072.0	452,358.0	373,691.0	304,455.0	343,536.0	365,497.0
Value (T$)	1,906	106	40	4,933	30,310	727,221	749,977	1,193,062	964,442	1,100,392	1,277,621	1,396,613	1,410,688

Exports of bottomfish to the Hawaii market by one company for six months in 1993 up to October were as follows:

Species	Quantity (kg)	Average unit price (US$/kg)	Total (US$)
Onaga (E. coruscans)	5,750	7.70	44,275
Opakapaka (P. flavipinnis)	670	7.70	5,159
Grouper	300	2.80	840
TOTAL	**6,720**		**50,274**

Export records of deep-water bottomfish by exporters, obtained directly from the operators and from various references, are presented in Table 2.2.7. The value figures given for Company 1 are estimates calculated using average prices for all fish exports, including tuna and marlin, for each year.

Table 2.2.7: Deep-water bottomfish export figures by operators, by species, as obtained from various references or directly from the companies concerned. The shaded figures are those for the same company for the same year but are different as given in another reference.

Exporter	Species	1989	1990	1991	1992	1993	Source
Company 1	Onaga		58,007.2	95,666.8	54,785.1	76,006.9	
	Opakapaka		8,836.5	7,392.4	13,047.0	28,370.0	
	Ehu		859.0	3,196.4	2,637.7	2,016.1	
	Lehi		959.5	6,018.3	3,027.3	3,560.7	
	Grouper		185.0	3,733.2	2,892.9	11,334.7	
	Bedford		27.0	10,899.0	11,844.6	5,255.3	
	Uku		57.6	0.0	141.2	81.3	Company database
Total (lb)			**69,529.4**	**126,906.1**	**88,375.8**	**126,625.0**	
Total (mt)			**31.60**	**57.68**	**40.17**	**57.6**	
Value (US$)			**236,490.04**	**459,969.41**	**301,304.14**	**443,187.5**	
Total (mt)				**61.7**			Fisheries Annual Report, 1991
Company 2				57.4			Fisheries Annual Report, 1991
Company 3				13.0			Fisheries Annual Report, 1991
Company 4				8.7			Fisheries Annual Report, 1991
Ministry of Fisheries	Onaga				2,327.93	511.9	
	Opaka				1,760.65	212.8	
	Lehi				453.65	-	
TOTAL	**(kg)**				**4,542.23**	**7,24.7****	Fisheries Annual Report, 1991
VALUE	**(US$)**				**33,024.15**	**6,770.60****	

Onaga=E. coruscans, Opakapaka=P. flavipinnis, Lehi=A. rutilans, **=2 shipments only

Repeated efforts to obtain export figures from one of the main exporting companies based in Nuku'alofa, failed. The company has been exporting both bottomfish and bêche-de-mer.

2.2.3 Stocks Status

Several estimates have been made of the bottomfish yield in Tonga dealing with different depth ranges and some species as presented in Table 2.2.1 above. King (1992) notes that for the deep-water snappers (depth of more than 200 m) yields of 200 to 300 mt may be taken and that for the whole demersal fishery (depths of 40-400 m) the estimate of 400-770 mt may be regarded as preliminary.

Mead (1987) reported CPUE (kg/line/hr) values recorded during the SPC exploratory bottomfish fishing in Tonga in 1980-1981 for handreel and handline as 3.3 and 2.3 respectively. Dalzell and Preston (1992) recorded the following catch information during the four SPC visits to Tonga:

			Deep-bottom fishing CPUE excluding shark	
Dates	**Sites**	**No. of trips/ fishing hours**	**Average per trip (kg)**	**Average per reel hour (kg)**
13 June '78-8 Sep '78	Slopes off Nuku'alofa	11 / 225	193.8	15.4
29 June '79-16 Aug '79	Slopes off Nuku'alofa and Ha'apai	7 / 69	194.7	5.9
29 Oct '81-125 Apr '81	Slopes off Nuku'alofa and Ha'apai	19 / 126	17.9	3.0
5 June '85-13 Dec '85	Seamounts	16 / 177	344.2	12.4

A decrease in median length, from 61 to 54 cm, in *P. filamentosus* was detected when comparing 1987 and 1988 figures for the southern seamounts in Tonga (Langi and Langi (1989). The same authors also detected a small decrease in size of *P. flavipinnis* at three depleted seamounts. For one of these seamounts, the *P. filamentosus* catches appeared to have dropped considerably and showing no signs of recovery resulting in the fishery targeting other species, especially *E. coruscans*. This shift "coincided with the fishermen fishing at greater depths" (Langi & Langi, cited above).

Comparing average catch per trip (using numbers of fish) for Vava'u and Tongatapu, the following were reported by King (1993):

	1987	1988	1989	1990	1991
Vava'u	55	168	119	92	97
Tongatapu	132	184	195	182	134

Using weight (kg) per trip, the annual CPUEs were calculated for the Tongan deep-slope fishery for the same period as follow:

	1987	1988	1989	1990	1991
CPUE (kg/trip)	365	414	457	436	422

Latu and Tulua (1991) calculated annual CPUEs for the Tongan deep slope fishery between 1986 and 1990 as:

	1986	1987	1988	1989	1990
CPUE (kg/reel hr)	13.36	5.16	5.32	5.22	4.84

However, the authors noted that the very high CPUE estimated for 1986 could be wrong as it was based on extrapolation of 2 months data. Changes in the CPUEs for the principal species were observed. There was an increase of CPUE for *E. coruscans* from 0.8 kg/reel hr in 1987 to 2.7 kg/reel hr in 1990 and a decline for *P. filamentosus* from 1.0 kg/reel hr in 1987 to 0.4 kg/reel hr in 1990. This change was suspected as being a reflection of deliberate targeting of *E. coruscans* for the Hawaiian market.

King (1992) gave the following table of estimated effort and catch for all demersal species in Tonga for all depths (40 to 400 m), as corrected data for the 1986-1990 period from Latu and Tulua (1991).

	1986	1987	1988	1989	1990	1991	1992*
Catch (t)	210.6	633.0	484.7	450.1	281.6	323.5	115.3
Effort (reel hours)	15,786	122,775	91,020	86,202	59,340	75,713	41,821
CPUE (kg/reel hr)	13.3	13.4	12.0	11.9	7.5	8.1	2.76

*Latu and Tulua (1992) for deep slope fishery.

An overall decrease in demersal fishing effort to about 60 per cent of the maximum reached in 1987 was noted, even though there was an increasing trend to fish in deeper waters for the more valuable species, especially *E. coruscans* (King, 1992). The author notes that because of the absence of fishing effort for particular depth zones, assessing changes in CPUEs of component species is difficult. In addition, since "only overall (all depths) effort is recorded, changes in catch rates of a particular species are likely to reflect changes in targeting by fishermen, rather than changes in fish abundance".

Using the principal species[1] caught in the entire Tongan deep slope fishery, Latu and Tulua (1992) summarized annual CPUEs from 1986 to 1992 as follows:

	1986	1987	1988	1989	1990	1991	1992
Catch (t)	210.57	514.04	451.55	403.26	214.16	256.58	115.34
Effort (reel hours)	15,764	103,562	80,189	65,048	36,089	44,688	41,821

[1]Principal deep slope fishery species used by Latu and Tulua (1992) include, *P. filamentosus*, *P. flavipinnis*, *E. coruscans, E. carbunculus, E. morrhua, E. septemfasciatus, L. chrysostomus* and Others.

CPUE (kg/trip)	983	365	414	457	436	422	202
CPUE (kg/reel hour)	**13.3**	**4.96**	**5.63**	**6.20**	**5.93**	**5.74**	**2.76**
Fleet size (no. boats)	32(?)	37	44	36	30	27	19

Annual catch composition by species (weight percentage) for the same period was also given and is recorded in the second table on page 30.

Latu and Tulua (1992) postulated that the decline in relative abundance of the *Pristipomoides* species could be a reflection of the fishermen targeting *E. coruscans*, which fetches a higher price in the export market, rather than a decline in stock. Even though the statement lacks the concrete catch data from different depths (and particular locations or fishing grounds) to support it, it is taken as a reasonable assumption considering the shift in target species.

Using catch data for the five principal deep-water bottomfish species caught on seamounts, *P. filamentosus, E. coruscans, E. carbunculus, E. morrhua* and *E. septemfasciatus*, which account for the export portion of the landing, Latu and Tulua (1992) estimated annual CPUEs (mt per trip) as follow:

	1987	**1988**	**1989**	**1990**	**1991**
Effort (trips)	1,117	695	656	387	405
Catch (mt)	391.5	216.4	253.4	179.3	205.5
CPUE (t/trip)	0.35	0.31	0.39	0.46	0.51

The data indicate a general decrease in effort, resulting in a decrease in total catch, but with an overall increase in CPUE.

2.2.4 Management

The deep-water snapper resource is fragile in nature, in that it involves species that are slow growing, with long life-spans and limited habitat ranges. Thus it is susceptible to increased fishing effort and over-fishing, without proper and practical fisheries management strategies.

Economics of fishing operations tend to limit fishing effort and fleet size in this particular fishery. With the current fleet size, this seems to be related to efficiency and selling prices, rather than declining stocks. However, King (1992) used a simulation model involving 10, 20, and 30 vessels to estimate profitability in terms of catch rates. The findings indicate that fishing effort reduces the stock, which stabilizes at new levels depending on fishing effort. At a fishing effort level of 30 vessels, catch rates are reduced to 3.4 kg per actual reel-hour, at which point profits from the fishery are negative. Latu and Tulua (1992) calculated that maximum profit occurs at the 16-17 vessels level considering fish prices at the time.

Current legislation/policy regarding exploitation: Current government policy includes the exclusion of foreign fishing vessels.

Section 28 of the Fisheries Act 1989 requires that anyone engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed.

Recommended legislation/policy regarding exploitation: Several management options have been documented for the bottomfish fishery in Tonga (e.g. in King, 1992; Latu and Tulua, 1992 and King, 1993). A management plan (King, 1993) has been drafted, but is being currently re-formulated to accommodate views from the fishing community involved, as is required by the Fisheries Act 1989. Continued monitoring of the fishery is necessary to confirm biological parameters of the fishery, as well as MSYs. Using these biological parameters, the number of fishing vessels which can fish the resource on a sustainable basis can then be estimated. As far as the management of the resource is concerned, this factor is more important than calculating the number of boats at which maximum profit occurs. Some other options for consideration include:

Quotas - some countries have suggested applying this option in the management of their bottomfish resource. King (1992) did not recommend this option for application to the Tonga snapper fishery because of the considerable difficulties in policing the quota. However, since the fishery is mainly targeted for export, perhaps quotas can be set for allowable export quantities, especially when most of the exporters now operate their own fishing vessels. This would mean submission of catch and export figures on a timely basis from the exporters as well as closer monitoring of these operations by the Ministry of Fisheries.

Limited number of commercial vessels and licensing - this seems to be the most practical means of controlling the level of fishing effort and thus the catch. King (1992) explains that the most common way of limiting the numbers of vessels is through a vessel registration and licensing system. He also notes that a corollary of this management measure is making it illegal for processors to purchase deep-water snappers from unlicensed vessels. A limit should be placed on new vessels entering the fishery especially the larger and more efficient fishing boats, as they tend to limit local participation and thus the distribution of the benefits from the fishery.

Limited boat size and gear - in association with limiting the number of commercial fishing vessels for the fishery, it would be necessary to define vessel sizes to which the limitation applies. In addition, limiting the amount of fishing gear and number of fishermen on a vessel could be possible. Special consideration should be given to those vessels constructed under local development programmes specifically for this fishery.

Submission of data to the Registrar, defined as the Principal Fisheries Officer or such other person designated by the Minister, as required under Section 28 of the Fisheries Act 1989, has not been adhered to by fish operators, especially those involved in the export of bottomfish. The Ministry of Fisheries will need to develop a mechanism to ensure compliance by the operators and improve the data collecting system to obtain these data. Submission of data should be taken into consideration when the concerned government agency grants permits to export fish for commercial purposes.

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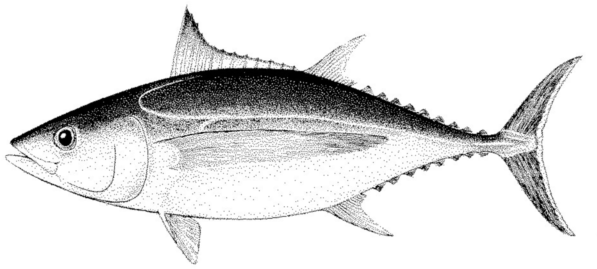
2.3 Tuna

2.3.1 The Resource



Thunnus alalunga

Species present: The tuna[2] species reported to have been caught in Tongan waters, and which form important components in the offshore pelagic artisanal and commercial fisheries, include; *Katsuwonus pelamis* (skipjack tuna - ***atu***), *Thunnus albacares* (yellowfin tuna - ***takuo***), *T. alalunga* (albacore - '***alapakoa***), *T. obesus* (bigeye tuna - ***piki'ai***), *Euthynnus affinis* (mackerel or little tuna - ***kavakava***), *Auxis thazard* (frigate tuna - ***kahikahi***), and *Gynosarda unicolor* (dogtooth tuna - ***valu Tonga (puku)***). Catches by Japanese and Taiwanese longliners in the area of the South Pacific Commission recorded bluefin tuna as being caught in Tongan waters. Both known species of bluefin tunas, *T. maccoyii* (southern bluefin tuna) and *T. thynnus* (northern bluefin tuna) were recorded as being caught in Tonga waters by Taiwanese longliners in 1973 and 1975 for the 1972-1976 period, as reported by Klawe (1978). No records for either species were recorded by Japanese longliners during the same period in Tonga waters.

Distribution: Collette and Nauen (1983) give the general geographical distribution of the scombrids including the tunas. They provide the following geographical distribution information concerning the tuna species, for those which have been recorded in Tongan waters. Additional and more specific information from Hampton (1993) is also included:

Skipjack tuna - cosmopolitan in tropical and warm-temperate waters but absent in the Black Sea. "Skipjack are highly mobile and are capable of unrestricted movement throughout the Pacific Ocean. Most spawning seems to occur in the western Pacific where most of the catch is also taken. Tagging results show substantial mixing of skipjack from Philippines and eastern Indonesia to at least 150° W. However movement, at least of adult skipjack, between the central and eastern Pacific appears more limited".

Yellowfin tuna - worldwide in tropical and subtropical seas of the Pacific Ocean, without any obvious barriers to movement, but absent from the Mediterranean Sea. "There is some evidence from fisheries, tagging and biological data that interchange between the eastern and western Pacific (divided at 150° W) is limited".

Mackerel tuna - throughout the warm waters of the Indo-West Pacific including oceanic islands and archipelagos. A few stray specimens have been collected in the eastern tropical Pacific.

Dogtooth tuna - tropical Indo-West Pacific from the Red Sea and East Africa east to Japan, the Philippines, PNG, and Australia and out into the islands of Oceania.

Albacore - cosmopolitan in tropical and temperate waters of all oceans, including the Mediterranean Sea, extending north to 45 to 50° and south to 30 to 40° but not at the surface between 10°N and 10°S. "Fishery data and tag returns suggest that albacore in the North and South Pacific constitute separate stocks. These data, along with gene frequency data, further suggest that albacore throughout the South Pacific should be considered as a single stock".

Bigeye tuna - worldwide in tropical and subtropical waters of the Atlantic, Indian and Pacific oceans, but absent from the Mediterranean. There are currently limited data to test stock structure hypotheses.

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[2] Tuna as used in this profile refers to the English context of the word, which is for the oceanic fish species in the family Scombridae, **not** meaning eel as is in the Tongan language, unless specifically indicated in the text.

Frigate tuna - probably cosmopolitan in warm waters but there are only a few documented occurrences in the Atlantic Ocean.

Southern bluefin tuna - probably found throughout the Southern Ocean south of 30° S.

Northern bluefin tuna - at least two subspecies with one in the Atlantic and the other in the Pacific. The Pacific subspecies occurs in the Gulf of Alaska to southern California and Baja California in the eastern Pacific, and in the western Pacific it is known from Sakhalin Island in the southern Sea of Okhotsk south to the northern Philippines.

During the FAO Marine Resource Development project in Tonga from 1975 to 1977, it was found that trolling was an effective fishing method, particularly during the summer months (August to April) over submerged reef areas and on top of seamounts (Thomas, 1978). In addition, schools of skipjack were sighted more often and in greater numbers off Vava'u, especially in the western side from Home Reef to Fonualei Island during December to April. During October and November juvenile skipjack and little (mackerel) tuna schools were noticed in smaller numbers. "During the best periods of skipjack availability, concentrations were observed west and north of Hunga Islands, Home Reef and around Toku Islands. The bulk of the skipjack fishing was conducted in these areas" (Thomas, 1978). The same author gave the occurrence of tuna species in Tongan waters as follows:

Species	Area of Fishing	Season
Skipjack	entire Kingdom, predominant W & SW of Vava'u	year round; peak January to May
Yellowfin	entire Kingdom, concentrations SW Vava'u, predominant Late area, Home Reef & E. Ha'apai	year round; peak September to May
Little Tuna	entire Kingdom, W & S Vava'u area	year round; peak September to May
Frigate tuna	S. Vava'u, E. Ha'apai	year round but catch insignificant
Dogtooth tuna	entire Kingdom; concentrations NW & SW of Vava'u Group	scattered; all year

On Ha'apai, the fishermen indicated that the skipjack season starts about October and lasts for up to five months (Halapua, 1981).

Because of Tonga's location in higher latitudes, tuna abundance could be more seasonal than other countries with established pole-and-line fisheries (Tuna Programme, 1983).

On 'Eua, Schuh (1981) during a two-year fisheries development project from 1980 to 1981, recorded the season for skipjack as limited to four months of the year. Using fish landing data collected during the project, approximate times during which different species were found in 'Eua waters were established as follows:

Yellowfin tuna	- November-March
Dogtooth tuna	- August-December
Skipjack tuna	- October-February
Wahoo	- June-September
Horse mackerel	- January-April

Biology and ecology: Smith (1992) notes that even though the tunas form the basis of one of the world's largest fisheries[3], many of the parameters regarding their life history are still unknown. Many

[3] Stamatopoulus (1993) ranks the production, in the Pacific Ocean, of tunas, bonitos and billfishes fourth on the list of ISSCAAP species groups for diadromous and marine fish and crustaceans and molluscs for 1990, after 1). herrings, sardines, anchovies 2). cods, hakes, haddocks and 3). misc. fish species

tuna species migrate considerable distances, swimming continuously. They eat substantial amounts of food and have rapid growth. Many species maintain core body temperatures several degrees above the surrounding sea temperature. Open sea species feed largely on epipelagic fishes, squids, and crustaceans. Near-reef species also utilize the larval and early juvenile stages of reef fish and crustaceans as prey. Reef-associated species prey on large zooplankton or fish occupying the water above the reef (Myers, 1991)

Examination of stomach contents of 118 skipjacks during the SPC skipjack and baitfish assessment surveys in Tonga in 1978 and 1980 indicated that the contents (thus food) were typical of other tropical waters in the South Pacific. A total of 36 different food items were identified, of which fish remains, squid, alima stage of stomatopods, megalopa stage of decapods and leatherjack (Aluteridae) were the most common (more than 10 per cent occurrence), (Tuna Programme, 1983). The second most common five food items include Chaetodontidae (butterflyfish), Acanthuridae (surgeonfish), Synodontidae (lizardfish), tuna juvenile and Balistidae (triggerfish). Anon (1974) reported that during a JAMARC survey in 1973, skipjack stomach contents consisted mostly of moonfish, fingerlings of mackerels, leatherjacks, crustaceans and squids.

Skipjack and yellowfin size frequencies caught by pole-and-line surveys in Tongan waters are as follows:

Year	Species	Details	Length range (cm)	Mode/Average	Source
1972?	Skipjack		45.0-80.2	64.5	Anon, 1973
1973	Skipjack	Male	55-57	55-57	Anon, 1974
		Female	60-61	60-61	Anon, 1974
	Yellowfin	most	50-57		Anon, 1974
		few	>60		Anon, 1974
1978	Skipjack	majority	45-55	50	Tuna Programme, 1983
1980	Skipjack		55-65	60	Tuna Programme, 1983

Examination of skipjack gonads by the Tuna Programme (1983) indicated that skipjack caught were mostly in late maturing and mature gonad stages. Immature, early maturing and spent gonad stages were encountered in 1978. Comparison with those sampled from tropical waters indicated that the dominant maturity stages (maturing gonads) correspond. Assessment of skipjack early life history and spawning activity within an area was determined by examining stomach contents of predators for juveniles. Using the number of juveniles per 100 predators as an indicator, it was observed that an average of 10.61 skipjack juveniles per 100 skipjack predator stomachs occurred in Tongan waters. This was reported as of intermediate level between the high incidence of 25 to 50 juveniles per 100 stomachs found in Vanuatu, Wallis and Futuna, and Marquesas Islands and the low levels of 0 to 4 found in northern and southern extremes of the study area in the Society Islands (Tuna Programme, 1983). This and results of other studies as recorded in the same report, indicate that Tonga is between two areas of relatively high juvenile skipjack abundance. Tagging data in Tonga from the same SPC survey indicated that interaction with fisheries at a considerable distance occurs, though the magnitude is small.

2.3.2 The Fishery

Utilization: Traditional fishing for skipjack in Tonga was carried out by trolling from canoes (***popao***), some with sails, using pearl-shell lures (***tofe***) and bamboo pole. This method was typical of Polynesian tradition. Bonito trolling is known as ***hi 'atu*** in Niuatoputapu where the ***'atu*** is still considered the king of fish (Dye, 1983).

Fishing as a communal effort was common, and catches in this case were distributed among the participants. Dye (1983) describes five mechanisms for catch distribution on Niuatoputapu, of which three (first listed below) were said to be the "Tongan way" of distribution of fish. The five mechanisms include ***vahevahe***, ***tufatufa***, ***kole***, donation to church feasts and sales. ***Vahevahe*** was most common and involved apportionment of fish to participants. ***Tufatufa*** is the distribution of fish to people outside the fishing party, to include church ministers, government representative, relatives and the neighbours. ***Kole*** is a request for fish either before or after the fishing expedition and adult's requests were always honoured. The three "Tongan" mechanisms clearly indicate the nature of fishing in the old times as wholly subsistence. On the existing development of fisheries on 'Eua, Schuh (1981) writes that the ***kole*** system in Tongan society is a constant barrier to developing commercial fishing, making it difficult for a private fisherman to own or maintain fishing gear, outboard engines and tools.

With the introduction and utilization of modern fishing gear including powered boats, tuna has become an important resource in the artisanal fishery for the local market. The fishing method employed is trolling, targeting skipjack, yellowfin, dogtooth tuna, marlin, barracuda, wahoo and dolphinfish.

Apart from the Japanese and Taiwanese fishing operations prior to the acceptance of the 200-nautical mile EEZ worldwide, commercial tuna operations in Tonga only started in 1967 on experimental basis as initiated by the Government, when it received its first longliner "Ekiaki" from Japan. A second long liner, "Tavake" (maximum storage capacity of 40 mt) was donated by the Government of Japan in 1976 (Weber, 1979). The operations were unprofitable until the arrival of the third, 37 meter 188-GT steel long-liner "Lofa" in 1982. Catches were mostly exported, thus earning foreign exchange for the kingdom. Long-lining has been mainly targeting albacore and yellowfin for the export market. Operation of "Lofa" was transferred to a semi-private fishing company in 1991.

In June, 1989 Tonga entered the Multilateral Treaty on Fisheries Between the Governments of Certain Pacific Islands States and the Government of the United States of America. This allows US purse seiners to fish in EEZs of those Pacific Island States that sign the treaty for a set fee.

Production and marketing: No estimated landing figures for tuna have been recorded for subsistence using traditional trolling gears both prior to and after the introduction of modern fishing gear and equipment. Nevertheless, the development of specialized traditional canoes, fishing methods and gear is an indication of the importance of this fishery in Tonga at the subsistence level, before the introduction of the cash economy.

Commercial long-lining for albacore seems to have started in Tongan waters in 1954 when the tuna fishery based in American Samoa began. Otsu (1966) and Otsu and Sumida (1968) gave general locations where the American Samoa-based longliners fished between 1954 and 1965. Fishing was originally concentrated near Samoa but gradually expanded to Tongan and nearby countries' waters. No catch statistics were given in the references for these operations in Tongan waters between 1954 and 1961. Catch statistics derived from published records of Japanese and Taiwanese longliners catches within the estimated EEZs of the South Pacific Commission area between 1962 and 1977 are summarized in Table 2.3.1 for Tonga as reported in Skipjack Programme (1981). Catches are in numbers of fish and effort in 1,000 hooks and excludes other catches such as billfishes, marlins and sailfishes, which are recorded under the "Other Pelagics" profile in this document.

Table 2.3.1: Annual tuna species catches by the Japanese and Taiwanese long-liners in Tongan waters excluding the non-tuna portions of their catches. The catches are in numbers of fish, effort in 1,000 hooks and CPUE in numbers of fish per thousand hooks. (Source: Skipjack Programme, 1981).

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
JAPAN																
B/fin	20	1	1	4	0	0	0	0	0	0	0	0				
Albaco	48,544	27,590	13,776	34,666	21,382	15,126	4,035	1,191	3,581	2,602	2,504	92				
Bigeye	2,550	1,138	651	1,134	1,240	592	259	64	154	122	113	3				
Y/fin	5,981	4,506	2,994	4,989	3,438	1,929	1,014	165	642	383	336	3				
S/jack	45	91	31	229	99	207	12	4	49	16	0	2				
S/tunas	0	0	0	0	0	0	0	0	0	0	0	0				
TOTAL	57,140	33,326	17,453	41,022	26,159	17,854	5,320	1,424	4,426	3,123	2,953	100				
Effort	1,643	892	431	881	654	515	169	31	133	124	87	4				
CPUE	34.78	37.36	40.49	46.56	40.00	34.67	31.48	45.94	33.28	25.19	33.94	25.00				
TAIWAN																
B/fin						0	27	328	2	1	0	17	0	0	0	0
Albaco						27,089	10,654	38,651	15,786	16,228	26,549	4,446	1,032	2,948	8,439	6,412
Bigeye						834	1,157	445	449	636	948	380	42	131	415	257
Y/fin						1,648	1,521	1,073	1,443	1,994	5,497	1,192	219	566	788	815
S/jack						0	0	0	0	0	0	0	0	0	8	1
S/tuna						92	31	1	436	3	0	3	0	0	0	0
TOTAL						29,663	13,390	40,498	18,116	18,862	32,994	6,038	1,293	3,645	9,650	7,485
Effort						601	259	581	388	469	925	198	80	189	474	294
CPUE						49.36	51.70	69.70	46.69	40.22	35.67	30.50	16.16	19.29	20.36	25.46

Rough approximations of tunas and billfishes catches by Japanese, Korean and Taiwanese longliners between 1972 and 1976 within the 200 mile EEZ's of the SPC member countries are given in Klawe (1978). Those recorded for Tonga are given in Table 2.3.2, which are the combined catches by the Japanese and Taiwanese longliners for 1972, 1973 and 1974, and Korean and Taiwanese vessels for 1975 and 1976. However, billfish (swordfishes, sailfishes and marlins) catches are excluded, but are reported under "Other Pelagics" profile in this document.

Table 2.3.2: Rough approximations (kg) of tuna catches in Tongan waters by Japanese, Korean and Taiwanese longliners (source: Klawe, 1978).

	1972	1973	1974	1975	1976
Northern Bluefin tuna	0	1,562	0	0	0
Southern Bluefin tuna	0	205	0	30	0
Yellowfin	178,663	37,485	5,883	19,544	134,338
Albacore	553,701	92,815	19,396	49,849	524,879
Bigeye	44,199	14,168	1,696	5,994	102,510
Skipjack	0	39	0	0	1,214
TOTAL (kg)	**776,563**	**146,274**	**26,975**	**75,417**	**762,941**
EFFORT (number of hooks)	1,014,095	221,747	73,301	177,182	1,543,859
CPUE (kg/1,000 hooks)	**765.84**	**661.87**	**369.52**	**426.08**	**494.45**

During the Japan Marine Fishery Resource Research Centre (JAMARC) survey in 1973 in Tongan waters to assess the feasibility of developing the skipjack pole-and-line fishery, (availability of skipjack and natural bait), the following catches (kg) and observations were made. The CPUE (mt/fishing day) has been estimated for those days that tunas were caught: (Source: Anon, 1974).

	24 Dec	25 Dec	27 Dec	7 Jan	9 Jan	11 Jan	14 Jan	16 Jan	17 Jan	18 Jan	21 Jan
Skipjack	5,770	161	426	427	960	431	846	2,786	3,014	994	743
Yellowfin	38				21			762	697		
TOTAL	5,808	161	426	427	981	431	846	3,548	3,711	994	743
CPUE	**5.81**	**0.16**	**0.43**	**0.43**	**0.98**	**0.43**	**0.85**	**3.55**	**3.71**	**0.99**	**0.74**
School type	breezer foamer	foamer breezer	breezer jumping	breezer	breezer foamer	breezer	jumpin g	breezer jumpin g	breezer jumpin g	jumping	breezer

Records for the Japanese pole-and-line fishing fleet catch and effort between 1972 and 1978 within 200 mile zones of the countries in the SPC area, indicate that very little fishing by this method occurred in Tongan waters during that period. Skipjack Programme (1980) recorded the following catches (mt), by species and effort of pole-and-line fishing that occurred in only three years in Tongan waters. No other species were caught except the three listed:

Species	1975	1976	1977
Skipjack	38	4	35
Yellowfin	0	0	2
Bigeye	1	0	1
Total (mt)	**39**	**4**	**38**
Effort (boat days)	**13**	**2**	**8**
CPUE (mt/boat day)	**3.00**	**2.00**	**4.75**

During the SPC assessment of skipjack in Tonga in 1978 and 1980, the following catches (by pole-and-line) and observation were made: (Source: Tuna Programme, 1983)

	Number of Schools sighted					**Fish caught (kg)**		**Total weight fish caught**
Fishing hours	SJ	YF	S+Y	OT	UN	SJ	YF	(kg)
158	26	7	16	4	64	8,483	1,163	9,713

Landings, exports and value of tunas and other pelagic fish species caught by Fisheries Division fishing vessels are summarized in Table 2.3.3 (a). Species composition of annual catches landed by the same vessels for those years that they were reported are presented in Table 2.3.3 (b). Shaded figures are those for the same vessel and year, but are different as given in a different reference.

Table 2.3.3 (a): Some statistics of fish catches by the fishing vessels (longlining or pole-and-line fishing) operated by Fisheries Division from 1973. Longliner, Lofa, started operation under a fishing company since 1991.

Year/Vessel	**# fishing days**	**Local sales (mt)**	**Local sales Value (T$)**	**Total Export (mt)**	**Export Value (US$)**	**Total catch (mt)**	**Total Value**	**Source**
1973								
Ekiaki	96					90.7		Fisheries Annual Report, 1974
1974								
Ekiaki	78	46.13	15,890	20.21	18,731	66.34		Fisheries Annual Report 1974,
1975								
Ekiaki			22,493	11	8,686	90.25		Fisheries Annual Report, 1975
1976								
Ekiaki	124	123.1	28,423	9.5	11,400	132.6		Fisheries Annual Report, 1976
1977								
Ekiaki	115			87.9	87,000	135.8		Wilkinson, 1977,. Fisheries
Tavake	117					102.4		Division Annual Report
1978								
Ekiaki	78					107.7		Wilkinson, 1978. Fisheries
Tavake	115				162,827	128.2		Division Annual Report
1979								
Tavake	73					50		
Takuo	58					27		
Kahikahi	27					4		Fisheries Annual Report, 1979
1982								
Lofa	201	134.26	139,111	176.86	T$300,083	311.15		Fisheries Annual Report, 1982
1983								
Lofa	192	122.38	120,684	198.54	T$345,721)	320.92		Fisheries Annual Report, 1983
Albacore	73		15,000			16.58		
Takuo	21		7,700			9.63		Fisheries Annual Report, 1983
1984								
Lofa	194	90.91	68,120	215.60	T$389,481	306.51		Fisheries Annual Report, 1985
1985								
Lofa	200	45.01	31,864	324.54	637,140	369.55		Fisheries Annual Report, 1985
Albacore	83		14,616			12.8		Fisheries Annual Report, 1985
Takuo	85		16,671			15.7		Fisheries Annual Report, 1985
1986								
Lofa	164	26.82	19,957	275.63	531,304	302.45		Fisheries Annual Report, 1986
Albacore??	37		9,697			7.7		Fisheries Annual Report, 1986
Takuo	45		11,946			9.7		Fisheries Annual Report, 1986

Table 2.3.3 (a) cont.

1987								
Lofa	198	3.15	25,830	305.51	T$751,224	337.04	T$777,054	Fisheries Annual Report, 1987
1988								
Lofa	158	48	40,608	271	746,231	319		Fisheries Annual Report, 1989
1989								
Lofa	180	44	35,967	256	T$698,713	300		Fisheries Annual Report, 1989
1990								
	??	17.14		232.20				Lofa captain records
1991								
Lofa	153	18.22		260.67				Fisheries Annual Report
Albacore	80							
Ekiaki	74							
Ngutulei	80							
1992								
Lofa	192	46.99	T$83,378	232.35	T$1,122,315	279.34		PFO
1993								
Lofa	163					30.123		PFO

Table 2.3.3 (b): Tuna species composition of catches by fishing vessels operated by the Fisheries Division. Where percentages are used these represent percentage of total catches including billfishes, marlins etc. The non-tuna portions not recorded here but are recorded under the "Other Pelagics" profiles. The composition are given for only the years in which the compositions were reported in references used.

Year /Vessel	Catch category	Weight (mt)	Albacore	Yellowfin	Bigeye	S/jack	Bill-fish	Marlin	Shark	Other	Other Information
1973											
Ekiaki	Total	90.7									fish & shark
1974											
Ekiaki[1]	Total	66.34	17.5%	28.4%	6.5%		6.5%			33.4%	Other=shark & misc.
1975											
Ekiaki	Total	90.25	14.7%				16.1%		20.8%	6.1%	
1976											
Ekiaki	Export	9.5									Export-albacore tuna
1977											
Ekiaki	Total	135.8	24.4%								
Tavake	Total	102.4	40.2%								
[2]	Total	101.66	37.08 mt	21.25 mt	4.5 mt		15.35 mt		15.20 mt	8.27 mt	
1978											
Ekiaki	Total	107.7									61.3% alb & y/fin
Tavake	Total	128.2									64.3% alb & y/fin
[2]	Total	136.93	57.46 mt	30.58 mt	10.33 mt		15.11 mt		10.85 mt	12.6 mt	
1983											
Takuo	Total	9.63									mostly skipjack
1987											
Lofa	Export	305.51	81.8%	8.0%	4.8%	0.6%					

[1] Reference: Fisheries Division (1975). Country Report to SPC Eighth Technical Meeting on Fisheries. [2] Reference: Weber (1979).

"Lofa" catch, export and local sale figures of tunas from records kept by the former captain of "Lofa" between 1989 and 1992 are summarized below by species. All non-tuna species such as marlins, etc are excluded but are reported under "Other Pelagics" profiles. The weights were in short tonnes but have been converted to metric tonnes by multiplying the short tonne figures by 0.91. Figures shaded (1992) and for 1993 were obtained from the principal fisheries officer (PFO).

	1989		1990		1991		1992		1992 Source:PFO		1993
Species	Local	Export	Local	Export	Local	Export	Local	Export	Local	Export	23/06 to 24/09
Albacore	0	217.155	0	158.300	0	204.000	0	224.100		214.969	21.546
Yellowfin	0	33.954	0	31.370	2.890	24.139	7.770	17.970		13.400	2.399
Bigeye	0	13.312	6.629	6.433	0.362	6.297	6.159	0		3.980	0.828
Skipjack	1.673	0	0	3.128	0.304	2.695	0.888	1.461	2.520		0.045
TOTAL	1.673	264.421	6.629	199.231	3.556	237.131	14.817	243.531	2.520	232.329	30.123
TOTAL LANDED	266.094		205.86		240.687		258.348		234.849		
No. trips	4		3		4		4		4		6
# Fishing days	180		?		153		192		192		?
CPUE (mt/day)	1.4783				1.5731		1.3456		1.2232		

The "Lofa" landings as reported by SPC are reproduced in Table 2.3.4. The CPUE is in numbers of fish per 100 hooks.

Table 2.3.4: Longliner Lofa catch statistics (source: Lawson, 1992 and 1993).

	Albacore		Bigeye		Yellowfin		Other		Total	
Year	MT	CPUE	MT	CPUE	MT	CPUE	MT	CPUE	MT	CPUE
1982	106	1.2	18	0.1	81	0.6	47		252	2.5
1983	143	2.6	17	0.2	48	0.6	30		238	4.0
1984	135	4.0	28	0.5	55	1.2	89		307	8.0
1985	174	1.9	15	0.1	44	0.3	137		370	3.3
1986	206	3.8	12	0.1	33	0.3	52		303	4.9
1987	252	3.4	14	0.1	32	0.2	57		355	4.3
1988	242	3.1	6	0.1	26	0.2	45		319	3.9
1989	195	2.1	12	0.1	27	0.3	66		300	3.0
1990	153	2.1	10	0.1	28	0.3	39		230	2.8
1991	174	2.6	5	0.0	19	0.2	33		231	3.4
1992	199	2.4	4	0.05	19	0.24	33		255	3.0

On 'Eua, Schuh (1981) estimated that skipjack made up 20 per cent of the annual catch during 1980-1981 and that tuna, jacks and barracuda made up 9 per cent. A catch of 50 or more skipjack per day for one boat using traditional pole-and-line was about average during the 4-month season. Trolling using modern methods and high boat speed yields a higher catch, with the best recorded during the 1980-1981 artisanal fisheries development project at 134 skipjack and yellowfin in four hours. Monthly catch records (in tonnes) for the two years were recorded by the same author as follows:

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1980	2.6	3.2	4.8	2.8	4.2	1.4	1.2	1.0	0.7	2.7	3.2	3.7	31.5
1981	5.6	6.3	5.8	4.2	3.7	1.5	1.1	0.7	0.8	4.4	5.2	11.4	50.7

Using data collected during a one-week survey in 1991 at the Vuna and Faua landing sites in Nuku'alofa, Udagawa and Tulua (1991) estimated fish landing for the whole year (50 weeks) in the artisanal fishery at those sites to be 499.2 tonnes of which 6.5 per cent, or 32.5 mt, was tuna.

Monthly weight estimates for three tuna species, made from fisheries surveys at Vuna and Faua landing sites in Nuku'alofa in the 1993 artisanal fishery, are summarized in Table 2.3.5. These figures are different from those extracted from the Ministry of Fisheries database in which the landing for tuna was lumped for the June-December period. This is given in Table 2.3.6 which records relative landings of the different fish categories landed at the same two sites in the artisanal fishery. The weights are in kg.

Table 2.3.5: Monthly estimates of tuna landed at Vuna and Faua in the Nuku'alofa artisanal fishery during 1993 (Source: JICA & Ministry of Fisheries).

Species	March	April	May	June	July	August	September	October	November	December
Skipjack (*'atu*)	4,486.26	5,880.66	7,163.23	676.13	-	1,480.40	-	-	-	-
Yellowfin (*takuo*)	851.69	1,230.67	1,341.16	1,632.54	-	315.20	-	-	-	-
Little tuna (*kavakava*)	142.66	173.10	128.21	53.30	67.20	50.15	31.20	62.40	22.60	-
Total	**5,480.61**	**7,284.43**	**8,632.60**	**2,361.97**	**67.20**	**1,845.75**	**31.20**	**62.40**	**22.60**	

The total tuna landing at the two sites, using figures in Table 2.3.5, is about 25.8 mt for ten months, or 31 mt for the whole year.

Table 2.3.6: Relative composition of tuna with respect to other fin-fish categories landed in the artisanal fishery at Vuna and Faua in 1993.

Fish Group	March	April	May	June-December	10 months total	Extrapolated 12 month total	Extrapolated Tongatapu Total	Percent
Mullet	118.22	177.33	458.40	1,258.20	2,012	2,415	3,219	0.83
Deep-water	33.98	15.08	0.00	1,094.55	1,144	1,372	1,830	0.47
Oceanic pelagic	45.41	325.78	227.29	934.53	1,533	1,840	2,453	0.63
Rays	0.00	16.32	44.58		61	73	97	0.03
Reef fish	7,823.26	18,004.81	16,409.45	126,130.62	168,368	202,042	269,389	69.43
Shark	0.00	67.26	0.00	160.20	227	273	364	0.09
Small pelagic	1,223.68	5,010.98	5,955.98	7,606.55	19,797	23,757	31,676	8.16
Tuna	**5,337.95**	**7,299.93**	**9,293.99**	**22,194.73**	**44,127**	**52,952**	**70,603**	**18.20**
Unclassified	47.93	189.09	203.93	4,797.08	5,238	6,286	8,381	2.16

Although there are a variety of methods enabling large industrial fishing operations to harvest tuna, the use of fish aggregating devises (FADs) is generally accepted as one of the few viable options for assuring that small scale fishermen can economically participate in harvesting tuna. The Ministry of Fisheries believes that the FAD programme will help small scale fishermen to markedly increase landings of this large under-exploited fisheries resource. Two FADs were deployed by the Ministry of Fisheries in October, 1993, one 7 nautical miles north of 'Eua and the other 5 miles northwest of Atata. This undertaking represents part of phase one of the Ministry's FAD programme. Phase two will be innovative, in that concepts will be introduced to eventually eliminate the recurrent government costs of placing FADs.

The DP5 gave an estimated annual landing of the Offshore Pelagic Zone to be 4,920 tonnes, valued at T$12 million, at the time of writing of that report. The estimated annual potential optimal from this resource was also given as 14,600 tonnes with a value of T$18 million. However, the author was unable to confirm these landing figures from data available and it seems there is an extra zero for each figure as reported. More realistic figures are given in DP6 (1991-1995) where estimated annual catch from the offshore pelagic zone given is 425 tonnes (valued at T$8 million) with an annual potential catch of 1,460 tonnes (valued at T$ 30 million). However, it is believed that the potential annual tuna catch is mush greater than this estimated figure.

During 1993, one of the locally based companies (Company 1 in the Bottomfish Profile) exported the following amounts of tuna:

	Weight	Value (US$)
Yellowfin tuna	1,278.1 kg	9,841.65
Bigeye tuna	2,710.0 kg	20,867.35
Dogtooth tuna	149.5 kg	1,151.15
Albacore	73.5 kg	565.60

No tuna catches have been made by US purse seiners in Tongan waters under the Multilateral Treaty on Fisheries Between the Governments of Certain Pacific Islands States and the Government of the United States of America, of which Tonga is a party. Purse seiners under the treaty, however, occasionally transit through Tonga waters en route between Pago Pago and Suva.

Very little information is available on the viability of purse-seine operation in Tongan waters. An experimental seining trip was made in 1980 by the purse seiner Pacific Princess. Weather and scarcity of logs were considered as factors discouraging purse seining for tuna.

2.3.3 Stocks Status

Due to their migratory behaviour beyond any country's EEZ, stocks of tunas are always considered on a regional basis rather than in a single EEZ. As such, catch per unit effort (CPUE) on a local level may not be reflective of the status of the tuna resources and may be useful only in assessing economic viability of a particular fishery type (eg. pole-and-line) in a local situation.

One of the conclusions made after the SPC assessment of the skipjack and baitfish resources in Tonga in 1978 and 1980, was that the level of utilization of the skipjack resource in the kingdom had negligible impact on the skipjack population, and that there was no biological reason why the yield from this particular resource could not be substantially increased to 10,000 tonnes a year (Tuna Programme, 1983). Abundance of surface schools of skipjack and yellowfin during the survey period were considered average but with strong seasonality. This factor, in addition to the limited availability of local live wild bait, was considered a drawback for the feasibility of large-scale pole-and-line fishery development in Tonga. Insufficient information is available to give an indication of the possibility of viable purse seining in Tongan waters.

Even though some trends can be noticed in the CPUEs in the longline operations in Tongan waters, they should not be considered as indicative of the status of stocks, but rather reflective of other factors such as efficiency, weather, timing etc. CPUE's for "Lofa" do not vary a great deal and no trend to indicate the status of stocks can be noted.

CPUE (mt per fishing day) of the Fisheries Division operated vessel, Lofa, as estimated from various information available of catch statistics.

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
CPUE (mt per fishing day)	1.548	1.672	1.580	1.542	1.844	1.702	2.019	1.667	?	?	1.555	?

The tuna resource potential in Tonga is believed to be much greater than that estimated in the DP6 document.

Tonga's estimated EEZ represents approximately 3 per cent of the total sea surface of the Pacific Islands yet the tuna landing of approximately 300 mt represents only 0.03 per cent of the total annual catches in the Pacific Islands (Gillett, 1994, note on draft).

The above information indicates that the tuna resources in Tongan waters are very much under-utilized and thus hold considerable potential for further development. The inshore fishery resources are presently heavily exploited in Tonga, and recent information on the deep-water bottomfish resources indicates that this particular resource cannot support much additional fishing pressure. Thus fisheries development in Tonga is highly dependent on the under-utilized tuna resources.

On the status of tuna stocks in the SPC Area, Hampton (1993) provides the following conclusions concerning those in the western Pacific (west of 150° W):

Yellowfin tuna - catches have doubled in the past decade with recent annual level being of the order of 370,000 mt. However, CPUE in the purse seine fishery, which is responsible for half of the total catch, has not declined. Longline CPUE has shown a declining trend since the late 1970s, when CPUE was at all time high, but the current level of CPUE is about the same as it was in the mid-1970s. Analysis of tagging results indicate that the impact of fishing on the yellowfin stock is mild currently and that using a conservative criteria to define "maximum safe" catches, further increases in annual catch to 600,000-800,000 mt could be accommodated.

Skipjack tuna - even though skipjack catches has trebled in the last decade, with recent catches being of the order of 1 million mt, CPUE by purse seiners and pole-and-line remains high and has shown a tendency to increase since the early 1980s. There are no currently known indicators that would suggest the stock as being heavily exploited. Recent tagging experiments suggests that the impact of fishing remains modest despite the increase in catch over the past decade and that maximum safe skipjack harvest of the order of 1.5-2.0 million mt could be sustained.

Bigeye - the current levels of catch, up to 150,000 mt by longline and 60,000 mt by surface fisheries, are sustainable as indicated by the stability of the longline CPUE time series and related abundance indices. However analysis of one age-structure indicates that this level represents moderate to high exploitation of age classes vulnerable to longline. Tagging results of surface fishery catch suggest that the current average exploitation rate of juvenile bigeye by the surface fisheries is no higher than those of yellowfin and skipjack which is believed to be modest.

Albacore - longline CPUE for the South Pacific albacore is high relative to CPUE in tropical tuna longline fisheries. However the longline CPUE time series has been fairly stable although recent levels have been the lowest on record. In the troll fishery, time series CPUE, although short, has been generally declining since the start of the fishery in the mid-1980s. Preliminary results from assessments using age-structured models, as well as tagging results, suggest that the surface fishery exploitation rates are low. It is also possible that higher catches of juvenile albacore could be sustainable. This however requires confirmation.

2.3.4 Management

As is obvious from the distribution and structure of tuna stocks in the Pacific region, management of these resources requires a regional approach. Management can be in the form of prohibition of certain fishing techniques employed, such as drift net, and limiting the number of fishing vessels in a particular fishery within a defined area. However the level of exploitation, especially that of skipjack, currently seems to be sustainable with some allowances for increase. At present the existing control of fishing for tunas within the region is geared towards maximizing benefits to the South Pacific countries from the utilization of the tuna resources by distant water fishing nations (DWFN) fishing in their EEZ's through bi-lateral and multi-lateral agreements. The SPC Tuna and Billfish Assessment Programme is geared towards obtaining sufficient statistical and biological information on which to base management of the South Pacific tuna fisheries.

Current legislation/policy regarding exploitation: The overall responsibility for the management of Tonga's fisheries resources and appropriate development of the fishing industry has been placed on the Ministry of Fisheries since its establishment in 1991.

Fisheries Act 1989: Under the Act the Director (now Secretary) is responsible to progressively prepare and keep under review plans for the conservation, management and development of fisheries in the fisheries waters.

The Act clarifies that the kingdom may enter into bi-lateral or multi-lateral access agreements or arrangements providing for the allocation of fishing rights.

Foreign fishing vessels require a fishing license to fish in Tongan fisheries waters under the Act.

Section 28 requires that anyone engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed.

Section 59 of the Act empowers the Minister to make regulations for the implementation of its purposes and provisions.

Cabinet Decision No. 30 of 1992 gave exclusive rights to the Sea Star Company over the exploitation of the Tongan tuna resources, particularly the albacore, big eye and blue-fin resources. The policy was considered by the Ministry of Fisheries as inappropriate and it was rescinded by Cabinet in September, 1993. This was replaced by the Tuna Exploitation Policy , dated 28 October, 1993.

Tuna Exploitation Policy: His Majesty’s Cabinet approved this policy on 28 October, 1993 and is as follows:

1. That with the exception of activities carried out under regional treaties, foreign-based fishing vessels be not allowed access to the tuna resources of Tonga and that only locally-based vessels working through local companies are allowed to harvest tuna;

2. That the Ministry of Fisheries be initially responsible for grading tuna for export;

3. That the Ministry of Fisheries be responsible for the implementation of this policy and assistance is to be provided by all Ministries/Departments as required.

The Territorial Sea and Exclusive Economic Zone Act 1978: This Act defines Tonga’s territorial sea and EEZ. Under the Act, a license is required for a foreign fishing vessel to engage in fishing within Tonga's EEZ. In addition, the Minister is empowered to determine allowable catch with respect to every fishery within the EEZ. However, this Act has not come into force because a date has not been appointed by the King in Privy Council for its coming into force as required under the Act.

Recommended legislation/policy regarding exploitation: Three separate sets of Fisheries Regulations have been proposed. These are the Fisheries (Foreign Fishing) Regulations, Fisheries (Conservation and Management) Regulations and Fisheries (Local Fishing) Regulations.

The current rate of exploitation of tunas in Tonga is low relative to the resource abundance present. Thus the potential for further development is substantial and the Ministry of Fisheries may need to encourage exploitation along the lines provided by DP 6, which is, to create an environment conducive to the development of private sector involvement in fisheries.

Compliance with Section 28 of the Fisheries Act 1989 needs to be improved by the fish operators and exporters in order to obtain more accurate figures on the resource in Tonga.

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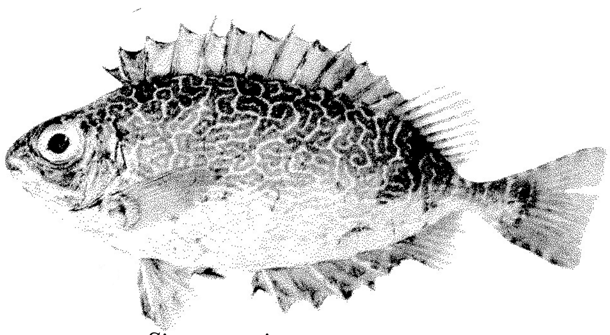
2.4 Shallow-water reef fishes

2.4.1 The Resource



Siganus spinus

Species present: Fish species of this profile include all those from shallow water reefs, mangroves and lagoons but exclude mackerel, scads, sardines and mullet. In the first six months of the Tongatapu Inshore Fisheries Project, over 250 species were identified (Ferguson, 1987).

The Ministry of Fisheries' Inshore Fisheries Statistics programme lists the major reef-fish species landed at the domestic markets. These include: Unicorn and Surgeon fishes (Acanthuridae), Squirrelfishes (Holocentridae), Wrasses (Labridae), Emperors and Sea-breams (Lethrinidae), Seaperches (Lutjanidae), Goatfishes (Mullidae), Sweetlips (Plectorhynchidae), Parrotfishes (Scaridae), Rabbitfishes (Siganidae), Half-peak parrotfishes (Sparisomidae), Sea-pikes (Sphyraenidae), Drummerfishes (Kyphosidae), Rock-cods (Epinephelidae), Silver-biddy (Gerridae), Trigerfishes (Balistidae), Bullseyes (Priacanthidae), and Majors (Abudefdufidae). The listing of individual reef fish species as recorded at Vuna and Faua landing sites during the Ministry of Fisheries Inshore Statistics data collection project are listed in Table 2.4.2, under the production section, together with catching method and estimated landings.

Distribution: Shallow-water coral reefs, lagoons and mangrove areas are the main habitats for the fish species discussed in this section. As such, fishing activities for these fishes are normally confined within or near these habitats.

In the Ha'apai region, the best fishing grounds within 15 km of inhabited islands are found in the extensive reefs and lagoons of Nomuka and Mango in Mu'omu'a; 'O'ua, Kotu and Lofanga in Lulunga; and 'Uiha island in Hahake. In contrast, Fonoifua in Mu'omu'a; Tungua, Ha'afeva and Matuku in Lulunga; and Lifuka, Foa, Ha'ano, Fotuha'a and Mo'unga'one in Hahake, possess relatively poor nearby fishing because of the smaller size of their reefs and lagoons (Halapua, 1981 and Anon, 1988). In addition to the "close-to-home" reefs and lagoon, other good fishing areas in Ha'apai include Bethume Bank (Reefs), north of Ha'ano; Nukupule and Niniva associated reefs; Luangahu's reefs, southern edge of 'Uiha; the barrier reef that stretches from the north west of Fonoifua to the south of 'Uiha; scattered reefs between 'O'ua and the barrier reef; and the 'Otu Tolu and areas around Nomuka and Fonoifua (Halapua, quoted above). Felfoldy-Ferguson (1987) estimated the inshore fishing ground in Tongatapu alone to be 947 km^2 of which 11.2 per cent and 0.36 per cent are reefs and mangroves respectively. The remaining 88.44 per cent are shallow and deep lagoon with outer shelf of less than 160 m isobath. On Niuatoputapu, most fishing takes place on or from the fringing reef (Dye, 1983).

Fishing areas for reef fish species throughout the Kingdom generally fall within the habitat frame as described above.

Biology and ecology: Ecological characteristics of some of the fish families in this category is given in Pyle (1993) as follows:

Family	Feeding Strategy	Reproductive Strategy	Habitat
Acanthuridae (surgeonfishes and tangs)	herbivorous	school-forming; spawn at dusk in large groups; pelagic eggs	all habitats depending on species
Labridae (wrasses)	omnivorous	harem-forming/school forming; protogynous; spawn at all times of day depending on species; pelagic eggs	all habitats depending on species
Serranidae	carnivorous/	harem-forming/pair-forming/aggregate-forming;	all habitats depending on species;

(groupers and basslets)	herbivorous/ planktivorous	protogynous; spawn at dusk; pelagic eggs	Anthiinae form aggregations above the substrate

Sexes are separate in most shallow-water reef-associated fishes including holocentrids, mugilids, mullids, gerrids, siganids, carangids (Wright, 1993). Protogynous (change from female to male) fishes include serranids, lethrinids, nemipterids and labrids while platycephalids, sparids, gobiids and muraenids change sex from male to female (protandrous). Most species produce pelagic eggs except for the majority of siganids, tetradontids and balistids which nest. Spawning migration, to a reef location contiguous to oceanic water, vertically in the water column or inshore, is common (Wright, 1993).

There has been no study conducted in Tonga on the biology and ecology of any of the shallow-water reef fish species.

2.4.2 The Fishery

Utilization: The shallow-water reefs and lagoons surrounding the islands have always been an integral part of the Tongan way of life. The resources from these areas have been a vital source of protein at the subsistence level, and with the change from a barter to a cash economy, these have become important in the artisanal, and recently the commercial fisheries.

In the northern groups, the subsistence inshore fishery provides the major source of the protein for the people. Halapua (1981) estimated that the reef-lagoon fishery resources supply more than 70 per cent of the Ha'apai islands' total annual catch. He also revealed that out of the 715 fishermen interviewed, none were occupied full-time with fishing, but fishing served to supplement subsistence agriculture and cash cropping. In Tongatapu, inshore fisheries provide the major source of income to most fishermen.

Fishing techniques used include traditional and introduced methods, the main types being speardiving (day and night), handlining, gill netting, fish fences, fish drive netting (***uloa***), trolling and hand collecting shellfish in the shallows. Data collected from the Vuna and Faua landing sites indicate that most of the reef fish landed there in 1993 were caught by night diving and netting.

Artisanal fishing is mostly done from wooden or GRP skiffs powered by outboard motors, and from traditional paddled canoes. The former are used for semi-commercial purposes whereas canoes are mainly used for subsistence fishing for home consumption.

Production and marketing: Halapua (1981) estimated that 70 per cent of Ha'apai's total annual fish catch is from the reef-lagoon fishery resources, consisting mainly of surgeonfishes, parrotfishes, squirrelfishes, wrasses, groupers, goat fishes, butterflyfishes and smaller mackerel/scads. Table 2.4.1 shows the revised estimated composition of the catches by principal fishing gears, in the Tongatapu artisanal fishery for 1987 as reported by Felfoldy-Ferguson (1987) and Munro (1990).

Table 2.4.1: Estimated catches in the Tongatapu artisanal fishery in 1987 classified under the main fishing methods.

Estimated total annual gear hours:	574,800	1,148,937	634,230	468,473		
Fishing Gear ->:	Gillnet	H/line	Spear	Other	**TOTAL**	
Estimated Annual Landing ->:	**mt**	**mt**	**mt**	**mt**	**mt**	**%**
Lethrinus nebulosus	12.39	76.34	105.94	.56	**195.23**	23.7
Mugil cephalus	81.85	.00	.00	58.18	**140.03**	17.0
Lethrinus elongatus	3.37	27.44	38.08	.00	**68.98**	8.4
Sargocentron spiniferum	11.62	10.49	14.56	.14	**36.81**	4.5
Lethrinus ramak	.70	10.87	15.08	.17	**26.82**	3.3
Leptoscarus vaigiensis	21.31	.00	.00	.81	**22.12**	2.7
Trichiurus lepturus	19.47	.00	.00	.00	**19.47**	2.4
Parupeneus pleurotaenia	12.79	.00	.00	5.39	**18.18**	2.2
Lethrinus harak	1.94	6.05	8.40	.51	**16.98**	2.1
Selar crumenophthalsus	9.48	.00	.00	3.62	**13.10**	1.6
Siganus argenteus	11.02	.00	.00	.78	**11.80**	1.4
Mulloidichthays vanicolensis	9.08	.00	.00	2.53	**11.61**	1.4
Rastrelliger kanagurta	11.45	.00	.00	.00	**11.45**	1.4
Lutjanus fulviflamna	4.94	2.02	2.81	1.14	**10.92**	1.3
Leiognathus equula	7.98	.00	.00	2.21	**10.20**	1.2
Sphyraena forsteri	3.94	1.86	2.58	.45	**8.83**	1.1
Gymnocranius japonicus	.70	3.10	4.30	.00	**8.10**	1.0
Mulloiddichthys flavolineatus	6.95	.00	.00	.81	**7.76**	1.0
Other species	102.98	24.98	36.67	22.92	**185.52**	22.3
Total	**333.96**	**163.15**	**226.42**	**100.22**	**823.75**	**100.0**

During 1992, a one-week survey was conducted at Vuna and Faua wharf in Nuku'alofa by the Ministry of Fisheries. Figures obtained were extrapolated to estimate the total landing for a 50-week year. The results of the survey, as well as the extrapolated figures for the whole year, are given in the following table.

Category	**Survey week (# strings)**	**Conversion to Weight for whole week (kg)**	**Estimated Annual Landing (mt)**
Fish	2,496	9,984	499.20
Crustaceans	87	261	13.04
Category	**Survey Week (# of Baskets)**	**Conversion to Weight for whole week (kg)**	**Estimated Annual Landing (mt)**
Molluscs	824	3,296	164.8

Composition (%) of the fin-fish component from the above survey are as follows, as given by Udagawa and Tulua (1992):

Fish category	**%**
Rabbitfish	19.2
Goat fish	3.7
Parrotfish	11.3
Thumprint emperor	12.9
Spangled emperor	4.5
Unicornfish	5.0
Surgeonfish	6.0
Parrotfish	15.8
Tuna, skipjack	6.5
Mullet	3.9
Other (silver biddy, sea bream, grouper)	1.1
Others	10.1

The above results clearly indicate that reef fish species form the most important component of the fish landings at these sites, which is very likely to be the case for the whole country.

The current Inshore Fisheries Statistics Programme of the Ministry of Fisheries in Tongatapu started at the beginning of 1993. Some modifications of the data collection process were found necessary in the first few months in order to obtain more accurate information and to refine the methodology used in estimating the total landing by fish family (or species) and fishing method. Landing estimates (weight in kg) at Vuna and Faua for most of the months in 1993 from these surveys are recorded in Tables 2.4.2(a) and 2.4.2(b) for different fin-fish groups.

Table 2.4.2(a): Estimated landings of Reef Fish at Faua and Vuna Landing sites in the Artisanal Fishery for the March-June, 1993 period. (Data source: Udagawa, JICA, Ministry of Fisheries).

Fish Group	March	April	May	June	Total	Percent
Deep-water	33.98	15.08	0.00	0.00	49.06	0.06
Mullet	118.22	177.33	458.40	98.80	852.75	0.99
Other pelagics	45.41	125.80	94.4	0.00	265.61	0.31
Rays	0.00	16.32	44.58	0.00	60.90	0.07
Reef fish	**7,823.26**	**18,204.79**	**16,542.93**	**5,410.80**	**47,980.19**	**55.55**
Shark	0.00	67.26	0.00	0.00	67.26	0.08
Small pelagics	1,223.68	5,010.98	5,955.98	226.40	12,417.04	14.38
Tunas	5,337.95	7,299.93	9,293.99	2,308.67	24,240.54	28.06
Unclassified	47.93	189.09	203.93	0.00	440.94	0.51
Total	14630.43	31106.58	32593.62	8044.67	86375.29	100

Table 2.4.2(b): Estimated landings of Reef Fish at Faua and Vuna for the July-December, 1993 period. (Data source: Ministry of Fisheries).

Fish Group	July	Aug	Sep	Oct	Nov	Dec	Total
Mullet							1,159.40
Reef fish	**12,686.90**	**18,467.30**	**16,710.05**	**21,148.15**	**23,494.42**	**22,807.10**	**115,313.92**
Small pelagic	41.80	32.20	73.95	7.20	41.80	34.50	231.45
Tuna	67.20	1,845.75	31.20	62.40	22.60	-	2,029.15
Ray	8.25	0.00	0.00	0.00	0.00	0.00	8.25
Unclassified	56.85	197.40	722.05	171.00	2,150.08	1,530.30	4,827.68

The break-down of the Reef Fish group only, in Table 2.4.2(a), by fish family is given in Table 2.4.3(a) with their respective estimated landings (kg) for the same months.

Table 2.4.3(a): Composition of the Reef Fish Group in Table 2.4.2(a) by family. Figures are in kg except the percent column. (Data source: Udagawa, JICA, Ministry of Fisheries, Tonga).

Fish Type	March	April	May	June	TOTAL	Percent
Parrotfish	1,782.31	3,977.16	4,081.20	826.22	**10,666.89**	**22.23**
Emperor	1,328.50	1,709.95	1,716.16	1,467.52	**6,222.13**	**12.97**
Soldier & squirrel fishes	360.17	1,971.35	2,389.03	485.36	**5,205.91**	**10.85**
Surgeonfish	455.50	2,911.41	1,541.81	269.36	**5,178.08**	**10.79**
Rabbitfish	1,248.02	1,411.16	521.15	103.94	**3,284.27**	**6.85**
Unicornfish	605.89	1,569.59	740.74	118.76	**3,034.98**	**6.33**
Silver biddy	0.00	149.96	1,847.36	74.43	**2,071.75**	**4.32**
Goatfish	276.72	759.48	482.26	416.72	**1,935.18**	**4.03**
Wrasse	564.79	669.43	385.58	314.34	**1,934.14**	**4.03**
Grouper	244.07	629.49	535.73	201.18	**1,610.47**	**3.36**
Sea bream	70.37	252.76	421.60	413.79	**1,158.52**	**2.41**
Bullseye	188.75	264.50	305.11	200.07	**958.43**	**2.00**
Sweetlips	103.68	345.87	32.86	174.66	**657.07**	**1.37**
Porcupine fish	40.42	365.67	169.66	65.85	**641.60**	**1.34**
Trevally	99.22	107.86	385.22	41.93	**634.23**	**1.32**
Sergeant	68.62	350.60	149.96	0.00	**568.59**	**1.19**
Sea perch	142.66	173.10	128.21	53.30	**497.27**	**1.04**
Drummerfish	93.86	237.20	15.00	117.52	**463.58**	**0.97**
Bonyfish	0.00	0.00	311.39	0.00	**311.39**	**0.65**
Barracuda	0.00	160.87	132.89	0.00	**293.76**	**0.61**
Filefish	21.75	29.61	94.85	7.61	**152.82**	**0.32**
Butterflyfish	36.86	45.67	56.08	0.00	**138.61**	**0.29**
Triggerfish	14.7	59.42	4.83	58.24	**137.19**	**0.29**
Cornetfish	14.7	7.82	94.25	0.00	**116.77**	**0.24**
Long tom	47.00	0.00	0.00	0.00	**47.00**	**0.10**
Sea pike	0.00	39.11	0.00	0.00	**39.11**	**0.08**
Boxfish	14.7	0.00	0.00	0.00	**14.70**	**0.03**
Moray eel	0.00	5.75	0	0	**5.75**	**0.01**
TOTAL	**7,823.26**	**18,204.79**	**16,542.93**	**5,410.80**	**47,980.19**	**100.00**

The break-down of the Reef Fish group only in Table 2.4.2(b) by family is given in Table 2.4.3(b) with their respective estimated landings (kg) for the same months.

Table 2.4.3(b): Composition of the Reef Fish Group in Table 2.4.2(b) by family. Figures are in kg except the percent column. (Data source: Ministry of Fisheries, Tonga).

Fish family	July	August	September	October	November	December	TOTAL	Percent
Parrotfish	3,334.75	4,406.20	3,365.05	5,570.40	6,159.04	7,652.80	30,488	26.44
Emperor	1,624.50	2,726.95	2,957.00	2,835.70	4,928.41	4,716.30	19,789	17.16
Rabbitfish	844.90	1,486.50	1,410.20	1,487.00	3,900.85	4,288.70	13,418	11.64
Unicornfish	1,151.30	1,962.15	1,407.65	3,089.90	1,691.53	1,513.40	10,816	9.38
Surgeonfish	1,724.25	1,866.35	1,920.85	1,825.20	1,628.45	1,561.05	10,526	9.13
Grouper	450.25	1,427.50	1,634.05	1,454.95	1,355.88	849.70	7,172	6.22
Goatfish	799.25	1,372.10	1,227.45	1,328.45	850.61	546.80	6,125	5.31
Squirrelfish	902.35	847.55	594.75	521.35	422.03	104.60	3,393	2.94
Silver biddy	191.10	49.75	126.95	836.50	825.95	0.00	2,030	1.76
Triggerfish	57.50	36.85	105.70	246.70	628.70	840.50	1,916	1.66
Wrasse	165.70	378.05	360.60	309.95	271.34	329.10	1,815	1.57
Sea perch	167.30	282.25	224.35	570.10	187.65	51.75	1,483	1.29
Sea bream	139.50	445.45	434.55	46.90	271.70	46.00	1,384	1.20
Sweetlips	117.15	269.45	298.80	261.85	125.30	18.00	1,091	0.95
Sergeant	114.45	209.65	92.60	398.15	0.00	0.00	815	0.71
Sea pike	263.80	162.45	30.70	56.80	58.05	88.50	660	0.57
Drummerfish	122.45	215.80	117.00	25.45	65.45	0.00	546	0.47
Bullseye	134.85	96.00	84.80	75.20	0.00	13.60	404	0.35
Trevally	68.20	40.10	53.65	13.60	5.40	153.90	335	0.29
Porcupinefish	173.40	42.10	30.80	34.15	36.45	0.00	317	0.27
Crescent perch	67.20	50.15	31.20	62.40	22.60	0.00	234	0.20
Moray eel	8.90	5.70	107.20	51.50	0.00	0.00	173	0.15
Long tom	6.80	14.70	37.80	6.20	23.13	32.40	121	0.10
Cornetfish	19.30	39.55	11.50	20.00	12.75	0.00	103	0.09
Batfish	15.50	29.15	18.20	0.00	1.35	0.00	64	0.06
Ponyfish	4.80	0.00	22.90	3.90	21.80	0.00	53	0.05
Filefish	17.45	4.85	3.75	15.85	0.00	0.00	42	0.04
TOTAL	**12,687**	**18,467**	**16,710**	**21,148**	**23,494**	**22,807**	**115,313**	**100**

The survey results indicate that parrotfishes, emperors, rabbitfish, surgeonfishes, unicornfishes, soldier/squirrel fishes and groupers are the most important families in the shallow-water reef artisanal fishery. Other important groups include wrasses, goatfish seabream and silver biddy.

The total reef fish landing at Faua and Vuna in the artisanal fishery for the 10 survey months is 163 mt. Extrapolation for 12 months gives about 200 mt of reef fish landed at the two sites in 1993. Landings at these two sites has been estimated to represent about 75 per cent of the total Tongatapu figure (Udagawa, 1993, *pers. comm.*). This would give an estimated reef fish landing of almost 270 mt a year for Tongatapu, worth about $T1,000,000. The Tongatapu 1993 estimated landing is much less than that reported for the 1987 artisanal fishery by Felfoldy-Ferguson (1987) and Munro (1990). However, mullet, small pelagic fishes, sharks and rays are excluded from 1993 reef fish estimate as they are treated in their respective profiles in this document.

The final modifications in the collecting and databasing system were made in August, and thus separation of species by fishing method, given in Table 2.4.4, were only performed on data for the June-December, 1993 period (seven months).

Table 2.4.4: Estimated landing by species, summarized for fishing methods used, at Vuna and Faua landing sites in Nuku'alofa, from June to December, 1993. (Source: Ministry of Fisheries Database, Inshore Fisheries Statistics).

ENGLISH COMMON NAME	TONGAN NAME	SPECIES	FENCE	H_LINE	NET	N_DIVE	DAY_DIV	TOTAL (kg)	TOTAL (T$)
Batfish	Sifisifi	Platax pinnatus	0.00	0.00	1.35	89.50	3.00	**93.85**	**249.30**
Bullseyes	Mataheheva	Priacanthus spp.	0.00	90.45	121.80	229.55	62.05	**503.85**	**1316.30**
Convict surgeonfish	Manini	Acanthurus triostegus	0.00	0.00	21.70	287.40	1.80	**310.90**	**829.55**
Cornetfish	Totao	Fistularia spp.	0.00	0.00	86.10	28.40	0.00	**114.50**	**265.80**
Crescent perch	Kavakava	Therapon jarpua	7.65	18.10	264.10	58.10	0.00	**347.95**	**852.00**
Drummerfish	Nue	Kyphosus cineracens	0.00	0.00	16.60	559.60	57.10	**633.30**	**1780.20**
Emperor	Liki	Lethrinus nebulosus	0.00	65.85	19.10	151.85	0.00	**236.80**	**616.95**
Emperor	Hoputu	L. mahensa	0.00	688.00	3.80	1554.20	11.45	**2257.45**	**6040.70**
Emperor	Koango	L. nebulosus	0.00	1375.80	353.75	604.60	2.40	**2336.55**	**5417.45**
Emperor	Liki'i koango	L. nebulosus	0.00	297.30	128.00	188.50	78.00	**691.80**	**1287.50**
Emperor	Tanutanu	L. harak	165.80	1564.15	9371.61	3338.70	165.25	**14605.51**	**31250.70**
Emperor	Manga	Lethrinus spp.	0.00	1588.85	0.00	94.50	6.00	**1689.35**	**4319.85**
Filefish	Papae	Aluterus spp.	0.00	0.00	0.00	59.00	0.00	**59.00**	**173.75**
Goatfish	Vete	Mullidae	0.00	5.30	538.33	1229.15	0.00	**1772.78**	**4198.15**
Goatfish	Tukuleia	Parupeneus spp.	17.20	30.60	903.25	3877.83	13.85	**4842.73**	**12077.40**
Long tom	Haku	Tylosurus crododilis	3.70	11.50	105.83	0.00	0.00	**121.03**	**300.25**
Moray eel	Toke	Gymnothorax spp.	0.00	0.00	1.60	174.10	1.80	**177.50**	**469.25**
Parrotfish	'Ufu	Leptoscarus vaigiensis	96.00	0.00	8684.53	730.95	199.36	**9710.84**	**19606.90**
Parrotfish	Olomea	Scarus spp.	0.00	0.00	122.30	5623.25	0.00	**5745.55**	**12951.25**
Parrotfish	Pose	Scarus spp.	0.00	0.00	96.40	1996.30	9.20	**2101.90**	**5142.20**
Parrotfish	Hohomo	Scarus spp.	0.00	0.00	357.15	13898.85	370.55	**14626.55**	**36886.65**
Parrotfish	Sikatoki	Scarus spp.	0.00	0.00	0.00	698.35	21.60	**719.95**	**1876.15**
Parrotfish	Menenga	Bolbommetopon muricatum	0.00	0.00	0.00	273.15	0.00	**273.15**	**3730.15**
Pony fish	Sipesipa	Leiognathus spp.	23.70	1.40	4.40	30.90	0.00	**60.40**	**179.25**
Porcupine fish	Sokisoki	Diodon spp.	0.00	0.00	15.20	342.55	46.65	**404.40**	**955.85**
Rabbitfish	Ma'ava	Siganus argenteus	22.00	0.00	1772.45	5944.90	5.85	**7745.20**	**17341.40**
Rabbitfish	O	S. spinus	0.00	0.00	5340.60	90.15	31.20	**5461.95**	**10445.90**
Rabbitfish	Pongongo	S. chrysospilos	0.00	0.00	98.60	702.45	0.00	**801.05**	**2318.65**
Rock-cod	Ngatala	Epinephelus spp.	29.15	750.45	124.50	6317.48	172.90	**7394.48**	**19971.30**
Snapper	Fate	Lutjanus kasmira	23.20	428.15	690.95	363.30	30.40	**1536.00**	**3635.05**
Snapper	Fangamea	L. bohar	0.00	15.00	4.50	63.30	3.00	**85.80**	**259.50**
Sea bream (emperor)	Mu	Gymnocranius spp.	0.00	1420.85	0.00	126.20	6.00	**1553.05**	**4128.95**
Barracuda	'Ono	Sphyraena barracuda	0.00	98.70	0.00	85.00	0.00	**183.70**	**429.10**
Barracuda	Hapatu	Sphyraena spp..	46.20	187.10	216.65	123.70	0.00	**573.65**	**1389.65**
Sergeant	Tukuku moana	Abudefduf septemfasciatus	0.00	2.50	23.50	760.45	76.40	**862.85**	**2337.35**
Silver biddy	Matu	Gerres spp.	1231.90	0.00	941.15	370.20	0.00	**2543.25**	**6390.05**
Squirrelfish	Ta'a	Ostichthys spp.	4.80	118.70	60.10	2087.98	769.45	**3041.03**	**7745.55**
Squirrelfish	Telekihi	Sargocentron spp.	0.00	0.00	55.40	189.95	0.00	**245.35**	**609.95**
Squirrelfish	Malau	Myripristis spp.	0.00	9.60	35.40	234.00	613.25	**892.25**	**2087.30**
Surgeonfish	Pone	Acanthurus spp.	0.00	0.00	323.10	7456.90	3254.10	**11034.10**	**26407.00**
Surgeonfish	Ponetuhi	Acanthurus lineatus	0.00	0.00	0.00	536.00	97.20	**633.20**	**1326.50**
Sweetlip	Fotu'a	Plectorhinchus Chaetodontidae	0.00	20.70	13.50	1142.10	50.20	**1226.50**	**3501.60**
Trevally	Lupo	Caranx spp.	0.00	166.30	213.40	38.00	4.80	**422.50**	**872.80**
Triggerfish	Humu	Pseudobalistes fuscus	0.00	67.95	0.00	1844.15	21.30	**1933.40**	**4584.55**
Unicornfish	'Ume lei	Naso spp.	0.00	0.00	80.50	599.00	0.00	**679.50**	**1593.60**
Unicornfish	'Ume	Naso unicornis	0.00	0.00	271.20	10954.43	47.65	**11273.28**	**28688.70**
Wrasse	Tangafa	Cheilinus undulatus	0.00	0.00	0.00	169.00	0.00	**169.00**	**2408.50**
Wrasse	Meai	Thalassoma spp.	4.80	61.65	925.90	99.35	11.15	**1102.85**	**2393.85**
Wrasse	Lalafi	Cheilinus spp.	0.00	405.90	0.00	441.75	5.44	**853.09**	**2151.90**
TOTAL			**1,676**	**9,491**	**32,408**	**76,859**	**6,250**	**126,685**	**305,792**

Comparison of estimated 1993 landings, at Vuna and Faua, of the major fin-fish categories and reef fish in the Tongatapu artisanal fishery, is given in Table 2.4.5.

Table 2.4.5: Relative composition of reef fin-fishes with respect to other fin-fish categories landed at Vuna and Faua in the Tongatapu artisanal fishery in 1993. Figures are in kg.

Fish Group	March	April	May	June-December	10 Months Total	12 Months Total	Tongatapu Total	Percent
Mullet	118.22	177.33	458.40	1,258.20	2,012.15	2,415	3,219	0.83
Deep-water	33.98	15.08	0.00	1,094.55	1,143.61	1,372	1,8230	0.47
Oceanic pelagics	45.41	325.78	227.29	934.53	1,533	1,840	2,453	0.63
Rays	0.00	16.32	44.58		61	73	97	0.03
Reef fish	**7,823.26**	**18,004.81**	**16,409.45**	**126,130.62**	**168,368**	**202,042**	**269,389**	**69.43**
Shark	0.00	67.26	0.00	160.20	227	273	364	0.09
Small pelagics	1,223.68	5,010.98	5,955.98	7,606.55	19,797	23,757	31,676	8.16
Tunas	5,337.95	7,299.93	9,293.99	22,194.73	44,127	52,952	70,603	18.20
Unclassified	47.93	189.09	203.93	4,797.08	5,238	6,286	8,381	2.16

The data indicate that almost 70 per cent of the fish landed at the two main landing sites on Tongatapu during those months comprises of fish species categorized as shallow-water reef fish species. This confirms that reef fishes play a very significant role both at the artisanal and subsistence level fisheries.

No records could be located of an attempt made to estimate annual landings in Ha'apai and Vava'u, 'Eua, Niuatoputapu and Niuafo'ou, though Halapua (1981) estimated that the reef-lagoon fishery resources supply more than 70 per cent of the Ha'apai islands' total annual catch.

Recently, some middle-men paid T$2.00/kg for reef-fishes from Ha'apai, for use or sales in their restaurants or at Tongatapu markets for $2.50-$2.80/kg. Detailed species composition data is not available for these ventures. However, an estimated 42 mt were sold in 1993 which comprised mostly parrot-fish, rabbitfish, surgeon-fish, and a few unicornfish and emperors.

On 'Eua, Schuh (1981) estimated that spear fishing and other methods used on the reef contribute 16 per cent of the annual catch there.

Production from shallow reefs and lagoon has been estimated for the whole kingdom in a few references. These are summarized in Table 2.4.6.

Table 2.4.6: An estimated total annual shallow reef and lagoon landing for the whole of the Kingdom of Tonga

Resource Area	Year	Estimated Annual Landing (mt)	Landed Value ($T, 000)	Estimated Potential (mt)	Estimated Potential Value (T$, 000)	Reference
Inner reef and plateau	1982	1,600		2,600		Carleton, 1982
Shallow reefs & Lagoon	1989	1,757	5,271	2,000	6,000	Fisheries Annual Report, 1989 & DP6

2.4.3 Stock status

Even though there has not been an attempt to assess the stocks of various reef fish species and the collection of consistent time series landing statistics has only just begun, it is generally believed that the shallow-water reef fish resources could be over-exploited. Comparison of the estimated Tongatapu artisanal fishery catches in 1987 and the reef fish landings in 1993 indicates a substantial decrease in the 1993 landings. In addition, species composition has also changed, where in 1987, emperors were the main reef fish species caught in the artisanal fishery but the 1993 reef fish landings indicate parrotfishes as the major fish species landed. However, this could be attributed to a change in fishing gear used. In 1987, most of the catches were made by gillnets, whereas in 1993, most fish landed was caught by night diving. The increase in human population, utilisation of more effective, non-selective and even destructive fishing methods, and the lack of appropriate legislation, all have negative impacts on these resources.

The main objective of the Ministry of Fisheries Inshore Fisheries Project on Tongatapu, initiated in 1987, was to obtain the data necessary for the formulation of management guidelines for these fisheries (Felfoldy-Ferguson, 1988). Unfortunately, though a report for the first six months was produced, there was no report at the completion of the project.

The current Fisheries Statistics Program was started in 1993, and is still being revised to accommodate several difficulties both in the collection and database components. Once the system is fully established, it will take a few years before sufficient information will be available to undertake analyses of the catches of certain species, and provide information on stock status.

2.4.4 Management

It has been noted in many islands in the South Pacific, that increases in human population generally lead to increasing pressure on the more easily accessible marine resources, especially those in the shallow-water reefs and lagoons. The result is always over-exploitation especially if appropriate management of utilisation is absent. The increased use of more efficient modern fishing gears, such as fish weirs, nets, spearguns, hookah and SCUBA, is apparent. Dynamite is still used illegally to catch schools of mullet, scads, mackerels and sometimes reef fish.

Fisheries statistics, as well as stock assessment work, are of vital importance to efforts to manage the resources, and this should be treated as a priority area within the work programme of the Ministry of Fisheries. Experimental work has started in Fiji and Solomon Islands on the use of Underwater Visual Census (UVC) in the assessment of reef fish species stocks. This methodology offers a possible means of direct stock assessment research of reef fish.

Both SPC and FFA provide assistance in fisheries statistics and stock assessment work. In particular the FFA Research Coordination Unit will provide assistance to coordinate technical assistance consultancies in the areas of design, execution and documentation of inshore fisheries research, technology transfer and research collaboration, if requested.

Current legislation/policy regarding exploitation: The use of explosives, poison or other noxious substance for the purpose of killing, stunning, disabling or catching fish is prohibited under Section 21 of the Fisheries Act 1989. The penalty for violation of this section of the Act is a fine not exceeding $T1,000 or imprisonment for a period not exceeding 2 years or both.

Section 23 of the same Act quotes a fine not exceeding $T50,000 for the use of any net the mesh size of which does not conform to the described minimum mesh size. Section 22 authorizes the Minister to declare by Order any area of fisheries waters to be reserved for subsistence fishing operations. Violation under this section, is a fine not exceeding $T50,000.

Section 28 of the Act requires that those engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar such information relating to such fishing, processing, marketing or export activities and in such form as may be prescribed. Contravention of this section is a fine not exceeding T$10,000.

Recommended legislation regarding exploitation: Recently the use of hookah and SCUBA in spear-dive fishing operations is apparent, which has led to substantial increases in catches, especially of parrotfishes, unicornfishes and surgeonfishes. Blast fishing, though prohibited, is still practised in some areas.

Consideration should be given to minimize or even ban the use of hookah and SCUBA for spear-dive fishing. More effective measures to enforce restrictions on blast fishing are necessary.

Other areas that may need to be considered for regulations include:

* limiting the number of operating fish fences and mesh sizes in certain zones within the country;
* a requirement for those who sell fish and other marine organisms to have a permit, for a very minimal fee, for statistical purposes;
* a requirement for those who fish or buy and re-sell fish and marine products on a commercial basis, whether to the local market or for export, to submit all statistics involved in the operation to the Ministry of Fisheries (this may require the Ministry of Fisheries to issue receipt books to these operators for convenience of both the operators and the Ministry). This requirement is covered under Section 28 of the Fisheries Act 1989 but has not been enforced properly.

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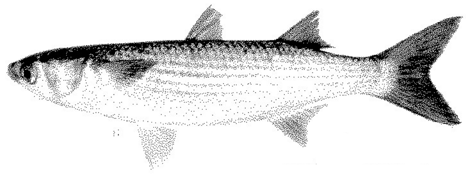
2.5 Mullet - *Kanahe*



Mugil cephalus

2.5.1 The Resource

Species: Seven species of mullet are present in Tonga, including, *Mugil cephalus* (sea or grey mullet), *Valamugil seheli* (bluespot mullet), *V. engeli* (Engel's mullet), *Liza macrolepis* (big-belly mullet), *L. vaigiensis* (yellowtail mullet), *L. melinoptera* (giantscale mullet), and *Crenimugil crenilabis* (warty-lipped or fringelip mullet).

In Tonga, several names are given for mullet, and these include, ***fua***, ***unomoa***, and ***kanahe***. On Niuatoputapu the marked growth stages of mullet, based on length, have specific names as listed below, from the smallest to largest: ***te'efo***, ***'aua***, ***'auapuna***, ***'aualele*** and ***kanahe*** (Dye, 1983).

Current relative abundances of the different mullet species in Tongatapu can be estimated from results of mullet fry collections conducted under one of the JICA aquaculture programmes within the Ministry of Fisheries. Between April 1992 and March 1993, a total of 4,543 specimens of mullet were collected using beach seine, from six points around Tongatapu, for the mullet culture project. The catch composition of the sampling was: *L. macrolepis* - 3,609 (79.4 per cent), *V. seheli* - 660 (14.5 per cent), *V. engeli* - 207 (4.6 per cent). These species represented 98.5 per cent of the catch. No juveniles of *M. cephalus* were collected at any of these sites.

Distribution: Sea mullet (*M. cephalus*) inhabits coastal waters and estuaries in tropical and temperate waters of all seas of the world, and are distributed mainly between the latitudes 42° N and 42° S. It has a strong tendency to school as juveniles, and during the spawning season, as adults. Juvenile schools commonly disperse over sand and mud flats of estuaries when feeding during high tide, but re-form on the ebb tide (Kailola *et al*., 1993).

During a one-year fry collection project by JICA and the Ministry of Fisheries between April, 1992 and March, 1993 at six different stations on Tongatapu, the following percentage composition of fry species by station, were recorded:

Station	% of Combined Fry Catch	*L. macrolepis*	*V. seheli*	*V. engeli*	*L. melinoptera*	*M. cephalus*	*M.* spp.	*C. crenilopis*
Nukuleka	34.2	86.55	9.85	1.54	1.74		0.32	
Navutoka	5.7	72.41	9.96	6.90	1.15			9.58
Nukunuku	24.6	97.58	1.61					
Watergate	8.9	10.59	65.52	23.89				
Muifonua	14.2	85.23	11.97	2.49				
Sopu	12.4	69.52	21.38	9.09				

A one-day mullet fry collection in October in Vava'u caught only *L. macrolepis* juveniles.

An annual mullet spawning migration starts from Fanga'uta Lagoon and moves around the western and eastern tips of Tongatapu to the spawning grounds on the exposed east and south-east coasts of the island (Langi *et al*., 1988).

Biology and ecology: Mullet feed on detritus, diatoms, algae and microscopic invertebrates in estuarine waters, which they filter from mud and sand through their mouth and gills (Kailola *et al*., 1993). Fish eggs may also be consumed (Randall *et al*., 1990). Most mullet species can tolerate a wide range of salinities, with some ranging into purely fresh-water, and are important in aquaculture. A few species are most at home on coral reefs (Myers, 1991).

Langi *et al*., (1988) reported that during a six month study from June to November in 1987, *M. cephalus*, *Liza* sp. and *V. seheli* were found to be reproductively active between June and September, and that the winter months (third quarter of the year) were a period of spawning. *M. cephalus'* spawning peak was recorded during July, while that for *Liza* sp. was in August. This was also the case in the findings of a one-year project from April 1992 to March 1993, as reported in Kawaguchi *et al*. (1993a). Reproductive activity was found to be related to the moon phases, with the highest recorded between the last and the first quarters of the moon. *M. cephalus* showed a clear reproductive peak during the new moon. Sex ratio (female to male) recorded for *M. cephalus* was 1.6:1 and 1.85:1 for *Liza* sp. Based on limited data available, the same authors postulated that there was sexual dimorphism between males and females of both species, *M. cephalus* and *Liza* sp., with females growing to larger sizes. Length-weight relation constants in the formula, $L=aW^b$, were calculated for the same species and are as follows:

Species	Sex	a	b	N
Liza sp.	M	$1.7x10^2$	2.89	8
Liza sp.	F	$1.3x10^2$	3.02	8
M. cephalus	M	$6.7x10^2$	2.54	10
M. cephalus	F	$4.0x10^2$	2.69	8

2.5.2 The Fishery

Utilisation: Mullet is the most highly esteemed fish in the diet of Tongan people (Langi *et al*., 1988) and is always sold out very quickly (Kawaguchi *et al*., 1993b). In a Pacific Island Development Program (PIDP) survey conducted in Vava'u in 1983, mullet (***fua, te'efo, kanahe***) was reported as one of the food items harvested from the tidal area (Kunatuba and Uwate, 1983a). No estimates of landing or consumption were made.

Traditionally, net fishing has been the most extensively used method, gaining the largest fish catches. Gill and cast nets have been in use for a long time in Tonga for both commercial and subsistence purposes (Sudo, 1990). Cotton and nylon twine nets have replaced the old traditional materials such as ***fau*** twine.

On Niuatoputapu, more fish are caught in nets than by any other method, and mullet is one of the main species caught (Dye, 1983). Cast nets are also used, mainly for catching bait for deep-water handlining. Mullet, small goatfishes and fry of other fish normally make up the catch. The dominant fish species caught in the ***kupenga toho*** are small goatfishes and mullet.

The mullet resource has been exploited in both the subsistence and artisanal fisheries. Ludwig (1979) reported that mullet was important in the local economy and that it is an important species when in season from late June to late September. However, the resource has been reported by local fishermen as dwindling both in numbers and size.

Langi *et al*. (1988) reported that almost 75 per cent of commercial landings of mullet consisted of *M. cephalus*, with most of the balance made up from *Liza* sp. The same authors reported that landings peak in July. During the six month survey in 1987 from June to November, the catches landed consisted mainly of *M. cephalus* which made up 70 per cent of the total. *V. seheli* and *Liza* sp. made up the rest.

Production and marketing: No figures are available on mullet production at the subsistence level.

Fishing for adult mullet is seasonal and gill nets and fish corrals (fences) are the main fishing methods used (Langi *et al*., 1988). Some details of both methods are described in both Zann (1981) and Fuka (1979). Zann describes the three types of nylon monofilament nets used in Tonga, with the most common ones having mesh sizes ranging from 3.8 cm to 9 cm. The three types of fish nets are ***fakamamaha***, ***fakamohe*** and ***tapo*** or ***silita***. Fish fence traps are made of small mesh (0.5 to 1.5 in) chicken wire using poles to hold it up. Fences are normally set on reef flats as a barrier to fish moving with the tide. Mullet is one of the main target fish species of dynamite fishing, which happens occasionally in Tonga. Fishing for juvenile mullet using cast nets occurs throughout the year (Langi *et al*., 1988). Fish traps were common within the eastern lagoon area in Fanga'uta, prior to the introduction of the Lagoon Protection Act. Immature mullet was a major portion of the catch (Tongilava, 1979).

Surveys conducted at the Vuna market in 1992 indicated that the three methods of catching mullet that were landed there include set net (fence using chicken wire), tidal set net (***uloa***) and dynamiting (Kawaguchi *et al*. 1993b). Great numbers of mature mullet were caught between May and August every year using set fish fences. Catches of mullet in the last two decades consisted mainly of *M. cephalus* and *V. seheli*, in good numbers. The surveys identified only two fishermen operating ***uloa*** on Tongatapu, using a total net length of more than 4 km. The number of mullet fishing operations using this method, was twenty times less than during the previous season, with their catches consisting mostly of *L. macrolepis*, *M. cephalus* and *V. seheli,* resulting in about 20 per cent reduction of their normal total catch. Mullet averaged 150-300 g each in weight with some specimens weighing more than 500g. Their usual catch reported during one fishing period was more than 100 mullet. Dynamiting is usually done in early morning and late evening. Most of the fish are not sold via the fish market, but are sold directly to restaurants and village people from a truck. Thus sampling was rarely possible.

Kawaguchi *et al* (1993a) reported that in the early 1960's when trapping by fence was first introduced to Tonga, a lot of mature mullet (mainly *M. cephalus* and *V. seheli*) were caught. However, the catches eventually declined.

Kunatuba and Uwate (1983b) estimated total sales of mullet in Tonga to be 5 per cent of the total 2,200 mt estimated fish production for 1983. This would put annual mullet landings at 110 mt. Prices at that time were set at T$2.50/kg by individual fishermen and T$1.40/kg at Vuna.

Wilkinson (1977) noted that mullet formerly accounted for about 40 per cent of all marketed fish. However, the resource was noted as rapidly declining in the early 1970's. Uchida (1978) also noted that mullet, *M. cephalus*, occur in abundance in the August-November period, and dominate landings at that time.

Kawaguchi *et al* (1993b) write that "in the last two decades, mullet was the main inshore fishery in the kingdom, where thousands of mullet were harvested in one fishing effort. But now, we can only catch a few hundred mullet in one whole season".

On Niuatoputapu, nets are used in 12 types of fishing. Of these, half have mullet as a commonly caught species (Dye, 1983). No figures were available.

Munro (1990) estimated total yearly landings (mt) in the late 1980's of major species in the Tongatapu artisanal inshore reef fishery, by different fishing gears, as recorded in Table 2.5.1. Mullet (*M. cephalus*) accounted for 17 per cent (140 mt) of the total.

Table 2.5.1: Relative species total annual landings (in mt) by major species in the Tongatapu inshore reef fishery (Source: Munro, 1990)

Species	Gillnet	Handline	Spear	Other	TOTAL	%
Mugil cephalus	**81.85**	**0.00**	**0.00**	**58.18**	**140.03**	**17.0**
Lethrinus nebulosa	12.39	76.34	105.94	0.56	195.23	23.7
L. elongatus	3.37	27.44	38.08	0.00	68.90	8.4
Sargocentron spiniferum	11.62	10.49	14.56	0.14	36.81	4.5
L. ramak (now *L. obsoletus*)	0.70	10.87	15.08	0.17	26.82	3.4
Leptoscarus vaigiensis	21.31	0.00	0.00	0.81	22.12	2.7
Trichiurus lepturus	19.47	0.00	0.00	0.00	19.47	2.4
Parupeneus pleurotaenia	12.79	0.00	0.00	5.39	18.18	2.2
L. harak	1.94	6.05	8.40	0.51	16.90	2.1
Selar crumenophthalmus	9.48	0.00	0.00	3.62	13.10	1.6
Siganus argenteus	11.02	0.00	0.00	0.78	11.80	1.4
Mulloidichthys vanicolensis	9.08	0.00	0.00	2.53	11.61	1.4
Rastrelliger kanagurta	11.45	0.00	0.00	0.00	11.45	1.4
Lutjanus fulviflamma	4.94	2.02	2.81	1.14	10.92	1.3
Leiognathus equula	7.98	0.00	0.00	2.21	10.20	1.2
Sphyraena forsteri	3.94	1.86	2.58	0.45	8.83	1.1
Gymnocranius japonicus	0.70	3.10	4.30	0.00	8.10	1.0
Mulloidichthys flavolineatus	6.95	0.00	0.00	0.81	7.76	1.0
Other species	102.98	24.98	34.67	22.92	185.52	22.3

TOTAL	334	163	226	100	824	100

Results of a one week survey at Vuna and Faua landing sites in April, 1992 were reported in Udagawa and Tulua (1992) . The weekly totals were used to estimate annual landings using a 50-week year, which came to 499.2 mt, valued at T$1.248 million. Of this, mullet comprised 3.9 per cent, thus, 19.47 mt valued at T$48,672 for that year.

Improvement in the data collection system, frequency and duration covering more months for the Vuna and Faua artisanal surveys in 1993, have led to better estimates at the two landing sites. Mullet catch estimates (kg) from these surveys for the period March-December are recorded in Table 2.5.2 as recorded under different Tongan names.

Table: 2.5.2: Estimates of mullet landings at Vuna and Faua in the Nuku'alofa artisanal fishery, 1993. (Sources: Data for March to May were from Udagawa, JICA, and the June-December data were from the Ministry of Fisheries database).

Mullet	March	April	May	June-December	10 Months Total	12 Months Estimated Total	Estimated Annual Tongatapu Total
Fua (kg)	118.22		55.02	43.00	**216.24**	**260**	**347**
Kanahe (kg)				404.05	**404.05**	**485**	**647**
Unomoa (kg)		177.33	403.38	731.75	**1,312.46**	**1,575**	**2,100**
Te'efo (kg)				79.40	**79.40**	**95**	**127**
Total (kg)	**118.22**	**177.33**	**458.40**	**1,258.20**	**2,012.15**	**2,415**	**3,220**

All of these catches were made from nets and fish fences.

Comparison of estimated landings, at both sites, of the major fin-fish categories and mullet for 1993 is given in Table 2.5.3. Based on the results of interviews conducted by the Ministry of Fisheries, the total estimated landing of the combined fin-fishes at these two sites is estimated to be 75 per cent of the total Tongatapu fish landings (Udagawa, *pers. comm*., 1993). The estimated Tongatapu total landings are given in the "Tongatapu Total" column.

Table 2.5.3: Artisanal fishery fish landings at Faua and Vuna comparing the different fish groups. The total Tongatapu landing has been estimated. Figures are in kg except those under the Percent column.

Fish Group	March	April	May	June-December	10 Months Total	12 Months Total	Tongatapu Total	Percent
Mullet	**118.22**	**177.33**	**458.40**	**1,258.20**	**2,012**	**2,415**	**3,219**	**0.83**
Deep-water	33.98	15.08	0.00	1,094.55	1,144	1,372	1,830	0.47
Other pelagics	45.41	325.78	227.29	934.53	1,533	1,840	2,453	0.63
Rays	0.00	16.32	44.58		61	73	97	0.03
Reef fish	7,823.26	18,004.81	16,409.45	126,130.62	168,368	202,042	269,389	69.43
Shark	0.00	67.26	0.00	160.20	227	273	364	0.09
Small pelagics	1,223.68	5,010.98	5,955.98	7,606.55	19,797	23,757	31,676	8.16
Tunas	5,337.95	7,299.93	9,293.99	22,194.73	44,127	52,952	70,603	18.20
Unclassified	47.93	189.09	203.93	4,797.08	5,238	6,286	8,381	2.16

Kawaguchi *et al*. (1993b) noted that a mullet string, weighing about 2.6-2.8 kg, would sell at Vuna market for T$10.

2.5.3 Stocks status

Almost all of the literature cited in this section points to the fact that mullet populations have been on the decline since the 1970's. Limited stock assessment work has been conducted, but the limited statistics available certainly confirm the vast decline in mullet landings. Sudo (1990) noted that grey mullet and giant clams were at an almost destroyed condition due to reckless fishing. Furthermore, the poor mullet catches in 1990 have lead to a 50 per cent decrease in the use of gill nets for fishing, in general, as compared to 1978.

Increasing concern about the noticeable decrease in fishery productivity in the Fanga'uta lagoon during the 1960's and 1970's resulted in a survey being conducted in 1979. The results indicated that the marked decrease in fishery productivity was due essentially to overfishing (Ludwig, 1979). A 3-year survey was initiated in 1978 to determine the importance of Fanga'uta Lagoon in the Tongatapu mullet fishery. Ludwig (cited above) reported that the results obtained indicated that the lagoon plays a key role in the mullet life cycle, in that the adult mullet enter the lagoon every year around June-July for a "pre-spawning" activity, then leave in schools and spawn mostly in the Liku coastal area. The lagoon also serves as nursery and feeding grounds.

Wilkinson (1977) reported that the situation where mullet accounted for about 40 per cent of all marketed fish, rapidly declined in the early 1970's. This decline was attributed to the introduction of fish fences some time before 1965. The concern generated by such a marked decline led to the banning of the use of fences and commercial fishing within the Fanga'uta Lagoon. However, Zann (1981) noted that some traps were still effectively blocking the entrance of the lagoon.

Kawaguchi *et al*. (1993b) noted that mullet was the dominant fish in Tonga's inshore fishery two decades ago, when thousands of them would be harvested during one fishing period as compared to a few hundred in one season today.

Kunatuba and Uwate (1983) estimated total mullet sales for 1983 to be 110 mt while Munro (1990) estimated that 140 mt of mullet were landed in the Tongatapu artisanal fishery. Only 19.47 mt was estimated by Udagawa and Tulua (1992) as the catch landed in 1992 at Vuna and Faua on Tongatapu. Extrapolation of 1993 survey figures indicated only 3.2 mt were landed for the year on Tongatapu.

Mullet species composition in the catch has also greatly changed. *M. cephalus* and *V. seheli* were reportedly the main species from the early 1960's until just prior to 1990.

Mullet fry collection conducted in 1990-1991 indicated that *M. cephalus* make up 20 to 40 per cent of the catch (Enomoto, 1993, *pers. comm.*). However, a recent (1992-1993) mullet fry survey conducted in six different sites on Tongatapu indicated *L. macrolepis* as the dominant species. A total of 4,543 mullet fry were collected during the survey period and the results were as follow: *L. macrolepis* (79.4 per cent, 3,609), *V. seheli* (14.5 per cent, 660), *V. engeli* (4.6 per cent, 207) and the other four species make up 1.5 per cent (67). No fry of *M. cephalus* were recorded in the 1992-1993 collection. *M. cephalus* therefore seems to be on the verge of local extinction in Tonga.

In addition to the above, the average sizes of the mullet caught today seem to has diminished. Kawaguchi, (1993b) reported that the average mullet weight caught with tidal set net in 1992 was 150-300 g with very few specimen weighing more than 500 g.

2.5.4 Aquaculture of Mullet in Tonga

A culture trial of mullet (*M. cephalus*), milkfish (*Chanos chanos*) and tilapia (*Oreochromis mossambicus*) was conducted in Sopu Lagoon starting in 1974. Located west of Nuku'alofa, Sopu Lagoon has an area of approximately 50 ha, and in earlier times was an extension of the Fanga'uta Lagoon (Ludwig, 1979). Good results were obtained for *C. chanos* in the 1974-1975 period but no further developments were made.

In an effort to create a new fishery within Lake Ano, Tu'anuku, Vava'u, the Ministry of Fisheries, with financial assistance from South Pacific Aquaculture Development Programme (SPADP), introduced 10,000 *M. cephalus* fry from the Oceanic Institute Hatchery in Hawaii, and stocked them into the lake in June 1990. Survival rate upon releasing into the lake was 95 per cent, with fish having an average fork length and weight of 33 mm and 12 mg respectively. In September, 1991, 16 months after stocking, 30 mullet were collected and measured for growth data. Average fork length and weight recorded were 28.07 cm and 302.3g. The Ministry of Fisheries estimated the number of mullet surviving to 1992 in the lake to be 6,000-7,000. Another shipment of fry from the Oceanic Institute was planned by SPADP in 1991, but fry was not available. The Ministry of Fisheries plans to continue stocking the lake using fry collected locally from the wild. However, there is some reluctance to do this, because, of the high probability of introducing other mullet species.

A mullet hatchery was considered but costs and expertise availability were considered prohibitive. There is presently no plan to restock Lake Ano, due to insufficient funds and lack of manpower (Fa'anunu, 1993, *pers. comm*.). However, results of a preliminary depth survey of the lake indicated that more than half of the lake has depths of more than 50 m (Enomoto, 1993, *pers. comm*.). These areas are not suitable for mullet culture. Suitable depths in the lake have been estimated to allow stocking of 30 to 40 thousand mullet fry.

A five year JICA project, Aquaculture Research and Development Project, was initiated in October 1991 at the Ministry of Fisheries. JICA assistance include provision of funds and expertise in various fields. Five long-term JICA experts in fish-culture, seed production, shellfish culture, stock survey and a coordinator, work for the project. The project started with the renovation of the existing land-based mariculture facilities at the Ministry of Fisheries complex that were damaged by Cyclone Isaac in 1982.

The main project purpose is to strengthen aquaculture and resource assessment capabilities at the existing mariculture centre in Tonga, and that technical cooperation would be implemented through technical guidance and advice to the Tongan counter-part personnel, in the following fields:

i. Biological and ecological research on natural stocks to identify distribution, spawning season, seasonal occurrence, growth rates, etc
ii. identification and development of proper methods of natural seed collection.
iii. examination of economic feasibility of mullet culture in tanks (nursery) and pen-culture system (grow-out).

Fish species targeted initially include, mullet, rabbitfish and milkfish, with priority placed on mullet.

At the request of the Tonga Government, research on the culture of mullet has been established as the first priority of fin-fish culture under this programme (Enomoto, 1993, *pers. comm*.).

The mullet fry collection survey initiated in 1992, continued in 1993 (Fa'anunu, 1993, *pers. comm*.). Preliminary results indicated August-October as the best period for fry collection and that *L. macrolepis* make up 90 per cent and *V. seheli*, 10 per cent, of the catches. Fry of *M. cephalus*, the original target species because of its fast growth rates in culture systems, did not appear in any of the fry catches.

In October 1992, 5,000 fry, consisting of *L. macrolepis* (90 per cent) and *V. seheli* (10 per cent), were collected from the wild in a two-day exercise. These were stocked in a nursery pen constructed in Fanga'uta Lagoon. The fry were healthy and grew well on a supplementary diet of mashed pumpkin mixed with flour and fishmeal (Fa'anunu, 1993, *pers. comm*.). However, the pen was damaged by Cyclone Kina in January 1993, and the juveniles escaped.

Four fish pens, each with an area of 0.25 acres, were constructed in the lagoon in 1993. A total of 6,000 mullet fry and fingerlings, consisting of *L. macrolepis* (90 per cent) and *V. seheli* (10 per cent), were stocked into these pens in September-October, 1993. A one-day collection on Vava'u in October, 1993, caught 200 *L. macrolepis* fry. Natural foods in the pens have been supplemented with cassava powder fed twice a week at 5-6 per cent of the estimated fish biomass (Enomoto, 1993, *pers. comm*.).

Feeding experiments planned include, comparison of performances with cassava powder, processed waste wheat from the brewery, pumpkin and processed copra. The results of these pen culture experiments will determine whether importation of *M. cephalus* fry will be necessary for the assessment of mullet pen culture in Tonga.

2.5.5 Management

Mullet has always been an esteemed food fish in Tonga, and has been a major fin-fish resource, forming a very important component of the subsistence and artisanal inshore fisheries before the 1990's. However, the mullet resource in Tonga, especially *M. cephalus*, has unfortunately become an example of the effects of over-exploitation through the use of very effective, non-selective fishing methods and absence of management strategies. The non-appearance of *M. cephalus* fry in the 1992-1993 collection expeditions conducted by the Ministry of Fisheries could be an indication of severely depleted stock status of this species.

Current legislation/policy regarding exploitation: Operation of a fish fence requires a permit in Tonga. Commercial fishing within the Fanga'uta Lagoon and other Marine Reserves within the kingdom is prohibited. Section 21 of the Fisheries Act prohibits the use of explosives, poison or other noxious substance for catching fish. Section 59 of the same Act authorizes the Minister to make regulations for the implementation of the purposes and provisions of the Act. One of the areas mentioned is the regulating of the setting of fish fences.

Recommended legislation/policy regarding exploitation: The draft Fisheries (Conservation and Management) Regulations proposes the closure of fishing for mullet in Fanga'uta Lagoon from 1 June to 31 July. Rigorous enforcement of the existing laws, e.g. dynamite fishing, is necessary. Additional considerations could include:

* limiting the number of fish fences that can be set up in various zones along the country's coastline;
* imposing a minimum size limit for mullet offered for sale;
* controlling the use of cast nets, by limiting numbers.

The long term objective of the current experimental culture of mullet is not yet apparent. Consideration must be given to the effects on the ecology of the lagoon, with increases in the number of structures for pen culture. Placement of structures in shallow waters, like those of Fanga'uta Lagoon, can be expected to accelerate siltation. Excessive application of artificial feeds have known to produce detrimental effects in shallow water bodies.

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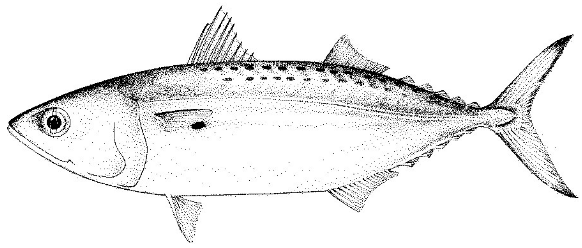
2.6 Small pelagics (Bait-fishes)

2.6.1 The Resource



Rastrelliger kanagurta

Species present: Most of the species discussed in this section include those which are normally considered as bait-fish for the skipjack pole-and-line fishery. Some species form an important component of both the subsistence and artisanal local fisheries.

Small pelagic species reported from Tonga include the following, which have been categorized into common family names as defined by Dalzell (1993):

Anchovies : *Stolephorus devisi* (gold anchovy).

Flyingfish: : *Cheilopogon unicolor*, *C. antoncichi*, *C. spilonotopterus*, *C. atrisignis.*

Fusiliers : *Caesio diagramma*, *C. chlorurus*.

Half-beaks : Hemirhamphidae (***hu'ila***)

Herrings : *Herklotsichthys quadrimaculatus* (gold spot herring - ***ulukau***), *Allanetta forskali* (round herring - ***hulî***), *Harengula ovalis* (herring - ***ulukau***).

Mackerels : *Rastrelliger kanagurta*.

Round herrings : *Dussumieri acuta.*

Sardines : *Amblygaster sirm* (spotted sardinella - ***satini***), *Sardinella* sp. (*aurita*?) (blacktip sardine - ***satini***).

Scads (roundscad : *Selar crumenopthalmus* (bigeye scad - ***'otule matafolahi***), *Atule mate* (yellowtail scad - ***'otule***), *Decapterus macrosoma* (scad - ***'otule kau***), *D. macarellus* - ***'otule kau***), *D. russelli*.

Silversides : *Athrrinomorus lacunosus* (broad-band silverside - ***helî***), *Hypoatherina ovalaua* (ovalaua silverside - ***helî***), *Atherinomorus lacunosa (=Pranesus pinguis*).

Sprats : *Spratelloides delicatulus* (blue sprat), *S. gracilis*, (*S. japonicus?).*

Distribution: Dalzell (1993) gives some details of the distribution of the small pelagics in the South Pacific. The smaller gracile stolephorid anchovies, particularly *E. heteroloba* and *E. devisi* and the sprats, *S. gracilis* and *S. delicatulus* (and *S. lewisi* in the waters of PNG and Solomon Islands) are found in the coastal lagoons of the coralline areas. The larger anchovies, including *Thryssa balaema*, *T. setirostris* and the larger stolephorids such as *S. indicus* and *S. waitei,* are often found in lagoons and passages that are bordered by mangroves. The fusiliers' (*Caesio* and related genera) distribution is determined largely by the extent of coral cover, which is associated with shallow coastal water (<30 m depth). The mackerels (*Rastrelliger* spp) occur further offshore whereas the roundscads (*Decapterus* spp.) are found between the neritic and oceanic areas, with flying fishes inhabiting both inshore waters and open ocean (Dalzell and Lewis, 1989). Kovalevskaya (1982, quoted in Gillett and Ianelli, 1993) notes that flyingfish species common in the tropical Pacific have limits of distribution bounded by 40° S and 40° N. Gillett and Ianelli (1993) note that depth at which flyingfish occurs affect the catchability in night surface fisheries. During the night, flyingfish is distributed as deep as 18 m with about 86 per cent found in the first 0-2 m layer (Nesterov and Bazanov, 1986, quoted in Gillet and Ianelli, 1993).

The shallow reef, lagoons and inshore pelagic zone in Tonga is quite rich with small pelagic species of mackerels and sardines (Fisheries Division, 1989). Tuna Programme (1983) gave the history of baitfishing in Tonga, listing species caught in areas assessed. The listing is summarized in Table 2.6.1 for areas sampled, vessel name and agency, sampling dates, species caught (occurrence) and method used, with additional information obtained from various sources.

Table 2.6.1: Baitfishing conducted in Tonga.

Survey Location	Vessel/Agency	Survey Dates	Method used	Time	Other Information	Main Species
??	Tonga Fisheries Division	mid-1954	beach seine	night		Large *Selar* sp. *Rastrelliger* sp. *Caranx* sp.
Ha'apai (Lifuka Is)	as above					*Spratelloides* sp. *Allanetta* sp.
Koko	as above	as above	as above	night		*St. devisi* *Atule mate* *H. ovalaua* *A. lacunosa* *Sp. gracilis* *Sp. delicatulus*
Neiafu Harbour	as above	as above	bouki-ami	night		*Se. crumenophthalmus* *H. quadrimaculatus* *Sa. sirm* *H. ovalaua* *A. lacunosa* *Sp. delicatulus*
Neiafu wharf (Port of Refuge)	as above?	Jan-Apr 1976		night	Ref: Anon. (1977) translated by Tamio Otsu, NOAA, 1980.	*Allanetta* sp. *Sp. delicatulus* *Rastrelliger kanagurta* *Decapterus* sp. *Harengula* sp. *Stolephorus* sp. *Etrumeus* sp. *Caranx* sp.
Nomuka Is	as above					*Spratelloides* sp.
Nuku'alofa Harbour	Hatsutori Maru No. 1 /SPC	April-May 1978	bouki-ami	night		*Sardinella sirm* *Gazza minuta* Scomberoides sp. *Atherinomorus lacunosa* *H. punctatus* *Dussumieria acuta* *Sp. delicatulus* *Selar crumenophthalmus* Species of Priacanthidae
Pangai Motu	as above	as above	beach seine	day		*A. lacunosa* *H. ovalaua* *Sp. delicatulus* *Caranx* sp. Sp. of Tetrodontidae *Mullodichthys samoensis*
Pangaimotu, Kapa Tapana Utungake	as above	Oct. 1976 - May., 1977	seine	day		good quality bait
Tapana Island	as above	as above	beach seine	day		*A. lacuosa* *H. ovalaua* *Sp. delicatulus* *Se. crumenophthalmus* Sp. of Synodontidae *Caranx* sp.
Tongatapu Nomuka Vava'u	Albatross/US Fish Commission	Dec., 1900	beach seine	day day day		mostly Mugilidae Hemirhamphidae Various
Tongatapu (Pangaimotu)	TROPAC FAO-70 KAHIKAHI /FAO	Sep & Oct 1975	lift net			*Spratelloides* spp. *Allanetta* spp. *Harengula* spp.
Vaimalo	as above	as above	as above	night		*Sp. delicatulus* *A. lacunosa* *Hypoatherina ovalaua* *St. devisi* *H. duadrimaculatus* *Se. crumenophthalmus*
Vava'u	Surugu Maru No.1 /Kyokuyo Hogei Ltd.	April-May, 1965	bouki-ami	night		*Sardinella* sp. Atherinidae *H. quadrimaculatus*
Vava'u	Kahikahi/Fisheries Division	Jan. 1977-Feb. 1978	lift net	night		Atherinidae *H. quadrimaculatus* *Sp. delicatulus* Stolephorus sp.
Vava'u	Hakula/Fisheries Division	Jul. 1978 - Jan. 1979	lift net	night		as above
Vava'u	Takuo/Fisheries Division	Jul. 1978 - Apr. 1980	bouki-ami	night		as above
Vava'u	Hatsutori Maru No.5 /SPC	Mar. 1980	bouki-ami & beach seine	night		*S. deliculatus* Atherinidae *H. quadrimaculatus*

Table 2.6.1 cont.

Vava'u	as above	as above	as above	day		*S. deliculatus* Atherinidae
Vava'u	M.V. Albacore/PIMAR (Tonga)	Apr 1992-Dec. 1993	purse seine	night	first four species accounted for 85%, by weight, of the total catches	*Amblygaster sirm* *D. macarellus* *D. macrosoma* *Herklotsichthys* sp. *Sadinella* sp. *A. mate* *Se. crumenophthalmus* *A. lacunosa* *H. ovalaua*
Vava'u (Neiafu Bay) Ha'apai (Lifuka Is) Tongatapu (Malinoa Is) Nomuka Is	Kuroshio Maru No. 72 /JAMARC	Nov., 1972	blanket net,	night	catches only made in Neiafu Bay	Atherinidae *H. quadrimaculatus* (*Harengula ovalis*)
Vava'u (Neiafu Bay)	Akitsu Maru No. 20 /JAMARC	Dec., 1973 Jan., 1974				*Allanetta* sp. *Harengula ovalis* *Spratelloides* sp. *Selar* sp. jack mackerel anchovies
Vava'u (Pangaimotu)	as above	Jan., 1974	common dip net bouki-ami			jack mackerel *Allanetta* sp. *Spratelloides* sp. anchovies *Leiognathus*
Vava'u bays	baitfishing raft/as above	Mar., 1976-May 1977	-lift net with underwater lamps -beach seine for day	night day		*Sp. japonicus* (*delicatulus*?), *A. forskali* (Atherinidae?) *H. ovalis* (*H. quadrimaculatus*?) *Se. crumenopthalmus* *Decapterus* sp.

Judging from the presence on many inlets and reefs on Vava'u, JAMARC (1974) noted that the group should have abundant baitfish resources. A project on baitfish assessment for small-scale longlining was conducted in the Vava'u area by RDA International, under USAID funding, for the Ministry of Fisheries from 1992 to early 1994.

On Ha'apai, the bigeye scad (*S. crumenophthalmus*) occurs seasonally, and smaller mackerel or scads are caught within reefs and lagoons using gill-net and handlining techniques (Halapua, 1981). Schuh (1982) indicated approximate times of the year that horse mackerel (which he listed as ***'otule*** - *S. crumenophthalmus*) is found in 'Eua waters as January to April. He listed ***'otule*** as one of the fish species found commonly in 'Eua waters. ***Tau 'otule*** is a nocturnal activity on Niuatoputapu (Dye, 1983). The halfbeaks (***hu'ila***) is one of the fish species caught in ***kupenga fakamamaha*** while catch is limited to this species using the ***fakapoa*** (bait, grated coconut, and seine net). The mackerel (*R. kanagurta*) and bigeye scad (*S. crumenophthalmus*) occur seasonally throughout the Tonga Group. [During the field work for this document in October, 1993, large catches of '***otule*** were observed being landed at Vuna wharf.]

Biology and ecology: Most studies on the small pelagic fishes in the Pacific have concentrated on the species that are important to the pole-and-line fishery, which include anchovies, sprats and clupeids. However, "the biology of the small mackerels, flying fishes, scads and halfbeaks has tended to be neglected in the region" (Dalzell, 1993). But one important study was conducted by Conand (1986) on the biology and ecology of the larger small pelagic fishes and the smaller clupeoid species in the lagoon of New Caledonia (quoted in Dalzell, 1993). Based on their life history parameters, Conand (1986), Lewis (1990) and Dalzell (1993) separated the tropical small pelagic fishes into three groups as follows:

Group	Life cycle	Size	Growth	Age sexual Maturity	Spawning period	Batch fecundity
1	< 1 year	7-10 cm max	rapid	3-4 months	extended period	500-1500 oocytes/grm of fish
Species: Stolephorid anchovies (*E. heteroloba*, *E. devisis*, *E. punctifer*), Sprats (*S. gracilis*, *S. delicatulus*, *S. lewisi*) and Silverside (*Hypoatherina ovalau*)						
2	1 to 2 years	10-24 cm max	-	towards end first year	restricted seasonal	300-500 oocytes/grm of fish
Species: Herring and sardines (*Herklotsichthys* spp., *Amblygster* spp., *Sardinella* spp.), Larger anchovies (*Thrissina* spp.,*Stolephorus*spp), Sharp nosed sprats (*Dussumieris* spp.).						
3	2-5 years	20-35 cm max	-	-	restricted seasonal	400-600 oocytes/grm of fish (50-100 for flying fish)
Species: Round scads (*Decapterus* spp), Big eye scads (*Selar* spp), Small mackerels (*Rastrelliger* spp), Flying fish (Exocoetidae), Half beaks (Hemiramphidae).						

Tropical flyingfishes grow rapidly with many species spawning several times per year. Small species spawn between 400 and 1,100 eggs at a time, with the larger forms in certain species in the genera *Cheilopogon*, *Cyselurus*, and *Hirundichthys*, having fecundity ranging between 16,000 and 24,000 eggs (Gillett and Ianelli, 1993; Kovalevskaya, 1982, quoted in Gillett and Ianelli, 1993).

Dalzell (1993) gave a summary table for the growth, mortality and maturity parameters for a number of small pelagic fish species in the South Pacific, and is reproduced in Table 2.6.2. The parameters calculated for Tonga, only for those species listed, are also included, for comparison.

Table 2.6.2: Biological parameters for some small pelagic fish species in the South Pacific.

Species	Location	L∞(cm)	K (yr^{-1})	M (yr^{-1})	t_{max} (year)	Lm (cm)	$L_m/L\infty$	Ref
Encrasicholina heteroloba	PNG	7.9	2.6	4.9	1.0	5.1	0.65	Dalzell (1984)
Stolephorus waitei	PNG	10.9	1.7	3.4	1.5	7.3	0.67	Dalzell (1987, 1989)
Spratelloies delicatulus	Fiji	7.3	4.6	6.9	0.4	4.0	0.55	Dalzell *et al* (1987)
Atherinomorus lacunosus	New Cale	11.4	2.5	4.1	1.2	8.5	0.75	Conand (1988)
Herklotsichthys quadrimaculatus	Fiji	12.6	2.0	3.5	1.6	9.5	0.75	Dalzell *et al* (1987)
Herklotsichthys sp.	Vava'u, Tonga	14.7	1.30	2.0		16.0		King *et al.* (1994)
Amblygaster sirm	New Cale	22.9	1.5	2.4	2.0	15.0	0.66	Conand (1988)
	Vava'u, Tonga	23.2	0.97	1.5		270		King *et al.* (1994)
Decapterus russelli	New Cale	24.9	1.3	2.1	3.0	18.0	0.72	Conand (1988)
Selar crumenophthalmus	Hawaii	27.0	2.57	3.4	2.0	23.0	0.85	Kawamoto (1973)
Rastrelliger kanagurta	New Cale	23.7	3.0	3.7	1.0	20.0	0.87	Conand (1988)

Gillett and Ianelli (1993) note that flyingfish in the tropics generally live to about 2 years of age and are mature after 10-14 months. In addition, many of the commercially important flyingfish species from the genera *Hirundichthys*, *Cypselurus*, and *Cheilopogon* grow to about 20-25 cm and attain weights of 300-450 g.

Most of the small pelagics are considered planktivorous, though scads, mackerel and the larger anchovies feed on small fishes. For flyingfishes, their food consists mainly of large zooplankton and small fish (Gillett and Ianelli, 1993). Flyingfish fall prey to skipjack tuna and large pelagics in the Pacific islands as well as yellowfin tuna as recorded in the eastern Pacific (South Pacific Commission, 1980-1985; Olson and Boggs, 1986, quoted in Gillett and Ianelli, cited above).

The only biological information available for small pelagic species found in Tonga, are those from the baitfish assessment research conducted by RDA International (Tonga) in Vava'u from 1992-1993. Preliminary results, for the first four months, were reported in Hurrell (1992) and are reproduced below, noting that an arbitrary age of one month was allocated to the first mode of each species and the relative age of each successive mode taken from the first mode:

Species	L∞(mm)	K (month)	K (year)	Mode mean length (mm)	Estimated Age (months)
Amblygaster sp.	236	0.252017	3.02421	144.2 171.0 190.7	1.00 2.63 3.00
D. macrosoma	224	0.200199	2.40239	165.0 172.1 190.0	1.00 1.70 3.77
D. macarellus	281	0.297047	3.56456	229.55 233.00 257.50	1.00 1.70 3.77

Estimates of biological parameters at the completion of the project are reported in King *et al* (1994) for the four major species. The summary of this information is reproduced from that reference and given in Table 2.6.3.

Table 2.6.3: Biological parameters on the four major baitfish species caught during the RDA International baitfish assessment research in Vava'u, Tonga, 1992-1993 (Source: King *et al*., 1994).

	Amblygaster sirm	***Herklotsichthys* sp.**	***Decapterus macrosoma***	***Decapterus macarellus***
REPRODUCTION				
spawning period	March			Feb. ??
mean length at first reproduction (mm)	200			259
RECRUITMENT				
recruitment period	Mar-May	Mar-Apr?	Sep-Feb?	Mar-Apr?
GROWTH/SIZE				
K (yr^{-1})	0.97	1.30	1.21	1.29
$L\infty$(mm)	232	147	151	296
$W\infty$(g)	169	46	180	341
mean length (mm)	197	118	175	227
maximum length (mm)	270	160	270	305
mean weight (g)	98	23	60	149
maximum weight (g)	283	60	225	374
WEIGHT/LENGTH RELATION (g/mm)				
a (in $W=aL^b$)	0.0000018	0.0000087	0.00000088	0.0000063
b (in $W=aL^b$)	3.37	3.10	3.05	3.13
MORTALITY (yr^{-1})				
total mortality, Z	2.4	3.4	2.9	2.5
natural mortality, M	1.5	2.0	1.9	2.0
fishing mortality, F	0.9	1.4	1.0	0.5
exploitation rate	38%	41%	35%	20%%
YIELD				
optimum fishing mortality	1.8	2.5	1.8	1.7
present fishing mortality	0.9	1.4	1.0	0.5
Percent of optimum (%)	50	56	56	29

2.6.2 The Fishery

Utilisation: Some small pelagic species formed an important portion of the subsistence fishery in Tonga prior to the introduction of modern fishing methods such as gillnets, fish weirs and dynamites. No information could be located that documents traditional catching of flyingfish in Tonga. Dye (1983) reported that absent from the Niuatoputapu repertoire are such widely distributed fishing strategies as snaring, flying fish netting, dip netting and shark noosing. However, ***tau 'otule*** is practised. This is the catching of the scad, S. *crumenophthalmus*, using baited hooks and a pressure gas lamp suspended above the boat anchored at depths of about 17 fathoms. The bait is normally the intestines of small goatfishes and the lamp light attracts the '***otule***. The halfbeaks is one of the fishes caught in the ***kupega fakamamaha,*** which involves setting a seine net in the shape of a "C" with each end anchored near the shore or on a shallow spit of reef rock at high tide (Dye, cited above). The net is often set at night in anticipation of an early morning low tide. As the tide goes out, the net acts as a barrier to fish trying to flee. The fish are harvested at low tide. ***Fakapoa*** is a method that utilizes a net and bait (grated coconut) to specifically catch halfbeaks (***hu'ila***). The method is employed just off the windward reef where the bait is used to attract halfbeaks. The seine net is set surrounding the feeding fish and is scooped up at will.

Apart from their use at the subsistence level, the small pelagic fishes, although mostly seasonal in abundance, form a significant contribution in the artisanal fishery. Dye (cited above) listed ***'otule*** as one of the polytypic ***ika*** taxa that is economically important on Niuatoputapu. On 'Eua, ***'otule*** is also used as bait for pelagic hand-line night fishing for the large tunas, jacks and jobfish (Schuh, 1982). The ***'otule*** caught in the ***tau 'otule*** fishery method mentioned above are often used as live bait for catching larger predator fish species such as trevallies, snappers, barracuda and sharks. The revised classification of species for the Ministry of Fisheries Inshore Fisheries Statistics project, targeting inshore fish landed in Nuku'alofa at Vuna and Faua landing sites, indicated ***'otule*** (horse mackerel) as one of the most important fish species (Class 1). The classification has been made in accordance with the amount landed by the artisanal fishery.

Attempts have been made to assess the availability of live baitfish resources in Tonga for use in the commercial pole-and-line fishery for skipjack. Locally caught live bait have been used both by the Ministry of Fisheries operated and research fishing vessels. The recent baitfish research examined the availability and suitability of the same resources for longlining of tunas, especially bigeye tuna but also albacore and yellowfin tuna.

Production and marketing: ***'Otule*** caught during ***tau 'otule*** is normally used as live bait for catching larger predator fish species such as trevallies, snappers and sharks. A number 1-4 hook on 60 lb test monofilament is inserted at the caudal peduncle and pushed up alongside the spinal column to reappear just behind the head. The still alive ***'otule*** is released and is able to swim erratically drawing the attention of larger predatory fish (Dye, cited above).

During the JAMARC baitfishing in Tonga in November, 1972 four hauls of blanket net in Neiafu Bay yielded 6.5 buckets (29.25 kg) of *H. ovalis* (*H. quadrimaculatus*?) (9.48 kg - 32.4 per cent), Atherinidae (19.10 kg - 65.3 per cent) and Mugilidae (0.67 kg - 2.3 per cent). Catches using small set net in 1973/1974 as recorded in Anon (1974) by the same research group are recorded in Table 2.6.4.

Table 2.6.4: Catches using small set net in 1973/1974 by JAMARC.

Date	Catch (no. buckets)	Main species	Percentage (%)	Other fish species	Other fish species catch (kg)
24 Dec 73	12	Dussumieria sp.		halfbeaks, Priacanthus sp., bonitos	2
25 Dec 73	3	Dussumieria sp. Trachurus sp. Leiognathus sp.	95 3 2	frigate mackerel, Priacanthus sp., bonitos	5
26 Dec 73	3	Dussumieria	100	jack mackerel, bonitos, halfbeaks, Leiognathus sp.	3
27 Dec 73	3	Dussumieria sp. Trachurus	95 5	jack mackerel, Priacanthus sp., halfbeaks, Leiognathus sp.	3
28 Dec 73	3	Dussumieria sp.	95	long-tom, Priacanthus sp., jack mackerel, Leiognathus sp., bonitos	5
29 Dec 73	1	Dussumieria sp.		Leiognathus sp., Priacanthus sp., jack mackerel, scad	4
30 Dec 73	1	Dussumieria sp. Trachurus sp.	50 50	goatfishes, jack mackerel, halfbeaks, Priancanthus sp., barracuda	3
31 Dec 73	2	Dussumieria sp. Trachurus	60 40	Priancanthus sp., Ostichthys sp.	3
1 Jan 74	2	Dussumeria sp. Trachurus sp. Leiognathus sp.	90 10 0	jack mackerel, goatfishes, barracudas, Priacanthus sp., Leiognathus sp., halfbeaks	3
2 Jan 74	3	Dussumieria sp. Trachurus sp. Leiognathus sp.	90 5 5	jack mackerel, barracudas, bonitos, scad, Priacabthus sp.	3
3 Jan 74	3	Dussumieria sp. Trachurus sp. Leiognathus sp. Cheilodipterus sp.	85 5 5 5	Priancanthus sp. bonitos	3
4 Jan 74	3	Dussumieria sp. Trachurus sp.	40 60	jack mackerel, barracudas, goatfishes	2
	4	Dussumieria sp. Leiognathus sp.	95 5	bonitos	2
5 Jan 74	3	Dussumieria sp. Trachurus sp. Leiognathus sp.	20 80 0		
6 Jan 74	2	Dussumieria sp.	10	long-tom	1

		Trachurus	90		
	1	Trachurus sp.	1		

Table 2.6.4 cont.

7 Jan 74	3	Trachurus sp.		long-tom	1
8 Jan 74	2	Dussumieria sp. Trachurus sp.	5 95		
9 Jan 74	8	Dusumieria sp. Trachurus sp.	95 5		
10 Jan 74	12	Dussumieria sp.		frigate mackerel	1
11 Jan 74	10	Dussumieria sp.		long-tom, bonitos, Echeneis sp.	2
12 Jan 74	0	Trachurus sp.		bonitos, Priacanthus so.	30
13 Jan 74	-	-	-	bonitos, hairtail, Monodactylus sp.	17
14 Jan 74	8	Dussumieria sp. Trachurus sp.	95 5	jack mackerel, scad, Priancanthus sp.	1
15 Jan 74	8	Dussumieris sp.		Plotosus sp., Priacanthus sp.	20
16 Jan 74	10	Dussumieria sp.			
18 Jan 74	7	Dussumieria sp.		Priancanthus sp., frigate mackerel	1
19 Jan 74	6	Dussumieria sp.		Priacanthus sp., frigate mackerel	1
20 Jan 74	2	Dusumieria sp.		bonitos	0
21 Jan 74	2	Dussumieria sp.		frigate mackerel, bonitos, Priacanthus sp.	
TOTAL	**127**				**116**

Results of baitfishing for assessment operations in Tonga for the skipjack pole-and-line fishery are recorded in Tuna Programme (1983) and Fisheries Division (1975 & 1976)* and summarized in the following table:

Date	Location	Project	Method	Species	Time	No. days or nights	Total weight (kg)	Catch rate (kg/day or night)
Dec 1973-Jan 74	Vava'u	JAMARC	bouki-ami, dip net, set net	*Sp. delicatulus, Selar sp.,* Apogonidae	night	31	568	18
*Feb-Dec 74	Pangaimotu	Fisheries	floating trap net	*Decapterus sp.((*'otule) *Dussumieria* sp. & barracuda etc	?	?	834.5 106.45	
Aug-Oct, 1975	Tongatapu, Ha'apai	FAO	dip net	*Sp. delicatulus,* Atheriidae, *H. quadrimaculatus*	night	?	?	11
*Dec 75-Sep 76	Pangaimotu	Fisheries	floating trap net	*S. crumenophthalmus*, Dussumieria sp., *H. ovalis*	?	?	6,475	
Mar 76-May 77	Vava'u	FAO	lift net operated from barge, beach seine	Atherinidae, *H. quadrimaculatus, Sp. delicatulus*	night	24	577	26
Jan 77-Feb 78	Vava'u	Fisheries	lift net	Atherinidae, *H. quadrimaculatus, Sp. delicatulus, Stolephorus sp.*	night	68	4,503	66
Jul 78-Jan 79	Vava'u	Fisheries	lift net	*as above*	night	37	3,428	93
Jul 78-pr 80	Vava'u	Fisheries	bouki-ami	*as above*	night	58	5,768	99
Apr-May 78	Vava'u, Tongatapu	SPC	bouki-ami, beach seine	Atherinidae, *Sp. delicatulus, Selar sp.,*	night	16	695	43
	Vava'u	SPC	beach seine	Atherinidae, *Sp. delicatulus*	day	3	176	58
Mar 80	Vava'u	SPC	bouki-ami	*Sp. delicatulus,* Atherinidae, *H. quadrimaculatus*	night	5	396	80
				Sp. delicatulus, Atherinidae	day	1	14	14
Summary:					**Days**	**26**	**767**	**29.5**
					Nights	**240**	**16,761**	**69.8**

In 1977, a string of 7 bigeye scad (*Trachurus* sp.) ranging in length between 15 and 25 cm sold for T$0.60 in Tongatapu (Anon, 1977).

Baitfish species catch composition, by weight, during the SPC skipjack programme survey in Tonga as recorded in the above table was reported in Tuna Programme (1983) as follows:

Species	Estimated Catch (kg)
Stolepphorus devisi	231
Pranesus pinguis	229
Spratelloides delicatulus	151
Selar crumenophthalmus	128
Atule mate	123
Hypoatherina ovalaua	108
Sardinella sirm	82
Herklotsichthys punctatus	72
Sp. gracilis	23
Scomberoides	4
Gazza minuta	4

St. indicus	1

(Note: These excludes other baitfish species which only occurred in small quantities).

Halapua (1981) reported that the use of gill-net in Ha'apai is confined to the exploitation of reef-lagoon fish species. During the big-eye scad (*S. crumenophthalmus*) season, gill-nets are used to surround detected schools. He estimated that the reef-lagoon fishery resources supply more than 70 per cent of the Ha'apai islands' total annual catch. No estimated figures were given. Using figures from an FAO survey in 1978, Carleton (1982) estimated the inner reef and plateau landing to be 1,600 mt for the whole country.

Tsubaki and Kawasaki (undated, quoted in Gillett, 1988) reported that *D. russelli* and *D. macrosoma* and other two carangids comprised 38 per cent of the catches made by a small purse seine vessel in the Vava'u area. Seining at night in some of the larger bays during February 1988 yielded an average of 116.5 kg per night for four nights. *D. macarellus*, *D. russelli* and *Selar* sp. made up 57 per cent (Gillett, 1988). Comparing February catches in Vava'u, the same author reports that February catches were only available for 1985 which indicated an average almost twice as large as that in 1988. The Hawaiian-style Decapterus fishing trials conducted in Tonga in February 1988 were not successful. However a species of fusilier (*Caesio* sp.) was attracted which reacted similarly to *Decapterus* (Gillett, quoted above).

The estimated total landings of major species by fishing gear in the Tongatapu inshore reef fishery was made by Munro in 1990. The results are summarized in the following table. The small pelagic species are in bold.

	Species	**Est. annual landing (mt)**	**Percentage**		**Species**	**Est. annual landing (mt)**	**Percentage**
1.	*L. nebulosus*	195.23	23.7	11.	*S. argenteus*	11.80	1.4
2.	*M. cephalus*	140.03	17.0	12.	*M. vanicolensis*	11.61	1.4
3.	*L. elongatus*	68.90	8.4	13.	***R. kanagurta***	**11.45**	**1.4**
4.	*S. spiniferum*	36.81	4.5	14.	*L. fulviflamma*	10.92	1.3
5.	*L. ramak*	26.82	3.3	15.	*L. equula*	10.20	1.2
6.	*L. vaigiensis*	22.12	2.7	16.	*S. forsteri*	8.83	1.1
7.	*T. lepturus*	19.47	2.4	17.	*G. japonicus*	8.10	1.0
8.	*P. pleurotaenia*	18.18	2.2	18.	*M. flavolineatus*	7.76	1.0
9.	*L. harak*	16.90	2.1	20.	Others	185.52	22.3
10.	***S. crumenophthalmus***	**13.10**	**1.6**				

One of the major fish species caught during the commercial net fishing operation is the horse mackerel and in 1990 a string of 25 small horse mackerels with body lengths of about 15 cm sold for $T8 in Nuku'alofa (Sudo, 1990).

During the first four months of the Fisheries Baitfish Resource Assessment Programme in Vava'u in 1992 using purse seine at night with lights, the following catch information were obtained: (Source: Hurrell, 1992).

Month	Number of fishing nights	# buckets	Weight (kg)
April	4	340	2,300
May	3	401	2,356
June	2	34	188
July	5	469	2,542

Monthly species composition, percentage numbers of fish, for the same catches were also given as follows:

Month	**Ambly-gastersp.**	**D. macro-soma**	**D. maca-rellus**	**Sardinella sp.**	**Herklot-sichthus sp.**	**A mate**	**S. crumenop-hthalmus**	**A. lacunosa**	**H. ovalaua**	Total number of fish
April	0.00	34.81	22.69	24.48	14.64	3.20	0.18	0.06	0.00	1,646
May	37.79	11.01	4.88	32.79	10.14	3.50	0.00	0.00	0.00	699
June	66.25	0.93	0.00	0.00	18.29	0.00	0.00	8.50	6.50	312
July	54.34	21.30	20.83	0.00	0.88	1.70	0.00	0.94	0.00	1,740

Overall %	32.77	21.76	17.35	12.53	7.15	6.91	0.07	1.00	0.46	

The baitfish caught during the operation were sold in Vava'u for $T2.00/kg as compared to $T2.80-$T3.00 per kg for reef and deep-water bottomfish (Hurrell, 1992).

At the completion of the baitfish assessment research conducted by RDA International in Vava'u waters from April, 1992 to the end of 1993, a total of 93 fishing trips were executed at nine different stations. King *et al*. (1994) reported that catches varied greatly, but the overall mean catch rate obtained was 475 kg per night. The maximum catch recorded was 2,537 kg per night. A total of 16.4 mt were landed in 1992 giving an average catch rate of 606 kg per haul. In 1993, the total catch landed was 27.8 mt but the catch rate was lower, 402 kg per haul. Four baitfish species accounted for 85 per cent of the total baitfish catch by weight. Details of catch composition of these main species are given in Table 2.6.5 as reproduced from King *et al*. (1994).

Table 2.6.5: Details of the combined baitfish catch composition for the four main baitfish species caught in Vava'u during the 1992-1993 surveys. (Source: King *et al*, 1994).

	Amblygaster sirm	*Herklotsichthys* sp.	*Decapterus macrosoma*	*Decapterus macarellus*
catch percent by weight	39	4	15	27
catch percent by numbers	36	17	22	16
mean kg per haul	183	20	69	125
mean length (mm)	197	118	175	227
maximum length (mm)	270	160	270	305
mean weight (g)	98	23	60	149
maximum weight (g)	283	60	225	374

A one-week intensive survey conducted at Vuna and Faua fishing landing sites in April 1992 did not record any small pelagic species. However a category, "Others", accounted for 10.1 per cent of the total estimated annual fin-fish landing at those sites of 499.2 mt (Udagawa and Tulua, 1992). The results of the time series surveys initiated in 1993 by the Ministry of Fisheries illustrate the danger of using data from a short survey, such as that mentioned above, in estimating annual landings and species composition, due to the seasonality of other species and the effects of weather and other factors on the catches landed. Monthly landings at the same sites have been estimated from surveys initiated in 1993. The estimates of fin-fish from March to December, 1993 are summarized in Table 2.6.6 for the various fin-fish groups landed in the artisanal fishery.

Table 2.6.6: Comparative monthly estimates of fin-fish groups landed in the artisanal fishery at Vuna and Faua landing sites in Nuku'alofa. The total for Tongatapu landings have been estimated. (Source: Udagawa, JICA, and Ministry of Fisheries database, Tonga).

Fish Group	March	April	May	June-December	10 Months Total	12 Months Total	Tongatapu Total	Percent
Mullet	118.22	177.33	458.40	1,258.20	2,012	2,415	3,219	0.83
Deep-water	33.98	15.08	0.00	1,094.55	1,144	1,372	1,830	0.47
Oceanic pelagics	45.41	325.78	227.29	934.53	1,533	1,840	2,453	0.63
Rays	0.00	16.32	44.58		61	73	97	0.03
Reef fish	7,823.26	18,004.81	16,409.45	126,130.62	168,368	202,042	269,389	69.43
Shark	0.00	67.26	0.00	160.20	227	273	364	0.09
Small pelagics	**1,223.68**	**5,010.98**	**5,955.98**	**7,606.55**	**19,797**	**23,757**	**31,676**	**8.16**
Tunas	5,337.95	7,299.93	9,293.99	22,194.73	44,127	52,952	70,603	18.20
Unclassified	47.93	189.09	203.93	4,797.08	5,238	6,286	8,381	2.16

These estimates indicate that small pelagics comprise 8 per cent (24 mt) of the total finfish landings (290 mt) in the artisanal fishery at the two sites for the year. The total Tongatapu small pelagic landing for the year is estimated at 32 mt, assuming that the landing at Vuna and Faua account for 75 per cent of the total Tongatapu landing.

Of the “small pelagics” group, ***'otule*** make up more than 90 per cent.

2.6.3 Stocks Status

Anon (1974) noted that there appeared to be fairly abundant baitfish resources in Vava'u, considering the many inlets and reefs that exist there. However, the baitfishing showed disappointing results, with the skipjack assessment work often disrupted due to insufficient baitfish supply. The baitfish catches varied both in amount and species composition with the method used, phase of the moon, weather condition and area fished. In an assessment of live baitfish availability for pole-and-line skipjack fishery, Thomas (1978) estimated that in Vava'u baiting rafts could yield 10-15 buckets per night for four months (15 days a month). Supplements could be supplied by beach seine with yields of 8-10 buckets per day for 15 fishing days a month. Overall, 4,550 buckets of live bait could be caught in Vava'u using different methods during the season for pole-and-line tuna fishing. Tuna Programme (1983) considers these estimates to be optimistic, and even though baitfish potential in Tonga is highest in the Vava'u area, it is not great overall. Considering baitfish availability and effectiveness, the tuna catch estimated from local live-bait was 300 mt per season, thus a large scale pole-and-line development based on local live-bait supply is not practical. The recent baitfish resource survey conducted by RDA International in Vava’u indicated, from yield per recruit analyses, that the survey vessel (“Albacore”) used during the research, imposed a fishing mortality of between 29 and 56 per cent (depending on species) of that required to obtain the maximum sustainable yield (King *et al*, 1994). The decreasing catch rates and the particularly low catch rates obtained in 1993, caused some concern though. However, these were thought to have been caused by the effects of a strong El Nino in early 1993. The baitfish resource in Vava’u waters was then estimated to be able to support commercial baitfish operation of one large purse seiner the size of the vessel (“Albacore”) used during the project or two or three smaller vessels using smaller gear (King, *et al*., cited above). The decision on one commercial purse seine vessel the size of “Albacore” (or two or three smaller vessels) was based on the fact that a more profit-driven commercial operation would be more efficient thus making higher catches closer to the estimated optimum.

No information exists on the status of other small pelagics in Tonga which are utilized both at the subsistence and artisanal levels. As Dalzell (1993) notes:

> "the most important small pelagic fishes in terms of subsistence and commercial exploitation in the South Pacific region are the larger species, principally the big eye-scads, round scads and flying fishes. Despite this, the smaller clupeoid fishes have received greater attention from fisheries workers in the region, because of their importance for tuna baitfisheries".

He further notes that even though the level of exploitation of small pelagic fishes in the South Pacific appear sustainable in the long term at present, there is little information on which to base this assessment.

In Tonga, some small pelagic species, especially *Selar* sp., have been targets of large surround nets, fish weirs (fences) and possibly dynamite fishing during their season. Johannes (1981, quoted in Dalzell, 1993) reported that *H. quadrimaculatus* stocks have been reduced in Palau through a combination of legal fishing and illegal dynamite fishing. However, Dalzell (quoted above) notes that the evidence is based on subjective reports of declines in seasonal abundance, rather than accurate time series of catch and fishing effort records and supporting biological data.

Polovina *et al*. (1985, quoted in Dalzell, 1993) used sustained catches in Hawaii (0.4 to 0.9 mt per nautical mile ($t.nmi^{-1}$) per year) for *S. crumenophthalmus* to make an empirical estimate of the potential yield of the same species in the Mariana Islands. The method uses the length of the 200 m isobath. Dalzell and Preston (in press, quoted in Dalzell, 1993) applied the same method and annual rates to estimate sustainable yields for the South Pacific. In addition they also used the same method and the annual sustained rate for *D. macarellus* in Hawaii of 0.13 $t.nmi^{-1}$ to estimate annual yields of the same species for the South Pacific. Applying the same method and using the same sustained catch rates for the different species, the following figures are obtained for *S. crumenophthalmus* and *D. macarellus* for Tonga (Note: for *S. crumenophthalmus*, the rate given was a range while that for *D. macarellus* was just one figure):

Habitat	Length of 200 m isobath (nmi)	Lower Annual Sustained Catch Rate ($t.nmi^{-1}$)	Upper Annual Sustained Catch Rate ($t.nmi^{-1}$)	Lower Annual Estimated Sustainable Catch (mt)	Upper Annual Estimated Sustainable Catch (mt)
Selar crumenophthalmus					
Seamounts alone	294	0.4	0.9	117.60	264.60
Seamounts & Islands	930	0.4	0.9	372.00	837.00
Islands alone	636	0.4	0.9	254.40	572.40
Decapterus macarellus					
Seamounts alone	294	0.13		38.22	
Seamounts & Islands	930	0.13		120.90	
Islands alone	636	0.13		82.68	

2.6.4 Management

The trend in level of importance of small pelagic fish species in both the subsistence and artisanal fisheries is not known in Tonga, due to the absence of landing statistics from previous years. However the survey results at Vuna and Faua indicates that small pelagics form more than 14 per cent of the landing and thus form an important component of the artisanal fishery. Even though there are currently no data to indicate the status of stocks and to use as a basis of management guidelines for the exploitation of this resource, the control of certain more effective methods currently employed needs some consideration, especially the size and mesh size of surround nets and fish fences. More effective means of enforcing the ban of the use of dynamite to catch fish are necessary.

Current legislation/policy regarding exploitation: Section 20 of the Fisheries Act 1989 prohibits the use or attempted use of any explosive, poison or other noxious substances for the purpose of catching fish. Offences under this section are punishable by a fine not exceeding $1,000 or imprisonment for a period not exceeding 2 years or both. Landing, selling, receiving or possessing any fish caught with the use of any of the above methods is prohibited, and the penalty for an offence is a fine not exceeding $1,000.

Recommended legislation/policy regarding exploitation: The majority of catches of small pelagic resources in Tonga involve handlining, nets and fish fence. Management of these resources seems only necessary through controls in fishing gear used. Handlining does not seem to pose any major concerns for the stocks or the environment, while nets and fish fences require regulating. It has been recommended in the proposed Fisheries Regulation, that putting up or use of a fish fence requires a license to be issued by the Registrar. Conditions given for license refusal include; placement within 200 metres of another fish fence, within one kilometre of any Government wharf or in any place where it may be a hazard or obstruction to navigation. Consideration should be given to ensure that the licensee of a fish fence, whether it be whole, damaged or in pieces, be responsible for its removal from the sea and disposal of it in an acceptable manner. Due to the potential detrimental effects of fish fences, limiting the numbers of fish fences erected in different zones along the coast line of the country might be worth considering.

The proposed Fisheries Regulations also includes a section on nets and mesh sizes which is considered sufficient.

In the event that commercial baitfishing will be initiated in the Vava'u waters, the findings and recommendations made at the completion of the RDA International baitfish assessment study should form the basis for the development and management of the baitfish resource there.

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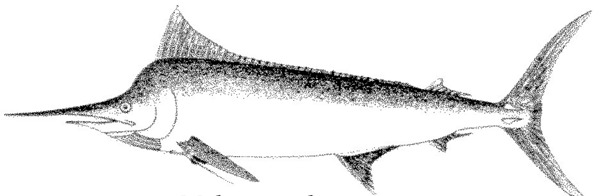
2.7 Other oceanic pelagic fishes

2.7.1 The Resource



Makaira indica

Species present: The species present in Tonga include; dolphin fish (*Coryphaena hippurus* - ***mahimahi***), rainbow runner (*Elegatis bipinnulatus* - ***lupo-umata***), blue marlin (*Makaira nigricans* - ***hakula***), black marlin (*M. indica* - ***hakula***), striped marlin (*Tetrapturus audax* - ***hakula***), broadbill swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*), wahoo (*Acanthocybium solandri* - **valu louniu**), and barracudas (*Sphyraena* spp - **'ono**).

Distribution: These species are normally distributed throughout the oceans in varying abundance, determined mostly by food availability, but they are documented as being associated with Fish Aggregating Devices (FADs).

Geographical distributions of the billfish species are given in Nakamura (1985). Generally, they are primarily oceanic and epipelagic, inhabiting tropical and temperate waters, and seasonally, also the cold waters of all oceans. They are usually confined to the water layers above the thermocline but some may occur at greater depths.

The following table summarizes the occurrence of some of these species in Tonga as documented in Thomas (1978), during the FAO Tonga Marine Resource Development Project (1975-1977):

Fish	Area of Fishing	Depth Range Caught	Fishing Method	Season
Dolphin fish	Entire Kingdom, concentrations Tongatapu Banks, 'Eua, E. Ha'apai, Duff Reef, S & W Vava'u	Surface	Surface troll & sub-surface troll	Year round, peak August to May
Wahoo	Northern island groups, eastern side of Ha'apai	Surface and mid-water	Surface troll & drift line sub-surface troll	All year, most catches during Aug., Sept., and Oct.
Rainbow runner	Entire Kingdom. Nomuka Groups, predominant-SW Vava'u, Late & around 'Eua Island	Surface and mid-water	Surface troll; pole & line drift line sub-surface troll	Year round, but peak Sept. to May.

Schuh (1982) reported that wahoo is found in 'Eua waters from June to September.

Biology and ecology: Smith (1992) notes that all of these fish species are predators, mostly on fish and squid. Some biological information for the billfishes is given Nakamura (cited above). Sexes are separate and they are active and voracious predators but are occasionally preyed on by large oceanic fishes such as tunas, wahoo and dolphinfish particularly during their younger stages. The young are sometimes also taken by adult billfishes. Smith (cited above) also notes that billfishes are solitary while other species tend to form small to medium sized schools. Migrations associated with spawning are known for billfish and dolphinfish. There has been no study conducted in Tonga on the biology of any of the oceanic pelagic fish species that occur in its waters.

2.7.2 The Fishery

Utilisation: The oceanic pelagic species form a portion of the catches made in the troll and longline fisheries for the tunas, in both the artisanal and commercial operations. They are an important component of the FAD catch. Sportfishing occurs in Tonga and it specifically targets billfish and ***mahimahi***. On Niuatoputapu, barracuda (*Sphyraena* sp.) is one of the species caught in the traditional ***tau 'otule***. In addition, wahoo is one of the fish species caught in the ***fakatele***, one of the indigenous trolling methods (Dye, 1983).

Production and marketing: No statistics are available on the amount of oceanic pelagic fish species landed in Tonga in the subsistence fishery. However, it is known that they are not important at this level of utilisation.

Klawe (1978) made rough estimations of various species of tunas and tuna-like fishes caught by longline fleets of Japan, Korea and Taiwan from within 200 nm EEZs of the South Pacific countries from 1972 to 1976. Oceanic fish species recorded as being caught in Tongan waters are shown in Table 2.7.1(a). The catches are given in kg while effort is in number of hooks. The tuna portions of these catches are recorded under the Tuna Profiles in this document, and the effort given here includes that for the tuna catches.

Table 2.7.1(a): Oceanic pelagic fish species catches, other than tuna, caught in Tongan waters by the Japanese, Taiwanese and Korean longliners. The catch figures are in kg.

	Effort	Sword fish	Blue marlin	Stripe marlin	Black marlin	Sail-fish
1972						
Japan	99,851	0	0	8,620	0	0
Taiwan	914244	1,609	32,608	20,945	667	120
1973						
Japan	6,417	14	270	68	0	50
Taiwan	215,330	784	8,133	967	1,166	0
1974						
Japan	0	0	0	0	0	0
Taiwan	73,301	150	1,401	35	372	0

	Effort	Sword fish	Blue marlin	Stripe marlin	Black marlin	Sail fish
1975						
Japan	0	0	0	0	0	0
Korea	3,795	0	33	0	0	0
Taiwan	173,387	425	5,090	1,510	0	0
1976						
Japan	0	0	0	0	0	0
Korea	1,079,773	3,517	11,668	4,786	4,623	1,151
Taiwan	464,086	1,496	24,527	1,532	39	287

Catches made by the Japanese (1962-77) and Taiwanese (1967-77) longline fleets within 200 miles of the countries in the area of the South Pacific Commission as recorded in Skipjack Programme (1981) are summarized in Table 2.7.1 (b) for those caught within Tongan waters. The catches are in numbers of fish while effort is in 1,000 hooks.

Table 2.7.1(b): Summaries of catches of oceanic pelagic fish species, apart from tunas, caught by Japanese and Taiwanese longliners within Tongan waters. Catch figures are in numbers of fish.

	Effort	Broad bill	Stripe marlin	Blue marlin	Black marlin	Sail-fish
1962						
Japan	1,643	419	3,634	1,030	123	2,056
1963						
Japan	892	159	1,156	733	32	632
1964						
Japan	431	62	374	261	20	108
1965						
Japan	881	129	558	478	18	183
1966						
Japan	654	200	411	292	28	246
1967						
Japan	515	229	145	202	7	140
Taiwan	601	7	142	379	1	0
1968						
Japan	169	42	38	131	5	68
Taiwan	259	12	29	161	0	0
1969						
Japan	31	4	20	35	0	26
Taiwan	581	90	229	100	4	57

	Effort	Broad bill	Stripe marlin	Blue marlin	Black marlin	Sail-fish
1970						
Japan	133	10	96	93	2	23
Taiwan	388	33	169	241	5	54
1971						
Japan	124	20	99	94	0	7
Taiwan	469	17	100	285	8	56
1972						
Japan	87	0	122	0	0	0
Taiwan	925	32	307	488	8	11
1973						
Japan	4	0	1	1	0	1
1974						
Taiwan	80	6	1	15	4	0
1975						
Taiwan	189	6	20	101	0	0
1976						
Taiwan	474	27	21	392	1	11
1977						
Taiwan	294	1	31	183	6	0

Catches made by the Government longline vessel, “Ekiaki”, in 1973 and 1975 consisted of 35,215 lb and 29,805 lb of billfishes, which represent 17.3 per cent and 16.5 per cent of the total catches respectively. The billfishes here included striped marlin, broadbill swordfish, Pacific blue marlin, sailfish, and black marlin (JICA, 1977). “Tavake”, another Government longliner, caught 15.35 mt (15.10 per cent of the total landing) and 10.85 (7.92 per cent of the total landing) of billfishes in 1977 and 1978 respectively.

During the FAO Tonga Marine Resource Development Project (1975-77), it was found that fish species usually landed by trolling in order of occurrence were skipjack, yellowfin, rainbow runner, dogtooth tuna, dolphinfish, wahoo and jacks. August to April was found to be the most productive period throughout the kingdom, with a drop in the catch rates from May to July, particularly along the southern grounds (Thomas, 1978).

Schuh (1982) reported that 6 per cent of the annual catch on 'Eua is from long-line caught fish species which include tuna, albacore, shark and sailfish, while 19 per cent of the total landing is composed of tuna, sailfish, barracuda and jacks caught by trolling.

Catches made by the longliner, “Lofa”, from 1987 to 1993, are recorded in Table 2.7.2 as reported by various sources. The oceanic fish species are in “bold” and weights in mt. The value figures, where recorded, are in brackets.

Table 2.7.2: Catches recorded for the Lofa. (The 1993 catch is for the period 23/6-24/9, 1993).

	1987	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
<u>Export</u>							
Albacore (Value-T$)	249.80 (668,590)	212.1	197.6	144.1	185.6	203.9	21.6
Big eye (Value-T$)	14.64 (20,399)	6.6	12.1	5.9	5.7	0	0.8
Yellowfin (Value-T$)	24.31 (37,888)	21.4	30.9	28.6	22.0	16.4	2.4
Skipjack (Value-T$)	1.79 (2,086)		0	2.9	2.5	1.3	0.005
Marlin (Value-T$)	**0.47 (5,495)**	**18.9**	**19.3**	**17.8**	**15.7**	**7.5**	**3.4**
Other pelagic (Value)	**0.15 (3,028)**	**18.2**	**0**	**0**			**1.9**
Swordfish (Value)	**0.37 (9,659)**		**6.1**	**4.9**	**3.6**	**1.4**	
Moro shark (Value)	0.51 (4,076)		1.4	7.4	2.1	2.7	
<u>Local sales</u>							
Butterfly?? (Value)	**1.08 (9,676)**						
Oilfish (Value)	0.80 (7,224)						
King fish (Value)	**0.50 (4,512)**						
Swordfish					**0.1**	**2.8**	
Marlin (Value)	**0.31 (2,802)**		**12.9**		**4.2**	**10.6**	
Others ?			**24.6**	**9.6**	**8.2**	**8.2**	**13.3**
Shark (Value)	0.39 (1,164)		1.9		0.8	3.6	
Shark liver (Value)	0.04 (119)						
Big eye (Value)	0.03 (232)			6.03	0.3	5.6	
Skipjack (Value)	0.01 (96)		1.5		0.3	0.8	
Yellowfin					2.6	7.1	

A one-week survey of the artisanal fishery conducted by the Ministry of Fisheries in April, 1992 at Faua and Vuna in Nuku'alofa did not record any oceanic pelagics being landed there during the week. However, a category, "Others", comprising 10 per cent of the total fin-fish landings was recorded (Udagawa and Tulua, 1992).

Results from the Inshore Fisheries surveys conducted by the Ministry of Fisheries at the same landing sites in Nuku'alofa, Faua and Vuna, in 1993 are summarized in Table 2.7.4 for oceanic fish species. The weights are in kg.

Table 2.7.4: Summaries of oceanic pelagic fish landing statistics, in the artisanal fishery, obtained from Vuna and Faua in 1993. (Source: Data for March to May-Mr K. Udagawa, JICA, and June-December-Ministry of Fisheries Database).

	March	April	May	June-December	10 Months TOTAL	Estimated 12 Months TOTAL
Mahimahi	45.41	125.80	94.40	162.68	**428.29**	**514**
'Ono		160.87	132.89	198.20	**491.96**	**590**
Hapatu		39.11		573.65	**612.76**	**735**
TOTAL	**45.41**	**325.78**	**227.29**	**934.53**	**1,533.01**	**1,840**

Relative landings of all finfish categories landed at the two sites in the artisanal fishery during 1993 are given in Table 2.7.3. Estimates for 12 months, extrapolations for the whole of Tongatapu, and relative percentages are also included in the table.

Table 2.7.3: Landing estimates, in the artisanal fishery, of the different fish categories for 1993. The 10-month total column is for those landed at Vuna and Faua. Figures are in kg except the Percent column.

Fish Group	March	April	May	June-December	10 Months Total	12 Months Total	Tongatapu Total	Percent
Mullet	118.22	177.33	458.40	1,258.20	2,012	2,415	3,219	0.83
Deep-water	33.98	15.08	0.00	1,094.55	1,144	1,372	1,830	0.47
Oceanic pelagics	**45.41**	**325.78**	**227.29**	**934.53**	**1,533**	**1,840**	**2,453**	**0.63**
Rays	0.00	16.32	44.58		61	73	97	0.03
Reef fish	7,823.26	18,004.81	16,409.45	126,130.62	168,368	202,042	269,389	69.43
Shark	0.00	67.26	0.00	160.20	227	273	364	0.09
Small pelagics	1,223.68	5,010.98	5,955.98	7,606.55	19,797	23,757	31,676	8.16
Tunas	5,337.95	7,299.93	9,293.99	22,194.73	44,127	52,952	70,603	18.20
Unclassified	47.93	189.09	203.93	4,797.08	5,238	6,286	8,381	2.16

In 1993, fillets of locally caught mahimahi and smoked marlin were sold for T$10.00/kg and T$8.00/kg, respectively, by one of the main fish processors in Tonga. No catch data was available on these sales. The same company exported only 12.1 kg of marlin, worth US$93.10, in the same year.

2.4.3 Stocks Status

There has been no research conducted in Tonga on the status of the oceanic pelagic fish species. However, no major concern is apparent as these are not targeted specifically for any current industrial fishery. Further development of fisheries based on these species, e.g. gamefishing, is unlikely to have any detrimental effect on the stocks. However, collection of catch data from such undertakings would be desirable.

2.4.4 Management

Current legislation/policy regarding exploitation: Most of the regulations applied under the section on tuna also cover these oceanic pelagic species.

Recommended legislation/policy regarding exploitation: No regulations seem to be required at present. However, collection of catch data from various development involving the oceanic pelagic species, including sportfishing, is necessary.

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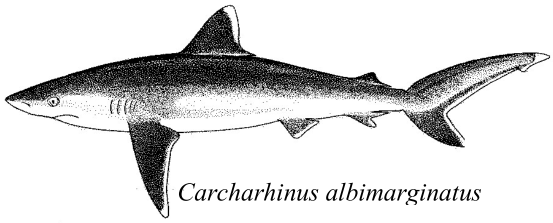
3. CARTILAGINOUS FISHES

3.1 Sharks - *'Anga*



Carcharhinus albimarginatus

3.1.1 The Resource

Species present: Sharks are known collectively in Tonga as '***anga***. During the SPC deep-bottom fishing expeditions in Tonga between 1978 and 1985 only *Triaenodon obesus* (white-tip shark) and an unidentified species were caught. During a 2-year (1980 and 1981) fisheries project on 'Eua, grey shark (*Carcharhinus amblyrhynchos*), white-tipped reef shark (*C. albimarginatus*), black-tipped reef shark (*C. melanopterus*), great white shark (*Carcharodon carcharias*), hammerhead (*Sphyrna lewini*), (shortfin) mako shark (*Isurus oxyrinchus*) and tiger shark (*Galeocerdo cuvieri*) were reported in the fish landings there. JICA (1977) also listed blue shark (*Prionace glaucal*), hiragashira (*Rhizoprionodon acutus*), smooth hammer shark (*S. zygaena*) and thresher shark (*Alopias pelagicus*) as present in Tonga.

Distribution: Smith (1992) notes that sharks occur from the reef and inshore areas through to the open oceans, at all depths. Nichols (1993) notes that "on a global basis, 55 per cent of the chondrichthyians inhabit the continental shelf area from the inter-tidal zone to a depth of 200 m". The same author also adds that the most common sharks in reefs and lagoons belong to the family Carcharhinus (the requiem sharks) including the black-tip reef shark and white-tip shark. Grey reef sharks as well as the larger species, including tiger sharks and hammerhead sharks, are found in deeper waters off coral reefs (Nichols, cited above).

Traditional shark noosing in Tonga is carried out on the outlying reefs and areas where sharks have not been recently disturbed by passing ships or other human activity. It is "often carried out some fifty miles to the south of the main island where sharks are so tame that they often come very close to the boat as if to inspect it" (Vaea and Straatmans, 1954). The same authors listed sharks as a deep-sea fish.

The list of important fish caught in Tonga and their occurrence and fishing method used listed for the FAO Marine Resource Development Project for Tonga during 1975-1977 included sharks with the following information:

	Size range (lb)	Area of fishing	Depth range	Fishing method	Seasons
Shark "anga" *Chondrichthys* spp.	5-550	-entire Kingdom. -concentrations in Hunga ,Metis, Shoal, Home reef	all depths, mostly bottom	surface troll drift line; bottom line & nets, sub-surface troll	scattered all year

Biology and ecology: Compagno (1984 (a) and (b) gives some information on habitat, distribution, biology and ecology of the known species of sharks in the world. For reproduction, a variety of modes are utilized but fertilization is internal with most species bearing their young alive in broods ranging from a few individuals to nearly one hundred (Smith, 1992). Sharks are generally slow growing with the majority of the commercially important species in the South Pacific having a long gestation period and low fecundity (Nichols, 1993). Further more, some species display sex and size segregation and females of some species may move inshore to give birth in selected nursery areas (Nichols, cited above).

There is no available information concerning the biology and ecology of any shark species in Tonga.

3.1.2 The Fishery

Utilisation: In the past, shark meat seems to have had an important role and contributed substantially to the fish portion of the local diet in Tonga, especially in the outer islands. Traditional fishing for shark also appears to have been more frequent then. An interview with an 81-year old fisherman (Tafakula Vaiangina) on 'Eua in 1980 indicated that local people used to catch and eat a lot more shark than "nowadays" (Schuh, 1982). ***Siu'anga*** (***tau 'anga***), the traditional shark fishing, was believed to have come to 'Eua from 'Euaiki. Traditional catching of sharks involves calling out invocations to coax the sharks to the boat, at which time a noose is then tied around the shark's tail.

Similar to other Polynesian traditions, e.g. Samoa, shark fishing in Tonga is only performed by certain specialized fishermen within a community. Traditionally, sharks are captured using a noose after being enticed alongside a boat by a coconut rattle which consists of a metre-long loop of twine from which several halved coconut shells were suspended (Zann, 1981). "The first shark to show up is always given great respect and is named after the most beautiful lady “Hina”. She is given flower laurels as well as a bowl of ***kava*** before she is asked to go and return with all her friends from the deep. A little while after Hina disappears, more sharks come up near where the boat is. Bait is then thrown out on a line, and as the shark approaches, it is drawn back to the boat. As the shark follows the bait alongside the boat, a noose is thrown around the bait and is drawn up and slipped round the shark's neck. The shark is then pulled on board and killed. If the first shark disappears from the water with little disturbance, the next can be caught in exactly the same way" (Vaea and Straatmans, 1954).

Modern methods are now used in shark fishing, e.g. on 'Eua "a No.1 shark hook secured with a chain leader to about 50 meters of strong nylon rope. Two 50 cm floats are attached to the line as tethers to tire the shark out. Baits used are skipjack, tuna heads or a dog" (Schuh, 1982). The same author noted that "many fishermen were reluctant to add gear and confusion to their boats by shark fishing in conjunction with troll and bottom fishing, yet a single shark can make the difference between a marginal fishing trip and a profitable one". Together with bottom-fish species, shark was reported by the same author as one of the main species caught in bottom handline fishing on 'Eua at depths of 80-250 m. During the 2-year project, the largest shark caught was a 4.6 m tiger shark in July, 1981.

At the subsistence and artisanal levels, hand-lines, gill nets and spear diving are the main methods by which sharks are now caught (Fuka, 1979). All sharks except the blue and mako sharks were being utilized as food in Tonga (JICA, 1977).

In longlining operations by the "Lofa", shark forms a fair portion of the catch and has been included in its commercial exports with tuna.

Production and marketing: There are no figures available for shark landings in the subsistence fishery, and there is very limited information on catches in the artisanal fishery.

During a fisheries survey in the Ha'apai Group in 1973 the following information was recorded about sharks on some islands (source: Koloa, 1973):

Nomuka Island - shark not seasonal, Peter Warner sells shark at $0.40 per lb, sharks poisonous in "Kao" and "Tofua"
Fonoifua Island - no shark information given, fishermen sells sharks to Peter Warner at $0.02 per lb
'O'ua Island - no shark information given
Tungua Island - no shark information given, Peter Warner sells shark at $0.04 per lb
Ha'afeva Island - shark not seasonal, Peter Warner sells shark at $0.04 per lb
Felemea Island - no shark information given, Peter Warner sells shark meat at $0.04 per lb
'Uiha Island - no shark information given, Peter Warner sells shark meat at $0.03 per lb
Pangai - selling to Peter Warner at $0.04 per lb
Koulo - shark not seasonal
Holopeka - no shark information given
Hihifo - no shark information given
Foa Islands - no shark information given
Ha'ano Island - shark not seasonal

On 'Eua, during the Fisheries Development Project from 1980 to 1981 an increase of 45 per cent in shark landing was gained by improving fishing gear (Schuh, 1982). Shark landed from shark fishing was estimated to comprise 8 per cent of the annual catch there. Long-lining catches contributed only 6 per cent of the landing, which comprises of tuna, albacore, sailfish and shark. The improvements were in trace wire and making hooks available. Shark was reported by Friedlander (1984) as one of the fish species caught during night fishing for pelagic fish on 'Eua. This type of fishing is carried out during moonless or dark nights when pressure lanterns (now 75 watt sealed-beam halogen lights) are used as attraction lights. Bait used is normally fish head or viscera. No catch figures were given.

During the FAO Marine Resource Development for Tonga during 1975-1977, shark comprised about 9.5 per cent of the total catch from a previously unknown bank (between 19° 23.0' south and 19° 24.0' south, between 174° 11.0' west and 174° 12.0' west) with an area inside the 100 fathoms of about 6 mi^2 and depth variation from 18 to 100 fathoms (averaged fished 18-40). The following results were reported by Thomas (1978).

Bank name	Area (mi^2)	Yearly average fish production	Mean Depth fished (depth range)	Shark catch composition (%)
South Akkumanes	48	12.7 lb/rh	15-60 (4-100)	-
Un-named seamount	6	12.2 lb/rh	18-40 (18-100)	9.5
Falcon	28	11.15	10-40 (2.5-100)	-
South Nomuka (Kelefisia)	150	9.75	15-60 (2-100)	3.0
North Akkumanes	68	9.3		
Tongatapu	100	8.7	15-60 (4-100)	4.0
Hunga	20	7.8	30-90 (?-100)	12.0
Bathume Bank	24	7.4	20-50 (7-55)	5.0

[Note: area is area between 18 and 100 fathoms].

Shark landings by Government longline fishing vessels for those years when data was available are given in Table 3.1.1.

Table 3.1.1: Shark landings by the Tonga Government longline Fishing Vessels.

	Weight (mt)	% Total Catch	Value (T$)	% Total Value	Reference
1973					
Ekiaki	21.86	23.7			JICA, 1977.
1975					
Ekiaki	17.08	20.82			JICA, 1977.
1977					
Tavake	15.20	15.10			Weber, 1979
1978					
Tavake	10.85	7.92			Weber, 1979
SPC	1.09	44.4			Dalzell and Preston, 1992
1982					
SPC	0.03	8.1			Dalzell and Preston, 1992
1985					
SPC	2.23	29.4			Dalzell and Preston, 1992
LOFA					
1987					
Export	0.51	1.66	4,076.03	0.54	
Local sales	0.43	13.42	1,283.60	4.97	Fisheries Annual Report, 1987
1989					
Export	1.43	0.53			Lofa Captain, 1993
Local sales	1.88	4.59			Lofa Captain, 1993
1990					
Export	7.35	3.48			Lofa Captain, 1993
Local sales	0.00	0			Lofa Captain, 1993
1991					
Export	2.08	0.88			Lofa Captain, 1993
Local sales	0.83	5.01			Lofa Captain, 1993
1992					
Export	2.65	1.14			Lofa Captain, 1993
Local sales	3.55	9.20			Lofa Captain, 1993

Landed price for shark at Vuna in 1973 was T$0.22 as compared to T$0.30 per kg in 1987. Retail price in 1987 was T$0.55 in 1987. Shark liver in 1987 was retailing at T$0.60/kg.

Shark landing (kg) at Vuna and Faua landing sites in Nuku'alofa in the 1993 artisanal fishery as recorded by the Ministry of Fisheries/JICA Inshore Fisheries Landing Statistics surveys, are as follow:

	March	April	May	June-December	10 months Total	Estimated 12 months Total	Percent of Total Fin-fish Landing
Shark landing (kg)	0	67.26	0	160.20	273	364	0.09
Ray (kg)	0	16.32	44.58	0	73	97	0.03

Estimate of total shark and stingray landing for the year at the two sites is only 461 kg.

The only shark fin export figures located are those for 1969 and 1973 in which T$100 and T$1,000 worth of shark fins, respectively, were exported.

3.1.3 Stocks Status

There has been no assessment conducted on the shark resource in Tongan waters.

3.1.4 Management

The low fecundity, long gestation, slow growth, and often very localised movements result in many shark populations being very prone to recruitment over-fishing (Holde, 1977; Okera *et al*., 1981, cited in Nichols, 1993). No commercial fishing operation is based on the shark resource in Tonga though it forms part of the tuna longline fishery catch.

Current legislation/policy regarding exploitation: There is currently no regulation that specifically deals with the shark resource.

Recommended legislation/policy regarding exploitation: No regulation seems necessary at this stage.

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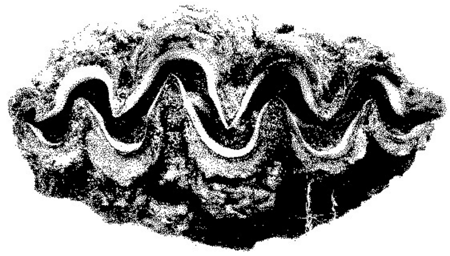
4. MOLLUSCS

4.1 Giant clams - *Vasuva*

4.1.1 The Resource



Tridacna maxima

Species present: *Tridacna derasa* (smooth giant clam - ***vasuva (tokanoa) molemole***), *T. maxima* (elongated or rugose giant clam - ***kukukuku***), *T. squamosa* (scaley or fluted giant clam - ***matahele***), and *T. tevoroa* (devil clam - ***vasuva (tokanoa) ngeesi manifi, vasuva toki***) are present in Tonga. *T. tevoroa* was recently "discovered" in Tonga and Fiji by the scientific world even though it has been known to the local people for ages. *Hippopus hippopus* (horse's hoof, rolling clam, bear paw, or strawberry giant clam) is believed to have become locally extinct, as its presence in Tonga was reported by Rosewater (1965). In addition, *T. gigas* (the giant clam) is also believed to have been present but had become locally extinct. However, no live specimens of these species have been found in Tongan waters in recent studies. Both *T. gigas* and *H. hippopus* were re-introduced into Tonga in 1991 during the ACIAR funded project on the “Culture of the Giant Clam (Tridacnidae) for Food and Restocking Tropical Reefs”.

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

McKoy (1980) recorded habitat and local distribution of the three native giant clam species known to exist in Tonga at that time. No live specimen of *H. hippopus* and *T. gigas* has been located in recent surveys. *T. tevoroa* has just been recently described. The following outlines the distribution of giant clam species found in Tonga, as summarized from available literature.

T. derasa - this species is usually found on sandy or coral rubble areas near reefs and is most commonly found in deeper waters down to 20-30 m even though some large specimens were collected from shallow waters among live corals in Ha'apai. It is found in moderately sheltered and exposed areas of the reefs and on outer reef slopes. (Source: McKoy, 1980).

T. squamosa - this species lives in relatively sheltered waters. It was the only giant clam species found in a sheltered lagoon at Hunga in Vava'u, where it was abundant, and in the sheltered area below Talau, Vava'u. It is usually found in sandy or coral rubble areas attached to small pieces of coral. Small specimens also attach to coral in the same area as *T. maxima* but many adult specimens are found on coral slopes among corals such as *Acropora*. It is most commonly found in depths of more than 4 m, but some have been found living in only a few cm of water near the top of reef slopes. A survey conducted in Ha'apai in 1989 noted that this species was more abundant at depths below 40 ft. The 1979 survey found that the deepest depth at which a specimen of this species was observed was 20 m in Ha'apai and Vava'u. (Sources: McKoy, 1980 and Manu *et al*., 1989).

T. maxima - the distribution of this species is limited by suitable habitat as well as degree of wave exposure and depth. It is not abundant where live coral is dominant but prefers solid coral limestones or large rounded Porites. It was found to be the dominant invertebrate inhabitant of coral limestone in some areas like Ha'atafu outer reef and below Mo'ungalafa in Vava'u. It was found in most lagoons, except very sheltered areas like Hunga lagoon and below Talau on Vava'u. It is uncommon on outer reef slopes but occurs on flat tops of many lagoonal or sheltered patch reefs exposed only on very low spring tides. An area surveyed in 1979 near Polo'a, which seemed to be free of fishing pressure, had an average clam density of one per m^2 on the top of the reef. The species seems to be moderately gregarious. (Source: McKoy, 1980).

T. tevoroa - the first live specimens of this species to be collected for taxonomic purposes were from the northern Ha'apai island in October 1989. The present known distribution of this species is limited to the Lau Islands in Fiji, and Ha'apai and Vava'u groups in Tonga (Lucas and Ledua, 1990). However, recent information from the Ministry of Fisheries indicate that the species also occurs in Tongatapu.

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

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

Growth parameters were estimated by Chesher (1989) for three of the species that occur in Vava'u as follows:

Species	L_∞	*K*	t_o
T. derasa	467	0.144	-0.035
T. squamosa	370	0.238	-0.026
T. maxima	250	0.131	-0.026

McKoy (1980) estimated that 50 per cent of *T. maxima* become fully mature at lengths 100-109 mm (4.5 to 5 years), and 200-250 mm for *T. squamosa*. Growth parameters were also estimated for *T. maxima*; L_∞=220 mm, K=0.132 year^{-1} and t_0 =-0.069 years. Other growth parameters estimated for *T. maxima* include the following:

lc (length at recruitment to fishery)=100 mm, Z (instantaneous rate of total mortality)=0.25-0.30,
F (instantaneous rate of fishing mortality)=0.05-0.20, M (instantaneous rate of natural mortality)=0.1-0.2?.

Length/weight relationships calculated for each of the three giant clam species were given as follows, where L is maximum shell length, W, the total wet weight, and M, the wet meat weight:

T. maxima	$W = (1.71 \times 10^{-4})\ L^{3.0269}$
	$M = (1.06 \times 10^{-4})\ L^{2.7218}$
T. squamosa	$W = (4.16 \times 10^{-5})\ L^{3.2663}$
	$M = (2.69 \times 10^{-6})\ L^{3.4102}$
T. derasa	$W = (1.29 \times 10^{-5})\ L^{3.4686}$
	$M = (4.14 \times 10^{-6})\ L^{3.2554}$

4.1.2 The Fishery

Utilisation: Giant clam meat is a very popular seafood in Tonga (ACIAR, 1992). McKoy (1980) noted that giant clams have probably been an important source of sea-food in Tonga. It is a resource that can be easily harvested. The fact that at least one giant clam species has become extinct in Tonga could be an indication of the importance of this resource at the subsistence level in the past. A shellfish consumption survey conducted in eleven villages on Vava'u indicated that overall *Tridacna* sp. (probably *T. maxima* and *T. squamosa*) was one of the most commonly eaten species and is one of the two most preferred shellfish (ranked equally with *Anadara*). However, it was the most commonly eaten species in Matamaka Village (Bondurant, 1987).

Today giant clams come under increasing pressure because of the increased levels of exploitation to supply several types of demands. They are still harvested on a subsistence basis but have become an important component in the artisanal fishery, where they are targeted for the domestic market, especially in Nuku'alofa. Large giant clam specimens, particularly those of *T. derasa* and *T. squamosa*, are sold individually in the local market whereas smaller ones, mostly *T. maxima*, are sold in baskets. Sometimes clam meat is sold in plastic bags or mixed with ***lomu*** (viscera of the sea cucumber, *Stichopus variegatus*) and sold in bottles. It has been a practise for Tongans to send clam meat to their relatives living overseas, especially those in the U.S.A. This is popular and involves sending clam meat in coolers.

Giant clams have entered the commercial area. Exports of giant clam meat to American Samoa from Vava'u have taken place and recently, small *T. maxima*, collected from the wild, have been a target of the aquarium trade operating out of Nuku'alofa for markets in U.S.A.

Production and marketing: No estimate has been made of the consumption of giant clams at the subsistence level.

McKoy (1980) estimated giant clam landings in Tongatapu between 1974 and 1978, as given below. He assumed that giant clams make up 80 per cent of the "shellfish" category of recorded landings, and that the recorded landings make up 50 per cent of actual landings. The landing figures are in whole weights:

	1974	1975	1976	1977	1978	
Estimated giant clam landing (kg)		24,090	41,344	83,450	88,096	153,293

The same author reported that giant clams made up 94-95 per cent of the recorded shellfish landings in Tongatapu during January and February in 1979. Giant clams were recorded as a separate category during these months.

Giant clam landings (whole weight) were lumped, for survey purposes, with jellyfish for the 1977-1978 period at two landing sites on Vava'u. Of the total landing for this category, giant clams were estimated to make up 70 per cent, other shellfish 10 per cent and jellyfish 20 per cent (McKoy, 1980). The monthly estimated landings (kg) were as follows (as given by the same author):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1977												
Total Shellfish landing (kg)	385	1,113	592	596	858	25	456	353	217	584	579	-
giant clam portion (kg)	**269.5**	**779.1**	**414.4**	**417.2**	**600.6**	**17.5**	**319.2**	**247.1**	**151.9**	**408.8**	**405.3**	
1978												
Total shellfish landing (kg)	-	-	-	-	-	2,132	1,119	1,488	462	0	0	-
giant clam portion (kg)						**1,492.4**	**783.3**	**1,041.6**	**323.4**			

Estimated shellfish landings (kg) at Pangai, Ha'apai are given below (as given in McKoy, 1980). Giant clams comprise the majority of this category.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1978	-	-	-	68	45	103	142	-	-	72	175	229
1979	198	190										

Species listed during the PIDP Vava'u housewife survey of tidal area usage in 1983 did not list giant clams as a food item, under the shellfish category harvested from the tidal area (Kunatuba and Uwate, 1983).

No estimates of giant clam landings in Tonga for the period 1980-1990 could be located. Udagawa and Tulua (1992) conducted a one-week survey in April 1992 at Vuna and Faua fish landing sites on Tongatapu, and estimated weekly molluscs sales to be 3,296 kg, valued at T$4,120. (The molluscs value was estimated using T$5 per 4 kg). These figures were extrapolated for the year (50 weeks) to obtain 164.8 mt for molluscs. Of this total, giant clams were estimated to make up 23.7 per cent, or 39.1 mt per year, landed at those sites.

Monthly shellfish landing estimates at Vuna and Faua Markets in Nuku’alofa in 1993 are presented in Table 4.1.1 as estimated from surveys conducted by the Ministry of Fisheries.

Table 4.1.1: Shellfish monthly estimated landings at Faua and Vuna landing sites. Numbers are in kg and composition (in percentages) are in brackets under each weight figure. .(Source: Udagawa, JICA, Ministry of Fisheries, Kingdom of Tonga).

Month	**Vasuva**	**Kaloa'a**	**To'o**	**Tengange**	**Elili**	**Kuku**	**Angaang a**	**Tu'ulalo**	**Kaipo**	**Tukumis i**	**Others**	**TOTAL**
March	**1,925.0 (16.1)**	6,579.8 (55.0)	425.0 (3.6)	435.0 (3.6)	915 (7.6)	170 (1.4)	135 (1.1)	595.0 (5.0)	0.0 (0.0)	585.0 (4.9)	198.6 (1.7)	11,963.4
April	**1,765.0 (20.2)**	3,920 (45.0)	210.0 (2.4)	180.0 (2.1)	180 (2.1)	310.0 (3.6)	85.0 (1.0)	910.0 (10.4)	0.0 (0.0)	1,160.0 913.3)	0.0 (0.0)	8,720.0
May	**3,130.0 (26.2)**	4,670.0 (39.1)	553.3 (4.6)	66.6 (0.6)	683.3 (5.7)	110.0 (0.9)	333.33 (2.8)	1,106.67 (9.3)	113.33 (0.9)	1,186.67 (9.9)	0.0 (0.0)	11,953.3
June	**1,769.2 (21.4)**	3,139.1 5 (37.9)	312.2 (3.8)	102.6 (1.2)	974.8 (11.8)	37.5 (0.5)	259.4 (3.1)	642.1 (7.7)	220.5 (2.7)	827.2 (10.0)	0.0 (0.0)	8,284.5
July	**3,533.8 (34.5)**	3,031.3 (29.6)	514.6 7 (5.0)	180.3 (1.8)	206.2 (2.0)	312.3 (3.0)	211.0 (2.1)	1,391.8 (13.6)	66.5 (0.6)	778.8 (7.6)	28.0 (0.3)	10,254.4
August	**3,790.5 (34.5)**	2,037.0 (18.5)	607.8 (5.5)	324.3 (3.0)	1,081. 5 (9.8)	721.0 (6.6)	101.5 (0.9)	1,692.2 (15.4)	0.0 (0.0)	451.5 (4.1)	180.8 (1.6)	10,988.2
September	**6,949.8 (61.0)**	1,893.5 (16.6)	401.3 (3.5)	266.0 (2.3)	508.7 (4.5)	46.7 (0.4)	239.2 (2.1)	414.2 (3.6)	98.0 (0.9)	533.2 (4.7)	37.3 (0.3)	11,387.8
October	**3,427.5 (39.2)**	2,623.2 (30.0)	173.5 (2.0)	586.0 (6.7)	176.0 (2.0)	137.3 (1.6)	366.3 (4.2)	686.0 (7.8)	136.0 (1.6)	318.0 (3.6)	116.0 (1.3)	8,745.8
November	**4,001.5 (45.2)**	2,727.0 (30.8)	368.2 (4.2)	206.2 (2.3)	245.0 (2.8)	77.5 (0.9)	312.2 (3.5)	470.8 (5.3)	174.3 (2.0)	266.0 (3.0)	3.0 (0.0)	8,851.7
December	**2,425 (35.2)**	2,655.0 (38.6)	185.0 (2.7)	163.3 (2.4)	116.7 (1.7)	75.0 (1.1)	200.0 (2.9)	403.3 (5.9)	203.3 (3.0)	458.3 (6.7)	0.0 (0.0)	6,885.0
TOTAL	**32,717**	**33,276**	**3,751**	**2,510**	**5,087**	**1,997**	**2,243**	**8,312**	**1,012**	**6,565**	**564**	**98,034.2**
Per cent	**33.4**	**33.9**	**3.8**	**2.6**	**5.2**	**2.0**	**2.3**	**8.5**	**1.0**	**6.7**	**0.6**	**100.00**

Note: Vasuva=giant clams, Kaloa'a=Anadara, To'o=Gafrarium sp., Tengange=Gafrarium sp., 'Elili=Turbans, Kuku=brown mussel, Angaanga=spider conch (Lambis),
Tu'ulalo=Codakis sp., Kaipo=small clam (Lioconcha sp., Pitar sp.), Tukumisi=sea urchin.

Using the figures for ten months in Table 4.1.1, an estimated 39.6 mt of giant clams are landed at these sites during the year. Some of the giant clams sold at these sites come from both Vava'u and Ha'apai.

It has been estimated that the amount sold at these sites account for approximately 75 per cent of the total landing for Tongatapu (Udagawa, 1993, *pers. comm.*). Thus an estimate of the 1993 giant clam landing in Tongatapu is 52.8 mt.

Small exports of clam meat were reported to have occurred from 1977 to 1980 (McKoy, 1980). The same author reported a weekly export of meat from 100 clams from Pangai, Ha'apai to American Samoa. This approximates to 5,200 clams a year for this venture, if shipment occurred every week.

Records of exports, indicating inclusion of giant clams, as compiled by the Statistics Department from Customs records, are shown in Table 4.1.2. Note that for some years (1982, 1983, and 1984) giant clams had a separate category and yet ***vasuva*** was also included in another category. The Statistics Department explained that no clam is included in the latter category. ***Vasuva*** was lumped with lobsters and crustaceans for 1980, 1981, 1982 and 1984 and ***vasuva*** and other clams were put together for 1985, 1986, 1987, 1988, 1989 and 1990. Giant clams were included in the former category for 1980 but not for the other years for the same category. The latter category had only giant clams. It is not clear whether any giant clam export records exist for 1991 and 1992 or whether they are included in any of the categories such as " lobsters, crustaceans, etc" or "crustaceans and molluscs including sea cucumbers". However, the Statistics Department claims that the latter category comprises mostly bêche-de-mer. In addition, clams are only separated when there are sufficient quantities.

Table 4.1.2: Export records of various marine animals from Tonga which include giant clams. Value is FOB. (Source: Statistics Department).

Year/category	Quantity (kg)	Value (T$)
1980		
Lobsters, crustaceans, **vasuva**, etc	833.0	1,906
1981		
Lobsters, crustaceans, **vasuva**, etc	2,872.0	15,284
1982		
Giant clams	2,201.5	15,295
Lobsters, crustaceans, **vasuva**, etc	2,952.0	12,806
1983		
Giant clams	717.0	3,556
Vasuva, frozen	225	1,085
1984		
Giant clams	3,252.0	6,514
Frozen molluscs	310	288
Lobsters, crustaceans, **vasuva**, etc	5,791.0	46,999
1985		
Vasuva and other clams	33	80
Lobsters, crustaceans, etc	869.0	6,940
1986		
Lobsters, crustaceans, etc	2,855.0	13,058
Vasuva and other clams	270.0	1,030
Crustaceans & molluscs (including sea cucumbers)	4,818.0	18,755
1987		
Lobsters, crustaceans, etc	3,421.0	30,351
Vasuva and other clams	1,36.0	5,106
Crustaceans & molluscs (including sea cucumbers)	657.0	4,500
1988		
Lobsters, crustaceans etc	3,844.0	964,442
Vasuva and other clams	798.0	3,005
Crustaceans & molluscs (including sea cucumbers)	237.0	230
1989		
Lobsters, crustaceans, etc	641.0	3,815
Vasuva and other clams	61.0	245
Crustaceans & molluscs (including sea cucumbers)	393.0	1,990
1990		
Lobsters, crustaceans etc	10.0	50
Vasuva and other clams	410.0	95 ??
Crustaceans & molluscs (including sea cucumbers)	602.0	2,990
1991		
Lobsters, crustaceans etc	1,192.0	13,405
Crustaceans & molluscs (including sea cucumbers)	17,131.0	102,325
1992		
Lobsters, crustaceans etc	1,454.0	13,110
Crustaceans & molluscs (including sea cucumbers)	67,221.0	615,432

Export records of live giant clams through the aquarium fish trade are presented in Table 4.1.3(a), as compared to other major categories. These are summaries of only some of the export records by one company.

Table 4.1.3(a): Summaries of some records of the aquarium fish exports by one of the companies operating out of Nuku'alofa.

Species category	1992 Pieces	1993 Pieces	1992 Percentage	1993 Percentage
Algae	4	0	0.02	0.00
Anemone	2,787	3,928	13.03	10.74
Corals	2,463	22,481	11.51	61.49
Crustaceans	1	0	0.00	0.00
Echinoderms	183	0	0.86	0.00
Fin-fish	15,747	8,059	73.61	22.04
Giant clams	**0**	**2,014**	**0.00**	**5.51**
Invertebrates	109	0.00	0.51	0.00
Shellfish	98	81	0.46	0.22

The export of giant clams by one of the new aquarium fish exporters in 1993, for only 6 shipments dated between July and December, is recorded in Table 4.1.3(b).

Table 4.1.3(b): Export of marine organisms in the aquarium trade by one of the new operators. The figures are for 6 shipments only in 1993.

Category	# Pieces	Percentage
Bivalve	8	0.11
Coral	1,632	21.74
Crustaceans	54	0.72
Fin-fish	4,498	59.91
Giant clams	**821**	**10.94**
Other Invertebrates	400	5.33
Shellfish	95	1.27
TOTAL # PIECES	**6,022**	
TOTAL VALUE	**19,184.70**	

4.1.3 Stocks Status

Relative abundance (percentages) of three giant clam species located during the 1979 survey by McKoy (1980) are reproduced below. These were based on field observations.

	Tongatapu	Ha'apai	Vava'u	Total
T. maxima	96.9	98.0	85.6	95.70
T. squamosa	2.4	1.0	14.1	3.50
T. derasa	0.7	1.0	0.3	0.80
Total number of clams observed	**576**	**1,104**	**327**	**2,007**

McKoy (1980) made estimates of abundance of giant clams in Tonga based on clams over 100 mm in shell length, seen and measured during 30 minute searches in several localities. Abundance estimates of *T. squamosa* and *T. derasa* were not made, due to insufficient data collected. Two divers searched fourteen localities on Vava'u, thirty-four on Tongatapu and twenty-five on Ha'apai. The average *T. maxima* abundance (mean number per 30 minutes for giant clams > 100 mm in shell length) calculated from results of dives in different localities is given in Table 4.1.4 for the different groups of islands. The localities for which *T. squamosa* and *T. derasa* were the main species are excluded as only abundances for *T. maxima* were estimated.

Table 4.1.4: *T. maxima* abundance as estimated by McKoy (1980) for various localities in Tonga.

Group/locality	Depth range (m)	Mean number per 30 mins
VAVA'U		
North of Foeata Is	0-7	3.5
NE Avalau Is	0-5	10.5
S of Mouna Is	6-20	7.0
Below Mo'ungalafa	0-7	12.0
Malafakalaua	0-6	6.2
SW Kapa Is	0-8	13.3
SE Kapa Is	0-8	3.0
E side Ofa South R	0-8	5.4
Inside Ofa South R	0-5	10.5
Reef E of Ofa South	0-7	4.0
HA'APAI		
Fakakakai Reef	0-7	10.7
Nukunamo - Ha'ano	0-5	2.7
Lotofoa Reef	0-6	3.3
Totua Reef	0-8	4.8
Hakau Faka'osi Toume	0-4	4.2
Muikuku Point	0-7	7.0
Ngahi Hakau Fatafehi	0-6	10.7
Hakau Vana	0-7	8.1
Hakau Sela	0-8	7.7
SW Hakau Loa	0-7	18.0
Channel Lifuk-Foa	0-3	3.6
E Hakau Kito	1-6	25.7
NE Hakau Faha	0-7	8.5
SW Hakau Faha	0-8	19.2
North Limu Is	0-4	24.6
Limu Is	0-4	20.2
South Limu Is	0-8	3.5

Group/locality	Depth range (m)	Mean number per 30 mins
TONGATAPU		
Monotapu	0-3	3.0
Ha'atafu	0-7	1.7
Ha'atafu N	0-6	0.7
Hakau Mama'o	0-6	19.0
Hakau Mama'o	0-7	22.8
NE Tufaka I	0-3	2.6
NW Fafa	0-4	4.4
Pangaimotu	0-5	3.5
E Fafa	0-5	11.5
NE Fafa	0-7	3.5
W Malinoa I	0-6	0.7
E Malinoa I	0-4	1.3
Reef W of Ata I	0-7	2.0
N Tau I	0-8	28.5
W Tau I	0-4	4.8
Ata-Tau	0-3	12.0
NW Makaha'a	0-6	0.7
W Monuafe	0-3	1.4
NW Makaha'a	0-3	1.3

A follow-up survey in the Ha'apai group of islands was conducted in 1989. Average numbers per hectare were estimated to be 7.25 for *T. derasa*, 13.6 for *T. squamosa* and 16.0 for *T. maxima* (Manu *et al*, 1989). However it seems that different localities were surveyed and the method employed in estimating abundance was different from that used in the original survey. Results could have been comparable if the areas covered by McKoy (1980) were given. Nevertheless, estimates indicated heavy exploitation on the resource in Ha'apai. The results of the follow-up survey in Ha'apai are extracted from Manu *et al.* (1989) for the different species and are recorded in Table 4.1.5.

Table 4.1.5: Giant clam abundance (numbers per hectares) in Ha'apai as estimated in 1989.

Species/Location	Depth (m)	*T. derasa*	*T. squamosa*	*T. maxima*
Kelefasia	3-5	0	0	0
Kelefasia	3-5	0	0	0
Nuku	5-7	0	0	0
Nuku	5-7	3.6	3.6	0
Tonumea	0.5-1.5	0	0	0
Tonumea	0.5-1.5	0	20.0	20.0
Mango	3-9	0	5.7	17.7
Mango	3-9	0	21.4	14.3
Mangoiki	3-7	11.4	2.9	0
W/Lofanga	5-10	60.0	90.0	0
E/Niniva	5-10	26.7	46.7	53.3
Nomukeiki	2-5	3.3	43.3	43.3
Nomuka	2-8	0	13.3	20.0
Ofolanga	3-8	6.7	0	30.0
Luahoko	2-6	0	33.3	6.7
Kauvai	2-8	0	6.7	40.0
Nukunamo	2-10	0	0	6.7
Fangale'ounga	2-10	0	0	26.7
Hakau Tu'aniu	2-20	0	10	26.7
Auhangamea	5-30	56.7	36.7	30.0
Ava Matu	5-10	3.3	16.7	23.3
Uoleve	2-3	0	6.7	10.0
Luangahu	10-20	16.0	0	12.0
Matuku	3-10	12.0	0	6.7
N.W Ha'afeva	3-15	0	6.7	20.0
O'ue	3-10	0	10.0	10.0
Fonoi	2-5	0	0	13.3
Lekeleka	3-6	3.3	6.7	16.7
Average		**7.25**	**13.6**	**16.0**

On Vava'u, surveys conducted between 1987 and 1988 showed no evidence of *T. derasa* recruitment before the installation of a sanctuary there (Chesher, 1993). In addition the results indicate over-fishing had seriously endangered the species in the inner island group of Vava'u and lowered the adult stock to below levels required for successful recruitment (Chesher, quoted above). Chesher (1989) gave relative abundance of three giant clam species in Vava'u as; *T. maxima*-90.9 per cent, *T. squamosa*-8.5 per cent and *T. derasa*-0.6 per cent.

4.1.4 Resource Enhancement and Aquaculture

Clam circles

The Ministry of Lands, Survey and Natural Resources, with the cooperation of the Fisheries Division of the Ministry of Agriculture, Forestry and Fisheries and the Marine Research Foundation, established the first giant clam circle in Tonga during the Environment Week in June 1986, on a reef in Nuku'alofa harbour, using broodstock of *T. derasa*. This was an attempt to revitalize the stocks of these animals on the northwestern reefs of Tongatapu Island (Chesher, 1989). Four such circles were set up in Vava'u Harbour (ACIAR, 1992). The first community giant clam sanctuary was established in early 1988 at Falevai, Vava'u. Three additional sanctuaries were established in September 1990 with funding from FAO (Chesher, 1993).

Chesher (cited above) reported that giant clam recruitment for both species, *T. derasa* and *T. squamosa*, has occurred as a result of the installation of sanctuaries in Vava'u. The Falevai sanctuary was reportedly very successful. However, the same author also wrote that when the villagers abdicated their responsibility to look after the clams, the clams began to vanish. This is presumably referring to the involvement of the Ministry of Fisheries, which took over responsibility for checking on the clams, starting in 1990. Failure of other clam circles were attributed to poaching of broodstock (ACIAR, 1992).

Ministry of Fisheries Hatchery and Ocean Nurseries

The Ministry of Fisheries was a partner in the second phase of the ACIAR funded project on, "The Culture of the Giant Clam (Tridacnidae) for Food and Restocking Tropical Reefs", from 1989 to 1992 (ACIAR, 1992). The principal objective of the Tonga section was to establish a hatchery-nursery for the production of clams, to enhance local populations, as well as possibly establishing commercial clam farming in the region. The Tonga module was executed by the Ministry of Agriculture, Fisheries and Forestry in collaboration with the James Cook University of North Queensland, and funded by the Australian Centre for International Agriculture Research. Fa'anunu (1993) listed the ACIAR project as providing:

- rehabilitation of the hatchery with all equipment necessary for giant clam spawning;
- operation costs;
- wages for project leader;
- training; two in Australia, 2 in Fiji for 1 month;
- technical advisers; twice/year for 1-2 months duration;
- travel for Project Leaders annual meeting.

The results during the ACIAR phase are reported in ACIAR (1992). The main achievements include:

- the establishment of a hatchery designed for simple operation and maintenance;
- successful application of hatchery production procedures;
- initiation of ocean nurseries for farming trials;
- training for local officers in all aspects of giant clam mariculture techniques;
- re-introduction of locally extinct giant clam species;
- establishment of the presence of the newly described giant clam species, *T. tevoroa*.

Under the current JICA Aquaculture Project at the Ministry of Fisheries, stock enhancement of giant clams forms a major component.

Spawnings at the hatchery as well as production are summarized below for the Giant Clam Project at the Ministry of Fisheries during both the ACIAR project and the current JICA programme:

1. Spawning and Hatchery Production:

Date	Species	Production	Ocean distribution
Dec, 1989	T. derasa	25,000 8-month old	placed in ocean nurseries 1990
1990/1991	T. derasa	30,000 1-year old	??
1991/1992	T.derasa	100,000, May, '92	
	T. squamosa	400,000, May, '92	16,400 to o/nursery in June 1993
	T. tevoroa	1,700 5-6-month	500 to Fiji after 3 months
		(1,200 remained in hatchery)	300 to o/nursery in June 1993
Nov., 1992	T. derasa	20,000 3-months old	fast growing 3,500 to o/nursery in Aug-Oct, 1993
Nov., 1992	T.tevoroa	2,000 3-months old	416 to o/nursery in Aug., 1993

Closer examination of specimens from the 1991/1992 batch that were claimed to result from *T. tevoroa* spawning, indicate that they are *T. derasa* (Sone, JICA, 1993, *pers. comm.*). Broodstock of both species were in the same tank at the time of spawning.

2. Introductions:

Species	Date	Number Imported	Age at Importation	Number Transferred to Ocean nursery
T. gigas	Aug., 1990	260	10 months	5, Dec., 1990
T. gigas	April/May, 1991	11,000	5 months	2,800 Vava'u in October, 1991 1,000 Ha'apai in October, 1991 4,000 Nuku'alofa in October, 1991
H. hippopus	April/May, 1991	20,000	3 months	14,000 Nuku'alofa, November, 1991

3. Ocean nurseries: Six trial farm ocean nurseries were established by the Ministry of Fisheries in 1990. These include four in Vava'u and one each on Ha'apai and Tongatapu. Most of the nurseries at Vava'u were set up inside established clam circles (ACIAR, 1992). The farm on Tongatapu is in front of the hatchery at Sopu. ACIAR (1992) listed the number of giant clams in nurseries at the end of 1991 as follows:

Location	Species	Number
Tongatapu	T. gigas	3,000
	H. hippopus	14,000
	T. derasa	13,000
Ha'apai	T. derasa	3,000
	T. gigas	1,000
Vava'u	T. derasa	8,000
	T. gigas	2,000

It was not possible to obtain updated data and information concerning the status of these ocean nurseries.

Two new nurseries were established in 1993 under the current JICA/Ministry of Fisheries giant clam programme. The first one was that on Atata Island, involving the whole community, which was initiated in March 1993. The number of giant clams transplanted in 1993 include 2,000 twenty-month old *T. derasa* and *T. squamosa*, and 20 two-year old *T. gigas*. By October, 1993, only 5 *T. gigas* were left. The second nursery was established in Kolonga in October, 1993. This is also a community undertaking and 2,000 two-year old *T. derasa* have been transplanted there.

Establishment of three more nurseries around Tongatapu is a possibility under the current JICA work programme. Under this 3-year programme, 2,000 *T. derasa* will be given free for each nursery established. In addition, cages and cement blocks will also be given free, providing that maintenance is done and security provided by the community. The project will concentrate on *T. derasa* and *T. tevoroa*. The choice for these two species is because of their superior growth and survival rates (Sone, JICA, 1993, *pers. comm.*).

The exploitation of wild juvenile clams, especially *T. maxima*, in the aquarium trade, indicates the existence of an export market for this species. The giant clam aquarium trade is a growing market and offers a potential development for the production of cultured *T. maxima* in Tonga. If the government hatchery can produce *T. maxima* yearlings and sell them, for a minimal price, to community-based farms, the farmers can culture them until they are big enough for the aquarium trade. The culture period of clams for the aquarium trade is much shorter and could be more profitable.

4.1.5 Management

Two species of giant clams, *H. hippopus* and *T. gigas*, are believed to have become extinct in Tonga. It is not clear whether this has come about as a result of over-exploitation or other factors. Over-exploitation, leading to local species extinction has been documented for giant clams, especially in countries where these vulnerable resources have been targets of large scale commercial exploitation.

Exploitation of giant clams in Tonga has proceeded without any consideration given to sizes and conservation of stocks. Giant clams sold in the local markets in baskets are often far too small to have allowed these clams to undergo natural reproduction for future stocks. The aquarium trade has targeted juveniles, especially *T. maxima*, in its collection of clams from the wild.

Collection of catch data on the giant clam resource, in addition to more assessment work, is required.

Current legislation/policy regarding exploitation: The export of giant clams for commercial purposes has been banned. Allowances are made only for export of limited amounts of meat for home consumption.

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

The proposed Fisheries Regulations recommend the application of minimum size limits for the three species as; *T. derasa*-260 mm, *T. squamosa*-180 mm and *T. maxima*-155 mm.

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

A special provision should be considered to exclude hatchery-reared giant clams from the export prohibition of giant clams.

If clam circles can be clearly shown to enhance recruitment of natural populations, then this development deserves the support of the government. The objective of establishing community-based ocean nurseries needs to be defined, and then explained to communities involved, so that there will be no misunderstanding as the project proceeds. It is only natural that people would want to know and see the benefits in real terms, not in theory. If the benefits are not seen within a few years, people normally give up. It has not been proven yet that farmed giant clams in ocean nurseries contribute a great deal in the natural recruitment process. Given these points, some consideration should be given to the establishment of community-run farms for both commercial purposes and as a source of broodstock. In this case, juvenile clams would only be given free for the first one or two years as an incentive. Farming clams for sale when mature will relieve pressure on the local wild stocks.

Other management options suggested by McKoy (1980) include; quotas on catches, closed areas and closed seasons. In addition, prohibition of the use of SCUBA and other compressed air breathing apparatus for the taking of giant clams, was suggested.

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4.2 Oysters, Pearl Oysters - *Sio, Fai'ahu, Fotu'ohua, Tofe*

4.2.1 The Resource

Species present: Edible oyster species found in Tonga include; *Saccostrea cucculata* (***sio***), *Pinctada margaritifera* (black-lip pearl oyster - ***tofe***), *P. radiata* (pearl oyster - ***tofe***), *P. furcata* (Japanese pearl oyster), *Spondylus squamosus* (thorny oyster - ***fai'ahu***), and *Chama iostoma* (jewelbox oyster - ***fotu'ohua***).

Introduced pearl oysters species include; *P. maxima* (white-lip pearl oyster) and *Pteria penguin* (winged Mabe pearl oyster - ***tofeloa***) brought in from Japan for pearl oyster culture trials starting in 1975. Edible oysters introduced to Tonga, also for culture experiments include, *Crassostrea commercialis*, *C. gigas* (Pacific oyster), *Ostrea edulis*, *C. belcheri*, *C. virginica*, *C. iradalei*, and *S. glomerata*.

Distribution: With the exception of the Arctic and Antarctic regions, oysters are found in all of the sea areas of the world. Species of oysters vary widely, from those living on the rocky reefs of outer ocean coasts with high salinity waters to those living in the inner recesses of bays with a high degree of fresh water flow. Among their species can be found a wide variety of life patterns as well. Approximately 200 species of oyster are known to exist in the world. For pearl oysters, temperature limits vary between species and are the main influence on their distribution (Gervis and Sims, 1992). Depth distribution in pearl oyster species also differs but all prefer full salinity seawater.

Very little is known about the distribution of native oysters species in Tonga waters, except for those recorded in a shellfish survey conducted in 1987 by the Fisheries Division in the Vava'u area. The survey was targeting shellfish consumption and the results are summarized below for the villages surveyed and where oysters were recorded, but not necessarily consumed: (Source: Bondurant, 1987).

Village	***S. cucculata***	***P. margaritifera***	***P. radiata***	***P. penguin***	***S. squamosus***	***C. iostoma***
Oloua		Y	Y	Y	Y	
Tefisi	Y	Y		Y	Y	
Hunga		Y	Y	Y	Y	
Ofu		Y	Y	Y	Y	
Talihau		Y	Y		Y	Y
Koloa	Y	Y	Y	Y	Y	
Taunga		Y	Y	Y	Y	Y
Matamaka		Y	Y		Y	
Tuanekevale			Y		Y	
Holonga						
Feletoa	Y		Y			
Vaipuna Lagoon	Y		Y		Y	

Oyster occurrence and consumption seems to be more confined to the Vava'u Group where habitat favours growth of these resources.

Biology and ecology: Among the varieties of shellfish presently inhabiting the earth, the most prolific are the conch (Gastropoda) and bivalve (Pelecypoda) families. The bivalves, such as scallops, tend to bury themselves in the ocean floor or, in the case of oysters, attach themselves to rock outcroppings or reefs.

The soft body of the bivalves is fully enclosed in a shell and a mantle with which the shell is lined. There is also a gill between the mantle and internal organs. On the back edge of the body are a number of water pores through which water is drawn in to pass through the gill enabling breathing.

At the same time, the gill also functions to separate debris in the water from edible suspended matter such as plankton for the ingestive process. The volume of water thus processed by the gill in the case of "***Magaki***" (Pacific cupped oyster) is said to be about 10 liters per hour. Virginia oyster (American cupped oyster) filters about 5-25 liters/hour at a water temperature of 20 C°. This means that some oysters process more than 1,000 times their body weight (without shell) of water every hour (Yamaha, 1989). The amount of vegetable plankton consumed by an adult oyster in one day is thought to be between 1 and 5 g.

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

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

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

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

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

In Tonga, a two-year study on three species of oysters in Vava'u was undertaken to determine spatfall timing, growth and reproductive phase, and to ascertain their viability for mariculture. The results indicated that spatfall for *S. cucculata* occurred throughout the year with peaks during the March-June period. However growth was poor, not exceeding 3.2 mm per month. Spatfall for *P. radiata* was also almost continuous throughout the year but peaked in the October-November period, and was heaviest in channels where tidal currents were swift. Growth recorded for this species averaged 4.5 mm per month. *C. iostoma* showed the slowest growth rate and had the poorest settlement rate.

4.2.2 The Fishery

Utilisation: Oysters are consumed in Tonga mostly at the subsistence level. However, some of the oyster species are collected not only for their meat, but also for their shells which are sold for handicrafts and curios. The results of a shellfish consumption survey conducted in Vava'u in 1987 are recorded in Table 4.2.1.

Table 4.2.1: Occurrence and consumption of oysters in Vava'u in 1987. (Source: Bondurant 1987).

Village (island)	Oyster species found	Consumed	Other information e.g. importance
Oloua Island	*P. margaritifera*	Y	one of most often eaten but not one of most preferred species
	S. squamosus	Y	one of most often eaten and preferred shellfish species
	P. radiata	?	collected
	P. penquin	?	collected
Tefisi	*P. margaritifera*	Y	one of most often eaten and preferred shellfish species
	S. squamosus	Y	not often eaten and not one of preferred shellfish species
	P. penquin	Y	not often eaten and not one of preferred shellfish species
	S. cucculata	N	only several hundreds away but not eaten
Hunga	*S. squamosus*	Y	one of most often eaten and preferred shellfish species
	P. margaritifera	?	collected
	P. penquin	?	collected
	P. radiata	?	found around coral heads and rubble
Ofu	*P. margaritifera*	Y	one of most often eaten and preferred shellfish species
	S. squamosus	Y	one of most often eaten but not preferred shellfish species
Talihau	*S. squamosus*	Y	one of most often eaten but not preferred species
	P. margaritifera	Y	one of most often eaten and preferred shellfish species
	P. radiata	Y	one of the most often eaten and preferred shellfish species
Koloa	*S. squamosus*	Y	one of most often eaten but not preferred shellfish species
	P. margaritifera	Y	one of the most often eaten but not preferred shellfish species
	P. penquin	Y	one of the most often eaten but not preferred shellfish species
	S. cucculata	Y	other species collected
	P. radiata	Y	on sand flats
Taunga	*S. squamosus*	Y	other shellfish species consumed
	C. iostoma	Y	other shellfish species consumed
	P. margaritifera	Y	other shellfish species consumed
	P. radiata	Y	other shellfish species consumed
	P. penquin	Y	other shellfish species consumed
Matamaka	*P. radiata*	Y	one of the most often eaten but not preferred shellfish species
	S. squamosus	Y	other shellfish species eaten
	P. margaritifera	Y	other shellfish species eaten
Tuanekevale	*S. squamosus*	Y	one of the most often eaten but not preferred shellfish species
	P. radiata	?	other shellfish species collected
Holonga	no oysters listed		
Feletoa	*S. squamosus*	Y	other shellfish species eaten
	S. cucculata	Y	other species eaten
	S. cucculata	Y	from roots of mangroves in Vaipuna lagoon
	P. radiata	N	present but not eaten due to small size

Oysters are, on rare occasions, sold in the Nuku'alofa fish market. Very small quantities of black-lip pearl oysters have been reported as being exported from Tonga.

Production and marketing: No reference could be located that specifically lists landings of oysters at any level of exploitation within the Kingdom of Tonga. Results of the Fisheries Division shellfish consumption survey conducted in eleven villages in Vava'u in 1987, are summarized in Table 4.2.1, which indicates the species collected and those consumed by villages. No actual figures were available. Oyster production is probably very small.

4.2.3 Mariculture trials of oysters in Tonga

Edible oysters: All of the information presented here were extracted from Uwate *et al*. (1984). The pilot oyster culture project in Tonga was initiated in Fanga'uta Lagoon in 1973 using 10,000 seed of *S. commercialis* imported from New Zealand. The following table records details available on imported oyster seeds for culture trials in Tonga.

Species Introduced	Amount of seeds	Import date	Seed Source	Use
S. commercialis	10,000	December, 1973	New Zealand	Fanga'uta culture trials
S. commercialis & *C. virginica*	10,000	1973	California	?
S. glomerata with *S. commercialis*	~7,000	?	?	raft culture trials in 4 localities
S. commercialis	~4,000			planted between 4 selected sites
C. gigas	?	1974?	?	Fanga'uta lagoon, rafts relocated to Pangaimotu Island and Vava'u
C. gigas & *O. edulis*	2 consignment	1975	U.S. and Japan	all dead on arrival
C. gigas & *O. edulis*	1 consignment	1975	?	high mortalities on arrival, site used not given
C. gigas	?	1975	Tasmania & Japan	cultched spat, Pangaimotu? & Fanga'uta?
C. iredalei	?	1976?	Philippines	Fanga'uta lagoon?
C. belcheri	?	1977	Malaysia	Nukunukumotu Channel & Vava'u
C. belcheri & *Perna viridis* (green mussel)	2 consignment, 100,000 seeds	1978	Malaysia	Nukunukumotu Island & Tongatapu

The introduced oyster spats grew well in some sites that were chosen, and some were able to reach commercial size. However, commercial culture was not feasible. Heavy siltation in Fanga'uta Lagoon area resulted in poor oyster growth and that *C. gigas* mortalities in Pangaimotu was almost 60 per cent. Mortalities were caused by the borer, *Thais* sp. and the drill worm, *Symbatium* sp. Heavy unexplained mortalities drastically reduced stocks. No natural reproduction was observed on the introduced oysters and by 1979, the introduction and culture of *C. gigas* was declared as a failure and that *C. belcheri* culture provided no meaningful results. By 1981 the cultivation of oysters was terminated, with inadequate growth rates and low market prices quoted as limiting factors.

In 1987, a 2-year study was initiated to investigate the potential of local edible oyster species for culture in Vava'u. It was found that none of the 3 species present offered commercial indications for culture.

Pearl oysters: (Hopson, 1980) The first pearl oyster culture trials conducted in Tonga involved the introduction of 135 one-year old Mabe pearl oyster (MPOs) or the giant winged pearl shell (GWPS), *P. penguin,* of 80-140 mm UVL (umbo-ventral length) and 84 two-year-old oysters of 125-165 mm UVL (umbo-ventral length) in July 1975. All the oysters were taken to Vava'u and suspended from rafts in two locations, Vaipua and Tefisi.

Growth data from August 1975 to March 1976, showed that the mean length of the 1-year old oysters had increased by 77-82 mm and the 2-year old ones by 61-70 mm. The first operation to implant oysters began in October, 1977 and was conducted on the then 3-year MPOs at Vava'u. At the same time, a shipment of seed oysters of 100 MPOs, 108 Japanese pearl oyster (JPO), 135 *P. margaritifera*, black lip pearl oyster, (BLPO), and 800 *P. maxima*, white lip pearl oyster (WLPO) arrived by air from Japan. Mortality during shipment was high, and subsequent mortality after arrival was also high in BLPO and WLPO due to oyster drill attacks.

Blister pearls from the 1977 MPO operation were collected in October 1978 and further operations were carried out on both JPOs and the original 75 MPOs. Blister pearl quality was moderate to very good. Several pearls were mounted in various settings and presented in December 1979 to the King and Minister of Agriculture. In December, 1979 the JPOs and MPOs operated on in October 1978 were examined. True pearls produced from JPOs at the Pangaimotu trial had very poor quality due to poor growth, while the blister pearls from MPOs at Vava'u ranged from poor to very good.

In December of the same year, an additional consignment of 4-month, 1-year and 2-year old WLPO arrived from Japan. Transhipment mortality was high especially in the younger oysters. These were mounted on an iron frame sitting on the sea bed off Pangaimotu Island. This was to be used for monitoring oyster growth of this species in Tongan waters and were to eventually serve as nucleus of stock for artificial breeding. Implantations were conducted on MPOs from another frame deployed near Pangaimotu Island in December 1979, using a new technique developed by Tasaki Pearl Co. for the production of 3/4 round blister pearls which were more valuable than ordinary blister pearls. Conclusion from the preliminary pearl oyster work at Vava'u suggested that sheltered inlets of the island group were suitable for WLPO.

The Tasaki Pearl Co. operation was terminated in 1979 when their request for exclusive rights of the Vava'u harbour bay area was refused by the Tonga Government (Ministry of Fisheries, 1992).

In 1989, a preliminary survey was conducted by SPADP to confirm the presence of GWPS stocks in Vava'u, observe spat falling, preferred substrata and identify suitable location for the deployment of spat collector and determine if natural stock has a potential for an adequate spat collection and culture trials to be undertaken. The survey found only small numbers of JPO broodstock and that their aggregation was restricted to FAD anchor ropes. A spat collection and culture trials were not recommended.

However, despite survey results, the Ministry of Fisheries, with full funding assistance from SPADP, initiated a spat collection programme in December, 1989. The objectives were to determine spawning season, spat falling and growth rate, determine adequate depth and sites for intensive spat collection, and determine the best suitable material to be used for spat collectors. The results were encouraging and indicated that the preferred settlement material was the black polyethylene rope; settlement decreased from May to a minimum in September and increased to a maximum in April; depth preferred was 30-34 m from surface; and that distribution was restricted to inside the Vava'u Harbour Bay.

Spat collected were used for grow-out experiments on survival and growth rates. They were cultured using the net basket hanging type, and transferred to nets with bigger mesh as they grew. Oysters with 60-80 mm length were drilled and tied individually with monofilament line to a growing rope at 15-20 cm intervals, and a completed line contained 60-70 oysters. Growth rates were excellent with young oysters which grew at 13.3 mm per month. This fast growth rate enabled early nuclei implementation by a year or two, which normally occurs in the fourth year. Mortality in net baskets was approximately 40-50 per cent, which was due mainly to crowding and poor management. Predation by fish was observed on oysters with hinge umbo-ventral length of up to 72 mm. It was recommended to keep oysters in baskets until they are bigger than 72 mm in length. Predation by *Cymatium* sp. was also observed in net baskets but was reduced by regular basket cleaning.

After 14 months from spat collection, 350 oysters were big enough for pearl grafting, and the Ministry of Fisheries staff underwent training in grafting technique conducted by Mr Tokito of Tokito Pearls of Fiji, funded by SPADP. Of the 350 operated oysters, 300 were *P. margaritifera* and the rest *P. penguin*. Results showed that 50% and 12.5% of harvested *P. penguin* and *P. margaritifera* had commercial value, respectively. The low pearl quality was due mainly to high growth rate after operation and poor nuclei placement. A second trial of 1/2 pearl grafting was conducted in September, 1991. Of the 50 *P. penguin* implanted, 25 yielded 1/2 pearls with market value, in 1992. These were sent to Japan for processing. Processed pearls were valued as follows: 1 @ 13,000 y, 4 @ 9,000 y, 1 @ 8,000 y, 4 @ 6,000 y, 2 @ 5,000 y, 5 @ 4,000 y, and 8 @ 2,000 y. Processing costs were US$8 a piece.

In 1992, 312 half pearls, produced from 500 implanted oysters, were also sent to Japan for processing. These were approximately of the same value as those sent earlier. By October of the same year, 1,000 oysters were implanted out of the 10,000 in culture, of various sizes. A programme was initiated in which 200 oysters were implanted per month. The spat collection experiment continues.

The project, "Commercial Feasibility of Pearl Farming in Tonga", was initiated in March 1993. The project is aimed at improving the quality of produced pearls. `Findings from a marketing tour to Japan indicated that quality of pearl depends on environmental factors, water quality, implanting and harvesting season and length from implanting to harvest (Fa'anunu, 1993). Thus this project's aims include, determining the best suitable site for farming, implanting and harvesting season, and positioning of the implanting nucleus (Fa'anunu, cited above).

A private, experimental pearl culture facility, has recently been established at Makava, Vava'u.

4.2.4 Stocks Status

The only assessment work conducted on some oyster species in Tonga were those at Vava'u to assess their potential for mariculture. Considering their growth, abundance and spat settlement rates, Bondurant (1990) concluded that only *P. radiata* had potential for culture, if it could be grown to attain the size of 60-80 mm in eighteen months.

During a survey in Neiafu Harbour in Vava'u to confirm and assess the winged pearl oyster population there, only very limited broodstock was located (Foscarini and Fa'anunu, 1989). As a result, only a spat collection programme was recommended. The spat collection programme by the Ministry of Fisheries has been successful for the pearl oyster species, *Pt. penguin* and *P. margaritifera*.

4.2.5 Management

The harvesting of the oyster resources in Tonga has been limited to a few areas where they are found. Even though they are consumed, they are not preferred in most cases. Spat collection within the Neiafu Harbour on Vava'u has been successfully conducted by the Ministry of Fisheries for the pearl oyster species, *P. margaritifera* and *Pt. penguin*. This was initiated in 1989.

Current legislation/policy regarding exploitation: There is currently no legislation dealing with the exploitation of oysters in Tonga. However, Section 25 of the Fisheries Act 1989 provides for the leasing of land for aquaculture purposes. These include areas on land, lagoons, the foreshore and sea-bed.

Recommended legislation/policy regarding exploitation: The proposed Fisheries (Conservation and Management) Regulations 1993 include a minimum size limit of 20 cm in dorso-ventral length for the introduced winged pearl oyster, *Pt. penguin*.

Consideration should be given to include some of the native oyster species in the minimum size limit regulations, especially pearl oysters, which are collected for the meat for consumption as well as for the shell to be sold in the handicraft trade. In Federated States of Micronesia, the collection of *P. margaritifera* is prohibited from 1 August to December 31. This is probably the peak spawning period there. In addition, the taking of shells of the same species under 6 in. (15.24 cm) is prohibited. The only exceptions to these are those collected for scientific purposes when authorized (Smith, 1992). Additional work is required to obtain certain information for the management, and possibly development, of the native oyster species, especially pearl oysters in Tonga. One such work is the establishment of a more vigorous spat collection programme for *P. margaritifera*, especially in Ha'apai.

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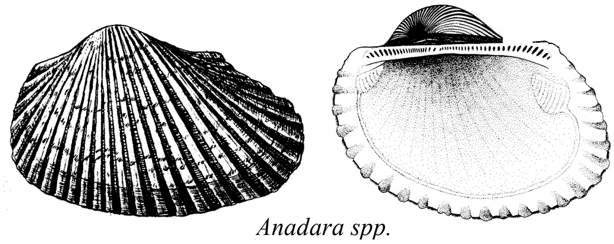
4.3 Ark shell (*Anadara* sp.) - *Kaloa'a*

4.3.1 The Resource


Anadara spp.

Species present: *Anadara* species are known collectively as "***kaloa'a***" in Tonga. Spennemann (1987) lists *Anadara antiquata* and *A. cornea* as the species found in Tonga. Bondurant (1987) classified the specie found in Vava'u as *A. scapha*. Recently, Sone (1993) identified the two species present in Tonga as *A. antiquata* and *A. maculosa* following the guide by Yamaguchi (1992).

Distribution: On Vava'u, ***kaloa'a*** was listed as one of the shellfish species harvested from the tidal areas there (Kunatuba and Uwate, 1983). In eleven villages on Vava'u, Bondurant (1987) describe areas from which *Anadara* sp. is harvested as follows: Oloua - in sand; Tefisi - sandflats in bay with fringing mangroves; Hunga - sandflats by the shore in bay; Ofu - off the beach on the western coast of the island in sand; Talihau - lagoon east of village in lagoon sandflats fringed with mangroves; Koloa - in sandflats at mouth of lagoon with mangroves further inside lagoon; Taunga - along beaches to south and east; Tuanekevale - lagoon nearby with fringing mangroves and *Anadara* sp. collected within the lagoon; Holonga (situated north and thus on the leeward coast of main island) - in sands of bays; Vaipuna lagoon fringed with mangroves, bottom mostly sand with more sediment and mud at end of lagoon - *Anadara* sp. on sandflats. *Anadara* sp. is plentiful in sand flats at Felemea village, 'Uiha Island, Ha'apai.

Spennemann (1987) describes the general habitat of *Anadara* sp. as in sand flats with free access to sea water. On Tongatapu, the main areas were listed as sandy flats of the fringing reefs NE of Tongatapu, especially at Makaha'a, Monuafe and Onevai islands. In addition, the same author reported that *A. antiquata* is found on the intertidal sand and sand/mud flats of the Kolovai/Fatai area, but only some distance out on the sandflats. Zann (1984, quoted in Spennemann, 1987) reported that, with respect to the Fanga'uta Lagoon, *A. antiquata* can be found only at the entrance. This could be due to high salinity in this area as compared to the gradual decrease in salinities going into the lagoon, as *Anadara* prefers high (oceanic) salinities.

Sone (1993) writes that around Tongatapu Island, both species of *Anadara* are common in seagrass beds with sandy substrate. The same author did not find any specimens of *A. maculosa* in the Nukuleka area.

Biology and ecology: Farmed cockles, *A. granosa*, in Thailand are harvested after 18 months when they reach about 4 cm and 24 g in weight (Tookwinas, 1983). In India the same species is found to spawn throughout the year and can have 2-4 reproductive cycles in a year. First maturity is attained at 20 and 24 mm for males and females respectively (Narasimham, 1988).

Even though *Anadara* spp. form a major component of the shellfish fishery both at the subsistence and artisanal levels, no study has been conducted on its biology, ecology and abundance in the kingdom prior to the initiation of the Aquaculture Research and Development Project by JICA in 1992. Preliminary results of that study between May 1992 and February 1993 form this section (all the results were extracted from Sone, 1993). Examination of monthly gonad samples from ten large specimens of both species, from seven sites on the north of Tongatapu island, provided the following information for each individual species. Gonad development was classified in three stages; (1) inactive or completely spent stage (ICS)-gametes cannot be seen in incised gonads, (2) developing or partially spent stage (DPS)-gametes spent but not much in gonads, intermediate conditions between

ICS and R were included and in some cases, incisions were needed to sex them, (3) Ripe stage (R)- gametes rich in swollen gonads and sexuality easy to determine externally.

A. antiquata - gonads are easy to identify as ovaries are reddish/orange in colour while testes are creamy white. Swift gonad deflation in April and the May-July period was shown as the inactive period for this species. The August-September period was found to be mostly inactive with only small amounts of gametes found in one specimen. Gonads rapidly develop during the October/November period. The majority of the sample were in fully ripe condition during the December sampling and that the January samples were mostly in spent stage. The majority of February and March samples were again in ripe condition with half in spent stage on 9 March, two days after full moon. The breeding season for this species in Tongatapu was then estimated to be from October to March. Sex differentiation and shell length relationship in *A. antiquata* is shown in Table 4.3.1(a) for the specimens examined (the numbers are the numbers of individuals from the total number sampled). Females under 40 mm in shell length were difficult to find and it is assumed here that males reach sexual maturity at smaller sizes.

Table 4.3.1(a): Sex differentiation and shell length relationship in *A. antiquata* .
(Source: Sone, 1993).

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

A. maculosa - inactive period is the same as *A. antiquata,* but the breeding season was determined to be from November to March. Sex differentiation and shell length relationship for this species is presented in Table 4.3.1(b).

Table 4.3.1(b): Sex differentiation and shell length relationship in *A. maculosa* .
(Source: Sone, 1993)

Shell length (mm)	Undetermined sex	Female	Male
-20	-	-	-
10-30	12	0	4
30-40	7	1	16
40-50	4	3	27
50-60	0	16	22
60-70	0	19	12
70-80	0	23	13
80-90	1	7	4
90+	0	5	4

4.3.2 The Fishery

Utilisation: Spennemann (1987) noted that the earliest sites, pottery-bearing middens indicate that as on other islands, the early Tongans relied heavily on the exploitation of molluscs, turtles and fish offered by the lagoon and fringing reef. McKern (undated, quoted in Spennemann, 1987) writes that shell fishing in ethnohistoric and modern Tonga is done collectively by the women, who walk at low tide to the reef and mudflats or into the lagoon, search the ground with their toes, and dig out/pick up the shells with their hands. Spennemann (cited above) noted that *Anadara* spp. was generally preferred over *Gafrarium* spp. because of their greater overall size even though *Gafrarium* spp. are considered tastier. He further noted that both species form a major portion of the shellfish resource and that both are exploited and locally marketed today. Sone (1993) writes that *Anadara* is the main target species of the subsistence shellfish fishery by the local population, and that both *Anadara* species are harvested together as they inhabit the same habitat.

Today ***kaloa'a*** is commonly sold in the market in baskets, plastic bags or bundles, and forms the major component, in terms of weight (and numbers), of the mollusc sales in the domestic market. The small scale commercial fishing (artisanal) for this resource is well established (Sone, 1993).

On Niuatoputapu, *A. antiquata* is one of the four principal resources from the Niuatoputapu Lagoon (Dye, 1983).

Production and marketing: No information is available that attempts to estimate the total landing and consumption of *Anadara* at the subsistence level.

In a survey of eleven villages on Vava'u in 1987, the most commonly eaten shellfish is *A. scapha* followed by *Turbo setosus* and *Atrina vexillum* which rank equally (Bondurant, 1987). In addition, the most preferred shellfishes for consumption were *A. scappha* and *Tridacna* spp. (sharing the first choice equally), followed by *Turbo setosus*. No production figures were obtained. In a survey of tidal area usage in seven villages on Vava'u in 1983, 5 villages indicate that seafood is both for home consumption and for sales while two villages indicated that seafood is harvested for home consumption, with the excess offered for sales.

The only landing figures available on *Anadara* spp. are those estimated from a one-week survey conducted by the Fisheries at Vuna and Faua landing sites on Tongatapu in April, 1992 (Udagawa and Tulua, 1992) and in 1993 at the same sites. During the 1992 survey period, a total of 824 baskets of molluscs were sold, estimated to be 3,296 kg in weight (average basket=4 kg). The figure was extrapolated to give 164.8 mt of molluscs per year (using a 50- week year) for the two sites. Of this total, *Anadara* spp. make up the highest portion (33.1 per cent, thus 55.51 mt). The total annual fisheries products sold via these sites was estimated at 677 mt valued at T$1.541 million. Thus *Anadara* spp. make up 8.2 per cent of the estimated total annual fish and shellfish landing at the two main landing localities in Tongatapu. Species composition, expressed as a percentage of the total, of the extrapolated molluscs landings for 1992 at the two sites were given as follows: (Source: Udagawa and Tulua, 1992).

Anadara	Giant clams	Others*	Octopus**	Gafrarium	Lucina clam	Turban shell	??
33.1	23.7	22.6	14.6	3.6	1.3	1.0	0.1

*=include mainly sea urchin and sea cucumber, (sea cucumber is sold bottled), **=sold fresh or dried

Monthly shellfish landings at Vuna and Faua, estimated from surveys in 1993, are presented in Table 4.3.2 for ten months.

Table 4.3.2: Shellfish monthly estimated landings at Faua and Vuna landing sites. (Source: Udagawa, JICA, Ministry of Fisheries, Kingdom of Tonga). Numbers are in kg and composition, in percentages, are in brackets.

Month	Vasuva	Kaloa'a	To'o	Tengange	Elili	Kuku	Angaanga	Tu'ulalo	Kaipo	Tukumisi	Others	TOTAL
March	1,925.0 (16.1)	**6,579.8 (55.0)**	425.0 (3.6)	435.0 (3.6)	915 (7.6)	170 (1.4)	135 (1.1)	595.0 (5.0)	0.0 (0.0)	585.0 (4.9)	198.6 (1.7)	11,963.4
April	1,765.0 (20.2)	**3,920 (45.0)**	210.0 (2.4)	180.0 (2.1)	180 (2.1)	310.0 (3.6)	85.0 (1.0)	910.0 (10.4)	0.0 (0.0)	1,160.0 913.3)	0.0 (0.0)	8,720.0
May	3,130.0 (26.2)	**4,670.0 (39.1)**	553.3 (4.6)	66.6 (0.6)	683.3 (5.7)	110.0 (0.9)	333.33 (2.8)	1,106.67 (9.3)	113.33 (0.9)	1,186.67 (9.9)	0.0 (0.0)	11,953.3
June	1,769.2 (21.4)	**3,139.15 (37.9)**	312.2 (3.8)	102.6 (1.2)	974.8 (11.8)	37.5 (0.5)	259.4 (3.1)	642.1 (7.7)	220.5 (2.7)	827.2 (10.0)	0.0 (0.0)	8,284.5
July	3,533.8 (34.5)	**3,031.3 (29.6)**	514.67 (5.0)	180.3 (1.8)	206.2 (2.0)	312.3 (3.0)	211.0 (2.1)	1,391.8 (13.6)	66.5 (0.6)	778.8 (7.6)	28.0 (0.3)	10,254.4
August	3,790.5 (34.5)	**2,037.0 (18.5)**	607.8 (5.5)	324.3 (3.0)	1,081.5 (9.8)	721.0 (6.6)	101.5 (0.9)	1,692.2 (15.4)	0.0 (0.0)	451.5 (4.1)	180.8 (1.6)	10,988.2
September	6,949.8 (61.0)	**1,893.5 (16.6)**	401.3 (3.5)	266.0 (2.3)	508.7 (4.5)	46.7 (0.4)	239.2 (2.1)	414.2 (3.6)	98.0 (0.9)	533.2 (4.7)	37.3 (0.3)	11,387.8
October	3,427.5 (39.2)	**2,623.2 (30.0)**	173.5 (2.0)	586.0 (6.7)	176.0 (2.0)	137.3 (1.6)	366.3 (4.2)	686.0 (7.8)	136.0 (1.6)	318.0 (3.6)	116.0 (1.3)	8,745.8
November	4,001.5 (45.2)	**2,727.0 (30.8)**	368.2 (4.2)	206.2 (2.3)	245.0 (2.8)	77.5 (0.9)	312.2 (3.5)	470.8 (5.3)	174.3 (2.0)	266.0 (3.0)	3.0 (0.0)	8,851.7
December	2,425 (35.2)	**2,655.0 (38.6)**	185.0 (2.7)	163.3 (2.4)	116.7 (1.7)	75.0 (1.1)	200.0 (2.9)	403.3 (5.9)	203.3 (3.0)	458.3 (6.7)	0.0 (0.0)	6,885.0
TOTAL	**32,717**	**33,276**	**3,751**	**2,510**	**5,087**	**1,997**	**2,243**	**8,312**	**1,012**	**6,565**	**564**	**98,034.2**
Per cent	33.4	**33.9**	**3.8**	**2.6**	**5.2**	**2.0**	**2.3**	**8.5**	**1.0**	**6.7**	**0.6**	

Note: Vasuva=giant clams, Kaloa'a=Anadara, To'o=Gafrarium sp., Tengange=Gafrarium sp., 'Elili=Turbans, Kuku=brown mussel, Angaanga=spider conch (Lambis), Tu'ulalo=Codakis sp., Kaipo=small clam (Lioconcha sp., Pitar sp.), Tukumisi=sea urchin.

The total *Anadara* landings at the two sites, for ten months, amount to 33,276 kg. Extrapolation of this data gives a total *Anadara* landing of approximately 40 mt for the year. *Anadara* make up 33.9 per cent of the total shellfish landing at these sites. Using the assumption that artisanal fishery landings at Faua and Vuna account for approximately 75 per cent of the whole Tongatapu landings, the estimated Tongatapu *Anadara* landing in 1993 is 53 mt.

4.3.3 Stocks Status

Conclusions drawn from archaeological work by Poulsen (1967, quoted in Spennemann, 1987) in the Fanga'uta Lagoon, suggested that the percentage of *Anadara* spp. shells represented in the Lapita shell middens decreased over time, whereas the percentage of *Gafrarium* spp shells increased. The indications were that exploitable *Anadara* at that time within the lagoon were quickly depleted but that neighbouring populations exploited different shell beds. Spennemann (1987) also observed a reduction in *Anadara* size and postulated that fishing for this resource must have become less and less sufficient, leading to the exploitation of other shellfish species. Evidence seems to have suggested that diminishing shellfish, in both quantity and quality in the later Lapita times, prompted the increase in horticulture practise. Spennemann (1987) writes that the consumption of shellfish continued in post Lapita times, but its role declined tremendously as compared to Lapita times.

Udagawa and Tulua (1992) estimated that *Anadara* spp. are the main mollusc species landed and sold at two landing sites on Tongatapu. Of the 164.8 mt of molluscs landed annually, 33.1 per cent is made up of *Anadara* spp. This is approximately 8.2 per cent of the total annual fish and shellfish landing of 677 mt. Surveys of seafood consumption in Vava'u indicate that *Anadara* is one of the main species harvested. The surveys conducted at the same sites in 1993 gave approximately the same level of landings.

Due to the absence of time series data on *Anadara* landings and effort, it has not been possible to trace any trends in landings, and so establish a possible indication on the stock status. There has been no attempt made to assess the *Anadara* stocks even though this resource currently plays a major role as far as seafood consumption in Tonga is concerned. It is, however, believed that *Anadara* is still plentiful in certain areas, even though the average sizes of individuals seems to be getting smaller.

4.3.4 Management

Current legislation/policy regarding exploitation: No legislation exists that specifically addresses the exploitation of *Anadara* in Tonga.

Recommended legislation/policy regarding exploitation: The major concern at this stage seems to involve the prevention of destruction and pollution of the habitats which are inhabited by *Anadara*. Application of a minimum size limit might be considered after further research on stocks and the estimation of biological parameters for species found in Tonga.

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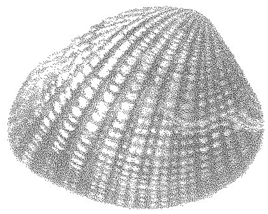
4.4 Venus clams (*Gafrarium* spp.) - *To'o*

4.4.1 The Resource



Gafrarium tumidum

Species present: *Gafrarium* spp. are collectively known in Tonga as ***"to'o"***. Spennemann (1987) listed three species, from archaeological evidence, that were present in Tonga and include; *Gafrarium tumidum* (***to'o teka***), *G. gibbiosum* and *G. pectinatum* (***to'o tengange***). Sone (1993) was only able to identify two species, *G. tumidum* and *G. pectinatum* from monthly samples taken from those sold at the Vuna wharf during the April, 1992 to March, 1993 period. Bondurant (1987) mentions only one species, *G. tumidum*, in a survey of eleven villages on Vava'u.

Distribution:

To'o was one of the three shellfish food items listed in Kunatuba and Uwate (1983) as a resource harvested from the tidal area, during a survey involving seven villages in Vava'u. Bondurant (1987) describes areas from which *G. tumidum* is harvested in eleven villages (some are actually islands) on Vava'u as follows: Oloua (one village island) - on sand flats and beaches around island, same area where *Anadara* is found; Tefisi (village on Vava'u Island) - within bay with fringing mangroves in sandflats; Hunga (one village island) - on sand flats by the shore; Ofu (one village island) - found but habitat not mentioned; Talihau (village on Vava'u island) - in lagoon with fringing mangroves in sand flats; Koloa (village on Vava'u island) - near mouth of lagoon in sand flats, mangroves further inland into lagoon; Taunga (one village island) - along beaches to the south and east; Matamaka (one village island) - not found; Tuanekevale (village on Vava'u island) - in lagoon nearby with fringing mangroves; Holonga (village on Vava'u island) - not found; Vaipua lagoon - in sand flats, lagoon is fringed with mangroves with bottom mostly sandy but more sediment towards the end.

Spennemann (1987) gave the general habitats for *Gafrarium* as sheltered areas, lagoons, mangroves and brackish-water. On Tongatapu he noted the areas as north-western coast, in a mangrove area from Fo'ui to Sopu, not the unsheltered Nuku'alofa waterfront, inner Fanga'uta lagoon from Nukuhetulu to Longoteme/Mu'a, along the mangrove area of the Fatai/Kolovai mudflats but no longer in Pea sector which is the most sheltered area of the lagoon. The disappearance of *Gafrarium* from this sector of the lagoon is believed to have caused by pollution from the hospital and destruction of its habitat by seagrass growth caused by increased nutrient input.

Sone (1993) notes that *Gafrarium* spp. are abundant in Tongan waters and that there is overlap of the habitats of both species in Tongatapu.

Biology and ecology: On the overall evolution of sizes of the *Gafrarium* species in Tonga, Spennemann (1987) writes "there is a very significant decrease in size from Early to Middle and Middle to Late Lapita layers" and that "the modern shells are very significantly smaller than those Early Lapita sites". The same author argued that the major change in size occurred during Lapita times and that instead of becoming larger as was predicted from favourable environmental changes, the shell became smaller. This was believed to be due solely to increased harvesting pressure.

Although *Gafrarium* forms a major food component in Tonga, its biology has not been studied in detail. It is only recently that an attempt has been made to document breeding seasonality of the species present in the kingdom. Under the JICA project, Aquaculture Research and Development Project, a preliminary monthly survey was conducted from May 1992 to March 1993, sampling specimens of both species from those landed at Vuna wharf. However the gonad development examination seems to have been conducted only on specimens collected from Popua, Patangata, Hoi

Pangaimotu and Nukuleka, with Popua as the main collecting site. Ten large and ten small specimens were selected each month for gonadal development examination. All gonad conditions were classified using only three general stages as used with *Anadara* (see 4.3.1). The results, using the largest ten specimens, as reported by Sone (1993) are summarized below for each species.

G. tumidum - gonads shrank from April to June, followed by a 3-month inactive period. Gonads developed rapidly after this period and by the beginning of December most of the sample was in spent condition. Ripe gonads were again observed in the January sample but the majority of the February sample was also in spent condition. The breeding season was estimated to be from November to April. The smaller size group sampled (mean shell length ranging from 26.3 mm to 37.9 mm) showed the presence of gametes throughout the survey period.

G. pectinatum - Ripe gonads were found throughout the survey period, except January, which tends to indicate spawning throughout the year. However, completely spent individuals were found in February, indicating perhaps the period of December to January as a peak spawning period. A lot of *G. pectinatum* spat were settling out in the land-based giant clam tanks at the end of March. The smaller size sample group had no significant difference from those of the bigger size. The minimum size that had gametes (eggs) was 19.5 mm. The investigator suggested that the majority might reach sexual maturity at over 20 mm in shell length.

4.4.2 The Fishery

Utilisation: Spennemann (1987) noted that the early Tongans relied heavily on the exploitation of molluscs, turtles and fish offered by the lagoon and fringing reef. McKern (undated, quoted in Spennemann, 1987) writes that shellfishing in ethnohistoric and modern Tonga is done collectively by the women, who walk at low tide to the reef and mudflats or into the lagoon, search the ground with their toes, and dig out/pick up the shells with their hands. From archaeological evidence, the changes in lagoon environment (more brackish), prior to the earliest Lapita settlement on Tongatapu, favoured *Gafrarium* growth as it constituted 45-65 per cent of shells in the subsoil underlying the Early Lapita sites.

Historical findings indicate that *Anadara* spp. was generally preferred over *Gafrarium* spp. for consumption because of their greater overall size even though *Gafrarium* spp. are considered tastier (Spennemann, 1987). He further noted that both species form a major shellfish resource and that both are exploited and locally marketed today. In a survey of tidal area usage in seven villages on Vava'u in 1983, Kunatuba and Uwate (1983) noted that "***to'o***" was one of the three shellfish species harvested for consumption from the tidal area. The same survey indicated that out of the seven villages, five indicated that collection of these seafoods were for home consumption and for sale while for the other two villages, it is mainly for home consumption with only the excess sold.

A shellfish consumption survey in 1987 in eleven villages on Vava'u concluded that the three most commonly eaten species include *Anadara*, *Turbo setosus* and *Atrina vexillum*. *Gafrarium* was eaten in almost all the villages surveyed with the three most preferred species being *Tridacna* sp., *Anadara* sp., and *Turbo setosus* (Bondurant, 1987).

Sone (1993) notes that *Gafrarium* spp. are one of the main target species of the subsistence shellfish fishery by the local people and that they are also commonly sold in the market in Tongatapu.

Production and marketing: No concrete figures are available for any level of exploitation for the *Gafrarium* fishery in Tonga. However preliminary estimates were made for 1992 from a one-week survey conducted by the Fisheries Department in April of the same year at the two main landing sites, Vuna wharf and Faua in Tongatapu (Udagawa and Tulua, 1992). A total of 824 baskets of molluscs weighing 3,296 kg with a value of T$4,120, were sold during the week at the two landing sites. This was extrapolated for the year (using a 50-week year) to be 164.8 mt of molluscs. Of the total mollusc sales estimate, *Gafrarium* was estimated to make up 3.6 per cent of the mollusc landing at these sites, thus 6.1 mt (worth T$7,625), per year. This represents about 1.0 per cent of the total annual fish and shellfish landing of 677 mt at the two sites. Species composition, expressed as a percentage of the total of the extrapolated molluscs landings for 1992 at the two sites, were given as follows: (Source: Udagawa and Tulua, 1992).

Anadara	**Giant clams**	**Others***	**Octopus****	**Gafrarium**	**Lucina clam**	**Turban shell**	**??**
33.1	23.7	22.6	14.6	**3.6**	1.3	1.0	0.1

*=include mainly sea urchin and sea cucumber, (sea cucumber is sold bottled), **=sold fresh or dried

Continuation of the above survey on a weekly basis in 1993 has led to some monthly landing estimates of different fish and shellfish species at the two sites. Table 4.4.1 records the results of these surveys for shellfish, landed at both Vuna and Faua, from March to December, 1993. Gafrarium (***to'o*** and ***tengange***) estimates are in bold.

Table 4.4.1: Shellfish monthly estimated landings at Faua and Vuna landing sites. (Source: Mr K. Udagawa, JICA, Ministry of Fisheries, Kingdom of Tonga). Numbers are in kg and composition in percentages are in brackets under each value.

Month	**Vasuva**	**Kaloa'a**	**To'o**	**Tengange**	**Elili**	**Kuku**	**Angaanga**	**Tu'ulalo**	**Kaipo**	**Tukumisi**	**Others**	**TOTAL**
March	1,925.0 (16.1)	6,579.8 (55.0)	**425.0 (3.6)**	**435.0 (3.6)**	915 (7.6)	170 (1.4)	135 (1.1)	595.0 (5.0)	0.0 (0.0)	585.0 (4.9)	198.6 (1.7)	11,963.4
April	1,765.0 (20.2)	3,920 (45.0)	**210.0 (2.4)**	**180.0 (2.1)**	180 (2.1)	310.0 (3.6)	85.0 (1.0)	910.0 (10.4)	0.0 (0.0)	1,160.0 913.3)	0.0 (0.0)	8,720.0
May	3,130.0 (26.2)	4,670.0 (39.1)	**553.3 (4.6)**	**66.6 (0.6)**	683.3 (5.7)	110.0 (0.9)	333.3 (2.8)	1,106.7 (9.3)	113.33 (0.9)	1,186.7 (9.9)	0.0 (0.0)	11,953.3
June	1,769.2 (21.4)	3,139.1 5 (37.9)	**312.2 (3.8)**	**102.6 (1.2)**	974.8 (11.8)	37.5 (0.5)	259.4 (3.1)	642.1 (7.7)	220.5 (2.7)	827.2 (10.0)	0.0 (0.0)	8,284.5
July	3,533.8 (34.5)	3,031.3 (29.6)	**514.7 (5.0)**	**180.3 (1.8)**	206.2 (2.0)	312.3 (3.0)	211.0 (2.1)	1,391.8 (13.6)	66.5 (0.6)	778.8 (7.6)	28.0 (0.3)	10,254.4
August	3,790.5 (34.5)	2,037.0 (18.5)	**607.8 (5.5)**	**324.3 (3.0)**	1,081. 5 (9.8)	721.0 (6.6)	101.5 (0.9)	1,692.2 (15.4)	0.0 (0.0)	451.5 (4.1)	180.8 (1.6)	10,988.2
September	6,949.8 (61.0)	1,893.5 (16.6)	**401.3 (3.5)**	**266.0 (2.3)**	508.7 (4.5)	46.7 (0.4)	239.2 (2.1)	414.2 (3.6)	98.0 (0.9)	533.2 (4.7)	37.3 (0.3)	11,387.8
October	3,427.5 (39.2)	2,623.2 (30.0)	**173.5 (2.0)**	**586.0 (6.7)**	176.0 (2.0)	137.3 (1.6)	366.3 (4.2)	686.0 (7.8)	136.0 (1.6)	318.0 (3.6)	116.0 (1.3)	8,745.8
November	4,001.5 (45.2)	2,727.0 (30.8)	**368.2 (4.2)**	**206.2 (2.3)**	245.0 (2.8)	77.5 (0.9)	312.2 (3.5)	470.8 (5.3)	174.3 (2.0)	266.0 (3.0)	3.0 (0.0)	8,851.7
December	2,425 (35.2)	2,655.0 (38.6)	**185.0 (2.7)**	**163.3 (2.4)**	116.7 (1.7)	75.0 (1.1)	200.0 (2.9)	403.3 (5.9)	203.3 (3.0)	458.3 (6.7)	0.0 (0.0)	6,885.0
TOTAL	32,717	33,276	3,751	2,510	5,087	1,997	2,243	8,312	1,012	6,565	564	98,034.2
Per cent	33.4	33.9	**3.8**	**2.6**	**5.2**	**2.0**	**2.3**	**8.5**	**1.0**	**6.7**	**0.6**	

Note: Vasuva=giant clams, Kaloa'a=Anadara, To'o=Gafrarium sp., Tengange=Gafrarium sp., 'Elili=Turbans, Kuku=brown mussel, Angaanga=spider conch (Lambis), Tu'ulalo=Codakis sp., Kaipo=small clam (Lioconcha sp., Pitar sp.), Tukumisi=sea urchin.

The combined ***to'o*** and ***tengange*** landings in the Nuku'alofa sites for the 10 months is 6.3 mt. This is approximately 7.6 mt for 12 months. Extrapolation of this figure gives an estimated annual ***to'o*** landing of 10 mt for Tongatapu.

4.4.3 Stocks Status

Conclusions drawn from archaeological work by Poulsen (1967, quoted in Spennemann, 1987) in the Fanga'uta Lagoon, suggested that the proportion of *Gafrarium* spp. shells increased while that of *Anadara* spp. shells decreased over time, in the Lapita shell middens. However the *Gafrarium* resource was severely affected by initial settlement phase (Early Lapita). Due solely to increased pressure from harvesting, the species became smaller in size over time. Recent information seems to indicate that one of the three venus clam species, *Gafrarium gibbiosum*, identified by Spennemann (1987) has become either locally extinct or very rare.

No figures are available on the more recent trends in this fishery. However, Sone (1993) notes that both species of *Gafrarium* are commonly sold, and they are the main targets of the shellfish fishery for the local population. Udagawa and Tulua (1992) estimated *Gafrarium* to make up 3.6 per cent of the total mollusc landings for two landing sites on Tongatapu, thus about 1 per cent (or 6.1 tonnes) of the total fish and shellfish landing for 1992. The 1993 estimates for the shellfish landings at the same sites indicated that *Gafrarium* spp. make up 6.3 per cent, totaling to almost 8 mt for the year.

Some indications of *Gafrarium* abundance relative to other shellfish can be made from the results of a survey conducted in eleven villages (some islands) in Vava'u in 1987 by Bondurant as follows:

Oloua - *Gafrarium* one of shellfish species most often eaten, though not preferred.
Tefisi - *Gafrarium* present but not often eaten; not a preference shellfish species.
Hunga - *Gafrarium* one of the shellfish species often eaten and a preference species.
Ofu - *Gafrarium* present but not often eaten; not a preference
Talihau - *Gafrarium* present, not often eaten; not a preference shellfish species.
Koloa - *Gafrarium* present nearby, not often eaten; not a preference shellfish species.
Taunga - *Gafrarium* present, not often eaten; not a preference shellfish species.
Matamaka - *Gafrarium* not present.
Tuanekevale - *Gafrarium* one of the shellfish species often eaten; a preference shellfish species.
Holonga - *Gafrarium* not present.
Feletoa - *Gafrarium* one of the shellfish species often eaten; a preference shellfish species.

However, the absence of time series data collection has made it impossible to trace any trends in landings for the different levels of fisheries in Tonga. Production figures are totally absent at the subsistence level while that for the artisanal level has just been started for Vuna and Faua in Nuku'alofa.

4.4.4 Management

Current legislation/policy regarding exploitation: There is no existing regulation that specifically addresses the exploitation of the *Gafrarium* spp. resource in Tonga.

Recommended legislation/policy regarding exploitation: Most shellfish resource management involves the application of a minimum size limit, quotas, closed season and sometimes the creation of reserves. However, adaptation of any of these management tools requires the input of research to confirm the appropriate management strategy to adopt.

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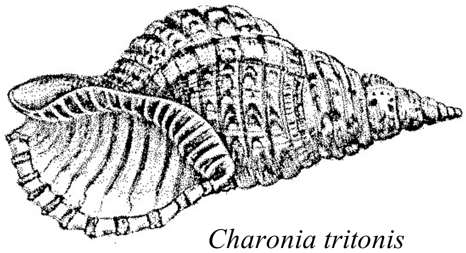
4.5 Other shellfish including ornamental (specimen) shells - *Fingota*

4.5.1 The Resource



Charonia tritonis

Species present: Apart from those included in other profiles in this document, several other bivalve, gastropod and echinoderm species are consumed in Tonga. The more important ones include:

Bivalves:	*Modiolus* sp. (brown mussel - ***kuku***), *Codakia tigerina* (lucina clam - ***tu'ulalo***), *Lioconcha* sp. (***pipi***) and *Pitar* sp. (***kaipo***);
Gastropods:	*Turbo setosus* (turban - '***elili***), *Tectus pyramis* (trochus - ***takaniko***), *Lambis lambis* (spider conch - ***angaanga***), *Cypraea tigris* (cowry - ***pule***), *Charonia tritonis* (giant triton or Pacific trumpet shell - ***kele'a***), *Atrina* (*Conus*) *vexillum* (***ufi***);
Echinoderms:	*Tripneustes gratilla* (sea urchin - ***tukumisi***).

A large variety of sea shells are collected for selling, mostly processed, to tourists. They include cones, cowries, helmet, trumpet, triton, spider, giant clams, nautilus, black-lipped pearl oyster (*Pinctada margaritifera*). Lewis (1985) notes that collector's shells are marine invertebrates from the classes Gastropoda (sea shells), Pelecypoda (bivalves), Scaphopoda (tusk shells) and Cephalopoda (nautilus). Spines of the slate pencil sea urchin (*Heterocentrotus mammillatus*) are used to make necklaces, wind-chimes etc. A general listing of reef and shore fauna of Tonga is contained in Fenn (1972).

Two hundred and fifty live trochus (*Trochus niloticus*) were introduced to Tonga from Fiji in 1992 (Gillett, 1992). Under the JICA Aquaculture Research and Development Programme, fifty mature green snails (*Turbo marmoratus*) were introduced from Vanuatu in August, 1993 (Fa'anunu and Sone, 1993).

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

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

T. niloticus imported from Fiji were released on a reef west of Tapana Island, Vava'u after one day in the land-based tanks at the Ministry of Fisheries in Nuku'alofa. Of the fifty green snails imported from Vanuatu, 20 were released in the wild at Hufangalupe while 23 were released in baskets at the giant clam ocean nursery in Sopu. These are fed with the sea weed, *Gracilaria* sp., once a week.

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

4.5.2 The Fishery

Utilisation: With the exception of some smaller-sized shells, most of the shellfish utilized in the ornamental shell trade in Tonga are also used in the subsistence and sometimes artisanal fisheries. Some species, e.g. Lambis, giant clams, triton, pearl oysters, etc., are sold alive with their shells in the artisanal fishery for the domestic market. In some cases, these species are collected by fishermen for home consumption of the meat, and the shells are then sold to processors. The non-edible shellfish species are collected solely for the shellfish trade. In a departure from the practise in some other countries in the South Pacific, direct selling of dead shells by the fishermen (collectors) to the tourists in the streets or in the markets is not practised in Tonga.

A survey conducted in some Vava'u villages in 1983 indicated that seafood gleaned from the tidal flats are consumed almost every day, and that harvested seafoods not consumed by the households were sold at the Neiafu market (Kunatuba and Uwate, 1983).

Production and marketing: There are no figures available, nor has there been an attempt to estimate production, of shellfish for the ornamental trade.

One operator in Nuku'alofa has piles of giant clam shells, mainly of *T. derasa* and *T. maxima,* of various sizes for sale. Data on sales and value of these shells were not possible to obtain. It was also not possible to confirm whether the piles of giant clam shells were bought/collected from the islands or whether the owner is an exporter/retailer of giant clam meat.

One of the operators visited in Nuku'alofa had only a few whole sea shells for sale. Most of the items were in finished, processed form. The majority of the products however were of black coral in origin with a few necklaces made from sea urchin spines and mother of pearl shells, cowries and a few from whale bones. Whole shells offered for sale included the giant triton, lambis and cowries. The operator has his own small factory at his home. Exports have been made mainly to Hawaii but very limited (each shipment worth US$1,500 with 3 shipments a year). Some of the processed products have also been exported to Western Samoa.

A fisheries development project on 'Eua from 1980 to 1981 estimated hand gathering, together with other "miscellaneous" fishing methods such as gillnetting, octopus fishing, fish drives, turtle fishing and fish poisoning, to account for only 4 per cent of the total annual seafood landings there (Schuh, 1982). A survey conducted in 1983 on Vava'u on the tidal area usage indicated that shellfish species, comprising of ***kuku***, ***to'o*** and ***kaloa'a***, are commonly harvested food items (Kunatuba and Uwate, 1983). The abundance period was mostly all year around for both sea shells and bivalves. A total of 232 mt of seafood per year was estimated to be landed by women and children from the tidal flats. Dye (1983) reported that on Niuatoputapu, the leeward reef flat supports small populations of edible gastropods including, *Polinices simiae* (***tui***), *Trochus maculatus* and *Nerita* sp. (***hihi***). The principal resources from the Niuatoputapu Lagoon are four bivalves; *Asaphis violascens* (***kahi***), *Laevicardium biradiata* (***tu'ahi***), *Periglypta puerpera* (***tava'amanu***) and *Anadara antiquata* (***kaloa'a***). However the lagoon is rarely fished. No estimates of landings were made. Results of the shellfish consumption survey conducted by the Fisheries Division in eleven villages on Vava'u in 1987 are summarized in Table 4.5.1, only for species listed in this profile. No estimates of the volumes landed were given.

Table 4.5.1: Shellfish consumption on Vava'u. Only species listed in this profile are included. Other species are recorded under their respective profiles. (Source: Bondurant, 1987). Key: 1=Occurrence, 2=Consumption rate, 3=Preference, Y=Yes, O=Often, S=Sometimes, N=No.

Species	Oloua			Tefisi			Hunga			Ofu			Talihau			Koloa		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Atrina vexillum	Y	O	N	Y	S	N	Y	S	N	Y	S	N	Y	O	Y	Y	S	N
Turbo setosus	Y	O	N	Y	O	Y	Y	O	Y	Y	O	Y	Y	O	N	Y	O	Y
Codakia tigerina	Y	S	Y	Y	O	Y	Y	O	N	Y	S	N	Y	O	Y	Y	S	Y
Tectus pyramis	Y	S	N	N			Y	S	N	Y	S	N	Y	S	N	Y	O	N
Lambis lambis	Y	S	N	N			Y	O	N	Y	O	N	Y	S	N	Y	O	N
Cypraea tigris	Y	S	N	N			Y	O	N	Y	S	N	Y	S	N	Y	O	N
*Perna viridis**	Y	O	N	Y	?	?	Y	O	N	Y	O	N	Y	S	N	Y	Y	N
Species	**Taunga**			**Matamaka**			**Tuanekevale**			**Holonga**			**Feletoa**					
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3			
Atrina vexillum	Y	O	Y	Y	O	N	Y	S	N	N			N					
Turbo setosus	Y	O	Y	Y	O	Y	Y	O	Y	Y	O	Y	N					
Codakia tigerina	Y	S	N	Y	S	N	N			N			Y	O	Y			
Tectus pyramis	Y	O	Y	Y	O	Y	Y	O	Y	Y	O	Y	N					
Lambis lambis	Y	O	Y	Y	O	Y	Y	O	N	Y	O	N	Y	S	N			
Cypraea tigris	Y	S	N	Y	O	N	Y	O	N	Y	O	N	Y	S	N			
*Perna viridis**	Y	S	N	Y	S	N	Y	O	N	N			Y	O	N			

*Perna viridis as listed by the author is probably Modiolus sp. (the brown mussel).

From a one-week survey conducted at Vuna and Faua landing sites in Nuku'alofa in April, 1992 by the Ministry of Fisheries, molluscs were estimated to comprise 24.2 per cent (3,296 kg worth T$4,120 during the week) of the total landings at the two sites (Udagawa and Tulua, 1992). These figures were translated to annual landings at the same sites using a 50-week year. Species composition of the molluscs category recorded was as follows (the species included in this profiles are in bold):

Species	Percentage
Venus clam	3.6
Lucina clam	**1.3**
Turban shell	**1.0**
Other (mainly sea urchin and sea cucumber)	**22.6**
Giant clams	23.7
Ark shell	33.1
Octopus	14.6

Results of weekly surveys conducted at the same landing sites in 1993 are presented in Table 4.5.2. The species included in this profile are also in bold. The percentage composition of each species relative to the total shellfish landing for each particular month are in parenthesis underneath the weight value.

Table 4.5.2: Estimated monthly Shellfish landings (kg) at Faua and Vuna Landing Sites in Nuku'alofa in 1993. [Translations: 'Elili=Turbo sp. (turbans), Kuku=Modiolus sp. (brown mussel), 'Angaanga=Lambis lambis (spider conch), Tu'ulalo=Codakia tigerina (lucina clam), Kaipo=Lioconcha sp., Tukumisi=Tripneustes gratilla (short spine sea-urchin), Vasuva=Tridacna sp. (giant clams), Kaloa'a=Anadara sp., To'o=Gafrarium tumidium, Tengage=G. pectinatum]. (Source: Udagawa, JICA, Ministry of Fisheries).

Month	Vasuva	Kaloa'a	To'o	Tengange	Elili	Kuku	Angaanga	Tu'ulalo	Kaipo	Tukumisi	Others	TOTAL
March	1,925.0 (16.1)	6,579.8 (55.0)	425.0 (3.6)	435.0 (3.6)	**915 (7.6)**	**170 (1.4)**	**135 (1.1)**	**595.0 (5.0)**	**0.0 (0.0)**	**585.0 (4.9)**	**198.6 (1.7)**	11,963.4
April	1,765.0 (20.2)	3,920 (45.0)	210.0 (2.4)	180.0 (2.1)	**180 (2.1)**	**310.0 (3.6)**	**85.0 (1.0)**	**910.0 (10.4)**	**0.0 (0.0)**	**1,160.0 913.3)**	**0.0 (0.0)**	8,720.0
May	3,130.0 (26.2)	4,670.0 (39.1)	553.3 (4.6)	66.6 (0.6)	**683.3 (5.7)**	**110.0 (0.9)**	**333.33 (2.8)**	**1,106.67 (9.3)**	**113.33 (0.9)**	**1,186.67 (9.9)**	**0.0 (0.0)**	11,953.3
June	1,769.2 (21.4)	3,139.15 (37.9)	312.2 (3.8)	102.6 (1.2)	**974.8 (11.8)**	**37.5 (0.5)**	**259.4 (3.1)**	**642.1 (7.7)**	**220.5 (2.7)**	**827.2 (10.0)**	**0.0 (0.0)**	8,284.5
July	3,533.8 (34.5)	3,031.3 (29.6)	514.67 (5.0)	180.3 (1.8)	**206.2 (2.0)**	**312.3 (3.0)**	**211.0 (2.1)**	**1,391.8 (13.6)**	**66.5 (0.6)**	**778.8 (7.6)**	**28.0 (0.3)**	10,254.4
August	3,790.5 (34.5)	2,037.0 (18.5)	607.8 (5.5)	324.3 (3.0)	**1,081.5 (9.8)**	**721.0 (6.6)**	**101.5 (0.9)**	**1,692.2 (15.4)**	**0.0 (0.0)**	**451.5 (4.1)**	**180.8 (1.6)**	10,988.2
September	6,949.8 (61.0)	1,893.5 (16.6)	401.3 (3.5)	266.0 (2.3)	**508.7 (4.5)**	**46.7 (0.4)**	**239.2 (2.1)**	**414.2 (3.6)**	**98.0 (0.9)**	**533.2 (4.7)**	**37.3 (0.3)**	11,387.8
October	3,427.5 (39.2)	2,623.2 (30.0)	173.5 (2.0)	586.0 (6.7)	**176.0 (2.0)**	**137.3 (1.6)**	**366.3 (4.2)**	**686.0 (7.8)**	**136.0 (1.6)**	**318.0 (3.6)**	**116.0 (1.3)**	8,745.8
November	4,001.5 (45.2)	2,727.0 (30.8)	368.2 (4.2)	206.2 (2.3)	**245.0 (2.8)**	**77.5 (0.9)**	**312.2 (3.5)**	**470.8 (5.3)**	**174.3 (2.0)**	**266.0 (3.0)**	**3.0 (0.0)**	8,851.7
December	2,425 (35.2)	2,655.0 (38.6)	185.0 (2.7)	163.3 (2.4)	**116.7 (1.7)**	**75.0 (1.1)**	**200.0 (2.9)**	**403.3 (5.9)**	**203.3 (3.0)**	**458.3 (6.7)**	**0.0 (0.0)**	6,885.0

TOTAL	**32,717**	**33,276**	**3,751**	**2,510**	**5,087**	**1,997**	**2,243**	**8,312**	**1,012**	**6,565**	**564**	**98,034.2**
Per cent	33.4	33.9	**3.8**	**2.6**	**5.2**	**2.0**	**2.3**	**8.5**	**1.0**	**6.7**	**0.6**	

The relative composition of the shellfish species included in this profile, as reported in Table 4.5.2, for the 10 survey weeks, estimates for 12 months and extrapolated landings for the whole of Tongatapu, are given in Table 4.5.3. The Tongatapu landings are estimated using the assumption that the landings at the two sites in Nuku'alofa account for about 75 per cent of the total Tongatapu annual landings (Udagawa, 1993, *pers. comm.*).

Table 4.5.3: Estimated landings for the shellfish species included in this profile, for 1993.

Species	Landings in the 10 survey months (kg)	Annual Estimated Landing (kg)	Estimated Tongatapu Annual Landing (kg)	Relative percentages of these shellfish species only	Species percentages relative to all shellfish landed
‘Elili	5,087.0	6,104.40	8,139.20	19.7	5.2
‘Angaanga	2,242.9	2,691.48	3,588.64	8.7	2.3
Tu’ulalo	8,312.0	9,974.40	13,299.20	32.2	8.5
Kaipo	1,012.0	1,214.00	1,619.20	3.9	1.0
Tukumisi	6,564.6	7,877.52	10,503.36	25.5	6.7
Other	563.8	676.56	902.08	2.2	0.6
Kuku	1,997.3	2,396.76	3,195.68	7.7	2.0
TOTAL	**25,779.60**	**30,935.12**	**41,247.36**	**100**	**26.3**

Live specimens of only a limited variety of shellfish species included in this section have been exported via the aquarium fish trade from Tonga. These are recorded under the "Aquarium fish" profile.

4.5.3 Stocks Status

There is no data available on the stocks of shellfish species included in this profile, nor has there been an attempt to conduct stock assessment on some of the more important species. Some indications of stock status can be derived from time series data collected at certain landing sites. Unfortunately, these are also absent.

The introduction of *Tr. niloticus* and *Tu. marmoratus* is part of the Ministry of Fisheries efforts to supplement native resources with fast growing species. Both species offer excellent potential in providing meat for the local population as well as exports of the shells for the manufacture of buttons and ornamental shells. The Ministry of Fisheries, under the JICA project, plans to import 1,000 *T. niloticus* from Lau, Fiji, in mid-1994. The green snails kept at the Ministry of Fisheries’ giant clam ocean nursery will be used for spawning trials, after which they will be released in the wild on the reef at ‘Euaiki Island. Three hundred juveniles of green snails are also planned to be imported from Japan.

4.5.4 Management

Shellfish fills a very important component in Tonga’s subsistence and artisanal fisheries. The development of the aquarium fish trade has resulted in a variety of the shellfish species entering the live specimen export trade. Ever since the establishment of the handicraft trade for tourists, various species of shellfish have been utilized in the manufacture of certain items, or sold as whole shells. Due to the involvement of the different fishery sectors on different levels, and the absence of information on the resources concerned, establishment of management strategies would be difficult.

Current legislation/policy regarding exploitation: There is currently no legislation concerning the exploitation of these resources.

Recommended legislation/policy regarding exploitation: The proposed Fisheries (Conservation and Management) Regulations 1993 include the prohibition of the taking, selling, purchasing etc. of *Charonia tritonis* less than 20 cm in length, when measured along the outside of the shell from one end to the other.

Other considerations for possible management of these resources include the prohibition of the export of *C. tritonis* for commercial purposes. Application of minimum size limits to other shellfish species, especially those in the artisanal fishery, is a possible management strategy. However, biological research into the appropriate areas concerning those species would be required first. In addition, minimum size limits seem to be only practical when applied to the selling and buying, but not on subsistence harvesting.

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

The introduction of exotic species has its advantages both socially and economically. However, it must be exercised with caution, to prevent introduction of new diseases and pathogens as well as other unwanted organisms. Thus all introduced marine organisms must be subjected to a period of quarantine (which can be as long as 6 months) in land-based tanks prior to their release into the sea. The drainage of such a system must be directed into a sump, not directly into the sea.

Although difficult, efforts should be made to collect data from the several shell processors operating in the three main centres; Nuku’alofa, Vava'u and Ha'apai. The current artisanal fisheries statistics survey conducted in Tongatapu should be expanded to include the other islands.

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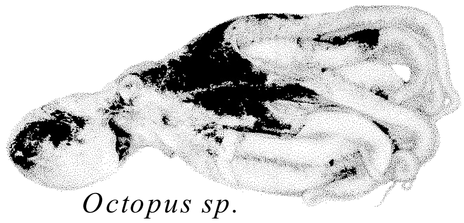
4.6 Octopus and squid - *Feke*

4.6.1 The Resource



Octopus sp.

Species present: Octopus (***feke***) species found and fished in Tonga for food have not been scientifically identified. However, distribution of octopus and squid given in Roper *et al*. (1984) include several species found throughout the Indo-Pacific region, and in tropical seas, to include the benthic, shallow-water reef-dwelling big blue octopus, *Octopus cyaneus* and the epipelagic, oceanic greater argonaut, *Argonauta argo* which occur in near-surface waters. The octopuses utilized in Tonga are those from the shallow-water reefs. ***Atalava*** is the name given to small octopuses and it is not apparent whether this constitutes more than one species. Squids do not seem to be important in Tonga.

Distribution: Octopus generally "hide" in small holes in reefs and are found both inter-tidally and sub-tidally around reefs and rocky areas.

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

4.6.2 The Fishery

Utilisation: Octopus are a Tongan delicacy (Zann, 1981) and are normally hooked out of crevices at low water using a steel hook, or are caught from canoes with a hook on a pole, which is used to probe holes below the tide mark (Zann, 1981). However, the best known method of octopus fishing is the ***makafeke*** (octopus rat lure baiting).

One of the important components of canoe fishing activities on Ha'apai is the octopus-lure fishing. This is confined to the reefs, but a good catch of octopus means a good source of income (Halapua, 1981). Dried octopus and salted fish that are often sold in Nuku'alofa market, usually originate from Ha'apai.

Thomas (1978) noted that the outer-island groups offer export potential for several marine species from Tonga, including frozen packed octopus.

In addition to the consumption of octopus locally, they also form an important part in the handline fishery as octopus is one of the main baits used. On most of the islands surveyed in the Ha'apai group in 1973 by the Fisheries Division, fish, octopus and clams are used as bait for handline fishing which is the most important fishing method that occurs there. This fishery normally occurs in the coastal waters but sometimes the fishermen go out in the deeper waters. It can be conducted in day or night time. Sometimes the fishermen do not use canoes but walk through the sea while fishing during low tide. Schuh (1982) also reported octopus as one of the most commonly used baits for bottom handline fishing (***taumata'u***) on 'Eua.

Octopus, particularly the small ones, are sun-dried and consumed after boiling in coconut cream.

Production and marketing: Catches using the ***makafeke*** can be as high as fifty octopus on a good day's fishing (Vaea and Straatmans, 1954). Sun-drying of octopus was reported to be prevalent in the islands of the Ha'apai group. Sticks are used to stretch the octopus bodies which are then hung on trees or lines in the sun for drying without salting or smoking. Because of their small sizes they are hung in bunches of hundreds. The octopuses caught by the ***makafeke*** were sun-dried and sent to Tongatapu and Vava'u in exchange for yams (Vaea and Straatmans, cited above).

Fuka (1979) noted that due to the time and effort needed to prepare the traditional lure (***makafeke***) fishermen have abandoned this technique and are turning to spear guns and skin diving equipment as the more popular method for octopus fishing.

On 'Eua, octopus is one of the target species of spear fishing in the inner reefs (***ama uku***) at free-diving depths of up to 18 m (Schuh, 1982). The same author estimated annual catch composition by fishing method. Catches from octopus fishing, together with hand gathering, gill netting, fish drives, turtle fishing and fishing poisoning account for only 4 per cent of the estimated landing for 'Eua though no actual figures were given.

Thomas (1978) noted that production of lobster tails and octopus could be increased in the outer-island groups for exports. He estimated the export potential of octopus (frozen packs), collected from Ha'apai group of islands and Nomuka to be 10 to 12 mt, worth US$10,000, per year.

During a one-week intensive survey of fish and shellfish landed at Vuna and Faua in Nuku'alofa in April, 1992, the total weight of octopus landed, dried and fresh, was estimated to be 481.2 kg (worth T$601.50 at T$5 per 4 kg) for that week. This represented 14.6 per cent of the total mollusc landings of 3,296 kg. The total annual production for molluscs was extrapolated for the year (using a 50-week year) and was calculated to be 164.8 mt, thus a total of 24.1 mt of octopus per year for the two landing sites worth T$30,125.

Total monthly octopus landings estimated from results of recent surveys conducted at the same two landing sites (Vuna and Faua) in 1993 by the Ministry of Fisheries are given in Table 4.6.1.

Table 4.6.1: Octopus landing at Vuna and Faua in Nuku'alofa for 1993. (Sources: March-June, Mr Udagawa, JICA, 1993; July-December, Ministry of Fisheries Inshore Fisheries Main Database.

	March	**April**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Octopus weight (kg)	0.00	0.00	362.67	302.38	0.00	0.00	729.10	1,618.70	3,170.30	1,002.50

The total estimated landing at the two sites for the ten months survey was 7,185.65 kg. This would equal an estimated total octopus landing of about 8.6 mt at the same sites for the whole year. Dried octopus sold in Nuku'alofa usually come from Ha'apai.

The only export figures located for octopuses were those reported in the Ministry of Fisheries Annual Report, 1989, and are recorded in the following table. It is likely that these were for relatives living overseas (home consumption).

Year	1985	1986	1987	1988	1989
Amount (kg)	147	140	176	48	428
Value (T$)	650	700	480	200	1,360

4.6.3 Stocks Status

The octopus resource in Tonga has not been subjected to any stock assessment work. The lack of reliable time series data has made it impossible for any observation on the trends of this fishery, especially in the artisanal fishery sector.

4.6.4 Management

The exploitation of the octopus resource seems to be limited to the subsistence and artisanal levels with no apparent huge commercial demand. It seems that the major threat to this resource in Tonga is the destruction of its habitat, coral reefs, and pollution. Habitat (coral) destruction is caused by both fishing for octopus and other sea-food, and natural disasters such as cyclones.

Current legislation/policy: There is no current legislation that specifically addresses the exploitation of octopus in Tonga.

Recommended legislation/policy: There does not appear to be any specific direct legislation required for the exploitation of octopus. However, it is indirectly covered under other legislation that prohibits destructive fishing methods on the reef.

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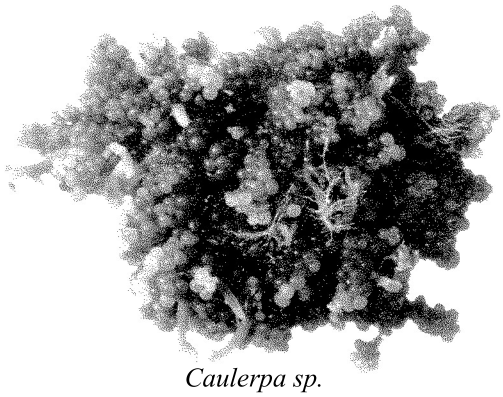
5. FLORA

5.1 Seaweeds - *Limu*

5.1.1 The Resource

Species present: The seaweed species present and eaten in Tonga include; the seagrapes, *Caulerpa racemosa* (***limu fuofua***), *C. serratula* (***limu kaka***), and *C. sertularoides* (*serrulata*?) (***limu loniu***) (Ludwig, 1979). There are two other species which are also consumed but have not been scientifically identified. These are known locally as ***limu tanga'u*** (probably a *Hypnea* sp.) and ***limu te'emoa***.



Caulerpa sp.

Eucheuma sp. was introduced into Tonga from Fiji in 1982 when a pilot project on culturing this seaweed was initiated in Vava'u.

Distribution: Seaweeds thrive on coral reefs in clear waters. Because they require sunlight their distribution is limited to shallow waters. Some species prefer sandy substrates.

The three *Caulerpa* species are found in the Fanga'uta Lagoon. ***Limu kaka*** is also found in the bays in Vava'u (in sheltered lagoons). ***Limu tanga'u*** is believed to be abundant in Felemea, Ha'apai on the sandy bottom of the lagoon. This species is also believed to be abundant in Nukuleka and Nautoka on Tongatapu.

The periods of abundance of seaweeds in some villages in Vava'u were recorded from interviews by Kunatuba and Uwate (1983) as follows:

Village/Island	Abundance Period
Houma	September - December
Ha'akio	October - January
Tu'anekivale	September - March
Ta'anea, Holeva	All year
Ha'alaufuli, Koloa	All year

Biology and ecology: Some seaweed species have been intensively grown in aquaculture enterprises since they require only sunlight and nutrients in the water. However, predation by rabbitfish, *Siganus* sp. has resulted in the failure of some of these mariculture undertakings.

5.1.2 The Fishery

Utilisation: A survey conducted in 1983 on the Vava'u housewife's usage of tidal areas in seven villages (Houma, Ha'akio, Ta'anea, Ha'alaufuli, Tu'anekivale, Holeva and Koloa) indicated that seaweed (***limu***) is one of the food items harvested from the tidal area (Kunatuba and Uwate, 1983). Of those villages surveyed, 5 indicated that seafood collected are for home consumption and for sale. The other two villages indicated that seafood is mainly for home consumption with only the excess sold.

All of the edible seaweeds found in Tonga can be eaten raw except ***limu tanga'u*** which requires cooking, sometimes with coconut cream.

Collection of seaweed is mainly for subsistence consumption. However almost all species have found their way to the local fish market as an artisanal crop. Seaweeds are normally sold wrapped in leaves and sold for T$2.00/wrapping.

Eucheuma is a primary source of phycocolloids for the production of agar and carrageenan which are important stabilising and suspension components in a variety of food, cosmetic, medicinal and other products (Smith, 1992).

Production and marketing: Kunatuba and Uwate (1983) did not make an estimate of the volume of seaweed collected and consumed in their 1983 survey on Vava'u.

No data is available of the actual level of production and consumption at the subsistence and artisanal levels. During the weekly surveys conducted by the Ministry of Fisheries at Faua and Vuna landing sites, 112 kg of seaweed was recorded in September 1993. However these records seem to be incomplete, as seaweed was seen being sold in October during the compilation of these profiles but none showed up in the database for that month. However, seaweed does not seem to be a major food resource in Tonga.

5.1.3 Seaweed aquaculture in Tonga

The initial *Eucheuma* farming trials initiated on Vava'u in 1982 were conducted by a New Zealand company, Coastal Biologicals Ltd. The Tonga Government approved the Vava'u seaweed farming in 1984 as a joint venture between the company and the government. In 1986 a Fisheries Division experimental trial was conducted in Nukuleka using seeds from the Vava'u farms (Anon, 1987). The same report indicated that twenty seaweed farmers were operating farms in the same year. However only fourteen were operating in 1987, each with 50 lines. The numbers dropped because some did not get seaweed for seeds from those shipped from Tongatapu. Two farmers stopped because the price was too low and some because they still had dried seaweed not bought by Coastal Biological. However they were still interested in the venture. In 1987, the Fisheries Division conducted grow-out experiments in the Fanga’uta Lagoon to locate a suitable site for commercial farming there. The eastern side of the lagoon's main entrance was recommended as a suitable site. The Fisheries Division’s plot that was started in 1986 on Tongatapu (Nukuleka) using 2 lines from Vava'u was expanded to 400 lines. Most was harvested in 1987 with much of the remaining plants taken as seeds for the Vava'u farms. Expansion of the Nukuleka plot created friction with the villagers and the plot was shifted to another area. Two fishermen from Alaki started farms with 50 lines each.

Maximum *Eucheuma* production was obtained in 1984 which yielded 7 mt. It was not clear whether this was dry or wet weight. The production fell to only 2 mt in 1985 and the operation eventually ceased in 1986. The failure of the project was attributed, as listed by Fa'anunu (1993, *pers. comm.*), to:

* low prices
* rabbitfish grazing
* `ice ice' disease
* environment conditions such as cold weather and storms, which sometimes destroyed farms completely.

5.1.4 Stocks Status

Apart from a few scattered pieces of information on its occurrence, no attempt has been made to assess the importance of seaweed species in the subsistence and artisanal fisheries.

The introduced *Eucheuma* sp. for mariculture purposes thrived in certain parts of the kingdom during the project operation. However, the dissolution of the project, due to reasons mentioned above, led to disintegration of grow-out structures and subsequent dispersal of this species. *Eucheuma* is known to be growing in certain areas, especially where trials and farms were located during the years of successful culturing.

5.1.5 Management

Current legislation/policy regarding exploitation: There is currently no legislation concerning the exploitation of the seaweed resource.

Recommended legislation/policy regarding exploitation: Native species of edible seaweed are only utilized on a very limited scale in the subsistence and artisanal fisheries. There does not seem to be a huge commercial demand existing in Tonga that would pose a threat to this resource. A possible source of concern with regards to this resource, however, seems to be from pollution and destruction of habitat.

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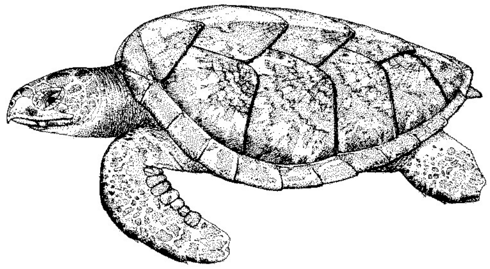
6. REPTILES

6.1 Turtles - *Fonu*

6.1.1 The Resource



Eretmochelys imbricata

Species present: The green turtle, *Chelonia mydas*, (known locally as ***tu'a'uli***) and the hawksbill turtle, *Eretmochelys imbricata* (***fonu koloa***), are the two most commonly found turtles in Tonga. The olive Ridley turtle, *Lepidochelys olivacea*, is believed to occur in Tongan waters. *C. agassizii* (the eastern Pacific green turtle) and *Dermochelys coriacea* (leatherback turtle) have also been reported.

It seems that the hawksbill turtle is the most commonly nesting species in Tonga, while the green turtle is the most commonly caught turtle species (Wilkinson, 1979).

Distribution: Sea turtles are marine reptiles which have inhabited the earth for over 100 million years. Eight species of turtles exist worldwide with all but one occurring in the Pacific region. The most frequently seen species in the Pacific are the hawksbill and green turtles, although the leatherback (*D. coriacea*), loggerhead (*C. caretta*) and olive or Pacific Ridley (*L. olivaccea*) turtles also occur. Details of the distribution of all sea turtles are reported in Márquez (1990).

Vaea and Straatmans (1954) reported that, due to the existence of vast areas with prolific growth of seaweeds providing feeding grounds for green turtles, most of the netting for turtles occurs in the Ha'apai group in Tonga. These areas of seaweed are located between uninhabited islands. The results of a survey, as recorded in Table 6.1.1, conducted by the Fisheries Division in 1972, located several turtle nests on five islands as reported by Koloa (1972). These islands were believed to be the five best nesting islands in Tonga and the peak nesting season was believed to be December to January. Braley (1973) reported the end of October to the end of February as the heaviest period of nesting of the turtle populations in Tonga. The October to February period was also reported by Hirth (1971), Wilkinson (1979), Pritchard (1981) and Balaazs (1981) as the main turtle nesting season in Tonga.

Table 6.1.1: Results of the turtle survey conducted in 1972 on the five islands believed to be the best nesting islands for turtles. (Source: Koloa, 1972).

Island	Turtle species	Nests	Island information
Meana (Nomuka Group)	not specified	2 x1-2 weeks old nests found plus 1 turtle nesting during visit (13 December, 1971)	uninhabited, 400 yds in circumference, steep sand beach surrounding whole island,
Fonuaika (Ha'apai Group)	not specified	9 x1-weeks old nests, 2x 1-2 days old nests, plus 1 during visit (15 December, 1991)	uninhabited, 3/4 miles in circumference, sand beach almost around whole island, has fringing reef about 75-100 yards wide
Luahoko Islands (Ha’apai Group)	not specified	4x2-4 weeks old nests but one nest had been dug up and eggs removed, no turtle came to nest during stay which was full moon which was believed to be nesting time	uninhabited, 5 miles circumference, has sand beaches almost around entire island, has fringing reef about 75-100 yards in width
Limu Island (Ha'apai Group)	not specified	2x1-3 weeks old nest, one nest was dug up and eggs taken to Nuku’alofa for hatching studies, no turtle came to nest during 3-day stay (Jan, 1992)	uninhabited, 3/4 miles in circumference, steep sandy beach all sides except south side, has fringing reef about 50-75 yards wide
Uanukuhahako (Ha'apai Group)	-	no turtle nests, no turtle visit during the 1-day visit (Jan, 1992)	uninhabited, 3 miles in circumference, sandy beach around entire island, surrounded by fringing reef.

Koloa (1972) concluded, from the number of nests and the number of turtles that came to nest during the survey period, that the breeding population was very low in Tonga, and recommended better laws to protect the turtles.

Braley (1974) reported on a turtle survey and tagging project that was carried out at the end of 1973. The survey covered various areas in the Ha'apai and Vava'u groups. The nesting survey results are summarized in Table 6.1.2.

Table 6.1.2: Results of the turtle survey conducted in Ha'apai and Vava'u in 1973 by the Fisheries Division. (Source: Braley, 1974).

Island	Turtle species	Visit Date	Nest Information	Remarks
Maninita	?	22-25 Nov	1 x1-week old nest which had been dug up and eggs removed, 4 older nests, no turtle visit to nest during survey	uninhabited, steep sandy beach around most of island, well-developed fringing reef
Taula	?	25-28 Nov	no turtle visit to nest during survey, 2-month old nests found but dug and eggs removed	uninhabited, steep sandy beach around 2/3 of island
Fonua'one'one	?	28 Nov	no new nests but found 2xmonth old nests found	uninhabited, steep sandy beach around 1/2 of island
Fangasito	?	28 Nov	no sign of any turtle nest	uninhabited, very steep sand beach around entire island, poorly developed fringing reef
Northern Ha'apai				
Uonuku	?	7-11 Dec	no evidence of old or new nests, however 2x1-1.5 weeks old dug up holes found	narrow island, well developed fringing reefs
Luahoko	?	20-24 Dec 30-31 Dec	no nesting during visit, reports of turtle nesting during storm 10 Dec and eggs taken' reports indicate a nest may have been taken	sandy beach almost around entire island, well developed fringing reef
Central Ha'apai				
Nukulei	*C. mydas* *C. agassizii*	2-6 Dec 22-24	1 green came to nest (4 Dec) turtle tracks & nesting 21 Dec, 4 nests found but 2 had been dug and eggs removed, the 4 Dec nest was found to have been dug and broken egg shells	Sandy beach 1/4 of island, rocky beach, fairly well developed fringing reef. Information received of 2 turtles shot off Kito Island and 1 on shoal south of Tungua in 2 days, 1 turtle (*C. agassizii*-black turtle-tu'akula) shot at Laulai Lahi in Jan, on Matuku 6 turtles caught in 1 week in Dec, egg collection common
Luamana	*C. mydas*	8-10 Dec	9 green nested (full moon, calm, tide going out)	sandy beach and good fringing reef
Kito	?	13-17 Dec	no nesting turtles	sand beach 95% of island rock beach 5%, good fringing reef
Southern Ha'apai				
Nomuka	*C. mydas*	8 Dec	a green female shot (speargun) near reef infront of Nomuka, turtle confiscated by Agriculture and released	inhabited
Tonumea		13,20,21 Dec	- no nesting, no signs of nesting, reports of unusual turtle that nested there about 1991 which was killed and eaten including eggs, that was last time nesting occurred	gentle slope sand beach around 2/3 of island
Nuku (small)		14-16 Dec	no nesting and no signs of nesting	
Nuku (big)	*E. imbricata*	16-19 Dec	no nesting, 3 old (2-3 weeks) nests found, but dug up and eggs removed. Reports from people of Tonumea and Mango that a hawksbill with eggs was killed in November before it laid eggs. Both turtle & eggs eaten	slightly sloping sand beach 1/4 of island, 1/2 steep sand beach, 1/4 rocky beach
Kelefesia			no signs of nesting, worker there reported last nesting there about 1965 which were both greens and hawksbill	gentle sloping sandy beach 2/3 of island, 1/3 50-60ft rock cliff
Nukufaiau		21-24 Dec	no nesting, no sign, island considered as one of the best turtle nesting islands in Southern Ha'apai. Report from Mango people that one large green taken while going up to nest in (November?), she had 170 eggs inside.	steep sand beach 4/5 of island, rest rocky, poor fringing reef
Nukutula small		22 Dec	no nesting, no signs, but storm (10-14 Dec) could have hidden any nest if present.	steep sand beach around island with scattered rocks in areas

Mangoiki	26-27	no nesting, no signs of nesting, Mango people reported that greens as well as a few hawksbills used to nest there until about 1970.	fairly steep sand beach around half of island, other half rocky, not well developed fringing reef.

These areas were believed to be where turtle nesting occurs in the Ha'apai and Vava'u groups. Most of the nesting turtles were hawksbill turtles.

Wilkinson (1979) wrote that on Ha'apai green turtles were seen by fishermen to nest on the uninhabited islands of Nukufaiva and Fetoa as well the inhabited island of Mango. The same author believed that green turtles also nest on two other islands on which hawksbill nest.

Malinoa Island, off Tongatapu, is the only area which is known to be a turtle nesting area, on or near Tongatapu (Wilkinson, 1979).

Biology and ecology: The hawksbill turtle feeds on a diet of invertebrates, sponges and soft corals. The green turtle, by contrast, is mainly herbivorous, feeding on seagrasses and algae. Because the seagrass beds often do not occur close to suitable breeding beaches, green turtles may have to migrate from a resident habitat to breeding beaches and back at intervals. Loggerheads and olive Ridleys are also carnivorous and, with the hawksbill, do not appear to migrate to the same extent as the green turtle, though some long distance movement has been recorded (Pickering, 1983). Movements of the olive Ridley are particularly poorly known. The loggerhead nests mainly outside the tropics, on subtropical and warm temperate coasts.

While green turtles often nest together in large numbers at sites called “rookeries”, the nesting of the hawksbill is diffused, with no great concentrations of nests. The single largest known green turtle rookery is Raine Island, on the northern Great Barrier Reef in Queensland, with 80,000 nesting females per year (Pickering, 1989). Other major rookeries occur around Australia, on the Caribbean coast of Costa Rica (Tortuguero), the Pacific coast of Mexico, Ascension Island, the coasts of Oman and Pakistan and islands in the Mozambique Channel (Pickering, 1989). Hawksbill nesting density is low throughout its range, with moderate concentrations in a few localities such as the Torres Straits islands of Queensland, the southern Red Sea and the Gulf of Aden and the Arnavon Islands near Santa Ysabel in Solomon Islands.

There is evidence that 7-14 months after hatching, young green and hawksbill turtles spend their time drifting passively in beds of floating seaweed, such as *Sargassum* spp., in the deep ocean. Green turtles are then thought to spend a developmental period in inshore estuarine, coastal and reef habitats before moving to their main resident areas (Pickering, 1989).

Age at first sexual maturity in green turtles has been estimated to be between 8 and 13 or more years (Márquez, 1990). The same author reported that in captivity (Cayman Turtle Farm), green turtles reach 35 kg in about three years and start to reproduce in less than 10 years.

6.1.2 The Fishery

Utilisation: In the past turtles are thought to have been a large protein source in Tonga, as well as providing material for local crafts (Anon, 1974). Nets made specifically for catching turtles were made of twine spun from coconut husks. Mesh sizes of these nets were 1ft 4 inches (Fuka, 1979). Small stones were used as sinkers while breadfruit timber served as floats. Nets were carried to the fishing grounds on a canoe or sail boat. The nets were hung across areas frequented by turtles, usually the green turtles, *C. mydas*, which become entangled in the net (Zann, 1981). Fishing for turtles at night was also practised where 2-3 fishermen take a canoe out, using lit dry coconut leaves as a torch, held by one fisherman standing in the front of the canoe. A spear was used when a turtle was sighted. Periods of rough seas near the beach were believed to be the best time to find turtles.

When fishing in the sea was not fruitful, the fishermen would wait on the beach for turtles coming to lay eggs. Cotton multifilament and monofilament nets have replaced the traditional fibre nets, and then spear-gun is a recent additional gear. On Tongatapu, there is a group of fishermen which specializes in spearing green turtles, using hand spear and spear gun (Anon, 1990). They search for turtles swimming on the surface of reef lakes or around the reef skirts. Special turtle fences made of chicken wire were also used to catch turtles (Pritchard, 1981).

By definition, the people of Niuatoputapu, as is common in other Polynesian cultures, include turtles as fish (***ika***) (Dye 1983).

Collection of turtle eggs at the subsistence level has been, and still is, a practise on islands where turtles nest. Nesting site surveys conducted in the early 1970's on uninhabited islands where turtle nesting is believed to take place indicated that the practise of turtle egg collecting by nearby islands inhabitants was very common.

Shell of the hawksbill is used for the production of tortoiseshell jewellery which includes combs, bracelets and hooks. Whole shells of both species are used for indoor decorations.

Poisoning from eating cooked meat of a 2' 4" long and 1' 4" wide hawksbill turtle was reported from Nomuka Island in March 1983 (Latu, letter dated 13 October 1983). The turtle was caught at Hakaufisi Reef. Of the twenty-one people who ate the meat, 18 became very sick and 3 died. The three that died and those who became very sick, ate part of the viscera (Muli, letter dated 7 February, 1984). This was the only time poisoning from eating turtle meat has been reported from Nomuka or elsewhere in Tonga.

Production and marketing: Consumption of turtle meat and eggs is mainly a subsistence activity. However, turtles of various sizes, from small to very large, are sometimes seen being offered for sale in the local markets. Products from hawksbill turtle shells as well as the shells of both species are sold as handicrafts. Turtle meat is sometimes also sold. On Pangaimotu, fishermen used to keep adult turtles in a corral, feeding them with turtle grass which washed up on the beach (Pritchard, 1981). There appears to be one such case in Tongatapu also.

On Tongatapu, a specialized group that fishes for turtles using spears goes out about 3 days a week and catches, on the average, 2 green turtles a week. The meat is sold at the Nuku'alofa pier for T$3.00 per kg (Anon, 1990). The same report noted that this gives them T$300 per fishing work, which is the highest source of income among fishermen engaged in diving. Turtle netting was reported by Vaea and Straatmans (1954) as being mostly carried out in the Ha'apai group, due to the presence of vast areas with prolific growth of seaweeds which are feeding grounds for the green turtles. A fisherman, after locating an area of seaweed between the small uninhabited islands, drops his net in a straight line at right angles to the flowing current and returns home. When the net is retrieved after two days, the catch usually comprises of turtles of all sizes. In a 50 feet by 12 feet net, as many as 10 turtles can be expected and often more.

Some figures on turtle catches during turtle surveys conducted by the Fisheries Division are included in Tables 6.6.1 and 6.1.2 under the Distribution section in this profile.

The following information was obtained from a Fisheries Division survey conducted in 1973 in the Ha'apai Group during May-June (Koloa, 1973):

Nomuka Island	- most turtles are caught during night and sometimes day dive fishing.
Fonoifua Island	- not many turtles but fishing for turtles is the same as Nomuka.
'O'ua Island	- a lot of turtles mostly caught by diving, using turtle net, but during Jan-Dec the fishermen go out to the uninhabited islands.

Tungua Island - reported to be one of the islands in Ha'apai where turtles are most abundant, fishing by diving.
Ha'afeva Island - turtles are plentiful and are caught using turtle nets, and sometimes when turtles are going to lay eggs.
Felemea Island - turtles are plentiful and most are caught by diving and when turtles come ashore to lay eggs, some fishermen use turtle nets.
'Uiha Island - a lot of turtles and island has been reported to have more turtles than the other island in Ha'apai. Turtle nets are used and turtles are also fished from uninhabited islands when going to lay eggs.
Pangai - not many turtles but fishermen mostly use turtle nets to catch turtles. Fishermen did not know where turtles nest.
Koulo - very few turtles are found here.
Holopeka - fishermen know little about turtles.
Ha'ano Island - not many turtles.

On 'Eua, Schuh (1982) reported turtle fishing under miscellaneous fishing methods together with hand gathering, gill netting, octopus fishing, fish drives and fish poisoning. The estimated annual catch contribution from miscellaneous fishing method, including turtles, was estimated to be 4 per cent.

No production figures are available except that Muli (letter quoted above) estimated in 1983 that more than thirty turtles were consumed in Nomuka a year. In the same letter, twenty or more turtles were caught in one night of fishing by Nomuka fishermen in one reef. This was never confirmed.

A one-week survey conducted at Faua and Vuna landing sites in April 1992 by the Ministry of Fisheries did not record any turtles. However weekly surveys conducted for the most part of 1993 at the same sites recorded turtle sales there, as summarized by months, in the following table. (The data was extracted from weekly totals of the Ministry of Fisheries Inshore database).

	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Turtles (kg)	0	0	0	0	90.9	0	559.9	268.9	0	0

There are no information available to suggest that export of turtle products from Tonga ever occurred on a commercial basis.

6.1.3 Stocks Status

Wilkinson (1979) wrote that even with the cessation of human predation, potential threats to turtle populations in the Pacific include pigs, dogs, rats, several crab species, sea birds, rocky shores and reef fishes.

Results of nesting turtle surveys conducted in the early 1970's, as reported under the distribution section of this profile, indicated heavy exploitation of this resource on islands frequented by turtles and where they nested. Collecting of eggs was very common and some fishermen even target turtles going to lay eggs. The 1976 Fisheries Division Annual Report reported that turtle populations in Tonga continued to decline, even though the closed season was extended for an additional month. It went on to recommend a ban on catching turtles and collection of eggs, for a year or more (Fisheries Division, 1977).

Pritchard (1981) reported that interviews with fishermen in Nuku'alofa indicated that only a few turtles occurred in the lagoon then, but were not as abundant as was the case in former times.

No information on any recent surveys was located but turtle populations in Tonga have been on the decline for many years, as indicated by various reports.

6.1.4 Management

Management of the turtle fishery has been difficult because of the interaction with local tradition on some islands. Enforcement of introduced legislation has been particularly difficult, due to the isolation of islands on which nesting takes place, as well as the remote location of some of the more important turtle catching areas.

Because of the close association of the turtles with some communities in Tonga, community-based management for turtles would be appropriate to assist the government in its effort to conserve this important resource. Dye (1982) reported that on Niuatoputapu the only marine animal that is actively conserved is the turtle (***fonu***), the capture of which is outlawed during December and January. This seems to indicate community cooperation in upholding government legislation.

Current legislation/policy: A closed season from 1 December to 31 January was introduced in 1967. This was subsequently changed to also include November. In addition a license was required to put up a fence to catch turtles. The minimum mesh size was 1.5 in. across and fence width and length was limited to 450 ft. (Braley, 1973).

Recommended legislation/policy: The proposed Fisheries (Conservation and Management) Regulations 1993 include the following, specifically for sea turtles:

No person shall -

(a) disturb, take, have in his possession, sell or purchase any turtle eggs;
(b) interfere with or disturb in any way any turtle nest;
(c) sell, purchase or export any turtle or the shell thereof of the species Eretmochelys imbricata, known as the hawksbill turtle;
(d) use a spear or spear gun for the purpose of capturing, destroying or taking any species of turtles;
(e) closed seasons: All turtle species except leatherback - 1 November to 31 January;
Leatherback - 1 January to 31 December.

It is not necessary to quote dates for a closed season, when it covers the whole year, as it reads for (e), as it can cause confusion. It would be clearer to just quote that catching etc of leatherback turtles is prohibited.

Establishment of some islands as reserves for turtles and other animals seems possible especially those that are government owned. Introduction of minimum size limits has been successfully applied in some countries as a step towards management of the turtle resource. Involvement of communities in the management of these resources and the enforcement of regulations is probably the most practical means towards attaining goals in this area.

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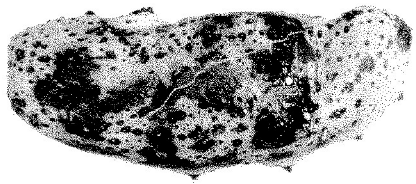
7. OTHER RESOURCES

7.1 Sea cucumber

7.1.1 The Resource


Holothuria fuscogilva

Species present: Sea cucumber species present in Tonga include: *Actinopyga* sp. (blackfish), *Actinopyga mauritiana* (surf redfish), *A. echinites* (redfish - ***telehea***), *Bahadschia argus* (leopardfish), *B. marmorata* (tiger fish), *B. marmorata vitiensis* (brown sandfish), *Dolabella* sp. (seahare - ***muli'one***), *Holothuria* (*Halodeima*) *atra* (lollyfish - ***loli***), *Holothuria* (*Microthele*) *nobilis* (black teatfish - ***mokohunu***), *H. fuscogilva* (white teatfish - ***huhuvalu***), *H. fuscopunctata* (elephant's trunk fish - ***mula***), *H. edulis* (pinkfish), *Stichopus variegatus* (curryfish - ***lomu***), *S. chloronotus* (greenfish), *Thelenota anax* (giant bêche-de-mer), *T. ananus* (prickly redfish), *T. anax* (giant beche-de-mer), *T. ananus* (prickly redfish - ***holomumu***), *Microthele axiologa* (elephant's trunkfish), *T. anax* (amberfish) and *H. edulis* (pinkfish). In addition, the recent boom in bêche-de-mer production has been targeting the species, currently called *H. scabra* (the sandfish - ***nga'ito***), which is found throughout the island groups in the Kingdom, but not reported in any survey reports. In addition, Preston and Lokani (1990) observed single specimens of at least two unknown species of *Actinopyga*, one of *Holothuria* and one of *Bohadschia* in Ha'apai. Twelve different species were observed in the Pangaimotu Reserve area (Bobko, 1993).

Several factors indicate that the sea cucumber species currently known in Tonga as the sandfish, *H. scabra*, is most likely to be a different species.

Distribution: Sea cucumbers are found throughout the world at depths from shallow coastal seas to the abyssal plain (Preston, 1993). Species of commercial value tend to predominate tropical coastal waters.

Because bacteria constitutes the major nutritional component for most holothuroids, "the complex relationship between bacterial populations and sediment structure may have a major influence on the distribution of holothuroids" (Preston, cited above).

Holothurian species reported from each island group within Tonga are recorded on Table 7.1.1 as reported in the various reports cited in this profile. No records can be located for species found on Tongatapu but those listed in the table (incomplete) were from observations by Fisheries Officer, Tevita Finau. A complication is that none of the reports of sea cucumber surveys conducted in Tonga recorded *H. scabra*, though it is currently believed to be the main species, locally known as sandfish, for the recent bêche-de-mer production for export. This species is found in all Tongan island groups.

Table 7.1.1: Sea cucumber species recorded from island groups in Tonga.

Species	Tongatapu	Vava'u	Ha'apai
A. mauritiana		+	
Actinopyga sp.			+
B. argus		+	+
B. marmorata vitiensis		+	+
H. atra	+	+	+
H. edulis		+	+
H. fuscogilva	+		+
H. fuscopunctata			+
H. nobilis	+	+	+
H. scabra (?)	+	+	+
M. axiologa	+	+	+
S. chloronotus	+	+	+
S. variegatus		+	+
T. ananus	+	+	+
T. anax		+	+

Specimens of unknown *Actinopyga*, *Holothuria* and *Bohadschia* species were recorded in Ha'apai by Preston and Lokani (1990).

Okamoto (1984) recorded sea cucumber species on three different substrates on Vava'u as follows:

	Percentage of specimen found		
Species	**On coral rock**	**Near coral rock**	**On sand, away from coral rock**
H. atra	100		
S. variegatus		50	50
B. argus	2	70	28
B. marmorata			100
M. axiologa		11	89
T. anax	2	22	76
T. ananus	11	64	25
H. nobilis	27	55	18

The distribution and relative abundance of sea cucumber species in Ha'apai, according to depth and substrate, was recorded by Okamoto (1983) as follows:

	2-5 m		5-10 m		10-20 m		20 m+
	Sand	**Sand coarse**	**Sand**	**Sand coarse**	**Sand muddy**	**Sand**	**Sand**
S. chloronotus	++	++	+	+		-	
H. atra	+++	++	++	+	+	+	
H. edulis	+++	++	++	++	+++	+	-
S. variegatus	+++	++	++	+	+	+	
B. argus	+++	++	++	+	+	+	-
B. marmorata	++	++	++	+	-	+	
M. axiologa	+++	++	++	+		++	-
T. anax	+	+	++	+		+++	-
T. ananus	-		-			-	-
H. nobilis	-		-			+	+

+++ = most commonly found, ++ = commonly found, + = sometimes found, - = rarely found, blank = did not find.

Preston and Lokani (1990) also observed a strong stratification of species abundance with depth in the Ha'apai Group. The combined depth distribution of six species considered to have commercial value showed a peak at the 5-10 m depth range. Densities (animals per 1,000 m$^{2)}$ per depth range for the six species were calculated as follows:

	Density (animals per 1,000 m^2) at depth ranges					
Species	**0-5 m**	**5-10 m**	**10-15 m**	**15-20 m**	**20-25 m**	**25-30 m**
Actinopyga sp.		0.06	0.01	0.02		
H. fuscogilva	0.03	0.07	0.06	0.09	0.18	0.26
H. fuscopunctata		0.19	0.03	0.02	0.03	0.03
H. nobilis	0.06	0.01	0.03	0.07	0.03	
T. ananas	0.06		0.04	0.02		
T. anax		0.13	0.11	0.11	0.03	0.08

Along the southwestern shoreline of Pangaimotu Island, Bobko (1993), observed a good population of sandfish in seagrass beds in water depths of 7 to 20 m with a coarse sandy substrate.

Biology and ecology: Conand (1989) reviews what is known of the biology of the main species of holothurian exploited commercially in the South Pacific. Additional information is provided in Preston (1993). Summaries of information from both sources on certain species of commercial interest are given in Appendix 7.1.1.

It is known that most aspidochirote holothurians are deposit-feeders, swallowing the upper few millimetres of sediment on which they live. The sediment consists of inorganic compounds, organic detritus, micro-organisms and their own or other animals' faecal material, with bacteria making up the major nutritional component for most species. They generally feed continuously or have a daily rhythm in their feeding frequency, often related to light levels. Species that live in reef flat areas "vacuum" the surfaces of their habitat, cleaning off the film of sediment that settles there.

The only study conducted in Tonga on the biology of a sea cucumber is that for sandfish by Bobko (1993). The study duration was very limited (February-May 1993) and the results are only preliminary. The following relationships were calculated:

Total Length and Total Weight - TW = 53.52 x TL - 549.87 (n=91, r^2=0.83)
Total Length and Drained Weight - DW = 39.01 x TL - 361.28 (n=91, r^2 =0.72)
Total Length and Eviscerated Weight - EW = 21.96 x TL - 163.45 (n=91, r^2= 0.60)
Total Weight and Drained Weight - DW = 0.75 x TW + 30.33 (n=91, r^2= 0.60)
Total Weight and Eviscerated Weight - EW = 0.41 x TW + 62.95 (n=91, r^2= 0.60)

Examination of the gonads indicate that the last portion of the spawning peak seems to be from February and March. However, because the study was conducted only from February to May, a yearly cycle was impossible to estimate. The following gonadalsomatic indices (GSI) mean values (%) were given for the different sample dates: (Source: Bobko, 1993).

	GSI Mean Values (%)			
	Female		Male	
Date	GSITW	GSIDW	GSITW	GSIDW
11 Feb 93	3.54	10.39	0.97	3.40
23 Feb 93	7.16	9.49	4.24	5.91
09 Mar 93	9.23	10.56	5.51	6.96
23 Mar 93	1.71	2.06	1.22	1.37
07 Apr 93	1.71	1.90	2.27	2.83
20 Apr 93	0.65	0.73		
03 May 93	1.30	1.56	1.53	2.00

Two indices were calculated for both male and female sandfish. GSITW was calculated as GSI1=GWx100/TW and GSIDW was calculated as GSI2=GWx100/DW, where GW is the gonad weight.

7.1.2 The Fishery

Utilisation: Collection of sea cucumbers for local consumption has not been a major component of subsistence fishing activities. However, they form at least a small portion of food items collected from the tidal areas. Some species are sold in the local markets in bottles, with the main component being the ***lomu*** (intestine of *Stichopus* sp.). Other sea cucumber species normally mixed with ***lomu*** include sandfish, lollyfish, brown sandfish and tiger fish. The use of other species is mainly to fill up the ***lomu*** bottle and the contents are consumed raw. A survey conducted on Vava'u by Pacific Islands Development Program (PIDP) in 1983 on the use of tidal areas indicated the sea cucumbers (***loli***, ***lomu*** and ***muli'one***) as some of the food items harvested (Kunatuba and Uwate, 1983). Of the combined seafood production from the tidal areas, most of the villages indicated that sea cucumber is collected for home consumption and for sales. A few indicated that only excess is sold.

Sea cucumber species consumed locally include; ***lomu*** (viscera of *S. variegatus*), ***loli*** (*H. atra*-meat), ***ngaito*** (*H. scabra*-meat), stonefish (*A. lecanora*?-meat), ***muli'one*** (*Dolabella* sp.-meat).

The history of commercial production of bêche-de-mer for export from Tonga is not clear, but there are indications of some very limited processing for export during the mid-1980's. However, exploitation of sea cucumbers for bêche-de-mer production for export has been a major and booming undertaking for the last several years starting in 1990 (Tevita Finau, 1993, *pers. comm.*). At the time of information compilation for this document, thirteen exporters of bêche-de-mer were registered by the Labour and Commerce Department.

For the commercial production of bêche-de-mer in Tonga, most of the teatfishes collected are from Vava'u. These species are not common in Tongatapu and Ha'apai. Conversely, the sandfish is abundant in both Tongatapu and Ha'apai, but not so in Vava'u.

Production and marketing: No figures could be located on the levels of exploitation in the local subsistence fishery and only very limited information has been collected for sea cucumber landing in the artisanal fishery.

During a one-week survey conducted at Faua and Vuna landing sites in Nuku'alofa in April 1992, sea urchin and sea cucumber formed 22.60 per cent (744.90 kg) of the total mollusc landing (3,296 kg) there for the whole week. Using a 50-week year, the sea cucumber and sea urchin figure translates to 37.25 mt landed at the two sites for the year.

The Inshore Fisheries Statistics surveys, initiated in 1993 as a Ministry of Fisheries/JICA project, attempts to estimate marine resource landings at Vuna and Faua landing sites in Nuku'alofa. No estimates of sea cucumber landing from these surveys at the two sites have been made available.

Data obtained from the Statistics Department on the export of bêche-de-mer from Tonga between 1980 and 1992 is presented in Table 7.1.2. There were no export records from 1980 to 1983. The Statistics Department data were based on information from the Customs Department. Preston and Lokani (1990) reported that "anectodal information indicates that at least one local individual was active in beche-de-mer processing and sale in ‘Uiha until about 1986, with most of his raw product coming from the Ha'apai area. Another local producer is said to have operated in Vava'u until about 1988, obtaining product from both Vava'u and Ha'apai areas". However, over the past few years bêche-de-mer production for export has been increasing leading to a "boom" industry by 1991. This has been mainly due to the establishment of overseas markets for the sea cucumber species currently known as sandfish, *H. scabra*. This species is very common in Ha'apai and Tongatapu.

Table 7.1.2: Export of beche-de-mer from Tonga (Source: Statistics Department)

	1984	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**
Weight (kg)	2,033.0	-	4,818.0	657.0	237.0	393.0	602.0	17,131.0	67,221.0
Value (T$)	2,383	-	18,755	4,500	230	1,990	2,990	102,325	615,432

Export figures of bêche-de-mer, by species where possible, as made available by certain exporting companies include the following. The “A”, “B”, “C” and “2nd” notations given after most of the species name, denote grade of the product as labelled for export:

COMPANY 1			
Date	**Species**	**Amount (kg)**	**Value (US$)**
1991			
09 Aug	Black teatfish	141.10	1,410.00
	Elephant trunkfish	265.4	1,592.40
	Tigerfish	74.0	370.00
	Prickly redfish	32.0	320.00
	??	117.1	1,171.00
	White teatfish	527.7	8,443.20
27 Aug	?? Grade A	176.0	4,048.00
	?? Grade B	49.0	980.00
	?? Grade C	61.0	sample
27 Sep	?? Grade A	404.0	7,600.00
02 Oct	Sandfish	400.0	8,000.00
09 Oct	Sandfish	364.0	
	B/W teatfish & e/trunkfish	36.0	8,000.00
13 Nov	?? Grade A	915.0	
	?? Grade B	657.0	31,440.00
15 Nov	?? Beche-de-mer	115.2	1,036.80
17 Dec	?? Beche-de-mer	1,140.0	14,250.00
TOTAL		**15,474.50**	**88,661.40**

	COMPANY 1		
1992	Species	Amount (kg)	Value (US$)
27 Jan	?? Grade A	640.0	9,600.00
	?? Grade B	135.0	1,485.00

	COMPANY 2		
1993	Species	Amount (kg)	Value (US$)
02 Jan	Sandfish A	528.0	15,840.00
	Sandfish B	630.0	17,010.00

29 Jan	Sandfish A & B	481.0	7,251.00
	B/l A	39.0	312.00
	Mix A	34.0	306.00
18 Feb	Sandfish A	640.0	10,240.00
	Sandfish B	37.0	407.00
4 March	Sandfish	1,259.0	19,949.64
11 March	Sandfish	943.0	16,348.38
1 April	Sandfish	932.0	18,466.00
29 April	Sandfish	632.0	12,492.00
	White teatfish	234.0	3856.00
22 May	Sandfish A	790.0	15,800.00
	Sandfish B	232.0	3,712.00
12 June	Sandfish A	766.0	15,320.00
	Sandfish B	293.0	4,688.00
	W/ teatfish B	59.0	944.00
1 July	Sandfish A	943.0	16,502.50
	Sandfish B	35.0	472.50
	W/teatfish A	61.0	1,403.00
	W/teatfish B	233.0	3,495.00
8 July	Sandfish A	530.0	9,010.00
	Sandfish B	737.0	14,740.00
19 Aug	Sandfish A	585.0	14,625.00
	Sandfish B	216.6	3,888.0
	W/teatfish A	69.0	1,380.00
	W/teatfish B	130.0	1,950.00
9 Sept	Sandfish A	765.0	19,125.00
	Sandfish B	180.0	3,240.00
	E/trunkfish	131.0	262.00
TOTAL		**12,761.60**	**231,270.02**

COMPANY 2

1992	Species	Amount (kg)	Value (US$)
28 Oct	Sandfish A	945.0	
	Sandfish B	1,065.0	
	W/teatfish A	410.0	
	W/teatfish B	105.0	54,391.25
12 Nov	Sandfish A	167.0	
	Sandfish B	40.0	
	Sandfish 2nd	295.0	
	W/teatfish A	140.0	
	W/teatfish B	161.0	
	W/teatfish 2nd	202.0	14,037.50
07 Dec	Sandfish A	91.0	
	Sandfish B	71.0	
	Sandfish C	71.0	
	Sandfish 2nd	46.0	
	W/teatfish A	69.0	
	W/teatfish 2nd	35.0	24,704.35
TOTAL		**3,913.00**	**93,133.10**

	Sandfish 2nd	77.0	1,617.00
	W/teatfish A	768.0	11,520.00
	W/teatfish B	256.0	2,816.00
	W/teatfish 2nd	160.0	1,120.00
01 March	W/teatfish A	1,400.0	
	W/teatfish B	420.0	
	W/teatfish 2nd	315.0	
	Sandfish A	217.0	
	Sandfish B	45.0	
	Sandfish 2nd	52.0	36,642.00
10 July	Sandfish A	440.0	
	Sandfish B	170.0	
	Sandfish 2nd	200.0	
	W/teatfish A	140.0	
	W/teatfish B	385.0	
	W/teatfish 2nd	665.0	33,120.00
10 July	W/teatfish B	40.0	640.00
	W/teatfish 2nd	30.0	360.00
	B/teatfish	11.0	330.00
	B/teatfish	7.0	70.00
22 Sep	Sandfish A	420.0	12,600.00
	Sandfish B	80.0	2,160.00
	Sandfish 2nd	99.0	2,079.00
	W/teatfish A	570.0	8,835.00
	W/teatfish B	270.0	2,970.00
	W/teatfish 2nd	536.8	3,757.60
	B/teatfish	26.0	260.00
	B/teatfish	26.4	211.20
	B/teatfish	11.8	141.60
	R/pricklyfish	17.80	213.60
TOTAL		**9,013.80**	**154,313.00**

COMPANY 3

1993	**Species**	**Amount (kg)**	**Value (US$)**
24 March	Sandfish	163.0	2,136.00
25 April	Sandfish	451.0	5,703.00
11 May	Sandfish	444.0	6,151.00
29 June	Sandfish	1,091.0	15,341.00
27 July	Sandfish	660.0	9,180.00
26 Aug	Sandfish	695.0	9,475.00
14 Sep	Sandfish	350.0	4,585.00
21 Oct	Sandfish	526.0	8,365.00
Sep-Oct	W/teatfish	131.0	1,155.00
TOTAL		**4,511.00**	**62,091.00**

It is obvious from these totals, as compared to the export figures recorded by the Statistics Department, that much more information on bêche-de-mer exports has not been documented on individual exporters.

7.1.3 Stocks Status

Estimates of population sizes for each species in the Vava'u Group were made by Okamoto (1983). The area between the 3 and 36 m depth contours was calculated for the Vava'u group of islands using a marine map from a British survey in 1898, and the Tonga Government map of the Vava'u Group published in 1975. The total area was estimated to be 100 km^2, of which 1/5, or 20 km^2, was assumed to be suitable sea cucumber habitat. The average numbers of the sites surveyed was also assumed to be consistent for the rest of the group. The results of population size extrapolations for each species were given as follows:

	S. chloronotus	H. atra	H. edulis	S. variegatus	B. argus	B. marmorata	M. axiologa	T. anax	T. ananus	H. nobilis
Population size	10,000	100,000	158,000	73,000	141,000	58,000	210,000	96,000	9,000	16,000
95% confidence	0-20,000	3,000-197,000	11,000-305,000	22,000-124,000	54,000-228,000	15,000-100,000	84,000-336,000	5,000-187,000	1,000-17,000	0-33,000

The average of the numbers of sea cucumbers found during one-hour dives for 21 sites around Vava'u for each species were recorded by Okamoto (1983) as shown in the following table.

S. chloronotus	H. atra	H. edulis	S. variegatus	B. argus	B. marmorata	M. axiologa	T. anax	T. ananus	T. nobilis
1.0	10.0	15.8	7.3	14.1	5.8	21.0	9.16	0.9	1.6

Sea cucumber population was estimated by Okamoto (1984) for Ha'apai for the species found there and is given in the following table.

	H. atra	S. variegatus	B. argus	B. marmorata	M. axiologa	T. anax	T. ananus	H. nobilis
Population size	2,800	2,000	48,000	3,800	18,000	43,000	34,000	85,000
95% confidence	0-6,000	0-4,000	1,000-94,000	0-10,000	0-38,000	10,000-76,000	14,000-52,000	38,000-110,000

Preston and Lokani (1990) estimated the standing stocks of the major species based on average density results to be 1,015,346 animals for Ha'apai inhabiting an estimated area of sea floor of about 263,053,000 m^2 between 0 and 30 m depth . The six commercially useful species had densities ranging from 0 to 26.93 animals/1,000 m^2 averaging to 3.86/1,000 m^2. The teatfish species, *H. nobilis* and *H. fuscogilva* accounted for one-third of the total numbers. Average densities of the six species is shown below in number of animals per 1,000 m^2:

	H. nobilis	H. fuscogilva	H. fuscopunctata	T. ananus	T. anax	Actinopyga sp.
Overall average (number/1,000 m^2)	0.46	0.86	0.64	0.30	1.37	0.24

The average numbers of sea cucumbers found in one-hour dives in 21 sites surveyed around Ha'apai for each species were calculated by Okamoto (1984) as given below:

	H. atra	S. variegatus	B. argus	B. marmorata	M. axiologa	T. anax	T. ananus	H. nobilis
Number/hour	0.14	0.10	2.38	0.19	0.90	2.14	1.67	4.24

It is very possible that the current status of the sea cucumber resource in Tonga would be very different from that found in the assessment surveys mentioned above. This is especially true where the commercial valuable species are concerned, due to the recent boom in the production and export of bêche-de-mer. It is worth noting that the main sea cucumber species targeted, classified locally as *H. scabra*, was not mentioned in any of the assessment work completed for Tonga.

A repetition of the stock surveys of sea cucumber seems necessary to assess the status of the stocks after the heavy exploitation of the resource as has been the case for a few years now.

The monthly flow of bêche-de-mer exported from Tonga by the three companies mentioned under the production section, is shown below. Company 1 ceased to operate after September 1992, but the operation was continued by Company 2 beginning October, 1992. The third company started in March, 1993. There was a marked decrease in monthly export frequency, thus lower amounts, by Company 2 in 1993 as compared to 1992 exports for the months of January to September. The numbers are in kg. However, because there are no data on collection sites and effort, it is impossible to use these trends as indication of sea cucumber stocks status.

	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
1991								1,442.30	404.00	800.00	1,687.00	11,140.00
1992	1,329.00	677.00	2,202.00	1,798.00	1,022.00	1,118.00	2,539.00	1,000.60	1,076.00			
										2,525.00	1,005.00	383.00
1993	2,419.00		2,449.00				2,088.00		2,057.80			
1993			163.00	451.00	444.00	1,091.00	660.00	695.00	350.00	657.00		

7.1.4 Management

Current legislation/policy regarding exploitation: There is currently no regulation that specifically deals with the exploitation of sea cucumbers in Tonga.

Recommended legislation/policy regarding exploitation: For the Vanuatu sea cucumber resource exploitation, Chambers (1990) recommended that:

"the correct strategy with regard to bêche-de-mer harvesting is to collect intermittently from sites which are both large enough and support sufficient densities of commercial species to be economic. Stocks should then be left for however long it takes them to recover to economic levels".

Conand (1989) and Preston (1993) describe several options available for the management of sea cucumber resources for sustainable utilisation. One such means is the application of minimum size limits regulations. Conand (1989) notes:

"the seasonal fishing ban can hinder exports, since the buyers on the Hong Kong and Singapore markets have always insisted that suppliers should be regular. A longer closed season can be considered where yields drop drastically. It is difficult to enforce closures of fishing zones and their boundaries must respect local customs, when these non-mobile resources are exploited under a system of traditional ownership. Limiting fishable sizes tends to favour recruitment. When applied to catches, such restrictions are hard to verify but when applied to the processed product, they are realistic and can be checked through exports. The limits should be set out on the basis of scientific results relating to size at first sexual maturity".

Length and weight values for processed bêche-de-mer with corresponding total wet length and weight at first sexual maturity have been calculated for some species with commercial value. These can then be used as a basis for setting legal size on the processed product (Conand, 1989). However, the author notes "that these are minima and that better knowledge about growth remains essential so as to be able to leave individuals undisturbed for one or more breeding seasons before harvesting them".

Preston and Lokani (1990) recommended a ban on the use of SCUBA gear for the collection of sea cucumbers. This recommendation “was proposed not only out of safety considerations, but because it was calculated that about half the estimated stocks of 1 million exploitable bêche-de-mer in the area (Ha’apai) was in water deeper than 30 m, and this would be largely inaccessible to local divers without SCUBA” (Preston, 1993).

The current proposed Fisheries Regulations recommend imposition of minimum size limits as follows for different species:

Species	Common name	Minimum Wet Length (mm)	Minimum Dry Weight (mm)
H. nobilis	black teatfish	260	130
H. fuscogilva	white teatfish	320	160
H. fuscopunctata	elephant's trunkfish	350	150
H. scabra	sandfish	160	70
T. ananas	prickly redfish	300	120
H. atra	lollyfish	165	80
A. echinites	redfish	120	60

It would be necessary to confirm the identification of the sea cucumber species currently known as *H. scabra* in Tonga before the regulations, which include minimum size for various species of sea cucumbers, including *H. scabra*, are passed. It is currently the most utilized and sought after sea cucumber species for bêche-de-mer production for export in Tonga. However, there are indications that the species is not *H. scabra*.

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Appendix 7.1.1: Biological Information on some species of sea-cucumbers exploited commercially in the Pacific (Conand 1989; and Preston, 1993).

H. scabra and *H. scabra* variety *versicolor* (the "sandfish"): Sexes are separate and sex-ratio does not significantly diverge from 1:1, with individuals showing a single annual sexual cycle. Reproduction is sexually and takes place mainly during the warmer months, peaking in October-December, with absolute fecundity ranging from 9-12 x 10^6 oocytes per gram of ovary weight. Sizes at first sexual maturity for *H. scabra* and *H. scabra* var. *versicolor* were found to be 140 g and 320 g drained weight respectively with corresponding lengths of 16 cm (total weight 184 g) and 22 cm (total weight=490 g). Growth is difficult to measure, however, Shelley (1985) studied the species length-frequency and concluded that in the size range of 10-25 cm *H. scabra* were growing at 0.5 cm per month, equivalent to an average monthly whole weight increase of 14 g. Juveniles (recruits) are rarely seen and Shelly (1981 - quoted in Preston, 1993) did not find any juveniles of *H. scabra* less than 60 mm in length. Length-weight relationship for *H. scabra* has been calculated by Conand (1989) to be Log W = 2.28 Log L-6.35 (correlation coeficient=0.78) and Shelly (1981) $W = 3.06L^{1.61}$ (correlation coeficient=0.75) while that for *H. scabra* var *versicolor* is Log W=2.26 Log L-5.97 (correlation coefficient 0.76) (Conand, 1989). (L in cm and W in g).

H. nobilis (the "black teatfish") and *H. fuscogilva* (the "white teatfish"): Sexes are separate with a ratio of about 1:1. Reproduction is sexual. A five-stage maturity scale has been identified which is typical for the family Holothuriidae and details are given in Conand (1989). Male and females develop synchronously and for *H. nobilis*, spawning occurs during the cold months (June-August) while *H. fuscogilva* spawns in the warmer months, peaking in November-January. Spawning periods for these two species do not overlap. (Fission can be induced in *H. nobilis*). Absolute fecundity for *H. nobilis* was estimated to be between 13 and 78 million oocytes with *H. fuscogilva* recording lower fecundity of between 8 and 14 million oocytes per gram of ovary weight. Total weights at first sexual maturity were estimated to be 800 g and 1,175 g for *H. nobilis* and *H. fuscogilva* respectively. Juveniles are only rarely seen. Length-weight relationship was calculated by Conand (1989) for *H. nobilis* to be Log W=2.34 Log L-6.39 (correlation coefficeint=0.80) and for *H. fuscogilva* W=11.94 L-2712 (correlation coefficient=0.70). (L in cm and W in g).

A. echinites (the "deep-water redfish"): Sexes are separate with a ratio of about 1:1. Spawning takes place during the warmer months, peaking in January-February, with absolute fecundity ranging from 4 to 25 million oocytes. Drained weight at first sexual maturity is 75 g corresponding to total weight of 90 g and total length of 12 cm. Shelly (1985) estimated the growth parameters of this species in PNG to be; L_∞= 23 cm, K=0.78 with a monthly length increase of 0.60 to 0.9 cm corresponding to a monthly weight increase of 1 to 5 g. Conand (1988 - quoted in Preston, 1993) gave estimates for growth and mortality parameters to be: L_∞=29.5 cm, K=0.09 and M=0.64. Length-frequency data for this species in New Caledonia showed the absence of animals less than 40 mm in length (Conand 1986, quoted in Preston, 1993). Length-weight relationship was calculated as $W=0.68\ L^{2.00}$ (correlation coefficient =0.61) (Shelley, 1982, quoted in Preston, 1993).

A. miliaris (the "blackfish"): Little is known about this species. Some observations on spawning in natural environment during February and early March on the Great Barrier Reef suggests that reproduction takes place in the hot season. Measurements of small specimens, in July 1982, weighing 5 to 30 g (3 to 9 cm) indicated their growth rates were approximately 1 cm (5 g) per month assuming these were spawned in February of the same year. The Length-weight relationship for this species was calculated by Conand (1989) to be $W=0.824 \times 10^3\ L^{2.441}$ (correlation coefficient=0.96).

T. ananas (the "prickly redfish"): Spawning occurs during the warmer months, probably from January to March. Fecundity is not high with absolute fecundity ranging from 2 to 7 million oocytes per gram of ovary weight. First sexual maturity is reached at total length of 30 cm (total weight of 1,230 g and drained weight of 1,150 g). Conand (1988, quoted in Preston, 1993) gave growth parameters for this species as; L_∞=66.3 cm, K=0.20, M=0.63 and Length interval=160-640. The species is long-lived, with a low mortality and high asymptotic length. In New Caledonia no animals were recorded with lengths less than 180 mm. Using growth and mortality estimates, Conand (1988, quoted in Preston, 1993) estimated the biomass of theoretical cohorts of this species as it aged which enabled her to estimate the average length at which the biomass of the cohort is greatest and fishing will give the highest yields ("critical length"). The critical length was found to be 28 cm, slightly lower than the length at first sexual maturity. The length-weight relationship was calculated to be $W=1.27 \times 10^{-3} L^{2.441}$.

H. atra (the "lollyfish"): The lollyfish is the most common and abundant species on the tropical shore. Asexually reproduction through fission is thought to be very important in this species and the products of fission may comprise up to 70 percent of the population. Growth and mortality parameters were estimated in Conand (1988-quoted in Preston, 1993) as: L_∞= 324 mm, K=0.11, M=1.02 and Length interval=130-220. The length-weight relationship has been calculated to be Log W=2.13 Log - 5.64 (correlation coefficient=0.90).

A. mauritiana (the "surf redfish"): This species is widespread in the tropical Indo-Pacific region and its habitat is restricted to outer reef flats subject to strong waves and currents. Its diet is mainly of plant debris. Reproduction is sexual but fission can be induced in this species. Absolute fecundity was estimated to be between 22-33 million oocytes per gram ovary weight. The growth and mortality parameters have been calculated to be L_∞ = 340, K=0.12, M=1.45, and length interval=70-280 (Conand, 1988, quoted in Preston, 1993).

7.2 Corals (including precious corals) - *Feo, Toatahi*

7.2.1 The Resource

Species present: No reference could be found which lists coral species, their distribution and habitat in Tonga. However rich coral growth, fringing and barrier reefs as well as *Porites* microatolls have been reported on many of the islands in the Tonga Group. A few coral species are mentioned in the records of exports in the aquarium trade. Smith (1992) lists coral species sought for ornamental or curio purposes to include branching corals (*Acropora*, *Seriatopora*, *Pocillopora*), stinging corals (*Millepora*, *Strylaster*), organpipe corals (*Tubipora*), brain corals (*Goniastrea*, *Euphyllia*) and mushroom corals (*Fungis*) . The few coral species actually named on export forms submitted by the local exporters in the aquarium trade include; *Acropora nana*, *Goniopora lobata*, *Goniastrea* sp. (honeycomb corals - brain coral), *Montipora foveolata*, *Caulastrea furcata* (torch rock), *Favites* sp. (brain coral), *Goniatrea australensis* (worm brain), *Actinodiscus* sp. (mushroom) and *Tubipora musica* (pipe organ). In addition, soft corals have also been utilized and include, *Sarcophyton* sp. (e.g. *S. trocheliophorum*), *Sinularia* sp., and *Lytophyton* sp. (green soft leather). Other names used for corals in the trade include; Scleractinia, live rock, yellow leather, coloured brain, coral candy, puffy brain, bio rock, mushroom rock, velvet rock, red brain, and runge rock.

During the CCOP/SOPAC (Cooperative Committee for Offshore Prospecting in the South Pacific) offshore areas dredging for deep-water precious corals in Tongan waters in 1978, the hard bottom corals, *Dendrophyllia*, *Keroeides*, hydrocorals and other species were collected at most localities where hard bottom was found. Only a few small specimens of *Corallium* were found in 3 dredgings out of a total of 55 (Eade, 1980). Pink and white specimens with commercial grade colour were found in Solomon Islands, Vanuatu and Tonga and Cook Islands during the CCOP/SOPAC dredging project, between 1978 and 1982 (Eade, 1988). In addition, non-commercial white specimens were found throughout the South Pacific region. Black corals, in the family *Antipatharia*, have been harvested and carved by a select number of diver-craftsmen for some years (Carleton and Philipson, 1987). Bamboo corals were reported by some divers in the Malinoa and Tau area (Fuka and Sione, undated).

Distribution: Coral reefs are tropical, shallow water ecosystems, largely restricted to the area between the latitudes 30°N and 30°S (Sheppard and Wells, 1988). Generally, vertical distribution of corals is determined by light and the actual depth limit depends on water transparency and no reefs develop in areas where annual minimum temperature is below 18°C (Achituv and Dubinsky, 1990).

The precious pink corals, *Corallium* spp., are distributed at depths of 5 to 1,500 m in the Mediterranean Sea, the eastern Atlantic between Portugal and Senegal, the northern Philippines to Japan and along the Hawaiian Archipelago (Carleton and Philipson, 1987). They grow best on solid substrata in areas of strong currents. In the Pacific, however, pink corals grow in deeper zone to that of black corals, and thus their distribution is not normally contiguous. No commercial beds of pink coral have been identified in the South Pacific.

Black corals are found throughout the tropical, semi-tropical and temperate seas, but are harvested commercially only in tropical regions, the Caribbean, the Indo-Pacific and the Hawaiian chain of islands, and have been identified in the waters of most island countries in the South Pacific (Carleton and Philipson, cited above). They are normally found in depths of 10 to 110 m, mostly on sediment-free hard substrate, and often in areas of strong currents (Parrish, 1988). Large samples have been located attached to solid coral or rock rises, banks or ridges swept by strong currents and thus clear of silt, sand and rubble.

The islands in the Tonga Group are mainly elevated coral reefs which cap the peaks of two parallel submarine ridges, although some are volcanic (UNEP/IUCN, 1988). Distribution of different coral species in Tonga has not been documented. However, the above report documented the occurrence and types of reefs around the islands in the Tonga group. These are summarized and recorded in Table 7.2.1 for only the islands on which reefs were reported. Wolterding (1985) noted that fringing reefs are the most common type, with all large islands in Tonga being surrounded by them. He further noted that barrier reefs were absent, with no atolls, but many small patch reefs are found all over the island group. However, one barrier reef was documented on Ofolanga island in Ha'apai.

Table 7.2.1: Reefs and corals occurrence around the islands of Tonga.

Island	Island type	Reef type	Other Information
Niuatoputapu	volcanic	fringing & barrier reefs	
Fonualei	volcanic	fringing reef	
Toku	volcanic	fringing reef	
VAVA'U			
'Uta Vava'u	limestone	reefs	many reefs
Ofu		algal ridge and reef; Porites microatolls at south end	thick coral growth
Fofoa			rich coral fauna
Lape			rich coral growth
Nuapapu		shallow reefs	on west
Vaka'eitu	limestone	reefs	
Ovaka		reef-bound	
Taunga		reefs	surrounded
Fonu'one'one		good fringing reef	
Fangasito		reef	poorly developed
Taula		fringing reef	well developed
Maninita		fringing	well developed
Late	volcanic		corals in pools
HA'APAI			
Ofolanga		barrier reef	enclosing lagoon
Mo'unga'one	limestone	fringing reef	only to south east
Luahoko		fringing reef	well developed
Luangahu		reef	associated reefs
Lofanga		fringing reef	narrow
Uonukuhihifo		fringing reef	well developed on west side
Uonukuhahake		fringing reef	well developed on west side
Nukupule		reef	associated reefs
Niniva		reef	associated reefs
Kao	Volcanic	coral patches	in shallow
Tofua	volcanic	coral	small amounts
Ha'afeva		barrier reef	
Kotu		reef	extensive
Kito		fringing reef	good
Nukulei		fringing reef	around 3/4 of island
Luanamo		fringing reef	good
'O'ua		reef	extensive
Fonuaki		fringing reef	not well developed
Nomuka	limestone	fringing reef	narrow
Nomukaiki	vol/lime	many reefs	
Mango	vol/lime	extensive reefs	
Nuku		fringing reef	good around big island, poor around small island
Nukutula		fringing reef	poorly developed
Meama		fringing	poor/fair
Nukufalau		fringing reef	poorly developed
TONGATAPU			
Tongatapu	limestone	fringing reef	
Pangaimotu		Reef reserve	
'Eua	volcanic	fringing reef	
MINERVA REEFS			2 reefs

On Ha'apai, Halapua (1981) describes good fishing grounds on some islands which include extensive reefs and lagoons in Mango, Nomuka, 'O'ua, Kotu, Lofanga and 'Uiha while the islands of Fonoifua, Tungua, Ha'afea, Matuku, Lifuka, Foa, Ha'ano, Totuha'a and Mo'unga'one have smaller areas of reefs and lagoons relative to their population and landmass.

The reef face on the southern shore of Tongatapu, being fully exposed to ocean wave forces, is made up of a series of thick rounded spurs which project seaward and alternate with deeper sand-filled grooves and channels (Wolterding, 1985). The leeward reefs are not exposed to strong wave forces and thus the corals grow in many types of plate-like and branching forms.

Precious corals, *Corallium* sp., were found only in south Vava'u and east Ha'apai during the CCOP/SOPAC 1978 dredgings in Tonga. The results given in Eade (1980) are reproduced as Table 7.2.2. Coral species utilized in the ornamental trade are those in the shallow reef areas.

Table 7.2.2: Results of the CCOP/SOPAC dredgings for precious corals in Tonga. (Source: Eade, 1980).

Sea Area	# dredgings made	# dredgings with Corallium	Depth range (m)
off Niuatoputapu	3	0	
between Niuatoputapu/Vava'u	3	0	
Fonualei	2	0	
north Vava'u	2	0	
west Vava'u	1	0	
east Vava'u	1	0	
south Vava'u	6	1	350-400
north Ha'apai	6	0	
west Ha'apai	4	0	
east Ha'apai	6	2	325, 375
east Nomuka	1	0	
west Nomuka	3	0	
between Tofua/Kao	3	0	
off Tongatapu	11	0	
off 'Eua	3	0	

The area off 'Eua was considered as having excellent conditions for deep-water coral growth, but strong currents and rough seas made sampling difficult there during the CCOP/SOPAC dredging for precious coral programme during 1978-1982. Two other areas that looked promising and requiring further surveys were southern Vava'u and east of Ha'apai (Eade, 1980).

Information collected on precious coral in Tonga in certain areas by Fuka and Sione (undated) from divers and business people indicated the following (all collection was by diving):

1. Ava Lahi and Ava Si'i - feasible for black coral in depth of 40-50 m, deeper in some places.
2. Egeria Channel and Piha Channel - concentration found in depth of 70-80 feet, sea floor abyssal with some sandy spots, currents fairly strong and diver sometimes just follow current direction, the slope of sea floor is like a terrace in which one platform can be about 1/10 of a mile long before a drop in depth to another, the coral tended to grow on the flat floor rather than on the steep side.
3. Malinoa - black and bamboo corals present and some brought up by divers from the area.
4. Malinoa, Makaha'a and Pangaimotu - bamboo coral at depth of 40-50 feet, deeper in some areas, diver claimed to see bamboo corals around Tau.
5. Beyond Vuna wharf - diver claimed seeing black coral in Ualaga and Mounu reefs, and he had sold some black coral to buyers.
6. 'Atata - bamboo coral seen in Langafonua.

One of the jewellery sellers at Talamahu market stated that concentrations of precious coral are seen around Tofua within depths of about 30 m.

Some small black coral specimens were observed at four sites during the mapping of sand bodies off Nuku'alofa. However the habitats near Nuku'alofa seemed not to be ideal for black coral growth (Eade, 1988). A copy of the SPREP black coral survey of Tonga could not be located.

Biology and ecology: Growth in coral is optimal only within a fairly narrow range of water temperature and salinities and thus varies considerably from area to area. Some *Acropora* grow fast (up to 20 cm per year) while *Favia* and *Porites* grow very slowly (Lewis, 1985 and Veron, 1986). Massive corals such as *Montastrea* and *Platygyra* may grow only 0.4-2.0 cm a year (Buddemeier and Kingzie, 1986, quoted in Wells *et al.*, draft). Achituv and Dubinsky (1990) notes that maximal growth usually occurs only down to 30-40 per cent of subsurface irradiance (the irradiance immediately below the water surface) and rarely is any significant reef formation found below 10 per cent irradiance. Reproduction is both sexual and asexual. Harrison and Wallace (1990) record that sexual reproduction patterns include hermaphroditic or gonochronic species with broadcast spawning or brooding modes of development with hermaphroditic broadcast spawners being the dominant group. Several asexual processes of reproduction can result in the formation of new colonies or solitary corals. These processes include fragmentation of established colonies, budding and transverse or longitudinal fission, single polyp bail-out, detachment of groups of polyps as drifting polyp balls and asexually produced planulae. Spawning has been observed mostly at night between dusk and mid-night.

Black corals are relatively fast growers, increasing at about 2 inches (5.08 cm) per year. Large specimens of black tree coral (*Antipathes* spp.) can grow to several meters in height and spread, with main stem diameters of forty to fifty millimeters, and up to 70 mm in the largest specimens. More commonly, branch and main stem diameters are of the order of 10-20 mm (Carleton and Philipson, 1987). Black whip coral (*Cirrhipathes* spp.) has been known to grow to 5-6 meters in length and is usually unbranched. Base diameters are up to 25 mm with more common sizes being 10-15 mm.

As with all other corals, gorgonians (including pink corals) grow by asexual reproduction within any one colony. Periodically, single-sex colony develop gametes (sperm or eggs) in sexual reproduction. The sperm are released and find their way into the polyps of sedentary female colonies. The fertilized eggs develop into larvae which are released into the current and travel as plankton for a period of one to fourteen days then they settle. If the environment is conducive for growth, they metamorphose into an anchored polyp which starts to divide asexually and form the base of a new colony (Carleton and Philipson, 1987). Pink corals are much slower growers than black corals, more typical of reef building corals, growing at about quarter of an inch (0.64 cm) a year.

The biology of any type or species of corals has not been studied in Tonga.

7.2.2 The Fishery

Utilisation: Reef-building corals have been subjected to the exploitation for the aquarium trade throughout the world. Although quite recent in the South Pacific, this type of development poses potentially detrimental effects to the balance of the marine environment and its inhabitants if not managed properly and consistently. In some countries, corals are additionally harvested as construction material, for the production of lime for traditional use and for medicine (Wells *et al.*, draft).

Of the twenty-six known species of pink corals, *Corallium* spp., only seven have known commercial value. However, no commercial beds have been located in the South Pacific and the utilization of the existing resources is limited to those sometimes hooked up on anchors of local deep-water snapper fishing boats.

Of the many species of black coral species that exist, only a few, belonging to the families *Antipathes* and *Cirrhipathes*, are considered of commercial value, due to the presence of density of horny material which take a high polish. Black coral resources have been identified in waters of most South Pacific countries, but have in general received only passing notice from the indigenous populations and occasional speculative ventures on the part of foreigners (Carleton and Philipson, 1987).

Traditionally in Tonga, as is common in other Pacific islands, corals have been non-targeted victims of the various fisheries performed on the reefs. These fisheries vary from simple collection of sea food from reef tops to spear fishing, gillnetting, fish drives and dynamiting. Chesher (1985) lists some factors that contribute to coral mortality in Tonga.

Recently, reef-building corals have become a target animal for the aquarium trade export from Tonga. Normally branches are broken off from a colony and sometimes a whole coral, if small and colourful, is taken. In addition to the exploitation of corals themselves for export, coral pieces (usually dead, but not always) are also exported because of other corals, algae, moss etc., growing on them. Pieces of coral are sometimes used for decoration in houses.

Jim’enez and Tongilava (1990) state that "Exploitation of the reef ecosystem is occurring by overharvesting and habitat destruction". They further noted that studies on corals in Tonga have only been directed towards black corals.

Carleton and Philipson (1987) reported that a select number of diver-craftsmen have harvested and carved black coral in Tonga for years, for both local and export markets. One of the currently operating coral jewelry shops in Nuku'alofa uses its own workshop to manufacture various items such as beads, sculptures, bracelets, ear-rings, rings and pendants. Although targeting the tourists, some black coral and black coral items are exported to Hawaii, and sometimes to neighbouring countries.

Production and marketing: No data is available on the levels of coral harvesting for domestic uses both commercially and on the traditional/non-commercial level.

Between June and December, 1993, one of the aquarium-fish exporters based in Tonga made several shipments comprising of fin-fish, corals (including soft corals), and other marine invertebrates. Of the total 7,508 pieces exported valued at $19,184.70, coral pieces made up 21.74 per cent. The corals category comprised of various corals (12.37 per cent of all species), soft corals (1.56 per cent) and live rocks (7.81 per cent). [Note: "live rocks" were given in kg but are used as number of pieces for the percentage calculations].

Export figures by the major exporter of aquarium marine animals from Tonga are shown in Table 7.2.3. The 1993 figures are for those up to December but may not be complete. The figures are in number of pieces and the categories were derived from the information given on the export forms, as submitted by the company to the Ministry of Fisheries.

Table 7.2.3: Number of pieces, by categories, derived from export forms of aquarium marine products by the major exporter in Tonga. Figures for both years may not be complete. (Corals include soft corals, live rocks and other forms corals are exported in).

	Coral	**Algae**	**Anemone**	**Crustaceans**	**Fin-fish**	**Giant clams**	**Live invertebrate**	**Echinoderms**	**Shellfish**
1992									
Pieces	**2,463**	4	2,787	1	15,747	0	109	183	98
%	**11.51**	0.02	13.03	0	73.61	0.00	0.51	0.86	0.46
1993									
Pieces	**22,481**	0	3,928	0	8,059	2,014	0	0	81
%	**61.49**	0.00	10.74	0.00	22.04	5.51	0.00	0.00	0.22

In 1992, 2,463 pieces of coral were exported making up 11.51 per cent of the total aquarium product export (21,392 pieces) of those recorded for that year. However, in 1993, the total number of pieces exported as aquarium product increased to 36,563 of which 22,481 (61.49 per cent) were corals. These figures represent an increase of more than nine times in coral export, as compared to almost only a doubling in the total aquarium product exports from 1992 to 1993.

No records are available on the amount of black coral harvested in Tonga, nor are there any data on the level of local sales and exports of products made from black corals. One of the curio shops in Nuku’alofa exports black coral worth $T1,500 per shipment three times a year to Hawaii. Black coral products manufactured and sold locally to tourist include necklaces, rings and ear-rings worth T$35 to T$125 each. The main source of black coral for this operation are those hooked up by fishermen on their anchors, when fishing for deep-water bottomfish. However it has been reported that searching for black corals involves dragging an anchor line along the seabed.

7.2.3 Stocks Status

Coral reefs are widespread in Tonga, but surveys and research have been sporadic and limited (UNEP/IUCN, 1988). Chesher (1990) noted that coral was everywhere in Tonga's shallow water. Wolterding (1985) considered Tonga's reefs to be healthier than those in many other areas in the Pacific, due to minimal pollution existing then. It was apparent though that the pressure would increase with the increase in population, especially those for reefs close to Neiafu, Pangai and Nuku'alofa. However, the continuing employment of certain destructive fishing methods, occurrence of natural disasters and exploitation of the resources for commercial purposes without proper management guidelines, have led to the deteriorating status of some of the coral reefs in the kingdom. Wolterding (quoted above) wrote that the reef flats of Sopu and Faonelua are examples of areas being badly damaged by over-collecting.

Reefs in certain areas are known to have been destroyed by certain factors including storm damage, pollution, causeway construction, and destructive fishing methods. Of the 100 locations surveyed in Tonga in 1984 by the Marine Research Foundation for pollution sources and black coral, 65 per cent of the reefs showed evidence of coral destruction (Chesher, 1985). The same author noted that the geographical distribution, depth of coral kill, species involved, and estimated time of coral death indicated a slowly developing problem, with multiple causes, and that some reefs were believed to have been dead for more than 12 years. In addition, on Vava'u, the destruction of extensive coral reef areas, have led to one site being reduced to rubble, various channels filled in, and normal reef habitats eliminated. The damage was done by people breaking up coral during fishing activities and when collecting shells for tourism. Even octopus which were formerly caught by lures, are now often broken out of their nesting sites. During cyclone Isaac in 1982, storm waves tore away large pieces of corals on the leeward fringing reefs off the north coast of Tongatapu, and tossed them on the leeward reef flat, adding to the rubble zone.

Chesher (1985) noted that a large population of crown of thorns starfish (*Acanthaster planci*) was observed on live corals near coral-battered areas. However, it seems that no massive crown-of-thorns infestation has yet occurred in Tonga. Wolterding (1985) postulated that if the collection of triton shells, a major predator of the crown-of-thorns, occurs in large quantities, Tonga may soon face its first crown-of-thorns plague soon. The extent of the effects of coral collecting for the aquarium trade is not known.

Carleton and Philipson (1987) reported that a number of concerns have been raised in Tonga concerning the harvest, and to a lesser extent, the processing of black coral for local and export markets. Chesher (1984, quoted in UNEP/IUCN, 1988) noted that black coral has suffered from over-exploitation, and large specimens have become rare especially in Nuku'alofa Harbour where siltation may have been one of the main reasons behind the death of some 49 per cent of the colonies. It was also noted that the method employed in searching for and harvesting black coral, which involves dragging an anchorline along the seabed, may be damaging.

7.2.4 Management

The relationship between people and reefs was simple and direct prior to industrialized society. On islands, people used and often depended upon reefs as sources of food and materials. If the reefs deteriorated, the food supply and resource base for humans declined (Kenchington, 1988). As Van't Hof (1988) puts it, "coral reefs and associated systems and their resources have always been used as a source of food and material" and that " small island nations, in particular, have been and continue to be, dependent to a large extent upon their nearshore marine environment". Certain traditional management regimes seem to have existed which presumably evolved to avoid damage to reefs and the subsequent consequences. However, the same author writes:

> "Growth of human populations in areas where reefs are accessible, the introduction of new technologies and the development of economies have placed many pressures on coral reefs. The likelihood of being able to manage these pressures depends in part on the extent to which the well-being of coral reefs is important to the economic well-being of the impacting human society. The management of environments is thus the management of human impacts and activities".

Actituv and Dubinsky (1990) note that as far as the evolution of coral reefs is concerned, corals reached their peak in the past, and at the present time they are in decline. On the importance of corals, Sheppard and Wells (1988) note that coral reefs rank among the most biological productive and diverse of all natural ecosystems, their high productivity stemming from efficient biological recycling, high retention of nutrients and a structure which provides habitat for a vast array of other organisms.

In addition to the value corals and coral reefs offer in sustaining all types of marine fisheries resources and other ecological balances within the marine environment, corals can also offer an additional opportunity for "small-scale" development where the resource is sufficient and that management guidelines to ensure sustainable utilization are rigorously adhered to. But as is typical of all harvestable resources, sustained utilization require proper assessment research from which the results can be transcribed into management approaches. Analysis of supply and demand is basic to management. The supply takes into account information on basic biology and estimates of maximum sustainable yield obtained from research while demand considers the consumer, socio-economics of the industry and analysis of optimum sustainable yield (Grigg, 1976, quoted in Gomez, 1983). In Phuket Thailand, the most effective strategy for managing coral reefs is to prevent damage while allowing sustainable uses to take place with reasonable controls (Lemay and Chansang, 1989). Corals are slow growing and damaged reefs have been known to take many, many years to recover.

In efforts to manage coral and coral reefs, there is always a tendency to over-emphasize one cause of the problem while overlooking others. For example, even though banning the export of corals through the aquarium trade might help in slowing the deteriorating state of reefs, but if no measures are taken to accommodate other developments or activities, (say, breaking up of corals during fishing, dredging for coral sand, construction etc that create excessive siltation) that might have more adverse effects, then the banning alone does not really help. Integrated planning and management involving the cooperation of different government departments on different aspects of the resources is vital for success. Initiation of a public education programme on the effects and consequences of the continuing use of certain destructive means of extracting marine food resources from the reefs, as well the direct and indirect effects of other land-based development on the resources, is a necessity.

Current legislation/policy regarding exploitation: The Fisheries Act 1989 defines "fish" as any aquatic animal, whether piscine or not and includes any mollusc, crustacean, coral (living or dead), sponge, holothurian or other echinoderm, and turtles, and their young and eggs.

Section 26 prohibits the import or export of any live fish into or from Tonga without the written permission of the Director (now Secretary) of Fisheries.

Section 28 of the same Act requires that any person engaged in fishing, fish processing, fish marketing or the export of fish or fish products shall provide to the Registrar such information relating to such fishing, processing, marketing or export activities. Punishment under these sections is a fine not exceeding T$10,000.

Section 20 of the Act prohibits the use, attempted use of any explosive, poison or other noxious substances for the purpose of catching fish. Offenses under this section are punishable by a fine not exceeding $1,000 or imprisonment for a period not exceeding 2 years or both. Landing, selling, receiving or possessing any fish caught with the use of any of the above methods is prohibited, and penalty for an offense is a fine not exceeding $1,000. Even though this section specifically refers to the catching of fish, the underlying spirit of the law also provides for the prevention of habitat (environment) destruction.

Section 27 of the Fisheries Act authorizes the Minister for Fisheries, with the consent of Cabinet, to make regulations prohibiting or restricting the export from Tonga of any prescribed species type or size of fish or other aquatic organism, where, in his opinion, such action is required to protect the supply of fish to the domestic markets of Tonga or in the interests of the proper management of a fishery. Section 59 authorizes him to make regulations for the implementation of the Act's purposes and provisions. Subsection (2) (p) (i) specifically mentions regulating the taking of corals and shells.

Section 36 Schedule II Part II (3) of the Customs and Excise Act [1988 Ed] prohibits the export of raw coral (including unprocessed black coral) except with the written permission of the Controller of Customs following approval by Cabinet

His Majesty's Cabinet's decision (CD No. 1853 of 1993) approved the Ministry of Fisheries' submission to prohibit the export from Tonga of reef corals of the orders, Scleractinia, Coenothecalia, Athecata and Stolonifera, on 15 December, 1993.

Section 4 of the proposed Fisheries (Conservation and Management) Regulations proposes that the Director (now Secretary) may establish annual production and export quotas by species and area for any commercial fishery for the purposes of fisheries conservation and management. Section 16 proposes the prohibition of the removal or taking of any coral from within the fishery waters except with the written permission of the Director (now Secretary) of Fisheries. Subsection (2) lists conditions which he may impose which include, the quantities that may be removed or taken, locations from which it may be removed or taken, duration of a permission granted, method of removal or taking, measures for the conservation of the marine environment and fees for the permission.

Recommended legislation/policy regarding exploitation: Several approaches to the management of the utilization of corals have been implemented in several countries. Kenchington (1988) lists three preliminary steps to the establishment of effective management as follow:

* define the problem;
* generate awareness of the problem amongst those who will suffer if the problem is not solved or benefit if it is solved;
* develop a management approach and a credible plan which will persuade those most concerned that management can and should address the problem.

He concluded that "the immediate challenge in many communities and countries is to interpret the scientifically documented threats and to establish that the benefits of management to sustain coral reef areas will outweigh the costs - in this the scientific research community has a key role".

The use of certain gear and some traditional fishing methods needs to be prohibited if persuasion through educational programmes to abandon their use is insufficient or ineffective.

Approaches in managing coral utilization for the aquarium trade can be broadly summarized under the three categories summarized below, (after Gomez, 1983 and Wells *et al.*, draft). Even though both reef-corals and precious corals (including black corals) can be accommodated under the same management approaches, they should be treated separately.

Total ban: this prohibits the harvesting of corals either for export or for local domestic uses either commercially or traditionally. This is probably the only feasible way of preventing excessive damage to reefs when sustainable figures are not available.

Limited use: several options can be taken into account under this category. Commercial export as opposed to commercial domestic use can be distinguished, as well as commercial as opposed to traditional (non-commercial). This should be applied in conjunction with "Regulated Harvesting", below. Recommended management strategies for the black coral resources in Tonga seem to fall under this category, in that harvesting is allowed for the local small cottage industry but exports of unprocessed product are prohibited.

Regulated harvesting: in the event that sustainable yields are available and that harvesting is allowed, management would be necessary for sustainable utilization. Allowances under "Limited Use" (above) can be regulated under this category. Some general guidelines for consideration include:

* licensing and permitting
* quotas
* minimum size limits
* prohibition of use of certain gear and method
* restriction of species collected
* zonation of areas for collection
* restriction on numbers of operators (if commercial)
* restricted duration if permit given

An important aspect in fisheries resource management that is gaining recognition in some South Pacific countries is the application of community-based resource management. This is of particular importance where commercial exploitation of shallow-reef resources is concerned. Even though there seems to be no traditional marine resource or area ownership in Tonga, the general principal offers a practical and meaningful management option. One of the considerations in the Exploitation Guidelines used in the aquarium fish trade in Fiji is to involve resource custodians in the collecting process to the maximum extent practicable (Lewis, 1985). This tends to spread the benefits wider than a few within the operator's circle. The Exploitation Guidelines used in Fiji for the aquarium fish trade are appended as Appendices 7.2.1. Additional information as provided in Wells *et al.* (draft) are also included.

Gillett (1994, note on the draft of this document) indicated that the general conclusion of the SPREP study is that, unless there are exceptional benefits, the harvesting of reef corals should not be allowed.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES): This convention was entered into force, by certain countries, on 1 July 1975 and it now has a membership of more than 150 nations. The aim of the Convention is to establish world-wide controls over trade in endangered wildlife and wildlife products - in recognition of the fact that unrestricted commercial exploitation is one of the major threats to the survival of species. For this purpose, endangered species of wild animals and plants are listed in three appendices to the Convention. Depending on their agreed degree of protection, the export and import of live specimens, and of parts or derivatives, is either prohibited or subjected to uniform licensing requirements recognized by all member countries. Appendix I include all species threatened with extinction which are or may be affected by trade. Trade in specimens of these species is subject to particularly strict regulation and is only authorized in exceptional circumstances. Appendix II include all species which although not necessarily now threatened with extinction, but may become so unless trade in specimens of such species is subject to strict regulation in order to avoid utilisation incompatible with their survival. Appendix III include all species which any Party identifies as being subject to regulation within its jurisdiction for the purpose of preventing or restricting exploitation, and as needing the cooperation of other parties in the control of trade.

Even though Tonga is not a party to CITES, the provisions of the Convention concerning the trade of certain animals, e.g. corals, are applicable. Under the convention, the following corals are listed as Appendix II species (Anon, 1991):

- all species in the order Scleractinia (stony corals);
- all species in the order Antipatharia (black corals);
- all species in the family Milleporidae, *Millepora* spp. (fire corals);
- all species in the order Coenothecalia, *Heliopora* spp. (blue corals); and
- all species in the family Tubiporidae, *Tubipora* spp. (organ-pipe corals).

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Appendix 7.2.1: Exploitation Guidelines used in Fiji for the aquarium trade (Source: Lewis, 1985):

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

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

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

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

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

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

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

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

Additional information of the system used in Fiji is given below as reported in Wells *et al.* (draft):

Management requirements for particular areas are determined through discussions between the collector and the Fisheries Division. Baseline surveys are carried out before any new area is harvested and the exporter trains villagers to recognize the desirable species. A maximum annual quota of 100,000 pieces is in place (which has not been reached) and the exporters supply the Fisheries with a full list of species exported.

Collectors are required to use outer fringing reefs and inner lagoon reefs rather than inshore reefs which are affected more by run-off and are likely to regenerate more slowly. Collecting is spread out and does not focus on one site but shift as often as possible.

The use of SCUBA gear is prohibited for collecting specimens. This is largely to ensure the participation of collectors from villages over a wide area.

Attachment 1.

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