REPUBLIC OF VANUATU
FISHERIES RESOURCES PROFILES

Prepared by

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FFA Report 93/49

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PREFACE

The South Pacific Forum Fisheries Agency (FFA) was requested by the Government of Vanuatu to provide assistance in the compilation of a set of marine resources profiles[1]. The profiles were to:

- provide information for the Government on the level of resources available for appropriate development planning and instigating regulatory controls for resources conservation;
- facilitate the dissemination of information and data that are required within government as well as internationally;
- ease the work of the Fisheries Department in providing concise and timely information required by potential investors and fishing companies.

Since no Terms of Reference were given, those used for profiles already completed were adopted and are as follows:

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

This report was prepared during and after a two-week visit to the Republic of Vanuatu in June, 1993. It provides an overview of the major fisheries resources identified as important to the commercial, artisanal and subsistence fisheries sectors within the Republic.

Each fisheries resource is divided into four main areas: (i) a brief description of the resource (species present, their distribution, biology and ecology); (ii) an overview of the fishery (utilisation, production and marketing); (iii) the status of the stocks; and (iv) management concerns (current legislation and policies regarding exploitation and recommended management options). In some cases a resource involves more than one species (e.g. aquarium fish and ornamental shells).

A comprehensive listing of fisheries and fisheries-related references has been compiled for Vanuatu by Gillett and Kenneth (1987). It was not possible to locate some of those listed in that bibliography. In addition a few references seemed to be available only from the Vanuatu National Library. However these were also not available as the library was closed during the time of compilation of this report due to damages from Cyclone Prima.

Funding for the preparation and documentation of this report was provided by the International Centre for Ocean Development (ICOD) under the FFA Research Coordination Unit Programme. The assistance provided by Mr. Wycliffe Bakeo, Director, as well as the staff of the Fisheries Department was greatly appreciated. In particular, Mr. Felix N'Guyen (Fisheries Research/ORSTOM Technician) and Mr. William Naviti (Fisheries Officer) extracted data from the Fisheries Data Base and were

[1]Because of the inclusion of profiles for those resources that are not marine in nature, the wording "marine resources profiles" has been changed to "fisheries resources profiles", which is more reflective of the contents of these reports.

responsible for obtaining data from the outer islands especially Santofish on Santo. Mr. Grant Boyes (FFA Maritime Boundaries Coordinator) produced the EEZ map of the Republic of Vanuatu included in this report.

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, Fisheries Department of Vanuatu or the Vanuatu Government.

LIST OF ABBREVIATIONS AND ACRONYMS

ACIAR-	Australian Centre for International Agriculture Research
AIDAB -	Australian International Development Assistance Bureau
AIMS -	Australian Institute of Marine Science
B.P.-	Burns Philp (now Better Price)
CITES -	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CPUE-	Catch per unit effort
CTL-	cephalothoracic length (used in coconut crab measurement)
DP1 -	First National Development Plan (1982-1986)
DP2 -	Second National Development Plan (1987-1991)
DP3-	Third National Development Plan (1992-1996)
EEZ -	Exclusive Economic Zone
EIA-	Environment Impact Assessment
ELEFAN-	*E*lectronic *Le*ngth *F*requency *An*alysis
FADs -	Fish Aggregating Devices
FAO -	Food and Agriculture Organisation of the United Nations
FFA -	South Pacific Forum Fisheries Agency
FOB-	Free on board
ICLARM-	International Centre for Living Aquatic Resources Management
ICOD -	International Centre for Ocean Development
IUCN-	International Union for Conservation of Nature
JAMARC-	Japan Marine Fishery Resources Research Centre
JICA-	Japan International Cooperation Agency
MSP-	Melanesian Shell Products Ltd
MSY-	Maximum Sustainable Yield
O.A.M.-	Open air market
OFCF -	Overseas Fishery Cooperation Foundation
ORSTOM -	French Scientific Research Institute for Co-operative Development
PNG-	Papua New Guinea
PWD -	Public Works Department
RALC-	Rural Alienated Land Committee
SCUBA -	Self Contained Underwater Breathing Apparatus
SPADP -	South Pacific Aquaculture Development Programme
SPC -	South Pacific Commission
SPFC -	South Pacific Fishing Company
TL-	thoracic length
U.S.A.-	United States of America
VFDP -	Village Fishery Development Programme

TABLE OF CONTENTS

TABLE OF CONTENTS

SUMMARY

The Republic of Vanuatu consists of over eighty mountainous islands, mostly of volcanic and coralline origin, extending over an area of over 12,200 sq. km. Of this total area, 5,500 sq. km is considered arable land. The area of inner reefs and lagoons is approximately 448 sq. km. with mangroves covering an area of 25 sq. km. The Exclusive Economic Zone (EEZ) covers an area of 680,000 sq. km. but resolution on the sovereignty over Matthew and Hunter Islands (EEZ of about 190,000 sq. km.) would have a significant impact. The projected population in 1991 was 165,260 while that in 1989 was 142,630. The intercensal population growth rate between 1979 and 1988 was 2.4 percent.

The Fisheries Department is the sole agency responsible for the control (regulation), development and management of the fisheries resources within Vanuatu. However, consideration of the impacts from developments on the environment is the responsibility of the Environment Unit of the Ministry of Natural Resources. There is a possible overlap of responsibilities between the two agencies in certain areas like assessment work and conservation of species.

The First National Development Plan (DP1-1982-1986) concentrated on diversification to reduce the dependence on copra. In the Second Development Plan period (1987-1991) efforts were concentrated in maximising the sectors' contribution to an expansion in the nation's income-earning and employment opportunities with export possibilities. Development of a small locally-based ocean tuna fishery was envisaged.

The South Pacific Fishing Company (SPFC) was established in 1957 on Espiritu Santo as a cold storage and fishing support base for longliners fishing in the southwest Pacific for tuna for canneries. The company ceased to operate in 1987 when the fleet transferred its operation to American Samoa. Fishing by foreign fleets in Vanuatu waters has only been a low level activity. During the 1970's, the Vanuatu-based longliners took only a small portion (500-2,000 t per year) of their catch (up to 15,000 t per year) in Vanuatu waters. The Japanese pole-and-line fishing vessels also in the 1970's took only modest quantities of 300-1,600 tonnes of skipjack per year. Under an agreement with the Government, Russian purse-seiners claimed to have caught a total of 12 t of tuna within Vanuatu during the agreement period. A fee of US$1.5m was paid for the duration of this agreement. By 12 January, 1993, 24 Taiwanese long-line vessels were licensed to fish in Vanuatu waters and Vanuatu is a party of the Multilateral Fisheries Treaty with America. Research conducted on the bait fishery in the Republic indicated that the resource will not be able to support a large-scale pole-and-line fishery.

One of the major projects undertaken during the DP1 period was the establishment of the Village Fisheries Development Programme (VFDP) mainly for the off-shore bottom fishery. The project was estimated to have met 80 percent of the local requirements for fresh, high quality fish for the urban populations thus it has been successful in import substitution. Several researches have been conducted on the off-shore bottom-fish resources of Vanuatu and indications so far seem to indicate that the current level of exploitation has not reached the estimated maximum sustainable yield of about 730 tonnes per year. All of the catch from this fishery is marketed locally via several avenues. Fisheries Extension Centres in the outer islands, Santofish on Santo and Natai fish market in Vila are the main marketing channels of fisheries products. However, direct sales to restaurants and stores, especially those in Vila, are increasing due to better prices offered for the fishermen.

Fishing has always been considered secondary to agriculture in Vanuatu. However, a village subsistence fishing survey conducted in 1983 indicated that over 50 percent of the country's rural population engage in fishing. Apart from the collection of trochus and green snail for the production

of button blanks etc. in local factories, most of the fishing within the reefs and lagoons has been on the subsistence/artisanal level. Reef and lagoon fishes as well as non-finfish animals such as lobsters are becoming increasingly important in the artisanal level. The current decreasing trend in the number of boats engaged in the bottom-fish fishery is a possible indication of the likely increased pressure on the inshore resources. Export of bêche-de-mer and aquarium fish has been relatively small and erratic. Shark fin exports are only known to have occurred up to 1989. At present, trochus is one of the major inshore resources in the Republic generating incomes for the rural communities. Although on a lower scale, higher prices are offered for green snails.

Due to the decline in prices of agricultural products, especially copra, coconut crabs have become a target species and form an important component of the income of the inhabitants of the more remote islands.

Two animal species have been introduced into Vanuatu in efforts to develop aquaculture initiatives in the Republic. These introductions of new species involved the marine Pacific oyster, *Crassostrea gigas* and the giant Malaysian fresh-water prawn, *Macrobrachium rosenbergii*. The oyster culture trials were conducted in three different areas but all failed due to poor growth, high mortality and predation. Good growth results were obtained from the trials conducted on Santo but predation and irregular spat supply were problematic. No information could be located on the failure of the *Macrobrachium* project but indications are that it may have been caused by high mortality and slow growth rates attained and possibly land disputes. Vanuatu was one of the countries included in the study conducted by the FAO/SPADP on the potential of green mussel aquaculture in 1989. The study indicated potential sites within the Republic, especially Erakor Lagoon, but water quality (pollution) could be a problem. The Fisheries Department currently operates a small-scale hatchery for two native mollusc species, *Trochus niloticus* and the green snails, *Turbo marmoratus*. The hatchery work on these species is for re-seeding purposes.

The Fisheries Act 1983 is currently under review. This process would hopefully lead to changes that seem necessary in the Fisheries Regulations currently in force. There is clearly a need for coordination in this area with other agencies to define responsibilities clearly to avoid conflict and overlap in work programmes which should complement each other.

A. BACKGROUND

1. THE COUNTRY

The Republic of Vanuatu comprises an archipelago, popularly described as "Y" shaped, of over 80 islands, 12 of which are described as major islands and 67 inhabited. These islands lie between latitude 13° South and longitude 166° East and 172° East in the western Pacific Ocean. The archipelago measures approximately 850 km in length and lies in the middle of a triangle formed by Fiji, Solomon Islands and New Caledonia. The islands include both volcanic rocks and marine limestone derived from fringing coral reefs (Done, 1990). Because of Vanuatu's location on the margin of the Indian and Pacific Plates, tectonic uplift and subsidence of islands periodically occur. In some instances, these uplifts have been catastrophic to coral reefs and seagrass beds. The total land area is 12,200 sq. km. of which 5,500 sq. km (45%) is considered potential arable land. The areas of inner reefs and lagoons have been estimated to be approximately 448 sq. km and mangroves 25 sq. km. The Exclusive Economic Zone (EEZ) covers an estimated area of 680,000 sq. km. However, resolution on the sovereignty over Matthew and Hunter Islands (EEZ of about 190,000 sq. km.) would have a significant impact on Vanuatu's total EEZ area. The climate varies from tropical in the north to subtropical in the south and annual rainfall ranges from 1700 mm at Tanna, in the south, to almost 3,000 mm at Santo in the North. Cyclones are regular, occurring somewhere in the country on average twice per year, but ranging in frequency from one every three years to three in a single year (Anon, 1984 quoted in Done *et al* 1990).

2. THE PEOPLE

The people of Vanuatu are Melanesian in origin. The 1979 census indicated that 93% of the total population were Melanesian ni-Vanuatu. Traditional values still govern village life which stress living in harmony with the physical environment. Even though it has strong features, the Melanesian traditional culture has remained diversified as indicated by the existence of over 100 indigenous languages throughout the archipelago. The presence of outsiders from Europe, Asia and other Pacific Islands, has, in part, enriched the traditional culture. The national language, Bislama, is a blend of both indigenous and foreign elements. Besides Bislama, there are two official languages, English and French.

In the 1989 census the total population of Vanuatu was recorded at 142,630, an increase of 28% from the 1979 census (Statistics Office, 1991). Population statistics for both censuses are compared in Table 1.1. Even though the country is little urbanised (urban population represented 18.5% of the total 1989 census figure), the urbanisation shift is increasing. The Port Vila population in the 1989 census was 19,400, an increase of 94.5% from 1979. In addition, its proportion of the total population has increased from 9.5 percent in 1979 to the 13.5 percent recorded in the 1989 census. Approximately 70% of the population live on the foreshore, within 2 km of the ocean and the average area per household has decreased from 26 to 22 hectares.

Table 1.1: Population Statistics for the Republic of Vanuatu.

	January 1979	May 1989	1991 (proj)
Total Population	111,251	142,630	165,260
Males	59,074	73,580	83,900
Females	52,177	69,040	76,900
Age Groups			
Under 15 years old	50,453 (44%)	73,400	
15-64	57,547 (51%)	83,100	
65 and over	3,241 (5%)	4,300	
Ni-Vanuatu	104,371	139,475	
Non Ni-Vanuatu	6,880	3,155	
Households	22,620	28,252	
Villages	790		
Urban Population			
Port Vila	10,601 (9.5%)	19,311 (13.5%)	
Luganville	5,183 (4.7%)	6,983 (4.9%)	
Rural Population	95,467 (85.8%)	116,650 (81.6%)	
Intercensal Growth Rate (% per annum) 1979-1988			
All population	2.4%		
ni-Vanuatu	2.8%		

Table 1.2 below is given in the 1989 National Population Census comparing populations using Local Government Regions.

Table 1.2: Population by Local Government Regions from the 1979 and 1989 censuses.

Region	Total Population 1979	Total Population 1989	% Growth per Annum 1979-1989
Banks/Torres	4,958	5,985	1.8
Santo/Malo - Rural	14,240	18,598	2.6
- All	19,423	25,581	2.7
Ambae/Maewo	9,576	10,958	1.3
Pentecost	9,361	11,341	1.9
Malekula	15,163	19,298	2.3
Ambrym	6,176	7,191	1.5
Paama	2,228	1,696	-2.6
Epi	2,597	3,628	3.2
Shepherds	4,444	3,975	-1.1
Efate - Rural	9,218	11,557	2.2
- All	19,819	30,868	4.3
Tafea	17,506	22,423	2.4
Port Vila	10,601	19,311	5.8
Luganville	5,183	6,983	2.9
TOTAL-Vanuatu	111,251	142,944	2.4

Source: Vanuatu National Population Census May 1989, Main Report. Statistics Office, Port Vila, Vanuatu, 1991.

3. THE GOVERNMENT

Prior to Independence in 1980, Vanuatu was known as New Hebrides and had been governed for 74 years by the joint Anglo-French Condominium. Achievement of independence was particularly difficult due to the involvement of three different colonial regimes (British, French and Condominium) as well as three courts of law (First National Development Plan 1982-1986). The first free and open elections were held in November, 1979, after the various political parties and the Condominium powers within the country agreed to a constitution for the Republic. This resulted in the Vanuaaku Pati gaining 26 of the 39 parliamentary seats. The Independence of the sovereign state of Vanuatu was celebrated on July 30, 1980 and it became the 155th member of the United Nations in September, 1981.

Vanuatu's national political structure consists of legislative, executive and judiciary branches. The legislative branch consists of a single chamber, Parliament, with 46 seats. Members of Parliament are elected every four years. The Executive consists of the Prime Minister and the Council of Ministers all of whom are members of Parliament (there are eleven ministers). The Judiciary consists of a Supreme Court with a Chief Justice and three Judges. The Head of State is the President of the Republic and is elected for a period of five years by an Electoral College consisting of Members of Parliament and the Presidents of Local Government Councils. There is National Council of Chiefs which is mainly an advisory body to Government and is composed of custom chiefs who are elected by their peers sitting in the District Councils of Chiefs. The Council of Chiefs advises on custom and tradition as well as the preservation and promotion of the country's culture and indigenous languages.

The government's capital sources of revenue include grant aid, government collection (e.g. import duties, export duties, licences, company registration, land registration, other taxes, public enterprises, interest and rent, fees and fines, other), foreign borrowing (soft loans) and direct investment.

4. THE ECONOMY

About 84 percent of the population aged 15 years and over were recorded as economically active in the 1989 census with approximately 75 percent of the work force engaging in agricultural and related activities. Almost 60 percent of these were subsistence farmers. The main sources of income in the rural areas are from sales of copra, cocoa, cattle, coffee, kava and green vegetables. In the urban areas, employment in the service industries account for 53 percent while trade, restaurants and hotel sectors account for about 17 percent. Between 1983 and 1987, the service sector contributed 65 percent of the total gross domestic product (GDP), agriculture 26 percent and industry 9 percent. Total GDP in 1987 was 13,000 million Vatu, an increase from 7,882 million Vatu in 1983 (Statistics Office, 1991).

The country's overseas trade continues to show a negative increase in trade balance in the export/import area as indicated from figures for the period 1981-1991. Principal domestic exports from Vanuatu during this period are shown in Table 1.3 below as given in Vanuatu Statistical Bulletin (1992) and is dominated by copra both in value and quantity. The table includes only quantity and value for each particular item for each year. Table 1.4 lists the imports cleared for home consumption for the country and Table 1.5 summarises overseas trade between 1981 and 1991.

Table 1.3: Principal domestic exports from Vanuatu between 1981 and 1991.

	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Copra (mt)	47,070	34,798	38,537	46,681	34,930	42,293	31,849	31,680	23,620	37,246	30,878
(Value-10^6 Vt)	1,060	710	1,308	2,735	1,392	461	719	953	750	598	516
Cocoa (mt)	944	548	1,232	791	814	1,197	1,243	813	1,572	1,956	2,455
(Value-10^6 Vt)	117	57	183	135	133	196	207	116	176	247	258
Beef & Veal (mt)	605	624	875	567	802	575	1,023	1,006	990	1,208	1,217
(Value-10^6 Vt)	100	125	142	118	185	146	250	243	267	365	340
Timber (mt)	718	652	3,900	19,161	17,423	7,859	19,281	6,999	12,597	1,939	1,594
(Value-10^6 Vt)	21	23	31	147	136	63	209	106	203	90	77
Cowhides (mt)	126	204	227	202	209	176	178	264	247	252	289
(Value-10^6 Vt)	4	8	12	16	23	17	25	33	37	37	22
Shells (mt)	61	79	27	34	47	24	38	50	90	61	80
(Value-10^6 Vt)	8	13	8	14	24	24	22	31	63	106	178
Kava (mt)	-	-	1	4	14	10	15	14	20	39	26
(Value-10^6 Vt)	-	-	1	2	7	5	6	6	9	14	6
Coffee (mt)	61	17	33	14	87	21	44	19	-	37	-
(Value-10^6 Vt)	8	2	5	2	21	7	8	4	-	6	-
Others	329	359	446	364	245	266	286	207	209	282	329
(Value-10^6 Vt)	73	89	91	52	49	52	56	65	85	143	119
TOTAL (mt)	49,914	37,281	45,278	67,818	54,571	52,421	53,957	41,052	39,345	43,020	36,868
Total (10^6 Vt)	1,402	1,027	1,781	3,221	1,970	970	1,503	1,558	1,590	1,607	1,516

Source: Vanuatu Statistical Bulletin. Overseas Trade, Part II, Exports, 1992.

Table 1.4: Vanuatu Imports Cleared for Home Consumption by SITC, in million Vatu, for the period 1983-1991.

	1983	1984	1985	1986	1987	1988	1989	1990	1991
Food & Live Animal	1,023	1,166	1,210	1,089	1,022	1,263	1,237	1,312	1,295
Beverage & Tobacco	269	310	295	252	204	368	360	335	374
Crude Materials, Expt Fuel	49	49	68	67	226	88	69	135	137
Mineral Fuels	572	560	651	573	634	584	663	863	937
Oils, Fats & Waxes	24	36	38	37	25	31	32	33	34
Chemical	320	408	395	364	450	421	550	642	593
Mfg Good Material	844	903	1,083	1,062	1,624	1,430	1,492	1,911	1,621
Machinery, Transport, Equipt	1,070	1,350	1,387	1,503	1,918	1,797	2,470	3,815	2,285
Misc. Mfg. Article	806	868	972	820	983	851	890	1,355	1,101
Goods, N.E.S.	252	175	286	138	364	233	251	290	228
TOTAL	5,229	5,825	6,385	5,905	7,450	7,066	8,014	10,691	8,605

Source: Vanuatu Statistical Bulletin. Overseas Trade, Part I, Exports, 1992.

Tale 1.5: Summaries of overseas trade for the Republic of Vanuatu between 1981 and 1991 (Vanuatu Statistical Bulletin, 1992). All values are in 10^6 Vatu.

Year	Domestic Exports	Re-Exports	TOTAL EXPORTS	Imports for Home Consumption	Imports for Re-Export	TOTAL IMPORTS	BALANCE (Exports-Imports)
1981	1,402	1,431	2,833	3,905	1,211	5,116	-2,283
1982	1,027	1,174	2,201	4,631	1,032	5,663	-3,462
1983	1,781	1,159	2,940	5,229	1,063	6,292	-3352
1984	3,221	1,174	4,395	5,825	986	6,811	-2,416
1985	1,970	1,293	3,263	6,385	993	7,378	-4,115
1986	971	871	1,842	5,905	200	6,105	-4,263
1987	1,502	440	1,942	7,450	188	7,638	-5,696
1988	1,558	508	2,066	7,066	295	7,361	-5,295
1989	1,590	970	2,560	7,882	336	8,218	-5,658
1990	1,606	596	2,202	10,691	520	11,211	-9,009
1991	1,516	682	2,198	8,605	611	9,216	-7,019

Source: Vanuatu Statistical Bulletin. Overseas Trade, Part II, 1992.

DP1 records that while certain primary sectors have contributed to economic growth for some time, others, notably fisheries and forestry have a potential which is yet to be realised. Another growing area within the Republic is tourism which is becoming increasingly important and significantly contributes to the country's economy. Vanuatu has established a "tax haven" status for itself, and its very active Finance Centre has attracted much investment to the country (Statistics Office, 1991).

5. INSTITUTIONS/AGENCIES

Fisheries Department, Ministry of Agriculture, Livestock, Forestry and Fisheries: The Second National Development Plan 1987-1991, Volume 1, lists the overall objectives of policy in the fisheries sector as:

- develop the exploitation of fisheries resources to achieve its potential as an important economic activity
- maximise the sector's contribution to an expansion in the nation's income-earning and employment opportunities
- increase the production of fish and other marine products for domestic and overseas markets
- reduce the level of canned and fresh fish imports
- increase the sector's contribution to government income available to support other areas of social and economic development.

Environment Unit, Ministry of Natural Resources, Energy and Environment: The Environmental Unit was initially established under the Ministry of Lands, Energy and Rural Water Supply and became operational in September 1986 with the arrival of an Environmental Adviser. The Second National Development Plan (1987-1991) noted that the proposed work of the Unit was related specifically to the national objective of Preservation of the Cultural and Environmental Heritage. It was the only agency charged with taking overall and cross-sectoral responsibility for environment and conservation and to oversee and coordinate environmental and conservation issues. The Development Plan lists the objectives established as:

- increase study and knowledge of the natural environment and its wildlife resources;
- study and recommend procedures for the rational and wise development of the natural resources and wildlife;
- initiate relevant legislation as necessary;
- increase the awareness of conservation and environment issues in Government and other agencies;
- train ni-Vanuatu personnel to take over the Environment Unit;
- provide technical expertise to Government and other agencies as required.

The establishment of the Unit presented an opportunity to produce legislation and procedures to ensure that considerations for the environment and conservation are adequately covered in the development process. Strategies adopted to obtain objective goals include:

- production of a National Conservation Strategy report which will provide the basis for the rational development of natural resources;
- identification and preparation of environmental legislation and administrative procedures as required;

- organisation of surveys to identify the country's most valuable wildlife and landscape resources;
- promotion of cross-sectoral discussions and information exchange between Government and other agencies concerned with environment issues;
- promotion of environmental education amongst government personnel and the country as a whole;
- development of contacts and co-operation with international environment agencies;
- recruitment and training of ni-Vanuatu to participate in, and then take over and develop, the above strategies.

In the DP3 (1992-1996) the Unit is listed as been "responsible for the coordination of all activities across sectors, Government agencies, NGOs and the private sector that deal with environmental matters; it also provides technical advice and specialist attention on environmental matters" (National Planning and Statistics Office, undated). Development objectives during the DP3 period are listed as:

- complete environmental legislation and formulate an environment master plan to guide future development activities;
- review the organisational structure of the Environment Unit with the view of upgrading its status to a full Department to monitor environmental changes, enforcing environmental legislation, continuing environmental awareness and educational programmes and continuing of Vanuatu's active participation in global environmental issues;
- prioritize environmental problems and ensure that scarce financial resources are committed to priority areas;
- provide community extension programmes that assist individuals to see the importance of a healthy environment and enable community leaders and land owners to establish their own policies of land use, resource protection and sustainable development.

ORSTOM, Port Vila: An agreement between the Vanuatu Department of Fisheries and the French Scientific Research Institute for Co-operative Development (ORSTOM) concerning fisheries research within the country was signed in 1979. During the 1982-83 period, a small research unit was formed under ORSTOM within the Fisheries Department with a senior scientist (biologist) as the head. The agreement specified that the biologist was to be responsible for co-ordinating:

- the survey of tuna stocks exploited by the South Pacific Fishing Company (SPFC) based in Santo;
- a radiometric survey of the Exclusive Economic Zone;
- studies associated with the development of an artisanal tuna fishery including work associated with fish aggregating devices;
- exploratory surveys of seamounts and reef slopes;
- surveys of trochus and green snails and the fisheries they sustain; and
- the creation of a coastal station for the study of the marine environment.

To date, the Government has benefited a great deal from the assistance ORSTOM has rendered in fisheries and resources assessment.

6. MARINE RESOURCES LEGISLATION

Marine Zones Act 1982 [CAP. 138].

This act provides for the delimitation of the maritime zones of Vanuatu and other matters incidental thereto.

Internal waters: comprise all waters that are contained within the baselines from which the breadth of the territorial sea is measured or for areas enclosed by straight archipelagic baselines, all waters that are contained within the innermost limits of the archipelagic waters.

Archipelagic waters: comprise all waters other than internal waters contained within the archipelagic baseline.

Territorial sea: comprises all areas of sea between the baseline and a line 12 nautical miles out to sea.

Contiguous zone: an area beyond and adjacent to the territorial sea measured 24 nautical miles from the baseline.

Continental shelf: comprises the seabed and subsoil of the submarine areas that extend beyond the limits of the territorial waters throughout the natural prolongation of the land territory to the outer edge of the continental margin or to a distance of 200 nautical miles from the baseline from which the territorial sea is measured where the outer edge of the continental shelf does not extend up to that distance.

Exclusive Economic Zone: comprises areas of the sea, seabed, and subsoil that are beyond and adjacent to the territorial sea measured 200 nautical miles from the baseline.

Fisheries Act 1983 [CAP. 158] (currently under review)

The Fisheries Act of 1983 (Revised Edition 1988) provides "for the control, development and management of fisheries and matters incidental thereto".

Section II of the Act deals with the Management of Fisheries with the following subsections:

- Fisheries Management and Development Plans
- Fishery Access Agreement
- Foreign Fishing Licenses
- Minister's Power to Enter into Agreements or Arrangements on Harmonisation of Licensing and Enforcement
- Regional Register of Foreign Fishing Vessels
- Foreign Investment in Fisheries
- Local Fishing Vessel Licences
- Minister's Power to Authorise Scientific Research Operations.
- Application for Fishing Licence
- Minister's Powers to Refuse to Issue or Renew Fishing Licences
- Conditions of fishing Licences
- Fees, Royalties and Other Charges
- Period of Validity of Fishing Licences
- Suspension and Cancellation of Fishing Licences
- Appeals Against Refusal to Issue or Renew, Suspension and Cancellation of fishing Licences
- Fishing for Marine Mammals Prohibited in Vanuatu Waters
- Prohibition of Use of Explosives and Poisons for Fishing
- Marine Reserves
- Licensing of Fish Export Processing Establishments

Section IV, Paragraph 24 of the same Act, empowers the Minister to make regulations to be consistent with the Act for the implementation of its purpose and provisions.

Fisheries Regulations Order No. 49 of 1983

The Fisheries Regulations provide for the conservation and regulation of fisheries in Vanuatu waters and the issue of licences. The regulations concerning individual fisheries resources are stated more fully under their respective profile.

Part I - Foreign Fishing Licenses
Part II - Local Fishing Licenses
Part III - Fish Export Processing Establishment Licences
Part IV - Fishery Conservation Measures
- Rock Lobsters
- Slipper Lobsters
- Coconut Crab (Coconut Crabs (Protection) Act)
- Green Snail
- Trochus
- Trumpet Shell
- Coral
- Aquarium Fish
- Turtles
- Crustaceans
- Beche-de-mer

Part V - Fish Aggregating Devices
Part VI - Miscellaneous Provisions

Foreshore Development Act [CAP. 90]

This act regulates the carrying out of works on the foreshore. Any development work in this area requires the written consent of the Minister for town and country planning. The foreshore is defined as the land below mean high water mark and the bed of the sea within the territorial waters including lagoons.

Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Vanuatu became a party nation to CITES on 15 October, 1989.

7. MANAGEMENT OF FISHERIES RESOURCES

The Department of Fisheries, Ministry of Agriculture, Livestock, Forestry and Fisheries, is responsible for the control, development and management of the fisheries resources under the Fisheries Act 1983 [CAP. 158].

8. DEVELOPMENT PLANS

The First National Development Plan covered the period 1982-1986. This was mostly a period of reconstruction and transition with the primary objectives being diversification, strengthening and expansion of productive economic base especially the reduction of dependence on copra. Natural resource-based major projects were initiated. These include the establishment of cocoa and coffee projects, copra rehabilitation programme, village-based fisheries programme and the expansion of tourism infrastructure.

The broad focus of the Second National Development Plan (1987-1991) shifted to sustaining and enhancing achievements made in DP1 through greater emphasis on manpower development and improved management (DP2). Thus DP2 national development objectives were to:

- achieve an increased degree of economic self-reliance based on natural resource development compatible with appropriate and acceptable levels of service provision;
- accelerate human resource development for increased ni-Vanuatu participation in, and control of, the economy;
- increase productive utilisation of the country's natural resources base as a means of generating viable and sustained economic growth;
- achieve a more even pattern of regional and rural development;
- further expand the private sector's contribution to national development efforts for the benefit of the whole country;
- ensure that Vanuatu's unique environmental and cultural heritage is not damaged in the process of economic development and change; and
- ensure continuation of a stable political environment, based on parliamentary democracy.

The implementation of these objectives were adopted under five broad strategies as follows:

- the decentralisation of administration, executive and some implementation functions to the Local Government Councils;
- the active promotion of both the small holder and the large commercial plantation agricultural sub-sectors;
- the continued promotion of new domestic and foreign investment in the leading sectors of the economy, particularly tourism, and the processing of primary produce;
- the development of human resources through on-the-job training, improving the quality of primary and secondary school education, and post-secondary education in scientific and technical fields;
- the establishment and operation of an integrated project planning, capital budgeting, manpower planning system and environmental impact assessment methodology, designed in order that: investment resources are channelled into priority sectors; the recurrent cost implications are fully appraised prior to implementation of capital projects and consolidated into the integrated capital and recurrent budget; the necessary manpower is either available or appropriate training programmes are devised; and adverse environment impacts are minimised.

Within the Fisheries Sector, the emphasis of development during the DP2 period was on activities with the greatest potential to generate or sustain income-earning opportunities and employment to stabilise or reduce imports, to expand exports and to increase government revenue. Developmental Strategies during the period were listed under six sectors as follows (as given in the DP2 Volume 1 Document):

<u>Subsistence Fisheries</u>

- conserve inshore fisheries resources to ensure their continued availability as food for the rural population.

<u>Small-scale Commercial (Coastal) Fisheries</u>

- continue to assist the formation of small-scale coastal fishing enterprises throughout the archipelago;
- Ensure the long-term viability of such fishing enterprises;
- Produce sufficient fresh fish to satisfy local demand;
- Improve local distribution, storage and marketing facilities;

- Develop export markets and create the necessary infrastructure to support the sale overseas of catches surplus to local demand; and
- Develop local canned fish products to substitute for imported canned mackerel and sardines.

Oceanic Fisheries
- Begin development of a small locally-based ocean tuna fishery;
- Encourage the revival and diversification of operations of the South Pacific Fishing Company (SPFC); and
- Encourage and consider requests for fishing rights within Vanuatu's EEZ from any foreign nation that is prepared to pay the appropriate fees.

Aquaculture
- Conduct pilot trials to test the feasibility of the artificial culture of aquatic organisms and the re-seeding of over-exploited areas of reef.

Research
- Provide the support necessary for the management and sustained economic development of the sector;
- Continuously monitor the availability of fisheries resources and the effects of fishing upon them;
- Develop improved techniques for the harvesting of the sector's resources; and
- Provide the scientific basis for aquacultural development.

Administration, Training and other Departmental Support Activities
- Develop a cadre of qualified personnel within a Fisheries Extension Service able to meet the needs of the expanded fisheries sector;
- Upgrade the training facilities for fishermen and departmental staff;
- Improve the capability of local staff to monitor economic and biological changes within the sector; and
- Improve and consolidate boat-building, marketing and gear supply support facilities provided to the industry.

A policy to concentrate efforts on small-scale fisheries and thus protecting the limited resources has been established by the Fisheries Department as the goal during the DP3 (National Planning and Statistics Office, undated). Of the thirteen development objectives listed under the Natural Resources chapter, only one specifically deals with fisheries and it states:

- continue to encourage and assist the fisheries sector to promote fishing as an economic activity, and expand levels of fishing activity, marketing and processing.

The strategies listed under that objective include:

- rationalize fisheries extension centres based on levels of fishing activity and privatization opportunities for ice making facilities;
- continue training of fishermen;
- privatize PVFL fish markets;
- reactivate and expand SPFC to include fish processing;
- upgrade boat construction facilities at Luganville with an eventual view towards privatization;
- continue fisheries research under the auspices of ORSTOM.

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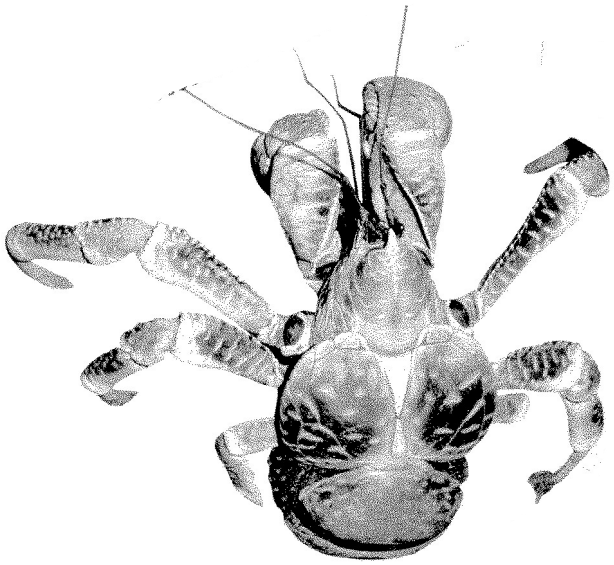
B. FISHERIES RESOURCES PROFILES

1. CRUSTACEANS

1.1 COCONUT CRAB

1.1.1 The Resource



Birgus

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

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

Within Vanuatu, coconut crabs are distributed over a wide area and are present on most islands of the archipelago. The areas of main populations for exploitation at present, however, are in the north, mainly in the Banks/Torres and Santo/Malo regions.

Biology and ecology: Coconut crab is a "close relative of the hermit crab group and has evolved to become the largest and least marine-dependent of the land crabs" (Brown *et al*., 1991). It is an omnivorous scavenger and its primary foods include coconut flesh, fruits of the screw-pine (*Pandanus*), *Canarium* spp., sago palm, *Terminalia*, *Barringtonia*, and *Artocarpus*. Coconut crabs are slow-growing and for the Vanuatu stocks, they take at least ten years to reach legal marketable size (9 cm, CTL=43 mm)[2]. The growth coefficient, K, of the von Berterlanfy's growth equation, was estimated to be 0.05, which is very low (Brown, 1988). Fletcher *et al* (1991) estimated longevity to be between 40 and 60 years and the asymptotic thoracic length (L_∞) of 80 mm and 50 mm for males and females respectively. Growth in coconut crabs, as in other crustaceans, has two components, the increment of growth at each moult and the time interval between each moult episode (Fletcher *et al*, 1991). Moulting is normally once a year with the exception of smaller-sized crabs that are believed to be able to moult more than once a year. For protection from predation and to minimise the risk of dehydration the crabs burrow or hide in small crevices that provide the same conditions as burrows, prior to moulting. The ecdysis process takes from one to two hours to complete while the time between moulting and emergence from the burrows is about 1 month for small crabs and up to three months for the larger individuals (Fletcher *et al.*, 1991).

Mature crabs mate on land in summer while both sexes are in the hard shell condition. However, fertilisation may require seawater. Laying of eggs is assumed to take place soon after copulation as females do not possess seminal receptacles. The females carry fertilised eggs attached to their pleopods for approximately one month, while maturing, before migrating to the sea for their

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

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

Mature eggs hatch immediately into the first zoea stage upon release into the ocean. The hatched eggs undergo four plantonic zoeal stages in approximately three weeks and the crabs (new recruits) emerge from the water as glaucothoe inhibiting small shells. The glaucothoe inhabit the wrack area above the high sea mark and are hard to find and be distinguished from other related coenobinids (Reese, 1987). "The glaucothoe subsequently metamorphose into juvenile crabs which maintain the shell carrying habit for one to two years" (Brown, 1988). Over a two-year period of extensive searches on various islands in Vanuatu, the ACIAR funded coconut crab project in Vanuatu failed to find any glaucothoe or juveniles in gastropod shells as newly recruiting coconut crabs (Fletcher, 1988). In addition, only 4 coconut crabs less than 2 cm long were found during the entire study. However, Reese (1987, quoted in Schiller *et al*., 1991) postulated that the fossorial nature of coconut crab glaucothoe and juveniles makes them extremely difficult to find. Fletcher (1988 quoted in Schiller *et al*., 1991) using size-frequency data, calculated that satisfactory recruitment of glaucothoe and juveniles into Vanuatu coconut crab populations occurred every 5-10 years and could be considered both infrequent and unpredictable. Fletcher (1988) gave a possible explanation for the dearth of recruitment in Vanuatu as due to the rapid drop-offs close to shore and because of the benthic nature of the *Birgus* larvae, they merely sink to the bottom in depths beyond their capacity to return to a sandy beach from which they gain access to a terrestrial existence. Thus recruitment may only occur if the larvae become entrapped in a shallow embayment.

1.1.2 The Fishery

Utilization: Because of its large size, terrestrial habit and delicate flavour of its flesh, *Birgus* is considered highly as a food item where it is still commonly found. In Vanuatu, the collection of coconut crabs is for both commercial and subsistence purposes. For the inhabitants of some of the more remote islands, sales of coconut crabs forms an important component of their income and is sometimes the only form of cash-crop available (Fletcher, 1992). Due to the improvement of air services to the outer islands, all areas where the crabs are located are now subject to exploitation. The crabs are offered as specialty dishes in (tourist) restaurants.

"Coconut crabs are readily captured using methods which require no capital investment in equipment. In most cases they are caught by hand, having first been attracted to a staked bait, often a split coconut" (Brown *et al* 1991). The methods have evolved as a result of the declining numbers. For the Torres region, the bait originally used involved entire coconuts with only a small circular hole cut in the side and which were usually set only an hour before dark and checked

shortly after dark . "If the coconuts were opened entirely or left for any longer period the larger number of crabs would have either taken the bait entirely or consumed most of the coconut. At most locations now, however, coconuts are split into two or three pieces and baits are not re-visited until after 11 pm to allow a long period of time for the big crabs to come out" (Fletcher, 1992).

Production and marketing: The level of exploitation both for subsistence use and commercial sales for the **entire** Republic is unknown. Coconut crab forms the only potential cash crop for some remote areas, such as Torres Island, due to the drastic drop in prices of agricultural products especially copra. Torres and Santo regions dominate production (with some from Erromango) and for 1991, Fletcher (1992), estimated total weight and numbers from both areas for sale and home consumption and presented them as follows:

Table 1.1.1: Estimated coconut crab production and use for Santo and Torres regions in 1991 (Fletcher, 1992).

		Weight (kg)	Number
Torres			
	Sale	23,000	18,000
	Home	2,600	2,000
Santo			
	BP	2,696	3,370
	O.A.M.	540	600
	Other	800	1,000
	Home	800	990

Coconut crabs sold at Vila restaurants mostly originate from either Santo and/or Torres regions. More than half of these are supplied by buyers based in either Santo or Vila who then re-sell them to the restaurants. A smaller portion come directly from the collectors on those islands. Estimates for 1991 indicated that 12-15,000 crabs are consumed through this channel yearly (Fletcher, 1992). On Santo, most of the crabs for the restaurants are provided by the collectors either directly or from the open-air market. The number sold in restaurants there are minimal (less than 2 each per week). Estimates by Fletcher from Vanair records in Torres for 1991 indicate that most of crabs from Torres for that year came from Hiu and Tegua islands with only a small percentage from Loh and Toga and that over 22,000 kg, corresponding to 18,000 crabs, could have been shipped out during the year. About half go directly to Vila and the other half to Santo where they are on-shipped to Vila at a later time (Fletcher, 1992).

Fletcher surveyed restaurants selling coconut crabs in Vila in 1991 and gave the following table:

Hotel/Restaurant	# crabs sold per week	Source of crabs	Buying Cost (Vatu)	Restaurant Price Prepared (Vatu)
Hotel Rossi	40	Santo		2,000
Iririki	10	Torres	600	2,000
Waterfront	10			2,000
Windsor	50	Torres		2,200
Le Lagon	15	Torres via Santo	500	2-2,500
Golden Century	??			
Golden Dragon	15-40	Santo via buyer		1,600
Mondia	2-5	Torres via local		
Harbour View	10	Local buyers		
Rendevous	35	Torres via Santo		
Man Wah40	Torres		1,900	
Erakor	5	Santo		
White Sands	5	Torres		
Takara	3	Emao or Santo		2,400

La Belle Etois	??
Radisson	??

Since February 1991, the Burns Philp company on Santo has been a major buyer of crabs both from Santo and Torres which are on-shipped to their store in Vila. Between February and October of 1991, over 2,700 kg, representing over 3,000 crabs were bought as detailed in the following table given by Fletcher (1991). Following the BP involvement with purchasing of crabs on Santo, the amount of crabs sold in the open-air market decreased to about 20% (600 crabs) of the crabs caught there in 1991.

Month	Region	Quantity (kg)
March	Santo/Malo	182
April	Banks/Torres	45
	Santo/Malo	21
May	Banks/Torres	53
	Santo/Malo	64
June	Banks/Torres	80
	Santo/Malo	214
July	Banks/Torres	11
	Santo/Malo	153
August	Banks/Torres	75
	Santo/Malo	137
September	Santo/Malo	417
October	Santo/Malo	1,508

The Bon Marche store in Santo buys their crabs from Banks and are on-shipped to their Vila store for sales at the supermarket or wholesaled to restaurants. No figures were available but sources indicated that only a few are sold each year.

No recent purchases of coconut crabs were recorded on the data obtained from Santofish but during the July 1983-July 1984 period, 705 kg were purchased (Crossland, 1984).

Purchases of coconut crab by the Natai Fish Market from 1988 to 1992 are as follows (sources: Fisheries Department Data Base). During the May 1983-July 1984 period, 4,662 kg were purchased by Natai (Crossland, 1984).

	1988	1989	1990		1991	1992
C/Crabs (kg)	3,261.5	3,493.6	1,521.2		231.3	1,271.1
Value (Vatu)	1,077,573	1,090,867	469,018	138,780	762,640	

The Fisheries Extension Centres also purchase coconut crabs but the data is mixed together with those of lobster under "Other Species". Even though the species in this category seem to have comparatively small inputs into the Fisheries Extension purchases, the resources included are important to the other sectors within the country at both subsistence, artisanal and commercial levels. The category is shown below (source: Fisheries Department Data Base):

Other Species	1990	1991	1992
Total numbers	168	421	444
Total wt (kg)	503.8	2,081	4,651.2

Collectors in Torres who send crabs directly to Vila restaurants get about 400 vatu/kg, and through wholesalers they get as little as 240 vatu/kg. In the open market in Santo crabs are sold for 500-1,000 vatu per crab, while BP in Santo offer 350 vatu/kg. Bon Marche in Vila retail crabs at 850 vatu/kg. Prepared crab dishes are sold in Vila restaurants for 2,000 vatu per crab.

1.1.3 Stocks Status

The expanding tourist industry and the decline in local copra-based economies has resulted in the significant increase in the socio-economic value of the coconut crab leading to increased exploitative pressures on the local coconut crab populations. Catch rates remain reasonably high (Brown, 1991) and substantial stocks still exist despite the crabs having been exploited for many years (Brown *et al*, 1991). However, substantial reductions in population size have been noted, (e.g crab populations on Efate and Erromango have diminished and average size small (Mr. Moses Amos, Fishery Biologist, Fisheries Department, *pers. comm*.). Certain management controls were enforced since 1983 but were insufficient to reverse the declining stocks which were suffering from growth over-fishing and possibly recruitment overfishing (Fletcher, 1992). The two-year ACIAR funded coconut crab project in Vanuatu found that apart from being slow growing, recruitment of juveniles was small and that the numbers of adult crabs can be easily and very quickly reduced in any area.

The aim of the 1991 study funded by AIDAB in Vanuatu was to re-examine the stocks of the coconut crabs and to determine if the newly introduced management proposals were sufficient to conserve the remaining stocks. Table 1.1.2 below, as given by Fletcher (1992), gives estimates of CPUE's, expressed as number of crabs per coconut bait, for different sites. All show progressive declines.

Table 1.1.2: CPUE, expressed as the number of crabs per coconut bait, at each of the sites sampled.

Site	1985	1986	1987	1991
Hiu Island				
Flatstone	5.0	3.6	2.40	1.30
Yurtawa			0.50	0.40
Yawatut			1.40	1.30
Yawa				1.50
Tegua				
Sandbeach	4.1	2.7	0.80	0.50
Antap Hill				0.35
Inland				0.90
South of Leonard				5.10
Motolava				
A				0.70
B				0.13
Hog Habour				
A	0.3	0.2	0.15	0.06
B	0.8	0.4	0.30	0.27
Ocean		0.8	0.45	0.24
Champ. Beach				0.22
Kole				
A (close)	0.15	0.24	0.25	0.38
B (far)	1.00	0.25	0.25	0.31
Mavea				
Hill	0.50	0.50		0.23
Ocean	0.60	0.58		0.03
Bokissa		0.30	0.22	0.25

Estimates of standing stocks (Table 1.1.3) for 1991 were made by Fletcher (1992) for the major collection areas of Santo and Torres Islands by converting the CPUE figures into number of crabs using a catchability coefficient (calculated by the same author) (and determining the area for which it was representative).

Table 1.1.3: Estimates of standing stocks of coconut crabs in the main collection areas in Vanuatu (Fletcher, 1992).

Area and Location	Area	CPUE		Number of Crabs	
		All	Legal	All	Legal
Santo/Malo					
Hog Hbr	2.1	0.20	0.020	5,040	504
	0.8	0.20	0.020	1,920	50
Kole	1.0	0.35	0.035	4,200	420
	1.0	0.35	0.035	4,200	420
	1.2	0.35	0.035	5,040	500
Mavea	1.0	0.23	0.030	2,760	360
Port Lory	6.2	0.20	0.020	15,000	1,500
Matantas	5.0	0.50	0.040	24,000	2,500
Cape Q	4.8	0.20	0.020	11,520	1,150
Dolphin I	0.8	0.20	0.040	1,920	400
Elephant I	0.6	0.30	0.040	1,200	300
Shark Bay	0.6	0.20	0.020	1,500	150
Remainder	5.0	0.10	0.010	6,000	600
			Total	84,300	8,854
Torres Region					
Hui Island					
Flatstone	1.2	1.30	1.000	18,720	14,400
Picot Bay	4.0	0.45	0.350	21,600	16,800
S west	2.4	1.30	1.000	37,440	28,800
S east	2.0	1.30	1.000	31,200	24,000
Hill	3.2	0.45	0.350	17,820	13,440
Tegua					
West	1.8	1.80	1.700	38,880	36,720
Village	0.4	0.50	0.400	2,400	1,920
Sth	3.1	1.50	1.300	55,800	37,200
Nth	4.2	1.00	0.600	50,400	30,240
			Total	274,260	170,040

Trends in the numbers of legal sized crabs for Santo and Torres regions between 1987 and 1991 were estimated as follows:

	Number of Legal sized coconut crabs		
Area	1987	1991	Drop
Santo	31,600	8,854	22,746
Hiu Is (Torres)	122,000	97,440	24,560
Tegua Is (Torres)	????	106,080	??

These represent annual net total number of crabs removed between 6,000 and 12,000 crabs.

1.1.4 Management

Current legislation/policy regarding exploitation: Chapter 158. The Fisheries (coconut crabs) Regulations No. of 1991.

Closed season:	Santo/Malo region - 31 October to 1 April
	Torres/Banks group - 31 August to 1 November.
Quota allowance:	All islands in the Banks/Torres region - 5,000 per year
	All islands in the Santo/Malo region - 2,000 per year

The regulation prohibits taking etc of coconut crabs carrying eggs and any crab less than 9 centimeters in length when measured along the carapace from immediately behind the rostral horn to the rear edge of the carapace in the mid-line. Removal of eggs from a coconut crab or possessing, taking etc of those from which eggs have been removed are prohibited under the same regulation. Under the same regulation, the Director of Fisheries may grant permission upon application for the taking of crabs during the closed season for the purposes of scientific research.

Penalty: Any person who contravenes or fails to comply with any of the provisions of the regulations shall be guilty of an offence and shall be liable on conviction to a fine not exceeding 100,000 Vatu.

Recommended legislation/policy regarding exploitation: Fletcher (1992) suggested the following additions and modifications to the current regulations for greater efficiency and effect on the crab populations:

- quota for the remainder of the country
- closed season similar to that of Santo
- expansion of the closed season at the Torres/Banks region to include November
- division of the Torres/Banks quota into smaller units such that Hiu and Tegua have 2,000 crabs each; Loh, Toga and the Banks each have 350 crabs. A similar division of the Santo/Malo quota into units for each area.
- investigate the feasibility of exporting
- alter quota system to weight instead of numbers
- Director of Fisheries to have the power to halt collection of crabs in area at any time if he believes that the quota has been exceeded or some other problem exists

However, exportation would probably worsen the situation in terms of managing the resource. In addition, the suggestion to use weights instead of numbers in the quota system would probably create greater difficulty in the enforcement part of the regulation.

Clarification is needed on the current closed season regulation to consider sales (in stores and prepared dishes in restaurants) during that time.

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

Data collected by the Department from Fisheries Extension Centres should separate out species lumped under "other species".

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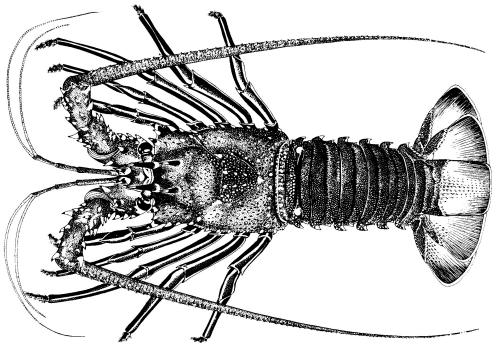
1.2 LOBSTERS

1.2.1 The Resource

Species present: Three species of rock lobsters are known throughout Vanuatu; the pronghorn spiny lobster, *Panulirus penicillatus*, painted spiny lobster, *P. versicolor*, and longlegged spiny lobster, *P. longipes femoristriga*. The main species of commercial value is *P. penicillatus*. The slipper (Caledonian mitten) lobster, *Parribacus caledonicus*, is also found.



Panulirus

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.

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

Within Vanuatu, George (1972) reported that *P. penicillatus* and *P. caledonicus* live on the "weather" sides (east and south) of the islands. *P. penicillatus* is reported to be known all around Aneityum, Futuna, Tanna, Erromango, the south and east coasts of Efate, Epi, Ambrym, Pentecost, Maewo and south and east coast of Malekula and Espiritu Santo. *P. longipes femoristriga* has been described from Tanna and in the northern region and on Maskelyne Island, Malekula and along the west coast of Espiritu Santo where it dominated *P. penicillatus* in abundance. *P. versicolor* has been reported from the northern islands as well as from around Efate, Tanna and other southern islands. A migration of small-medium sized blue *P. versicolor* up onto the reef near Port Vila was reported by Barley (quoted in George, 1972). Baird (1973) reported that considerable populations of spiny lobsters were present in Santo and Malekula.

P. penicillatus is (was) the main rock lobster species in Vanuatu that lives on the "weather" sides of the islands amongst the surf, surge channels and undercut *Porolithon* alga reef where good shelter away from light and good water circulation are guaranteed. Specimens have been trapped off Tanna Island in shallow holes (19 m deep ???) of fringing reef and at offshore depths down to 122 m (??). (Holthuis, 1991 reports that the depth range for this species is 1-5 m). Best places were spurs of reef running offshore which were interpreted as old lava flows. Large males seem to accumulate close to shore on the reef flats on dark nights (neaps) particularly following a heavy swell.

P. longipes femoristriga was described from Tanna as a smaller species than *P. penicillatus* which can be trapped in about the same numbers as *P. penicillatus* in deep waters, to 122 m, and in much lower numbers on the reef flats. *P. longipes* is more abundant than *P. penicillatus* on Malekula and along the west coast of Espiritu Santo where the reef is more compact, receives moderate but regular surf action with small blowholes through the narrow fringing reef flats.

P. versicolor is the largest of the three species and inhabits quiet, turbid or clear waters down to 37 m. It has also been described as living in silty, quiet lagoon waters, often near stream mouths or deeper on the outside face of reefs receiving moderate to high wave action.

P. caledonicus has been reported to occupy about the same habitat as does *P. penicillatus*, i.e. on the weather sides of the islands amongst the surf, surge channels and undercut *Porolithon* alga reef with good shelter away from light and good water circulation.

Biology and ecology: 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 species above 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. 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).

Slipper lobsters are found on reefs in shallow water, often in surge channels on the exposed side. They hide in crevices and marine caves in the day time, often attached to the ceilings of the caves (Holthuis, 1991).

No comprehensive study has been done on the biology and ecology of lobsters in Vanuatu.

1.2.2 The Fishery

Utilization: Rock lobsters are reported to be abundant in Vanuatu waters and at times surplus from subsistence exploitation is offered for sale. A small experimental fishery was initiated at Tanna and other southern islands using beehive cane or wicker pots two to three feet in diameter, baited with chitons or sea urchins. Pots were set on the reef edge in reasonably sheltered pools or crevices, often covered with stones, and out beyond the reef to at least 122m (???). Pot trapping was unsuccessful with *P. versicolor* as they could not be enticed into pots. On the shallow reef, fishermen regularly catch lobsters either by diving or on foot on the reef during moonless nights (David, 1985). For subsistence purposes, lobsters are normally speared but commercially, they are either caught by hand using gloves or trapped to maintain quality. Diving at night, using under-water torches is also practised.

Production and marketing: Baird (1973) reported catches of two to three sacksfull a night in Santo and Lamap (southern town on Malekula island). He estimated the weight of these to be between 50-100 kg with an fob value of A$1.00/kg at the time. An estimated potential yield of $250,000 to $500,000 p.a. was quoted, but is not clear whether this figure was for Vanuatu. Currently, there is no information available concerning the level of exploitation and production for the restaurant and commercial stores. However, the artisanal harvest of crayfish for 1983 was estimated to be approximately 20.5 % (490t) of the subsistence harvest of 2,402 t of marine organisms annually (David, 1985) worth an estimated value of more than US$1 million. Of the total harvest, approximately 555t were produced for sale of which 45% was of crayfish and 42% was made up of fish.. The estimated market value was VT147 million of which 83% was attributed to crayfish. Of the crustaceans, lobsters are the only ones being actively marketed, with half of the catch offered for sale (David and Cillaurren, 1992). Dalzell (1990) reported that "anecdotal sources suggest that lobsters are increasingly important as a source of cash revenue for villagers and increasing amounts are sent by air to Port Vila".

The amount and value of spiny and slipper lobsters landed at the Natai Fish Market from 1988 to 1992, and between 1983 and 1984, are as follows (source: Fisheries Department Data Base and Crossland, 1984).

	May 83-July 84	1988	1989	1990	1991	1992
Lobster (kg)	3,306	1,810.0	850.4	1,301.3	1,716.3	1,483.2
Value (Vatu)		1,020,110	511,515	396,428	1,604,385	1,042,551
Slipper Lobs		0	37.3	0	9.1	71.9
Value (Vatu)		0	11,005	0	2,730	28,920

Lobsters purchases between July 1983 and July 1984 at Santofish amounted to 120 kg (Crossland, 1984).

The Fisheries Extensions also purchase lobsters but the data is mixed together with those of coconut crabs under "Other Species". Even though the species in this category seem to have comparatively small inputs into the Extension purchases, these species are important to the other sectors within the country at both subsistence, artisanal and commercial levels. The category is shown below (source: Fisheries Department Data Base). (Note: this table is also duplicated under the coconut crab section:]

Other Species	1990	1991	1992
Total numbers	168	421	444
Total wt (kg)	503.8	2,081	4,651.2

Very few lobsters are sold via Au Bon Marche supermarket, Vila, as most fishermen sell directly to the restaurants. In 1992 approximately 500 kg was sold to this supermarket. The proportion going directly from the fishermen to the restaurants is unknown but indications are that it would probably be much higher than that going to Natai fish market as David and Cillaurren (1992) report that the major buyers are the restaurants of Port Vila and Luganville. Thus the total annual landings for the country are impossible to estimate due to the absence of data from the restaurants.

1.1.3 Stocks Status

No information is available on the status of the spiny lobster stocks within the Republic of Vanuatu. Prescott (1988) states that this resource is probably difficult to growth overfish.

There is certainly a need for research (or a better data collecting system) on this resource as spiny lobsters are increasing in importance as a resource but could be easily over-exploited.

1.1.4 Management

Several options have been proposed or implemented in other countries. However, the decision on the strategy to adopt normally follows from results of specific research. Even though harvesting of lobsters is regulated under the the Fisheries Regulations, there is a need for research to form the background requirement for management strategies as well as to adjust or justify (confirm) current 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 maximise yield from the available stock by carrying out Yield Per Recruit (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: Fisheries Regulation under Fisheries Act 1982 prohibits taking, possessing, selling or purchasing of:

(a) any rock lobster carrying eggs; or
(b) any rock lobsters which is less than 22 centimeters in length when laid flat and measured from immediately behind the rostral horns to the rear edge of the telson or whose carapace is less than 7.5 centimeters when measured along the mid-line from immediately behind the rostral horns to the rear edge.

Under the same regulation, spearing of lobsters is prohibited as well as the removal of eggs or possession, selling or purchasing lobsters from which eggs have been removed.

For slipper lobsters, *P. caledonicus*, the above regulation applies except that the minimum length is 15 centimeters measured from the front edge of the carapace to the rear of the telson.

Penalties for violation of these regulation is a fine of up to VT50,000.

Recommended legislation/policy regarding exploitation: It is probably unnecessary to apply two separate parameter measurements for the application of minimum size limits as is currently used for lobsters (i.e. carapace and tail length). Carapace lengths are normally used. Using two means of measurements complicate enforcement etc (e.g. lobster in Hawaii). Lobster tail lengths (widths) are used in areas where marketing is for tails only (e.g. an island in Tonga). In other

countries (e.g. PNG) tail weights are used. In both these cases, comprehensive data from local research allowed for the conversion of carapace lengths to either tail widths (or lengths) and tail weights.

Efforts should be made to separate this "other species" category in the data collected from the Fisheries Extension Centres into individual species. It was not possible at the time of writing this report but should be made by the Department.

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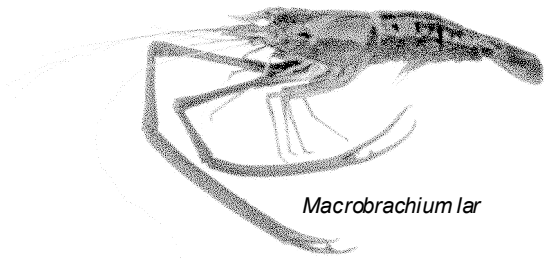
1.3 FRESH-WATER PRAWNS

1.3.1 The Resource


Macrobrachium lar

Species present: *Macrobrachium* sp. (probably *M. lar*). The giant Malaysian fresh-water prawn, *M. rosenbergii,* has been reported as being tested for its culture potential starting in the late 1970's. The project ceased by March, 1983 (Wright, 1989). It is indicated from (Grandperrin *et al*., undated) that *M. rosenbergii* was introduced for this project. Grandperrin (1977) noted that several species of fresh water shrimps exist in Vanuatu but none "were sufficiently abundant to be systematically and profitably collected".

Distribution: Freshwater prawns are abundant in the streams of the northern islands e.g. Santo (George, 1972). Baird (1973) reports that prawns appear to occur in nearly all streams and rivers in Vanuatu. Freshwater prawn fishermen were recorded in Erromango, Anatom, Efate and Maewo during the 1983 survey of village fisheries in Vanuatu (David, 1985). Fresh-water prawns are also found on Malakula and Epi and in areas with major fresh-water streams in Vanuatu (Mr. Moses Amos, Fishery Biologist, Department of Fisheries, Vanuatu, *pers comm*.).

Biology and ecology: Biology of the giant Malaysian prawn, *M. rosenbergii*, is well known and numerous articles have been published on its larval cycle during the hatchery phase as well as the species grow-out performance in aquaculture. Grandperrin *et al.* (undated) noted that local fresh-water prawns are not appropriate for setting up prawn farms due to their slow growth rates and their ability to abandon ponds to wander off through wet grass.

1.3.2 The Fishery

Utilization: Trapping and collection by hand from pools during the dry season is practised. Sometimes when irrigated taro patches are drained, prawns are caught there. This has been the case in Maewo and Pentecost. Prawns for home consumption are mostly caught by spearing. However it is becoming an important commercial item for islands where rivers exist. To keep the quality high for sales, prawns are caught using traps. Freshwater prawns are usually brought in from the islands and are sold directly to restaurants and the big supermarkets in Vila and Natai (Moses Amos, Fishery Biologist, Department of Fisheries, Vanuatu, *pers comm*.).

Baird (1973) reckoned that fishing for prawns could be a useful cottage industry and that using juveniles caught in traps and rearing them in small scale ponds may generate economic returns.

A fresh-water prawn farm, culturing *M. rosenbergii* was initiated in the late 1970's but was terminated by early 1980's. This was a private undertaking and in 1979 two ni-Vanuatu underwent SPC supported training in New Caledonia on rearing and hatchery techniques (Wright, 1989). Attempts to obtain reports concerning this venture were unsuccessful. To date, no further development in this area has been attempted and Grandperrin *et al.* (undated) recommended that any future attempts should only be undertaken after carrying out a socio-economic study, a study of land disputes, and local market research. The people of Aneityum Island have expressed interest to the Fisheries Department in setting up a small-scale prawn farm using the local species. This may involve collection of juvenile prawns and stocking them into enclosed pools.

Production and marketing: The 1983 survey estimated an annual fresh-water prawn production for Vanuatu to be 18 tonnes (0.7% of the annual village fishing production). No sales were recorded (David, 1985). JICA (1986) reported a 1984 freshwater prawn yield for Vanuatu as 12

tons. The amount going through the restaurants and supermarkets as well as current consumption at subsistence level are unknown. However, Fisheries Department data from the Natai Fish Market gave the following figures of those purchased.

	1988	1989	1990	1991	1992
FW prawns (kg)	88	422.6	271.6	136.9	67.1
Value (vatu)	70,400	336,470	657,280	90,545	49,730

Yields from the fresh-water areas have been estimated to be about 56 tonnes per year with virtually all used for subsistence by the local populations (Second National Development Plan, 1987-1991).

1.3.3 Stocks Status

No study has been directed towards estimating or assessing the stocks of the native fresh-water prawns in Vanuatu.

1.3.4 Management

Although fresh-water prawns are a commercially marketed resource, management seems to be self-regulating for this particular fishery. Indications are that most of the catch from this resource is consumed on the subsistence level. Since current collection is mainly traditional, it may help to keep it traditional. However, the use of chemicals, including the household bleach has been reported as being used in some countries. Creating an unnecessary regulation on banning the use of such chemicals might create more problems as people will become aware of them and tend to use them. The impacts as a result of other economic developments such as habitat destruction and pollution from e.g. deforestation, is likely to have more detrimental effects on this resource than those imposed by the fishery itself.

Current legislation/policy regarding exploitation: There is no current legislation regarding the exploitation of this resource.

Recommended legislation/policy regarding exploitation: There does not seem to be any need for introducing any regulation specifically for the exploitation of the fresh-water prawn resource in Vanuatu. Threats for the resource include those posed as a result of other developments and the introduction of any exotic species into the river system. The use of chemicals to catch fresh-water prawns poses a wider range of detrimental effects than on the fishery alone.

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1.4 LAND CRABS

1.4.1 The Resource

Species present: Three species of land crabs exist in Vanuatu (Mr. Moses Amos, Fishery Biologist, Department of Fisheries, *pers. comm*.), probably all belonging to the genus *Cardisoma.* Lal and Esrom (1990) mention *Cardiosoma hirtipes*, known locally as "nevri".

Distribution: Land crabs occur all throughout Vanuatu but abundance, as indicated by their being utilized for consumption, is restricted to certain islands. Islands where land crabs are often observed to be offered for sale include Emae and Efate (mostly in Erakor and Eton and probably northern Efate) (Mr. Felix N'Guyen, Fisheries Research/ORSTOM technician, Fisheries Department, *pers. comm*.). Lal and Esrom (1990) write that the *Cardiosoma* sp. is caught on the outskirts of mangrove areas and along the sandy strand bordering *Rhizophora* mangroves.

Biology and ecology: No information is available for land crabs in Vanuatu. Smith (1992) and Nichols (1991) give the following summary for land crabs of *Cardiosoma* species. Adult crabs live in the inland areas of the islands amongst the ground cover vegetation, and come out at night to feed. Several days before the full moon, especially during the summer months, they undertake mass migrations to the sea. The crabs emerge at dusk, around two days before the full moon and make their way to the shore. The larvae are released from the eggs into the waves by vigorous flapping of the abdomen. Release of larvae at spring tides presumably maximizes dispersal along the coast. Amos (1993, *pers. comm*.) however, reckons that spawning migration in Vanuatu is during new moon (dark nights).

1.4.2 The Fishery

Utilization: The capture (collection) of land crabs is mainly for home consumption. Crabs are caught at night during their migration to spawn. In areas where crabs are abundant some are offered for sale in bundles or small baskets. In Port Stanley on Malekula, *C. hirtipes* is regularly caught mostly for subsistence as well as for selling. Lal and Esrom (1990) report that all households in this area harvest "nevri" for subsistence, but a large proportion of them also sell crabs in the Norsup market, mostly on Saturdays. Some are airfreighted to Vila via middlemen.

Production and marketing: There are no records of land crab production in the Republic except some estimates made for Norsup market on Malekula. On Emae where crabs are abundant, they are sold at the airport in baskets for VT 200 per basket, targeting those flying out to Vila. On Efate crabs that are sold come mostly from Erakor and Eton though probably also from Northern Efate (Mr. Felix N'Guyen, Fisheries Research/ORSTOM technician, Fisheries Department, *pers. comm*.). At the open market in Vila, a basket is sold at VT 400. A basket has been estimated to contain 10-20 crabs.

On Malekula (in Port Stanley), Lal and Esrom (1990) reports that on a Saturday (5/5/90) seventeen women were selling an average of 10 bundles each. They estimated a weekly production for that market at 170 bundles. Using 10 crabs per bundle, 2 kg/bundle and VT 100/bundle, an estimate was made of 8,500 bundles (thus 17,680 kg) worth VT 850,000 are marketed via Norsup market annually. Some of these were bought by at least two individuals who were known to airfreight them to Port Vila where they are sold at VT 250-300 for a bundle of five crabs.

1.4.3 Stocks Status

No data nor any attempt has been made to collect any information on the land crabs.

1.4.4 Management

Current legislation/policy regarding exploitation: No legislation exists that concerns the exploitation of land crabs.

Recommended legislation/policy regarding exploitation: There does not seem be any need to regulate the resource at present. However, if exploitation gets high in the main areas, e.g. Port Stanley, limiting or banning the export to Vila might be a consideration. But collection of data would be necessary to see any trend.

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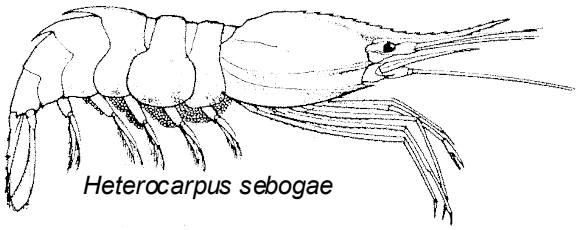
1.5 DEEP-WATER SHRIMPS

1.5.1 The Resource



Species present: Seven species of the caridean shrimps have been reported in waters of Vanuatu at depths between 229m and 650m. They all belong to the family Pandalidae and at least three genera; *Heterocarpus*, *Plesionika* and *Parapandalus*. These are listed by King (1986) to include, *Parapandalus (=Plesionika) serratifrons (*the pyjama shrimp), *Pleisionika longirostris (=edwardsii)* (stars and stripes shrimp), *P. ensis* (striped gladiator shrimp), *Heterocarpus ensifer* (armed nylon shrimp), *H. sibogae* (mino nylon shrimp), *H. gibbosus* (humpback nylon shrimp), and *H. laevigatus* (smooth nylon shrimp).

Distribution: The distribution of *Heterocarpus* species is at least in the Indo-Pacific and has been found in India and islands in the Indian Ocean as well as the Pacific Islands from Palau in the west to French Polynesia in the east (King, 1993). Species occupy particular depths but with overlapping ranges with the smaller shrimps (*P. serratifrons* and *P. edwardsii*) being widely distributed in shallower waters (< 400 m). The medium-sized *Heterocarpus*, *H. sibogae* and *H. ensifer*, predominate catches over 400 m and *H. laevigatus*, one of the largest species, is common in depths of more than 500 m.

King (1980) found that within Vanuatu, catch weight of *H. ensifer* varied significantly with depth whereas *Pleisionika longirostris* accounted for up to about half of the shallow water catch. *H. ensifer* occurred throughout the sampled depth range but catches between 400-500m consisted almost exclusively of this species. The *H. laevigatus* catch proportion increased in the deepest depths with a corresponding decrease in the *H. ensifer*. The following table (Table 1.5.1) shows the species composition by weight expressed as a percentage of the total shrimp catch in each depth. In the shallowest depth sampled (229 m) *P. serratifrons* accounted for 31 % of the small total catch.

Table 1.5.1: Species composition by weight (% of total catch) at each depth (King, 1980).

Depth (m)	*P. longirostris*	*H. ensifer*	*H. laevigatus*	Other species
229	15	54		31
262	51	48		1
324	47	49		4
384	27	73		0
421	< 1	99		< 1
436	< 1	99		< 1
454	2	98		0
461	< 1	99		< 1
560		57	43	0
650		68	32	0

The Fisheries Department and ORSTOM in 1982 conducted a survey at depths between 400 m and 700 m. The best results were obtained between 450m and 500m (Wright, 1989).

Biology and ecology: Deep-water caridean shrimps have separate sexes (King, 1993). Biological parameters for *H. laevigatus* in three countries are given in same with figures obtained in Fiji reproduced below in Table 1.5.2. Female sexual maturity in this species is attained between 4 to

4.6 years (40-43 mm carapace length) and spawning seems to be in winter. Growth parameters[3] for some other species are also given and are reproduced below.

Table 1.5.2: Some biological parameters of a few deep-water shrimps (King, 1993).

Species	$L\infty$ (mm)	$K(yr^{-1})$	$M\ (yr^{-1})$	L_c	t_c
*H. laevigatus**	57	0.27	0.66	40.5	4.6
P. edwardsii	29.5	0.66			
H. sibogae	41	0.38			
H. gibbosus	45	0.35			

*figures for Fiji.

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

1.5.2 The Fishery

Utilization: A few species of carid shrimps form the bases of commercial fisheries. For example, carid shrimps are commercially harvested in Alaska, North America and Chile (King, 1986) and also in Europe, Japan and Chile (Crossland, undated).

There has been no fishery based on deep-water shrimps in Vanuatu, even though this resource can be utilized for speciality food items in local restaurants and possibly export.

Baited two-entrance box traps were used for the survey in Vanuatu by King (1980). Some were covered with hessian sacking while others were not.

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

Production and marketing: *H. ensifer* was the only species that occurred over the entire depth range surveyed and catches of individual species varied with depth. In addition dominant species in a particular depth range differ. When grouping the catch data in 100 m depth ranges, it was estimated that the "total mean catches were low in shallower water but increased with depth to a maximum in 500 to 600 m" (King, 1980) which gave a mean catch rate of 2.83 kg per trap. Shrimp abundance seemed to decrease beyond this range. However, he noted that the important factors for consideration when contemplating a fishing strategy include the catch weight and the size of individual shrimps.

Best catches made by the Fisheries Department /ORSTOM 1982 survey averaged 1.0kg/trap with the catch comprising mainly of *H. sibogae* and *H. laevigatus*. The results were considered to show limited economic potential for the development of this fishery in the vicinity of Port Vila.

The preliminary survey by King in 1983 produced catches that were considered high enough for consideration for commercial trials.

[3] L_∞ is the asymptotic carapace length, K is the growth coefficient, M is the natural mortality rate, L_c is the mean length at first reproduction and t_c, the relative age at first reproduction

King (1986) provided the following table comparing catch rates and optimum depths of Caridean shrimps from different countries:

Location	Catch Rate (kg/trap)	Optimum Depth (m)	Comments and Reference
Hawaii Northwestern group	2.9	550-600	Catch of *H. ensifer* and *H. laevigatus* combined (Gooding,1984)
Guam Western coast	2.1	440-680	Catch of *H. ensifer* and *H. laevigatus* combined (Wilder,1977)
Western Samoa near Apia	1.4	500-600	Catch of *H. sibogae* and *H. laevigatus* combined (King, 1980, 1984)
Tonga near Nuku'alofa	0.6	600-700	Catch of *H. sibogae* and *H laevigatus* combined (King, 1981b, 1984)
Fiji near Suva	1.2	450-650	Catch of *H.sibogae H. gibbosus* and *H. laevigatus* combined (King,1984)
Vanuatu	2.8	500-600	Catch of *H. sibogae* and *H. laevigatus* combined (King, 1981a, 1984)
New Caledonia	2.0	800	Catch of *H. laevigatus* (Intes, 1978)

No attempt has been made to further assess the feasibility of deep-water shrimp exploitation for commercial purposes in Vanuatu.

1.5.3 Stocks Status

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

15.4 Management

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

Current legislation/policy regarding exploitation: No current legislation.

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

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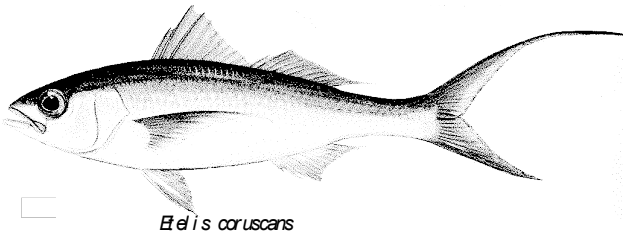
2. FIN-FISHES (OSTEICHTHYES)

2.1 DEEP-WATER BOTTOM FISHES


Etelis coruscans

2.1.1 The Resource

Species present: One hundred and seven species were recorded by Brouard *et al*. (1985) with best represented families being the Lutjanidae (subfamilies Etelinae, Lutjaninae and Apsilinae), Serranidae (subfamily Epinephelinae) and Lethrinidae. The main species listed by Schaan *et al* (1987) include, *Lutjanus malabaricus*, *Etelis carbunculus*, *E. coruscans*, *E. radiosus*, *Pristipomoides filamentosus*, *P. flavipinnis*, *P. multidens*, *Aphareus rutilans*, *Epinephelus magniscuttis*, *E. morrhua*, *E. septemfasciatus*. Other species include; *Aprion virescens, L. gibbus, L. bohar, L. rufolineatus, L. argentimaculatus, L. timorensis, Lethrinus variegatus, L. miniatus, Paracaesio kusakarii* and *T. zonatus*.

Distribution: Throught-out 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 individual species known distribution and identification. He also writes that "the family is divisible into four discrete geographical faunas: eastern Pacific, Indo-West Pacific, eastern Atlantic and western Atlantic" with no species found in more than a single region. Furthermore, " many species, particularly members of *Aphareus, Aprion, Etelis, Lutjanus, Macolor, Paracaesio, Pinjalo* and *Pristipomoides* have broad distributions encompassing wide areas of the Indo-West Pacific region. Some of these species such as *Lutjanus bohar, L. gibbus, L. kasmira, L. monostigma,* and *L. rivulatus*, as well as species of *Etelis*, *Paracaesio* and *Pristipomoides* are frequently associated with oceanic insular localities. Relatively few species have greatly restricted distribution and some of these may be more widespread, but because of their relatively deep habitat, they are seldom collected".

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

The deep-water bottom-fish inhabit the outer reef slope at depths ranging from 100 to 400m (Brouard, 1985 and Schaan *et al,* 1987). This area has been estimated by Davis (1985), by region within Vanuatu, to be approximately 7,360 km^2 as given in Table 2.1.1 below.

Table 2.1.1: Surface area for the 100-400 m depth band, by region, in Vanuatu (David, 1985).

Area	Surface 100-400 (ha)	Percentage of Total	Area	Surface 100-400 (ha)	Percentage of Total
Torres	20,596	2.7	Epi-Paama-Lopevi	76,512	10.1
Banks	51,876	6.9	Efate	95,330	12.6
Santo-Malo	142,970	18.9	Erromango	55,658	7.4
Maewo	33,468	4.4	Tanna-Aniwa	47,568	6.3
Pentecost	25,000	3.3	Futuna	3,700	0.5
Malakula	101,344	13.4	Aneityum	14,816	2.0

Ambrym	26,650	3.5

Vanuatu Total	754,685	100

However, this does not indicate areas that are potentially rich in bottom-fish, as sea bed charts would be required.

Brouard and Grandperrin (1985) gave depth ranges for 84 different bottomfish species in Vanuatu. Classification of species by three depth zones of maximum concentration as recorded during deep bottom fishing in Vanuatu was also given. This is shown for some commonly caught species in Table 2.2.2 below:

Table 2.1.2: Classification of the major species by depth zone of maximum concentration.

Shallow species (<120 m)	Intermediate depth species (120-240 m)	Deep species (>240 m)
P. filamentosus	*P. multidens*	*E. carbunculus*
A. virencens	*P. flavipinnis*	*E. coruscans*
L. gibbus	*L. malabricus*	*T. argyrogrammicus*
L. bohar	*E. morrhua*	*S. megalops*
C. amblyrhinchos	*S. rivoliana*	*E. radiosus*
L. variegatus	*L. miniatus*	*L. carnolabrum*
	A. rutilans	*E. septemfasciatus*
	L. argentimaculatus	*T. zonatus*
	E. magniscuttis	
	G. mossambicus	
	E. chlorostigma	
	E. areolatus	
	L. rufolineatus	
	P. kusakarii	

The largest fishing grounds within the country are off the east coast of Santo. Around Efate, the fishing effort during the 1987-88 period seemed to have concentrated in the north east Efate region, Emao and Forari (Cillaurren, 1988).

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.

Examining catch data within Vanuatu Brouard and Grandperrin (1985) found that the only significant sex ratio possible was that calculated from fishing trials carried in Santo for 656 *P. multidens*, giving a male to female ratio of 1:18. The same authors hypothesized, using results from microscopic examination of fresh gonad for different stages of maturation, that shallower species have maximum breeding activity in summer, although capable of spawning all year round, while deep water species do not have such a marked cycle. In all species intense sexual activity in

the spring (months 10 and 11 - Oct/Nov) seems to be very common. Length at sexual maturity (L_m) were calculated by same authors for 26 deep-water species, without any sex distinction, as presented in Table 2.1.3 Because of limited numbers in samples for estimating L_m, the authors were limited to determining the smallest size recorded of sizes associated with sexual maturity on the basis of the occurrence of a high GSI (gonosomatic index[4]) and maturation stages 5, 6 and 7. (Appendix 2.1 (a). lists the stages for sexual maturation scale used). In addition the Beverton and Holt relationship $L_m=kL_{max}$ was used. The K value (K=0.576) used was that obtained for 34 tropical fish species on the West Coast of Africa. The choice not to use k=0.71 as calculated by Loubens (1980) for New Caledonia was that maximum lengths obtained were much higher than those in New Caledonia which would have yielded higher values than actual.

Table 2.1.3: Minimum sexual maturity sizes recorded and calculated sexual maturity sizes ($L_{m)}$ using L_m=0.576 mean L_{max} (after Brouard and Grandperrin, 1985).

Species	Minimum sizes with raised GSI *1	Minimum sizes associated with stages 5, 6 and 7 *2	Lm*3	Species	Minimum sizes with raised GSI *1	Minimum sizes associated with stages 5, 6 and 7 *2	Lm*3
A. rutilans			48	*L. argentimaculatus*			44
A. virescens			44	*L. bohar*			36
E. areolatus			22	*L. gibbus*			21
E. magniscuttis			40	*L. malabaricus*	38	38	35
E. morrhua	44	41	44	*L. rufolineatus*			16
E. septemfasciatus			83	*P. kusakarii*			33
E. carbunculus	28	30	54	*P. filamentosus*			35
E. coruscans	38	33	47	*P. flavippinis*	28	27	33
E. radiosus	-	31	40	*P. multidens*	32	33	37
G. mossambicus			25	*S. rivoliana*			49
L. miniatus			42	*S. megalops*			47
L. variegatus			30	*T. argyrogrammicus*	21	19	14
L. carnolabrum			35	*T. zonatus*			20

*1 = minimum sizes for which the GSI was above the mean GSI calculated for maturation stage 5

*2 = minimum sizes where maturation stages 5, 6 and 7 were first noted.

*3 = sexual maturity sizes worked out from mean maximum lengths (Lmmax) using the formula Lm=kLmmax, where K=0.576.

The growth rates of the main Lutjanidae species occurring on the outer reef slope of Vanuatu seem to be very low, lower for the more deeper ones like *E. carbunculus* and *E. coruscans* than shallower *P. flavipinnis* and *P. multidens*. Brouard and Grandperrin (1985) gave the following table (Table 2.1.4) and notes for the Von Bertalanffy parameters, total mortality index (Z) and natural mortality index (M) for six major species of the outer reef slope in Vanuatu.

Table 2.1.4: Some biological parameters for six major species of the outer reef slope in Vanuatu.

[4]GSI was calculated by dividing the weight of both gonads (in grams) by the weight of the whole fish body (in kg).

Mean growth (cm/year)

Species	K	L_{∞}(cm)	30<L<40	40<L<50	mean L(cm)	Lc (cm)	$Z_1(a^{-1})$	$Z_2(a^{-1})$	$M(a^{-1})$
E. car	0.07	94	4.2	3.42	57	28	0.07	0.089	0.149
E. cor	0.128	82	5.99	4.71	55	30	0.107	0.136	0.237
L. mala	0.310	60	7.65	4.47	44	32	0.447	0.401	0.545
P. flav	0.356	58	8.06	4.39	35	27	0.648	1.006	0.602
P. fila	0.295	60	7.28	4.26	41	31	0.467	0.587	0.527
P. mult	0.244	64	7.01	4.53	44	34	0.375	0.460	0.448

K=1000/W, $W=aLm^b$ (a, b obtained by means of the length/weight relationship; meanL=mean maximum lengths, $Lc=(L_{100}+Lo)/2$, Z1: total mortality calculated by regression of the Log of the number of individuals as a function of time, Z2: K (L∞-meanL)/meanL -Lc), M: natural mortality expressed by the equation LogM=-0.0066-0.279 logL∞+0.6543 logk+0.4634 logT.

Carlot (1988) estimated growth and mortality parameters (L_{∞} and K) of *E. carbunculus* in Vanuatu to be 132.4 cm and 0.22 $year^{-1}$ respectively using ELEFAN I. Brouard and Grandperrin (1985) estimated the same parameters for the same species, using otoliths, to be 94.0 and 0.07^{-1} respectively. Length-weight relationships for some species are given in Appendix 2.1 (b).

2.1.2 The Fishery

Utilization: The deep-water bottom-fish fishery target the high commercial-valued snappers ("poulet" - chicken fish) which are locally sold to the fish market, hotels and restaurants. Some enter the subsistence economy at the village level (Dalzell, 1992).

The deepwater bottom fish resource was virtually unexploited until after the initial surveys on the resource were conducted by the SPC Deep Sea Fisheries Development Project between 1974 and 1981. These surveys demonstrated the existence of commercial deep slope resources in Vanuatu (Dalzell, 1990). The hand-reel, developed for deep-water bottom handling in Western Samoa, were used, and were mounted on 8 m catamarans or 5 m dories powered by 25 hp outboard motors. The trial fishing for bottom-fish initiated by SPC were continued by the Fisheries Department from 1981 to 1982. Trapping fishing using the Z-type of traps were tried by the Fisheries Department between 1987 and 1988. Results were mostly poor catches with only very few traps making good catches (Guerin, 1989).

The interest generated from the trials and the government's desire to promote the exploitation of the deep-water resources initiated the establishment of the Village Fisheries Development Project (VFDP) by the Fisheries Department in 1982. After fishing trials using several boat types of catamarans and mono-hulls, the 8.6 m alia catamaran, 5.0 m and 5.6 m Hartley half cabin launch were chosen, with a marked preference for the Hartley type (Schaan *et al*, 1987). The VFDP aimed at setting up 25 village fishing projects over a three year period (Carlot and N'Guyen, 1989). Under the scheme, fishermen benefited from grants, the supply of equipment, training and technical assistance. Duty free (reduced duty) fuel was available to fishermen who provided the Fisheries Department with details of fishing activities and catches. In addition ORSTOM gave 50 vatu for every returned and completed form they distributed. These concerned details on species and length frequencies. Due to the provision of subsidies by the government, development of the bottom-fish fishery was fast and "applications to establish fishing projects quickly exceeded the planned 25 enterprises" (Dalzell, 1990). The project was designed so that each of the 25 enterprises would receive a fully equipped boat, and a small freezer or ice plant which were supplied on a 50% grant, 40% loan and 10% local cash contribution basis (Vanuatu Second National Development Plan).

Dalzell (1990) noted that "by 1988, a total of 180 fishing projects were registered under the VFDP, although not all of these were directly involved in fishing but concentrated on marketing

instead". A summary of operating projects by area and year, under the VFDP between 1982 and 1986 is given
Schaan *et al.* (1989**)** as is in the table below. Figures for 1992 were estimates by MacAlister, Elliot and Partners Ltd (1992). The number of current operational fishing vessels was not available.

Area	'82	'83	'84	'85	'86	'92
Tanna	1	1	2	2	8	
Efate			2	8	5	10
Tongoa		2	3	3		
Epi	1	1	1	1	2	
Paama	1	1	1	5	5	
Ambrym		1	3	3		
Malekula	1	2	1	6	11	<8
Santo	2	2	5	15	17	23
Pentecost		2	3	4	5	
Ambae			3	5	6	
Banks-Torres				1	3	
Total in Vanuatu	6	10	21	53	69	

Production and marketing: Catch rates from various SPC bottomfishing trials in Vanuatu were given in Dalzell and Preston (1992) as follows. The average catches are in kg and these exclude shark and locally unsaleable species.

Area	Date	Average catch per trip	Average/ reel-hour
Lamap, Malekula	1 Aug 74-28 Feb 75	53.4	3.5
Tanna	19 Sep 78-15 Mar 79	18.7	2.5
Lolowai, Ambae	1 Mar-22 Mar 1981	174.3	9.7
Luganville,Espiritu Santo	26 Mar-30 Apr 81	37.3	3.7
Lakatoro, Malekula	2 May-3 Jun 1981	44.7	3.1
Tahi village, Paama	29 Aug-5 Nov 1980	83.4	7.4
	31 May-7 Jun 1983	71.8	7.4
Abwatuntora, Pentecost	24 Nov-12 Dec 80		
	3-19 Feb 1981	98.9	9.8
Port Olry, Espiritu Santo	17-24 Jun 1983	113.3	12.6
Hog Harbour, Espiritu Santo	10-15 Jun 1983	74.2	6.9
Luganville, Espiritu Santo	27 Jun-1 Jul 1983	90.1	10.6
Lamen Bay, Epi	18-30 May 1983	71.3	4.1
Port Vila	15 Jan-5 Apr 1983	67.2	6.1
Atchin Island, Malekula	3-5 Jul 1983	53.9	2.2

Based on 80kg/trip and 160 trips/year Crossland (1984) estimated production of 320,000 kg (32 m Vatu) per project.

The advent of the deep-water fishery also established a marketing scheme. Originally, the Natai Fish Market, in Vila, received all of the catches from fishing projects from all over Vanuatu including those based on Efate. Transportation to Vila was all by air using large coolers. A second marketing operation, Santofish, was established in 1983 at Luganville which absorb fish caught in the east coast of Santo (largest fishing grounds) and other outer islands. Fisheries Extension Centres on the outer islands (seven - one each on Tongoa/Sheperd, Malekula/Lakatoro, Banks/Sola, Ambae/Lolowai, Epi, Santo and Efate/Tafea) currently purchase and re-sell fish. On Santo and Efate, fisheries extension centres do not deal with purchases and sales of fish as they are handled by Santofish and Natai respectively. Excess is sent to Natai Fish Market. Because of better prices, bottom-fish is increasingly going directly to the restaurants and supermarkets in Vila.

The total catch (kg) landed and the average catch per trip (kg - in brackets), by area and year, under the VFDP fishing operation between 1982 and 1986 is recorded below (adapted from Schaan *et al*, 1987):

Area	1982 Catch	1983 Catch	1984 Catch	1985 Catch	1986 Catch
Tanna	1,540	1,165	2,867	3,883	13,547
(C/trip)	(45.3)	(35.3)	(33.7)	(39.2)	(33.1)
Efate			4,021	11,212	5,593
(C/trip)			(45.7)	(40.3)	(40.5)
Tongoa			6,874	6,323	1,010
(C/trip)			(44.6)	(40.0)	(36.1)
Epi	4,412	6,481	8,219	2,082	2,093
(C/trip)	(33.9)	(38.6)	(39.3)	(32.5)	(30.3)
Paama	2,981	11,895	6,314	10,118	7,059
(C/trip)	(69.3)	(43.6)	(29.0)	(28.8)	(27.7)
Ambrym			3,515	7,033	4,383
(C/trip)			(41.8)	(27.9)	(20.1)

Area	1982	1983	1984	1985	1986
Malekula	416	5,514	502	6,648	15,646
(C/trip)	(23.1)	(35.3)	(31.4)	(27.2)	(30.6)
Santo	399	16,936	5,935	22,716	16,154
(C/trip)	(20.0)	(22.9)	(27.0)	(35.1)	(26.4)
Pentecost		1,883	3,040	6,950	2,315
(C/trip)		(12.6)	(27.1)	(30.2)	(21.1)
Ambae		663	8,508	5,587	4,696
(C/trip)		(30.1)	(23.6)	(19.9)	(21.3)
Banks-Torres				328	1,469
(C/trip)				(41.0)	(24.5)
Vanuatu	9,658	44,177	49,795	82,501	73,965
(C/trip)	(39.7)	(28.9)	(32.2)	(31.6)	(28.4)

In an attempt to estimate production of the bottom-fish fishery in Vanuatu by species, Schaan *et al* (1987) established a length/weight correlation for the main 11 species of which length data were collected. This was used to estimate weight, by species, of those landed under the VFDP between 1982-1986 and was presented by Schaan *et al* (1987) as follows:

Species	Est. wt (kg)	% by weight	# measured	% by Number
L. malabaricus	4,224	5.7	3,720	8.6
E. carbunculus	13,639	18.4	4,635	10.8
E. coruscans	8,550	11.5	2,992	6.9
E. radiosus	2,218	3.0	791	1.8
P. filamentosus	3,671	4.9	2,556	5.9
P. flavipinnis	3,978	5.4	4,940	11.4
P. multidens	10,938	14.7	7,924	18.4
A. rutilans	917	1.2	301	0.9
E. magniscuttis	1,715	2.3	742	1.7
E. morrhua	1,573	2.1	904	2.1
E. septemfasciatus	1,532	2.1	414	1.0
Sub-total	52,955	71.3	29,919	69.5
Others	21,320	28.7	13,131	30.5
Total	**74,275**	**100**	**43,050**	**100**

Cillaurren (1988) estimated the bottom-fish production around Efate in 1988 to be 48,800 kg. The maximum sustainable yield for Efate was estimated to be 98,000 kg, thus the catch represent only 50% of the total potential production from the area.

Combined catch landings at the Fisheries Extensions from 1990 to 1992 by species are given in Table 2.1.5 (figures in kg - source Fisheries Department data base).

Table 2.1.5: Deep-water bottomfish landed at all the outer islands Fisheries Extensions.

Species	1990	1991	1992
E. carbunculus	1,586.8	1,892.2	1,845.0
E. coruscans	1,733.3	1,562.2	3,322.7
E. radiosus	157.7	413.6	518.3
P. multidens	557.7	55.2	1,884.7
P. flavipinnis	81.1	168.6	805.3
P. filamentosus	1,492.1	3,321.6	9,810.9
L. malabaricus	909.2	1,346.8	3,695.1
A. rutilans	49.5	67.8	601.6
S. rivoliana	229.2	546.0	1,119.8
E. magniscuttis	325.9	270.6	1,067.0
E. morrhua	116.4	279.2	363.1
E. septemfasciatus	252.8	118.4	264.9
Total	7,491.7	10,042.2	25,298.4

All of the deep-water bottomfish purchased by the Natai fishmarket between 1988 and 1992 are recorded in Table 2.1.6. Weights are in kg and Value in Vatu. (Source: Fisheries Department Database).

Table 2.1.6: Natai Fishmarket Deep-water fish purchases between 1988 and 1992.

Species	1988 Weight	1989 Weight	1990 Weight	1991 Weight	1992 Weight
Poulet	29,138.6	26,867.3	25,779.4	34,194.3	31,551.6
(Value)	6,255,248	7,122,309	7,442,506	10,571,647	10,065,338
Sea perch	5,054.3	2,671.6	2,355.5	8,283.0	2,355.5
(Value)	967,100	843,992	938,523	2,429,147	938,523
Loche	4,097.1	3,077.2	2,031.5	3,186.8	2,031.5
(Value)	774,296	648,618	516,554	768,463	516,554
Amberjack	1,677.1	1,033.9	1,433.6	938.7	1,433.6
(Value)	231,128	154,304	224,781	180,943	224,781
Bream	5,597.9	2,301.1	3,155.7	2,800.6	3,155.7
(Value)	676,283	449,911	611,644	665,062	611,644
Jobfish	1,538.0	210.0	270.1	450.0	270.1
(Value)	125,882	40,752	65,482	100,314	65,482
Total Wt	47,103.0	36,161.1	35,025.8	49,853.4	40,798.0
(Value)	9,029,937	9,259,886	9,799,490	14,715,576	12,422,322

Sales of bottom-fish at Santofish from 1989 to 1992 are summarized in the following table (weights

in kg). (Source: Santofish Database):

Species	1989	1990	1991	1992	Total
Poulet[5]	28,247.9	29,626.6	34,180.4	27,033.0	119,087.9
Snapper	5,274.8	8,214.5	10,035.2	20,276.3	43,800.8
Bream	2,058.6	3,700.8	3,078.3	1,121.5	9,959.2
Loche	2,708.0	3,228.9	3,520.8	2,431.1	11,888.8
A/Jack	1,081.4	2,163.5	1,513.0	1,270.9	6,028.8
GJ Fish	152.9	330.6	369.4	159.5	1,012.6
Red Emp	85.0	90.8	57.6	44.2	277.6
Total	39,608.6	47,355.9	52,754.7	52,336.5	192,055.7

Because of the fact that excess fish are sent to Natai fish market in Vila from Santofish and Fisheries Extension Centres, there is a possibility of duplication of data if the sets are combined to obtain the actual total landings using these three sources.

Purchases of poulet fish by Bon Marche, Vila, in 1992 indicated that 3,000 kg were received from Santo, 800 kg from North Efate (Lelepa) and 45 kg / week for 3 months (thus 550 kg) from one Efate fisherman. This amounts to 4,350 kg for that year.

2.1.3 Stocks Status

Analysis of data, by Cillaurren (undated), for the Efate area for the 1987-1988 two year period yielded an average catch of 49.2 kg per trip or 0.91 kg per trip hour per reel. Figures calculated by Schaan *et al*, (1987) from 1984-1986 data for the same area were almost the same (i.e. average catch per trip averaged 42.2 kg). Fish species composition for the same area remained almost the same from 1984 to 1988 with *Etelis* and *Pristipomoides* species making more than 60% of the total catch. Schaan *et al* (1987) estimated that *E. carbunculus* and *P. multidens* account for almost 50% of the Efate catch from 1984 to 1986. Cillaurren (undated) estimated that 74% of the 1987-88 catch comprised of the *Etelis* and *Pristipomoides* species, and that species composition in the 1987 landings showed that 18.2% were of *E. carbunculus*, 14.3% *E. coruscans*, 26.4% *P. multidens* and 15.3% *P. flavippinis*. No significant change was observed for the 1988 catch except that percentage composition of *P. flavippinis* decreased to 6.9. The catch production around Efate, with seven operating fishing vessels, landed about 48,800 kg, only about 50% of the estimated annual potential production of 98,200 kg around Efate. This study however, did not take into consideration length frequencies analysis.

Examination of catch data for the 1982-88 period for catch and effort analysis for the fishery and length frequency analysis on the four most commonly caught deep-water snapper species, *E. carbunculus*, *E. coruscans*, *E. radiosus* and *L. malabaricus* is reported in Carlot and N'Guyen (1989). The results indicated that, overall, the CPUE (catch per unit of effort) generally declined slightly as the number of boats increased. The CPUE's for some specific locations however, remained about the same except for a marked decline detected for the Paama area. The authors showed that the overall relationship between catch and effort gave little or no curvature even at the highest level.

The exploitation rate, E, was calculated to be 0.26 which suggested moderate exploitation of the stocks of these species, given limitation of the data.

5Note: Poulet = *Etelis* and *Pristipomoides*, Snapper = *L. malabaricus*, sea perch, Bream = *Paracaesio*, Loche = *Epinephelus* (especially, *E. septemfasciatus, E. morrhua* and *E. malgaiscuttis*), A/jack = amber jack, GJ fish = gray jobfish, Red emp = *Lutjanus sebae*

Examination of the data also indicated evidence of decline in both the mean length and the 95 percentile. The authors concluded that their results appeared to be consistent with the conclusion that the stocks were at that time underexploited.

The same authors calculated Optimum fleet size for the bottom-fish fishery in Vanuatu using two methods, those of Gulland 1971 and Pauly 1984. The Gulland method yielded optimal fleet size to be 138 vessels while that of Pauly gave 55 vessels. Based on different assumptions and calculation, Brouard and Grandperrin (1985), estimated that 120 boats might generate the Maximum Sustainable Yield (MSY). MSY per island area, number of alia-type boats that would give MSY was also estimated and is reproduced below in Table 2.17.

Table 2.1.7: MSY and number of boats to fish that MSY per area within Vanuatu (Brouard and Grandperrin (1985).

Area	Length 100 m isobath (miles)	100-400 m isobath surface area (ha)	MSY (tonnes per year)	# of boats to fish MSY
Torres	64	20,596	21	3
Banks	136	45,826	46	8
Santo/Malo	235	142,970	143	24
Malekula	165	101,344	101	17
Maewo	70	33,468	33	5
Ambae	52	11,843	12	2
Pentecost	75	25,000	25	4
Ambrym	68	26,650	27	4
Paama-Lopesi-Epi	101	76,512	77	13
Sheperd	86	45,354	45	7
Efate	126	95,330	95	16
Erromango	75	53,658	54	9
Tanna	65	42,438	42	7
Anatym	40	14,816	15	2
Total Vanuatu	1,358	735,805	736	121

Initial calculations by the above authors indicated a MSY for the whole of Vanuatu to be between 147.0 and 380.0 tonnes/year and that around Efate it would be between 13.7 and 34.4 tonnes per year. These figures were recalculated taking into account the Hawaiian experience where MSY was under-estimated due to non-comprehensive data recording and non-recording of the data in the recreational fishing. The re-calculated MSY for Vanuatu was then estimated to be between 300 and 700 tonnes/year.

Considerations on the economics of fishing for the deep-water bottomfish, taking into account market availability, in Vanuatu were given in MacAlister Elliot & Partners (1992). The following table was given as summaries of indicative MSY and MEY (maximum economic yields) estimates for Santo, Malekula and Efate for different types of boats utilized in the fishery.

	Indicative MSY (tonnes)	Number of Boats at MSY	Indicative MEY (tonnes)		Number of boats at MEY	
			Hartley 25 hp	KIR 4 15 hp	Hartley 25 hp	KIR 4 15 hp

Santo	143	52	104	116	25	30
Malekula	101	37	44	66	9	15
Efate	95	124	81	85	21	24

Brouard and Grandperrin (1985) concluded that:

> "although these figures are rough estimates, they should nevertheless assist development planners in choosing their objectives. The bottom-fish resources of the outer reef slope are, as it turns out, rather limited, which means that the fishery must be managed with great care".

Furthermore, it was noted that:

> "the growth rates of the main commercial species are fairly low but comparatively higher for the shallow and intermediate species (*Pristipomoides* spp.) than for the deep species (*Etelis* spp.)" and that
>
> "the depth stratification of the species corresponds to a stratification in their vulnerability to intensive fishing" and because analysis was done on virtually virgin stocks, very large-sized, therefore very old, *Etelis* are frequently caught. If fishing pressure were to be increased significantly, it is very likely that these large specimens will disappear.

Carlot and N'Guyen (1989) concluded that:

> "from both the catch and effort and length frequency analysis there is evidence to suggest that the fishery is still underexploited though there are slight declines both in mean length and the larger fish (the 95 percentile) and also in the CPUE for each island. The fact that the relationship between catch and effort for the whole country suggests that there is room for more effort, this should proceed with caution as there might be some locations where the effort has reached its optimum level".
>
> The optimal fleet size using the different methods were 55 and 138 vessels. The number of boats fishing actively fishing at the time of the report writing was about 80. Their results and those by Brouard and Grandperrin (1985) indicated that effort could be increased.

2.1.4 Management

The change in marketing strategies has made it harder to collect accurate data consistently. Thus tracing the trends in the fishery using only catch landings from the private sector would require an improvement of the current data collecting system to include those sold to stores and restaurants. Even though exploitation seems to be moderate currently, small specimens (6-8") of *Pristipomoides* were seen being offered for sale in one supermarket in Vila that was visited. Brouard and Grandperrin (1985) noted that some species were being caught before they reach sexual maturity if 45 cm was taken as the full recruitment length and would thus be sensitive to fishing pressure. However, "the smaller species are not recruited into the fishery until they are well above their sexual maturity size".

There are indications that the interest and involvement of the private sector in this particular fishery is levelling off or even declining due to the lack of government support and limited local market. It has been noted that fishermen in Vanuatu can be so easily tempted away from the sea that it must be ensured that there is a ready supply of inputs to fishermen (MacAlister Elliott & Partners, 1992). Overall this could indicate the trends in profitability of fishing for the fishery when either the resource or the market, or both, are limited. The local market alone limits the fleet number that can economically operate within the fishery.

Current legislation/policy regarding exploitation: There is currently no legislation that specifically controls the exploitation of the deep-water demersal fishery.

Recommended legislation/policy regarding exploitation: Even though the economics of fishing tend, at this stage, to limit fishing effort, a possibility still exists for development for export. In this case the Fisheries Act should be able to accommodate making regulations to limit boat numbers or even quotas in specific fishing areas (grounds) within Vanuatu when the need arises. However, more research is required to confirm biological parameters of the fishery as well as MSYs. Sales of very small *Pristipomoides* (6-8 inches) were witnessed in the Bon Marche supermarket on 25 June 1993. Setting a maximum hook size for certain depths seems to be an applicable management tool, however, it has been found that increasing hook size does not really affect the size distribution of the catch (Ralston, 1982, 1990) although Ralston (1978) found a vertical stratification in *P. filamentosus* with smaller individuals being caught in the shallower depth range of this species.

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Appendix 2.1 (a)

The different stages in the sexual maturation scale as recorded by Brouard *et al* (1985):

Stage	Males	Females
1	Indeterminate sex.	Indeterminate sex.
2	Gonad poorly developed, long and thin; translucid; whitish to pinkish in colour.	Gonad poorly developed but rather thicker than a mere filament; translucid; slight vascularisation.
3	Flattish testicle; pinkish white colour; does not run after cutting.	Opaque ovary; clear vascularisation ranging from pink to red; oocytes not visible to the naked eye.
4.	Thick testicle, white; runs slightly after cutting.	Well developed ovary with strong vascularisation; colouring yellow to dark red; transparent membrane; granulous appearance; oocytes visible to the naked eye.
5.	Thick testicle, often with a triangular section; curdled milk appearance; white colouring, runs easily after cutting.	Swollen and granulous ovary with very thin and fragile membrane.
6.	Running ripe.	Running ripe.
7.	Flaccid testicle, spent and burgundy strong vascularisation.	Spent ovary with strong vascularisation; red colour; early in this some isolation oocytes can still be found after cutting.

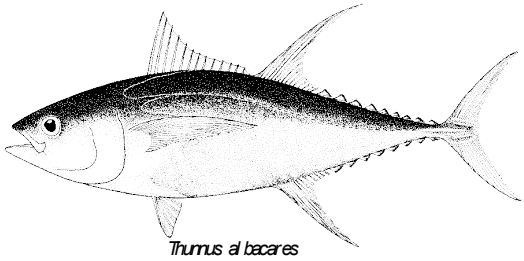
Appendix 2.1 (b)

Length-weight relationships for some deep-water bottomfish species as calculated by Brouard *et al* (1985). $W = aFL^b$ where FL is the fork length in cm, and W is weight in grams.

Species	a	b
Aphareus rutilans	0.00336	3.311
Aprion virescens	0.00345	3.330
Epinephelus areolatus	0.13556	2.327
E. magniscuttis	0.03916	2.754
E. morrhua	0.06058	2.624
E. septemfasciatus	0.00332	3.348
Etelis carbunculus	0.02161	2.950
E. coruscans	0.04105	2.758
Gnathodentex mossambicus	0.04012	2.824
Lethrinus miniatus	0.03293	2.728
L. variegatus	0.18224	2.284
Lutjanus argentimaculatus	0.00540	3.206
L. bohar	0.00003	4.606
L. gibbus	0.00006	4.646
L. malabaricus	0.00853	3.137
Paracaesio kusakarii	0.01059	3.135
P. stonei	0.19977	2.402
Pristipomoides flavipinnis	0.02991	2.825
P. multidens	0.02003	2.944
P. typus	0.03909	2.733
Seriola rivoliana	0.00636	3.170
Tropidinius argyrogrammicus	0.00976	3.221
T. zonatus	2.50119	1.612

2.2 TUNAS

2.2.1 The Resource


Thunnus albacares

Species present: The important commercial species in the local tuna fishery include, skipjack (*Katsuwonus pelamis*), yellowfin tuna (*Thunnus albacares*), mackerel tuna (*Euthynnus affinis*), dog-tooth tuna (*Gymnosarda unicolor*), and albacore (*Thunnus alulunga*). Big-eye (*T. obesus*) and frigate tuna (*Auxis thazard*) have also been recorded.

Distribution: Collette *et al* (1983) give the geographical distribution of the scombrids including the tunas. The following geographical distribution information concerning the above species was given:

Skipjack- cosmopolitan in tropical and warm-temperate waters but absent in the Black Sea.
Yellowfin tuna- worldwide in tropical and subtropical seas but absent from the Mediterranean Sea.
Mackerel tuna- and throughout the warm waters of the Indo-West Pacific including oceanic islands archipelagos. A few stray specimens have been collected in the eastern tropical Pacific.
Dog-tooth 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.
Bigeye tuna- worldwide in tropical and subtropical waters of the Atlantic, Indian and Pacific oceans, but absent from the Mediterranean.
Frigate tuna- probably cosmopolitan in warm waters but there are only a few documented occurrences in the Atlantic Ocean.

Grandperrin (1977) indicated that "surface fish" (mackerel tuna, skipjack and related species) inhabit both the outer slope of the reef and nearby pelagic area, and the offshore deep-sea area in Vanuatu (quoted in Habib, 1984). He described the pelagic resource to include, sub-surface yellowfin tuna and adult albacore, and surface resource to include yellowfin, skipjack and related species. Skipjack and yellowfin are present year round in Vanuatu waters (Petit and Henin, 1982). Aerial surveys for the surface tunas, conducted by ORSTOM and funded by the Vanuatu Government, between April 1980 and April 1981 spent 250 flying hours (prospecting for tunas). One hundred and ten schools were sighted in different areas with the best areas around Efate accounting for 17.30% of the schools sighted, West Santo 15.5%, East Loyalty 10% and East Tanna and Aneityum 9.1%. The survey indicated no clear seasonal pattern of abundance and distribution in Vanuatu waters except that poor months were April and November.

Biology and ecology: Smith (1992) notes that even though the tunas form the basis of one of the world's largest fishery[6], a lot of their parameters regarding their life history are still unknown. Many tuna species migrate considerable distances, swimming continuously. They eat substantial amounts of food and have rapid growth. Many species maintain core body temperatures several degrees above the surrounding sea temperature. Open sea species feed largely on epipelagic fishes, squids, and crustaceans. Near-reef species also utilise the larval and early juvenile stages of

[6]Stamatopoulus (1993) ranks the production, in the Pacific Ocean, of tunas, bonitos and billfishes fourth of 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

reef fish and crustaceans as prey. Reef-associated species prey on large zooplankton or fish occupying the water above the reef (Myers, 1991)

Analysis of data obtained during the SPC (October 1977 to August 1978) assessment indicated that by maturity stage, maturing skipjack dominate female skipjack. "Presence of female skipjack with recovering gonads in Vanuatu in December 1977 and January 1978 indicated that some spawning occurred during the survey period (Tuna Programme, 1983). Data suggested that skipjack spawning in Vanuatu waters exhibits seasonal periodicity. An average of 29.9 skipjack juveniles per 100 skipjack predator stomachs was observed in Vanuatu. Because of the lack of information on the movements of juvenile skipjack, the extent to which local spawning contributes to recruitment in Vanuatu and elsewhere could not be established. Common diet of skipjack in Vanuatu waters include squid, tuna juveniles (several species in the family Scombridae), surgeon fish (Acanthuridae) and the alima stage of stomapods. A small number of tagged fish were shown to have migrated either into or out of Vanuatu and although there was suggestion of an appreciable degree of international movements, the recovery effort was too low for more accurate analysis (Tuna Programme, 1983). Skipjack growth is a function of size but is highly variable in time and space. Because only two fish were tagged and recaptured in Vanuatu, no generalised growth of skipjack was possible for those within Vanuatu waters.

4.1.2 The Fishery

Utilization: Offshore traditional fishing for tunas was not practised in Vanuatu. However, presently, tunas form an important component of the local artisanal and commercial fisheries. Catches are made by trolling, mostly around FAD's, using small (~5+m in length) outboard powered vessels. Most of the catch are sold locally but skipjack forms the major bait of the deep-bottom fishery for "poulet" (deep-water snappers-*Etelis* and *Pristipomoides* species).

Since the mid-1950's, commercial fishing for the tuna resource within the EEZ of Vanuatu was exploited by the Taiwanese, Korean and Japanese longliners on a low scale (Wright, 1989). The Japanese longliners were the first but were replaced by the Koreans around 1967 and after 1975 by Taiwanese vessels (Habib, 1984). Albacore was the principal target species for canning in the US, Japan and other countries. Handling of the catch from the longline vessels was done by South Pacific Fishing Company Limited which was established in 1957, based in Palekula. In 1983 the twenty Taiwanese longliners based in Santo were targeting albacore in the Tasman Sea between April and August, Northern Vanuatu waters in September to October, and northeast of Santo and east of Santa Cruz from November through to March (Habib, 1984). Between 1974 and 1979, Japanese pole-and-line tuna vessels fished the Vanuatu zone (Wright, 1989). Habib (1984) listed the following general observations from this activity:

- effort and catch were generally greatest between November and March, which could be indicative of the period of high abundance of high surface tunas in Vanuatu;
- there was no fishing between May and August, which could indicate that this is a period of low abundance of tunas in Vanuatu, or alternatively it could simply mean that the Japanese pole-and-line fleet was profitably fishing elsewhere during those months;
- fishing was concentrated in northern areas to the west and north of Espiritu Santo;
- effort was sufficient to give only a rough indication of seasonal and regional differences in the fishery, and of the resource.

An Agreement with the Soviet Union was negotiated with the Vanuatu Government to allow Russian tuna purse-seiners to operate in the Republic's EEZ. This undertaking lasted for only one year (1987). No information was available on this undertaking. In December 1989, 51 Taiwanese longliners were licensed to fish within Vanuatu's 200 mile zone (Fisheries Department Annual

Report for 1989). Vanuatu is a party to the Multilateral Treaty with US which was signed in 1987. The treaty allows US purse-seiners to fish in the Forum Fisheries Agency's countries' EEZ's.

Production and marketing: The Vanuatu-based Taiwanese vessels harvested up to 15,000 tonnes per year fishing in the albacore-rich waters of the open ocean south of Vanuatu and in the EEZs of neighbouring countries. These "longline vessels (and formerly Korean and Japanese) fishing for albacore took only a small portion (500-2,000 tonnes per year during the 1970's) of their catches in Vanuatu waters" (Government of Vanuatu Second National Development Plan, 1987-91). The catch/effort data, including tunas and billfish, between 1962 and 1977 by the Japanese and Taiwanese longliners within Vanuatu fishing zone is given in Skipjack Programme (1981). The combined catch of tunas (in numbers of fish) is summarised in Table 2.2.3 for 1967 to 1977.

Table 2.2.3:

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
B/fin	33	1	1	19	7	26	219	0	14	10	33
Albaco	49,048	30,116	11,390	25,409	33,929	43,421	57,245	10,300	11,550	24,010	30,843
Bigeye	3,349	1,807	865	1,100	2,145	2,127	3,588	1,102	378	2,376	910
Y/fin	7,758	6,176	6,146	4,709	15,931	12,826	18,066	5,473	8244	7,064	6,317
S/jack	148	6	0	20	13	2	18	4	0	164	968
S/tunas		403	404	235	314	0	1	0	0	0	0
Total	60,303	38,509	18,806	31,492	52,339	58,402	79,137	16,879	20,186	33,624	39,071
Effort[1]	1,104	475	2	33	143	188	102	14	5	2	1
Effort[2]	546	493	417	667	1,152	1,271	2,216	772	749	1,305	1,332
Effort[1+2]	1,650	968	419	700	1,295	1,459	2,318	786	754	1,307	1,333
Rate*	36.55	39.78	44.88	44.99	40.42	40.03	34.14	21.47	26.77	25.73	29.31

Effort[1] : Japanese vessels-effort in thousands of hooks

Effort[2] : Taiwanese vessels-effort in thousands of hooks

Rate* : Number of fish per thousand hooks - the number of fish is not the total number of fish caught as billfish are excluded. The other portion of the catches comprises billfish reported under the Profile for Other Oceanic Pelagics.

Habib (1984) gave the following table for combined catches (tonnes) by Japanese and Taiwanese fleets in Vanuatu waters from 1972 to 1976:

	1972	1973	1974	1975	1976
Albacore	726	925	168	193	493
Yellowfin	420	525	172	211	250
Bigeye	101	164	53	19	132
Other	105	144	39	25	137
Total	1,352	1,758	432	448	1,012
No. Fishing Days	737	1,144	409	342	798
Catch per Fishing Day (t)	1.8	1.5	1.0	1.3	1.3

The Japanese pole-and-line fishing vessels, operating in the 1970's in the northern part of the EEZ, took only modest quantities (300-1,600 tonnes per year) of skipjack **(**Government of Vanuatu Second National Development Plan, 1987-91**)**. The monthly summary catch by the Japanese pole-and-line vessels operation within the Vanuatu's EEZ from 1974 to 1979 is presented in Table 2.2.4

below (adapted from Habib, 1984). The data gives a catch range by pole-and-line of about 5 to 8 tonnes per boat day. Skipjack Programme (1980) gave figures for the Japanese pole and line catch/effort within the Vanuatu fishing zone between 1972 and 1978, which were slightly different and is summarised in the same table but marked*.

Table 2.2.4: Monthly catches by the Japanese Pole-and-Line Vessels between 1974 and 1979 within Vanuatu's EEZ.

	1974		1975		1976		1977		1978		1979	
Month	#Boat Days	Catch (mt)	#Boat Days	Catch (mt)	#Boat Days	Catch (mt)	#Boat Days	Catch (mt)	#Boat Days	Catch (mt)	#Boat Days	Catch (mt)
Jan			1	5			2	4	3	18	2	2
Feb			31	147			209	1,321	5	40	9	35
Mar	2	16	9	24			55	271			1	1
Apr			8	58								
Sep			2	4			1	2				
Oct			10	69								
Nov			6	8	1	4					34	279
Dec					13	90					36	338
Total Boat Days	2		67		14		261		8		82	
Total Catch (t)		16		315		94		1,598		58		655
Catch/boat day		8.0		4.7		6.7		6.1		7.3		8.0
Total Boat Days*	1		31		12		134		8			
Total Catch (t)*		14		138		96		697		53		
Catch/boat day*		14.0		4.5		8.0		5.2		6.6		

Landings and number of boats for the SPFC Longline Fleet are presented in Table 2.2.5 below. However, these do not reflect the proportion caught in Vanuatu waters nor catch rates.

Table 2.2.5: South Pacific Fishing Company (SPFC) Landings by Longline Vessels at Palekula, Espiritu Santo.

Year	No. of Boats	Albacore	Yellow-fin	Bigeye	Others	Total (mt)	Total Fish Re-exported (mt)	Value of Re-exports
1969	24					8,450		
1970	26					9,240		
1971	45					13,403		
1972	55					15,054		
1973	57					14,310		
1974	67					12,704		
1975	46					6,314		
1976	28					4,956		
1977	55					10,063		
1978	48					9,478	9,182	US$ 14,376,143
1979	50					7,887	7,724	US$ 13,929,587
1980	53	4,734	1,659	503	407	7,304	4,523	US$ 9,348,498
1981	27	3,384	858	252	296	5,121	4,840	US$ 9,348,498
1982	28	2,981	614	193	273	3,876	3,881	688,931,000 VT
1983	19	4,178	369	204	280	5,030	4,541	794,869,000 VT
1984	18	3,132	309	173	292	4,050	3,945	710,302,000 VT
1985	12	3,058	516	222	136	4,032	3,962	760,830,000 VT
1986	12	829	219	59	79		2,492	373,494,000 VT

(Source: Fisheries Department Annual Reports (for 1983, 1984, 1985, 1986, 1987, 1989), Habib (1984), Government of Vanuatu Development Plans (first 1982-1986 and second 1987-1991)
Note: SPFC operation terminated as of June 1986.

Catches from the trolling trials conducted by the Fisheries Department between September 1980 and April 1982 indicated that skipjack comprised 61%, yellowfin 23% and others 16%. The results of the 1980-81 aerial surveys indicated surface schools to comprise of 40% skipjack, 26 % yellowfin, 13% mixed skipjack/yellowfin, and the rest indeterminate.

The Russian purse-seiners that operated within Vanuatu waters in 1987 claimed to have caught a total of 12 t of tuna. No report was ever submitted to the Government. An access fee of US$1.5 m was paid for the duration of the agreement (Wright, 1989).

All of the tuna catches by the small-scale fishery are marketed locally. Some of the catch is sold at site of landing with most of the fish being sold to the Fisheries Extension Centres on islands where they exist and where proper ice and freezer facilities are located, Santofish and Natai fish markets. In cases of over-supply on the outer islands, the excess fish are sent to the Natai Fish Market in Vila. The tunas landed at the Natai Fish Market as well as those purchased by the Fisheries Extensions between 1988 and 1992 are shown in Table 2.2.1 below. Value of fish landed at Natai are also given (figures: weight in kg and Value in Vatu).

Table 2.2.1:

Species/	1988	1989	1990	1991	1992	1990	1991	1992
Value	Natai	Natai	Natai	Natai	Natai	F.Ext	F.Ext	F.Ext
S/jack	564.7	381.4	669.7	195.9	1,172.5	219.7	1,199.6	3,964.3
Value	32,125	32,746	64,215	19,280	119,861			
Y/fin	1,335.7	2,487.6	2,633.0	274.5	2,122.1	592.1	1,467.6	3,218.0
Value	199,685	372,222	479,990	61,530	503,785			
D/tooth	768.0	478.3	567.7	76.3	268.6	481.7	1,859.2	1,144.1
Value	99,973	68,825	116,813	17,106	45,806			
Albacor						39.2	69	1,227.9
Value								
Total Wt	2,668.4	3,347.3	3,870.4	546.7	3,563.2	1,332.7	4,595.4	9,554.3
Total Value	337,783	473,793	661,018	97,916	669,452			

The tunas landed at the Natai fish market seems to be stabilising around two tonnes per year while those going through the Fisheries Extension Centres have increased tremendously from one tonne in 1990 to almost ten tonnes in 1992.

Summarises of tuna sales, by species, at the Santofish market between 1989 and 1992 are recorded in Table 2.2.2 below. An increase is also shown from about half a tonne in 1989 to almost three tonnes in 1992.

Table 2.2.2:

Species	1989	1990	1991	1992
S/jack	12.4	219.6	272.8	718.8
D/tooth	486.9	666.1	815.6	487.2
Y/fin	72.7	146.8	256.7	1,740.7
Macker/tuna	8.0	546.8	0.9	0
Total	580.0	1,579.3	1,346.0	2,946.7

The total tuna landing in the three outlets would be around 16 tonnes for 1992. However, because excess fish from the Santofish market and the Extension Centres are sent to Natai, the actual total figure is probably lower due to duplication of data.

Under the FFA Member Countries' Multilateral Treaty with the United States of America the following catches were recorded in Vanuatu's EEZ by the American Purse-seiners from the inception of the Treaty to the end of 1992 (Source: Forum Fisheries Agency):

Tuna	1989	1990
Skipjack (t)	692	39
Yellow-fin(t)	97	0

The number of Taiwanese Long-line fishing vessels holding fishing licences to fish in Vanuatu's EEZ under bi-lateral arrangements is as follows:

Date: as of	4 Dec 89	30 Nov 90	6 Dec 91	30 Dec 92	12 Jan 93
# of Vessels	43	37	22	22	24

Catches by distant-water longline fishing vessels (Japan, Korea and Taiwan) between 1979 and 1990 within Vanuatu's EEZ are presented in the following table. The figures for 1992 are incomplete (Source: Forum Fisheries Agency).

	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Y/fin	0	0	0	6	7	8	37	21	3	1	4	1	0	2	0
B/eye	0	0	1	10	15	38	102	81	13	2	54	5	0	11	0
Albacore	0	0	2	77	106	351	838	427	74	38	232	44	0	90	10
Billfish	0	0	0	9	5	16	29	19	2	0	4	1	0	2	0
Others	0	0	0	4	1	3	7	2	0	0	4	1	0	2	0
TOTAL	0	0	3	106	134	416	1,013	550	92	41	298	52	0	107	10

2.2.3 Stocks Status

The status of tuna stocks in Vanuatu is unknown. Grandperrin (1977) indicated that the larger subsurface tuna resource in the Pacific has decreased in size as fishing effort has increased. However the skipjack resource could be quite substantial and therefore worth considering as a development prospect. Good concentrations of skipjack were observed by the SPC Skipjack Survey and Assessment Programme during its tagging operations in 1977-1978 (Kearney *et al* 1978). Even though high estimate of potential commercial catch, 5.5 tonnes per day were obtained within Vanuatu waters the data was very limited in that fishing was only carried out for 6 days and thus could not be used to extrapolate to an annual expectation. In addition the operation was carried out during mid-summer, a period of possible abundance above average (Skipjack Programme, 1983). However, the researchers were confident that even with a ten-fold increase in the skipjack fishery in Vanuatu, "there should be no immediate concern that recruitment would be significantly impaired as a result of this increase". The results of the aerial survey conducted by ORSTOM indicated a small overall quantity of tuna sighted. This was considered as a feature of the method and its limitations rather than an indication of tuna abundance. The ORSTOM scientists estimated the potential surface tuna catches, from aerial surveys results, at around several tens of thousands of tonnes (Petit and Henin, 1982). Habib warned that "such statements should be treated with caution. Without ground truth such as would be provided by a commercial fleet, aerial prospecting has an ephemeral quality".

The SPC survey indicated that significant increases in fishing activities, especially purse-seining, in neighbouring countries may have a serious detrimental effect of the resources available within the Republic's EEZ.

2.2.4 Management

Due to the migratory nature of the tuna species, management of the resource requires a regional approach. These can be in the form of prohibition of certain fishing techniques employed, e.g. no drift gill-netting, and limiting the numbers of fishing vessels. However, the level of exploitation, especially that of skipjack, at present seems to be sustainable. The only kind of control currently operating in the region is geared towards maximising benefits to member countries from the utilisation of the tuna resources by distant fishing nations fishing in the EEZ's through bi-lateral and multi-lateral agreements. However the SPC Tuna and Billfish Assessment Programme is geared towards obtaining sufficient biological information to base management on for the South Pacific tuna fisheries.

Current legislation/policy regarding exploitation: The Department of Fisheries is responsible for the management of the Republic's tuna resource under the Fisheries Act 1983.

Recommended legislation/policy regarding exploitation: The Fisheries Act is currently being reviewed.

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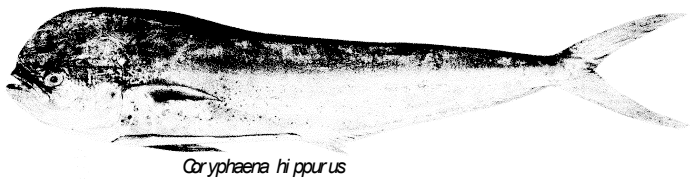
2.3 OTHER OCEANIC PELAGIC FISHES


Coryphaena hippurus

2.3.1 The Resource

Species present: Dolphin fish (*Coryphaena hippurus*), rainbow runner (*Elegatis bipinnulatus*), blue marlin (*Makaira nigricans*), black marlin (*M. indica*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), sailfish (*Istiophorus platypterus*), wahoo (*Acanthocybium solandri*), barracudas (*Sphyraena* spp).

Distribution: These species are normally distributed throughout the oceans in varying abundance determined mostly by food availability. The OFCF study mentioned elsewhere in this report documented them as associated with FADs and in coastal deep waters of Vanuatu and formed a good portion of the by-catches from various specific fishing methods targeting big tunas. Marlins may be more abundant from Espiritu Santo north than further south and that striped marlin are likely to be caught around the southern half of Vanuatu from September to December with a distinct peak in October and November (Williams, undated). Vanuatu is towards the southern limit of the normal range of blue marlin and towards the northern end of the range of striped marlin.

Geographical distributions of the billfish species are given in Nakamura (1985). Generally, they are primarily oceanic, 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.

Biology and ecology: No study has been conducted for these species within Vanuatu waters. Smith (1992) notes that all of these are predators mostly on fish and squid. Some biological information for the billfishes is given Nakamura (quoted above). Sexes are separate and that they are active and voracious predators but are occasionally preyed on by large oceanic fishes such as tunas, wahoo, dolphinfishes and skipjacks particularly during their younger stages. The young are sometimes also taken by adult billfishes. Smith (1992) 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.

2.3.2 The Fishery

Utilization: The survey of village subsistence fishing conducted in Vanuatu in 1983 indicated the production of deep-sea fish but no records were made on offshore pelagic in home consumption. It is assumed then that these species did not form any important component of the subsistence fish consumption.

However, the development of the village fishing programme for off-shore fishing has led to the utilization of these resources on all levels, i.e. village, artisanal and commercial. The majority of the catches are sold to customers at the landing sites, Fisheries Extensions on the islands, Natai in Vila or directly to restaurants (include hotel restaurants). A minor portion is consumed by the family.

Fishing within Vanuatu's EEZ between 1962 and 1977 by the Japanese and Taiwanese longliners also caught several species of marlin, in addition to sailfish and broadbill swordfish.

Production and marketing: No figures are available on the amount consumed on the village level as well as those that go directly to restaurants.

Details of catches by the Japanese (1962 to 1977) and Taiwanese (1967 to 1977) longliners operating within Vanuatu waters between 1962 and 1977 is given in Skipjack Programme (1981) and is summarised for the period 1967 to 1977 in the Table 2.3.2 below. Catch figures are in numbers of fish and effort in thousands of hooks.

Table 2.3.2:

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
Japan											
B/bill	564	104	1	12	47	54	11	3	0	0	0
Str/mar	163	178	2	98	324	223	34	0	0	0	0
Blu/mar	170	99	1	50	217	46	37	23	2	1	1
Bla/mar	33	10	0	5	23	10	16	6	0	1	0
Sailfish	202	18	2	40	171	126	84	41	0	7	0
Total	1,132	409	6	205	782	459	182	73	2	9	1
Effort	1,104	475	2	33	143	188	102	14	5	2	1
C/effort	1.03	0.86	3.0	6.21	5.47	2.44	1.78	5.21	0.40	4.50	1.00
Taiwan											
B/bill	22	44	73	52	70	102	128	50	39	70	85
Str/mar	75	33	20	129	104	313	287	16	30	91	352
Blu/mar	248	329	240	585	610	486	633	338	171	882	358
Bla/mar	9	24	19	50	43	89	60	17	17	30	24
Sailfish	0	28	57	81	18	55	109	42	50	538	166
Total	354	458	409	897	845	1,045	1,217	463	307	1,611	985
Effort	546	493	417	667	1,152	1,271	2,216	772	749	1,305	1,332
C/effort	0.65	0.93	0.98	1.35	0.73	0.82	0.55	0.60	0.41	1.23	0.74

Note: These figures only constitutes the non-tuna portions of the catches using the effort recorded. The rest of the catch (the major portions) are recorded under the Profiles for Tunas.

During the OFCF fishing trials in southern and eastern coastal areas and around FADs off Santo Island during the 1985-86 period the following data were recorded (figures in kg):

Species	1985	1986	Total	Percentage of Total
Skipjack	1,109.3	208.5	1,317.8	17.97
Young yellowfin	1,008.1	391.3	1,399.4	19.09
Yellowfin	204.0	418.8	622.8	8.49
Little Tuna	231.3	54.7	286.0	3.90
Dolphin-fish	**1,374.7**	**642.9**	**2,017.6**	**27.52**
Rainbow runner	**146.5**	**149.2**	**295.7**	**4.03**
Spanish mackerel	**139.8**	**499.8**	**639.6**	**8.72**
Marlins	**38.5**	**670.6**	**709.1**	**9.67**
Other	**13.0**	**30.5**	**43.5**	**0.59**
TOTAL			7,331.5	100

The data extracted from the Fisheries Database did not show any marlin figures been sold through Natai fish market. However, a visit to the facility confirmed the sales of marlin meat as freshly

smoked marlin chunks were offered for sale at VAT 1,500 per kg. Crossland (1984) reported the following purchases (in kgs) of two oceanic pelagic species by both Natai and Santofish for a one

year period between 1983 and 1984:

	Wahoo	Mahimahi
Natai (May 1983-July 1984)	2,011	1,918
Santofish (July 1983-July 1984)	325	743

Those sold to the island Fisheries Extensions, the Natai Fish Market and Santofish are listed in Table 2.3.1 below: (Source: Fisheries Department and Santofish Databases). The value of fish were only available from Natai Fish Market.

Table 2.3.1:

	Natai (kg)	Value (Vatu)	F/Ext (kg)	Santofish (kg)	Total (kg)
1988					
M/mahi	240.2	45,413			240.2
Wahoo					
R/runner	173.8	26,442			173.8
1989					
M/mahi	155.0	31,117		61.5	216.5
Wahoo				263.1	263.1
R/runner	41.0	5,690		37.6	78.6
1990					
M/mahi	103.4	22,616	988.3	131.3	1,223.0
Wahoo				173.1	173.1
R/runner	42.7	6,534		139.4	182.1
1991					
M/mahi	102.4	30,278	73.0	106.9	282.3
Wahoo				527.2	527.2
R/runner	4.6	831		32.5	37.1
1992					
M/mahi	774.2	169,150	3,412.1	548.8	4,735.1
Wahoo				147.0	147.0
R/runner	20.7	3,933		19.3	40.0

2.3.3 Stocks Status

No assessment work on the oceanic pelagic species has been conducted in Vanuatu. Since no fishery specifically targets these except they tend to be "by-catches" of the troll fishing for the tunas, there is no indication of over-exploitation of these resources. Local market demand for these species is very limited except for dolphin fish which has a high value close to that of poulet.

An ACIAR study, conducted by AIMS, looked at the development of gamefishing tourism, with emphasis on billfish, in PNG, Solomon Islands and Vanuatu. Based on Japanese longline catch data between 1962 and 1970 the results indicated that fishing for billfish is likely to be very highly seasonal in Vanuatu. However, blue marlin is expected to be in significant numbers from November through March (Williams, undated-draft document).

2.3.4 Management

Current legislation/policy regarding exploitation: There is no national specific legislation that deals with the harvesting of these resources. However, since they, especially the marlins, form a good portion of the catches by longliners, their utilization would fall under bi-lateral agreements for DWFN to fish in Vanuatu's EEZ.

Recommended legislation/policy regarding exploitation: None seems necessary at present. However, if gamefishing is initiated in Vanuatu, a system of collecting catch data from this development would need to be administered by the Fisheries Department.

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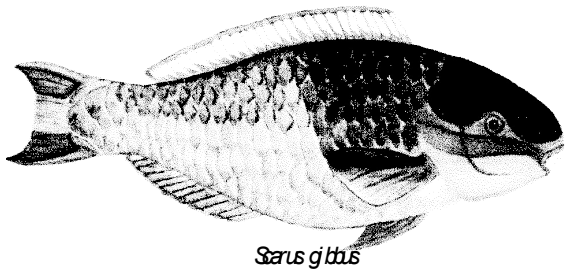
2.4 SHALLOW-WATER REEF FISHES

2.4.1 The Resource


Scarus gibbus

Species present: Fish species accounted for in this section include those that associate with shallow-water reefs, lagoons and mangroves and excludes mackerel and sardines. Species and descriptions of most of the fishes in Vanuatu is given in Fourmanoir and Laboute (1976). The Fisheries Department and ORSTOM are presently compiling a reef-fish species poster of twenty-two species they believe constitute the major commercial reef-fish landings. These include: *Naso lituratus* (orangespine unicornfish), *Kyphosus cinerascens* (highfin rudderfish-topsail drummer), *Epinephelus merra* (honeycomb grouper), *Variola louti* (lunartail grouper), *Scarus blochi* (quoy's parrotfish), *Cheilinus undulatus* (napoleonfish-maori wrasse), *Hemigymnus melaptarus* (blackedge thicklip wrasse), *Plectorhynchus gibbosus* (black sweetlips), *P. orientalis* (oriental sweetlips), *Chaetodon lineatus* (lined butterflyfish), *Lethrinus harak* (blackspot emperor), *L. miniatus* (longnose emperor), *Sargocentron tieroides* (pink squirrelfish), *Lutjanus fulvus* (flametail snapper), *L. gibbus* (humpback snapper), *Mulloidichthys flavolineatus* (yellowstripe goatfish), *Siganus canaliculatus* (seagrass rabbitfish), *S. doliatus* (pencil-streaked rabbitfish), *Acanthurus lineatus* (bluebanded surgeonfish - convict tang), *Shyraena genie* (blackfin barracuda), *Valamugil seheli* (bluespot mullet), *Caranx melampygus* (bluefin trevally) and *Geres oyena* (oyena mojarra).

A recent study, conducted by the Australian Institute of Marine Science on the shallow-water (<30 m) reef fishes in Vanuatu, compiled a check-list of sight records of taxa readily observed by a SCUBA diver (Done and Navin (Eds), 1990). A total of 469 species were identified of which 25, under 6 major groups, were easily distinguishable. These include 10 species of *Pomacentridae*, 5 of *Scaridae*, 3 of *Labridae*, 3 of *Acanthuridae*, 2 *Siganidae* and 2 *Chaetodontidae* (Williams, 1990).

Distribution: Detailed examination of fish communities at Aneityum, Cook Reef, Santo, Gaua and the Reef Islands indicated significance difference amongst the sites although the differences were small compared to those observed for reefs only tens of kilometers apart in the Great Barrier Reef (Williams, 1990). It was also observed that there was no latitudinal variation in structure or species diversity of the communities and no major differences were found between communities on platform reefs and those on fringing reefs. Williams (1990) notes that the south-eastern side of Cook Reef and the eastern side of Santo were particularly rich in fish species and that some species, especially scarids, were more abundant in these areas.

David and Cillaurren (1989) presented the following table on the area distribution of the reefs in Vanuatu down to 400m:

ISLANDS	SURFACE AREA (ha)				
	Island	Shelf	10-100m	100-400m	Total Reef Area
Torres	12,000	1,600	26,130	20,600	48,330
Ureparapara	3,900	289	1,650	5,150	7,080
Vanua Lava	33,000	1,640	6,500	16,390	24,530
Mota	1,500	110	850	3,170	4,130
Mota Lava	3,100	570	2,450	4,120	7,140
Mere Lava	1,500	30	550	1,780	2,360
Gaua	33,000	1,510	3,280	16,990	21,780
Rowa	10	2,630	1,700	4,270	8,600
Santo-Malo	424,800	4,500	60,000	142,970	207,470
Ambae	41,000	230	3,850	11,840	15,920
Maewo	28,000	780	6,030	33,470	40,280
Pentecost	49,000	1,730	8,950	25,000	35,680
Malakula	205,300	10,110	45,100	101,350	156,560
Ambrym	66,500	700	7,250	26,650	34,600
Epi-Paama-Lopevi	47,800	2,500	19,130	76,510	98,140
Tongoa-Tongariki	5,000	150	4,720	16,530	21,400
Emae-Makura-Mataso	3,600	2,020	4,660	30,820	37,500
Efate	92,300	8,070	28,450	95,330	131,850
Erromango	88,700	1,340	4,250	55,660	61,250
Tanna	56,100	1,310	7,450	42,440	51,200
Aniwa	800	310	1,150	5,120	6,580
Futuna	1,100	100	1,400	3,700	5,200
Aneityum	16,000	2,580	18,450	14,820	35,850
TOTAL	1,218,900	44,800	263,950	754,680	1,063,430

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 (groupers and basslets)	carnivorous/ herbivorous/ planktivorous	harem-forming/pair-forming/aggregate-forming; protogynous; spawn at dusk; pelagic eggs	all habitats depending on species; 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, tetradonids 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).

2.4.2 The Fishery

Utilization: The reef fishery has been the main source of fish protein on the subsistence level. The change to a cash-based economy, improved and introduction of modern fishing gear, have further increased the pressure on these very important but potentially vulnerable resources. The methods

employed range from mere collection by hand to gill netting on the reef, set or surround net and diving using spear guns. Spear gun is better to use at night especially when fishing for parrot-fish (Mr. Felix N'Guyen, Fisheries/ORSTOM Technician, *pers. comm*.).

David (1989) differentiated shallow-water fish from deep-sea fish by the ability to see the bottom of the fishing grounds. Thus shallow-water fish are found in areas where the bottom is visible and include reef flats, upper parts of reef slopes, beaches and mangroves with reef flat being the most intensively fished area.

Subsistence village fishing, concentrating mostly around the reefs, has been widely considered secondary to agriculture in Vanuatu. Grandperrin (1977) did not even mention reef fish in his general inventory of the fisheries resources of Vanuatu. However, the village subsistence survey carried in 1983 indicated that throughout the country, half the population, from 8,600 households, was estimated to be involved in some form of fishing activity (David and Cillaurren, 1989). Except for the few villages that are located inland (mostly in Santo and Malekula) all of the fishing households live near the coast, which is about 70% of the population. Throughout the Republic, Malakula, the Banks archipelago, Efate, Santo, Pentecost and Tanna constitute the major fishing population centres. Speaking of reef resource exploitation, David (1990) noted that "fishing is simply a side-line, either for commercial purposes, to bring in extra money for the household in order to meet particular expenses such as taxes, school fees, celebrations; or for subsistence purposes, in which case fishing activity is a regular operation, and only the surplus is marketed".

Apart from the fin-fish resource, species collected mostly for their commercial value from the reefs include trochus, green snail and sea cucumber. These are treated separately under their individual profiles.

"In Vanuatu, fishing in the reef zones is still generally steeped in tradition, using age-old ways and means of fishing" and "generally limited to the shallower areas of coastline, the intertidal zones and infratidal zones, less than 10 metres deep, and to the coastal zones sheltered from the swell" (David, 1990). Fishing boats used in these zones are either traditional canoes with paddles or outboard motors. The reef flats are easily reached on foot. The collection of mollusc is normally done by the women. Fishing methods used include; assegai or spears, bows and arrows, cast nets, fish fences and traps, fishing reel, gill nets, handlines, poisoning using leaves and under-water spearguns. Fin-fish catches from the reefs are becoming a common commodity in the fish markets.

Production and marketing: No recent estimate of the contribution of the shallow waters reef-fish to the subsistence as well as the local market sectors has been made. However, a survey of village fisheries production was estimated for 1983 as part of the country's agriculture census. A comprehensive report was produced on this and the results are presented in David (1985). David (1989) summarized the annual village fishing sector production (confidence interval:1,920-3,011) from that survey to be 2,402 tonnes, consisting of:

Item	Percentage
Fish	42.5
Shellfish	33.5
Lobster	20.5
Octopus	3.0
Fresh-water prawns	0.5

Details of the 1983 survey results, including portion sold and value, as presented by David (1985

and 1989) are as follows, including deep-sea fish:

Product	TOTAL PRODUCTION		PRODUCTION SOLD			
	Number	Weight (tonnes)	Number	Weight (tonnes)	% total production	Value 10^6 vatu
Deep-sea fish	1,430,000	572	307,500	123	21.5	9.8
Shallow-water fish	3,980,000	398	1,114,000	111.5	28	8.9
Fresh-water fish	963,500	48	132,000	7	14	0.5
Octopus	331,800	66	52,000	10.5	15	1.5
Lobsters	981,000	490	498,400	250	51	125
Marine shell-fish (baskets)	202,600	810	13,400	53.5	6.5	1.6
Fresh-water prawns (baskets)	9,000	18				
TOTAL		2,402		555	23	147

Note: -no sales of fresh-water prawns was recorded in the survey.

Records of reef fish sold to the Fisheries Extensions on the outer islands for the period from 1990 to 1992 were given as "mixed reef fish" and is shown in Table 2.4.1. However, mullet is recorded as a separate category. The table also includes shallow reef fishes purchased by the Natai Fish Market, also lumped under a label ("reef-fish") in the Fisheries Department Database (figures in kg).

Table 2.4.1: The purchases of reef fish by the Natai and Fisheries Extension Centres.

	Natai Market		Fisheries Extensions	
	Reef-fish	Value (Vatu)	Mixed reef fish	*V. seheli*
1988	34,064.0	7,708,089	-	
1989	6,492.0	1,086,295	-	
1990	12,881.6	1,973,169	2,679.8	524.7
1991	20,909.1	4,993,410	4,477.3	2,339.1
1992	24,074.2	6,137,480	7,862.0	1,422.6

On the day of the visit to the Natai fish market on 23 June 1993, the "mixed reef fish" for sale that day were made up mostly of parrot-fish (recorded as "blue fish"), a few surgeon-fish (Acanthuridae) and goatfish (*Parupeneus*) which were sold at VT 360 per kg.

Santofish Market sales of reef fish (excluding inshore pelagics, sardine and mackerel, which are discussed under Profiles for Baitfishes-small pelagics) between 1989 and 1992 are recorded in Table 2.4.2 below. Mullet is composed almost exclusively of *V. seheli*. The combined records show increasing totals from this component of the total fish landing. (Figures in kg.).

Table 2.4.2: Sales of reef fishes at Santofish.

	1989	1990	1991	1992
Trevally (caranx)	340.8	1,518.9	821.3	656.3
Rabbitfish	0	4.1	2.0	764.4
Mullet	122.5	204.9	491.7	2,155.7
Reef fish	3,457.2	8,828.8	11,219.0	10,122.5
Total	3,920.5	10,556.7	12,534.0	13,698.9

In addition to the shallow reef fin-fish the Natai Fish Market also purchases reef crabs and mud crabs as shown below for the 1988-1992 period (source: Fisheries Department Data Base).

	1988	1989	1990	1991	1992
Reef crab (kg)	51.9	22.5	8.6	11.3	0
Value (Vatu)	7,943	4,170	2,290	2,663	0
Mud crab (kg)	0	7.5	22.5	13.6	65.5
Value (Vatu)	0	2,550	10,625	4,760	39,300

Information obtained from Bon Marche, Vila, indicated that about 1 tonne of reef fish, including sardines and mackerel, were sold via this supermarket during 1992.

2.4.3 Stocks Status

No information is available that attempts to assess any species stock of the reef fish resources in Vanuatu. Compilation of data by the Fisheries Department make it impossible to trace any trends of individual species. Detail record keeping of landings of the more important species can be initiated. This data can be generally used to deduce trends status of the stocks.

Williams (1990) found no significant human-induced disturbance of the fish communities in those reefs that they studied. However, most reefs examined showed evidence of major disturbances by cyclones and/or crown-of-thorns starfish.

2.4.4 Management

It is only on very rare occasions that dynamite is used to catch fish. Target species include mullet, mackerel, goatfish and topsail drummer schools. However, regulations against dynamite use seem to be widely observed within Vanuatu. Increases in population generally lead to increasing pressure on this more easily accessible resource. Over-exploitation always follows. Growth in the use of more efficient modern fishing gears is apparent and the decline in fishing effort for the deep-water fishery could result in a shift of pressure to shallow-water fishes. There are some indications of pressure coming from foreigners, especially Asians, for access to certain inshore fisheries.

Current legislation/policy regarding exploitation: The use of explosives and poisons for fishing is prohibited under the Fisheries Act 1983 [CAP. 158].

Recommended legislation/policy regarding exploitation: There is some concern on the unregulated use of gillnets utilized in this fishery especially over the reefs. Consideration should be given to setting minimum mesh size limits. The use of speargun and under-water flashlight at night is believed to be very effective on certain species, especially parrotfish, which is the main target species of this method. In addition, the use of SCUBA gear seems to be increasing. Efforts should be made to control these practises. Thorough investigation would be necessary prior to any major undertaking involving commercial operation in the inshore area.

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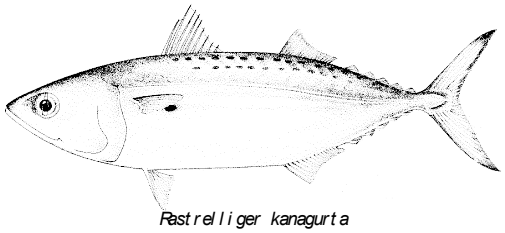

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2.5 BAIT-FISH (SMALL PELAGICS)

2.5.1 The Resource

Species present: The SPC 1977 and 1978 skipjack and baitfish resources assessment in Vanuatu waters identified sixty bait-fish species caught in bouki-ami hauls. The dominant species include: *Spratelloides delicatulus*, *Stolephorus indicus*, *S. devisi, Hypoatherina ovalaua*, *Herklotsichthys punctatus* (*quadrimaculatus*), *Apogon (Rhabdamia) cypselurus, Pterocaesio pisang,* and *Pterocaesio* sp. Other common species include; *Benthosoma fibulatum, P. diagramma, Selar crumenphthalmus, Decapterus macrosoma, Priacanthus* sp., *Xiphasia setifer*, and *Archamia lineolata*. The only information found (available) on the 1982 joint survey of the bait-fish resource by the Fisheries Department and SPFC is a diary of activities (Blackburn, 1982). The dominant species caught by stick-held dip nets fishing using fish gathering lamp at night, as conducted by OFCF in 1985, reported bait-fish catches of the following species: *Herengula ovalis*, *Sardinops melanosticta*, *Allanetta*, *Spratelluides delicaturus*, *Thachurops cruenophthalmus*), *Siphamia versicolor*, *Engraulidae*, *Dussunieria hasselti*, *Grammatorcynus*, *Elagatis bipinnulata*, *Decapterus muroadsi*, *Rastrelliger kanagurta* and others (Anon, 1987).

Distribution: Dalzell (1993) gave some available details of the distribution of the small pelagics in the South Pacific as follows. 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).

Several bays were surveyed using purse-seine, dip net and trap nets yielding very poor results. This survey concluded that areas of high baitfish concentrations could be absent in Vanuatu due to the lack of suitable wide coastal shelf that is characteristic of good baitfish environment (Habib, 1984).

Using admiralty charts, the SPC Assessment survey in 1977 identified only three islands that seemed to have suitable sites for baitfishing using bouki-ami. These were Espiritu Santo, Malekula and Efate. Only five hauls were set in three different sites in only two islands, Turtle Bay (Santo), Port Stanley (Malekula), and Port Sandwich (Malekula) (Tuna Programme, 1983). (Note: The use of the bouki-ami for baitfishing requires that water depth is suitable and the area protected from excessive wind, current and wave action).

Surveys using beach-seines and lampara net were conducted in 1982. Results from both methods yielded results that compared favourably with those of the Skipjack Programme from other parts of the Pacific (Habib, 1984).

The OFCF/Fisheries Department survey in 1982 concentrated in the Santo area within the southern and eastern coast. Because of the presence of many "curves and indentations and numerous inlets and coves", the area was thought to have good fishing grounds for bait-fish. Bait-fishing trials were carried out in twelve locations within these coasts using the stick-held dip net technique. The 12 locations were Port Olry, Hog Harbour, Shark bay, Turtle Bay, Aise Island, Souranda Bay, Palekula Bay, Aore Island, Luganville Anchorage, Tangoa Point, Tasmalne Point and Tasiriki Bay. Schools of *H. ovalis* and *S. delicatulus* were often observed under the wharves within the Luganville anchorage and Palekula Bay where night bait-fishing was prohibited. Adult bait fishes of these two species were only observed for short periods of time (Anon, 1987).

The S.P.F.C./Fisheries Department bait-fish survey of 1982 also conducted surveys within the Palekula Bay, Hog Harbour, Port Olry, Shark Bay, Turtle Bay, Aore and Malo Islands, Tangoa and Tangice Islands and Tasmalum.

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 and 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). The only exception here is the study 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	Spawn	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.), Sharp nosed sprats (*Dussumieris* spp.).				Larger anchovies (*Thrissina* spp., *Stolephorus* 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).

Dalzell (1993) gave a summary table (Table 2.5.1) for the growth, mortality and maturity parameters for a number of small pelagic fish species in the South Pacific and is reproduced below:

Table 2.5.1: 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)	L_m (cm)	L_m/L_∞	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 a*l (1987)
Amblygaster sirm	New Cale	22.9	1.5	2.4	2.0	15.0	0.66	Conand (1988)
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 kanaurta	New Cale	23.7	3.0	3.7	1.0	20.0	0.87	Conand (1988)

Most of the small pelagics are considered planktivorous except that scads, mackerel and the larger anchovies feed on small fishes.

Although the presence of suitable fishing grounds, e.g. along the eastern and southern coasts of Santo Island, due to the presence of numerous coves, inlets and indentations, the absence of atolls there to act as nursery grounds for bait fish fry seem to have an effect on the abundance available. The general features of the coves and inlets are "either shallow for some distance from the shore with coral sand and reef or rocky" (OCFC, 1987). In addition, the areas, except Palikula Bay, are all liable to be influenced by trade wind and are often turbid.

The OFCF report (1987) noted that during April (1985) when most of the nights were calm and stable, schools of *S. melanosticta*, *H. ovalis*, *Allanetta* and *S. delicaturus* gathered well around the fish aggregating lights at night. However, the unsuitable species for bait, such as *S. melanosticta*, *D. muroadsi*, *Grammatorcynus* and *E. bipinnulata* increased in proportion after mid-May. During

poor weather condition in and after June there was a marked decrease in schools aggregating around the lights at night except for very few fry and juvenile fish.

2.5.2 The Fishery

Utilization: Sardines (clupeids) and mackerel *(Rastrelliger* and *Selar* spp.) are caught locally using cast nets, fine mesh gillnets (25 m long) and sometimes jigging (for mackerel) just off the reef using lights and hook-and-line. There is no data available on species composition from the subsistence fisheries to give an indication of the importance of the small pelagic fishery to the local fish-food consumption. The only available data are some from Santofish market on Santo and the Fisheries Extensions on the outer islands. Excess small pelagics, like other marine products, in the outer islands is normally sent to the Natai fish market in Vila. Sardines and mackerel are also sold in the supermarkets, e.g. Bon Marche in Vila.

No details was found on whether the pole-and-line fishery operations that occurred in Vanuatu waters utilized baitfish caught there.

The OFCF baitfish survey had 76.4% of the total catch consisted mainly of *H. ovalis*, *S. melanosticta*, *Allenetta* and that only *H. ovalis*, *S. melanosticta* and *S. delicatulus* were found to be hardy enough to be kept and used as live bait-fish. Other species were unsuitable due to size and poor survival.

During the SPC skipjack and baitfish assessment in Vanuatu, the blue sprat, *S. delicatulus* was the dominant species by numbers and weight. This particular species is regarded as an excellent skipjack bait and is easily attracted to lights around which it forms surface aggregations. The second most abundant species was *S. indicus* but due mainly to its large size and it being extremely delicate, it is useless as bait. The hardyhead, *H. ovalaua* and the sardine, *H. punctatus*, also contributed substantially to the catch but only *H. punctatus* is regarded as a good baitfish for skipjack.

Production and marketing: The total bait-fish catch in four hauls during the SPC survey in December 1977 amounted to 124.5 kg for an average of 31.1 kg per haul. An additional haul was made in Port Stanley in January catching 52.5 kg of bait. It was noted that the results were similar to those executed during the JAMARC surveys which, from 9 hauls, yielded an average of 30.7 kg per haul (SPC, 1983). These figures were among the lowest obtained by the Skipjack Programme in the different countries surveyed and were insufficient to support commercial fishing of vessels the size of Hatsutori Maru 1 which normally requires 50 kg per fishing day.

Catches by the OFCF were as follows:

Species	Catch (kg)
H. ovalis	196
S. melanosticta	104
Allanetta	60
S. delicatulus	17
T. crumenopthalmus	1
S. versicolor	4
Engraulidae	1
D. hasselti	2
Grammatorcynus	10
Elagatis bipinnulata	9
D. muroadsi	41
R. kanagurta	20
Other	6

Baiting in shallower areas was tested in January, February, March and June 1982 by the Fisheries Department. Beach seine was used during the day and lampara net at night. Nine sets of beach seine yielded an average of 29 kg per set and 14 sets of the lampara net gave an average of 39.2 kg. The results compared favourably with those in other countries using these same methods (SPC, 1983). However one of the lampara sets hauled in 364 kg which consisted mainly of the sardine *H. punctatus*, a species which had been shown to undergo significant natural fluctuations in abundance, as noted in Vanuatu, Marshall Islands and Kiribati (SPC, 1983). Excluding the 365 kg haul, the average lampara catch for 13 hauls would be 14.2 kg, a figure much less than the beach seine and bouki-ami catches in Vanuatu.

During the SPFC/Fisheries Department Survey in 1982 the potential bait catches were estimated by Japanese experts to be 2 and 5 tonnes per haul in Hog and Turtle Bay (Santo) respectively (Blackburn, 1982). "However, actual night baitfishing trials in September of that year failed to confirm these estimates, suggesting that the estimates were unduly optimistic and/or were affected by the seasonality of the resource" (Grandperrin et al 1982, quoted in SPC, 1983).

Fresh sardines were sold at Au Bon Marche supermarket on the day (22/6/93) of a visit there during the compilation of information for this report. The sardines were about 4" and were selling for 400VT/kg. No figures are available for the subsistence or artisanal fisheries. The artisanal fishery for sardines and mackerel are mainly in Santo and Efate. Mackerel in Santo is usually caught using nets and spears. The catch in 1991 was reported to be so huge that the Fisheries Extension Centres could not buy it all and the village concerned complained. The catch was loaded on a truck and taken for sale around the island (Mr. Felix N'Guyen, Fisheries/ORSTOM Technician, *pers. comm*.).

Yearly data (weights in kg) of small pelagic fish sold to the Fisheries Extensions on the outer islands are as follows (source Fisheries Department data):

	1990	1991	1992
S. crumennophthalmus	129.0	210.7	689.3
Clupea sp.	1,225.6	192.0	228.5

The summary of inshore pelagics sales at Santofish on Santo is presented in the following table

(weights in kg) (source: Santofish database, Santo):

	1989	1990	1991	1992
Mackerel	6,583.9	9,882.6	12,257.9	6,649.5
Sardine	1,348.6	216.1	238.5	405.3

For the Bon Marche supermarket in Vila, it was estimated that 1 tonne of reef fish was sold during 1992 of which part included sardines and mackerel.

2.5.3 Stocks Status

No study has been done to assess the stocks of small pelagic fishes in Vanuatu and there is currently no bait-fishing for pole-and-line tuna fishing.

The high catch of the sardine, *H. punctatus*, in one of the lampara hauls does not reflect its abundance. This particular species, even though a good bait-fish for skipjack, is vulnerable to exploitation.

The SPC assessment in 1983 concluded that:

> "..examination of coastal charts for Vanuatu suggested that there were few suitable, large baitfishing areas and that total baitfish resource would thus be limited. The SPC survey confirmed this limitation of the baitfish resources vulnerable to exploitation by the bouki-ami technique. Surveys in other areas have shown that species which are available exhibit wide seasonal fluctuations in abundance. The absence in Vanuatu of large quantities of species such as *S. heterolobus*, *S. devisi* or *S. gracilis*, which constitute the bulk of baitfish catches in PNG and Solomon Islands, certainly detracts from the stability of the baitfish resource."
>
> "..the results of day-baiting potential showed some reasonable daily catches but constituted mainly of species which are likely to show marked variability in abundance and rapid decline in abundance in response to fishing pressure. It is therefore concluded that even though some sizeable catches are possible on a seasonal basis, the baitfish resources of Vanuatu are inadequate to support a commercial pole-and-line fleet year-round."

There are indications that some species caught locally in the subsistence and artisanal fisheries as inshore pelagics include those that form the bait-fish fishery for pole-and-line. Subsistence and artisanal levels of exploitation of the small pelagic fishes in Vanuatu, as it is in other South Pacific states, seems to be on a sustainable level. As Dalzell (1993) noted "most reports on possible overfishing of small pelagic stocks are anecdotal without any supportive quantifiable evidence".

Studies in the Solomon Islands have indicated that the occurrence of reef fish juveniles (non-target species) in the commercial bait catches could have a detrimental effect on the subsistence fishery in commercial baitfishing areas (Rawlinson, 1989). However fish caught in the subsistence-artisanal fishery do not eat baitfish except for some pelagic species, mainly Scombridae, which are caught by trolling (Blaber *et al*, 1989 and 1990).

2.5.4 Management

The SPC surveys suggest that supply of live bait-fish may present problems for the commercial operation of a pole-and-line tuna fishery within Vanuatu. Thus the stocks would not be able to sustain and support any commercial harvesting of tuna. In addition the species show seasonality in occurrence. Because of the lack of information on the species caught locally in the subsistence and artisanal fisheries management strategies would be difficult to devise. This is particularly so with the species which have short lifespans and high mortality rates where high fishing might be advantageous as many will die before completing much of their growth (Dalzell, 1993). However, constant heavy fishing pressure would eventually, in addition to the effects of environmental factors, lead to recruitment failures. Perhaps the only management necessary at this stage is the prevention of the use of fine mesh nets and destructive methods to catch species, such as mackerel (*Selar* and *Rastrelliger* spp.) which have a longer (2-4 years) lifespan.

Biological data is required to determine strategies with regards to the management of this important fishery.

Current legislation/policy regarding exploitation: No legislation exists with regards to the exploitation and management of commercial baitfishing or small pelagic fishing for subsistence and artisanal purposes.

Recommended legislation/policy regarding exploitation: Net mesh size for the catching of *Selar* and *Rastrelliger* spp. could be considered. Any attempt to commercially exploit the baitfishery should proceed only after detailed research on the fishery is completed.

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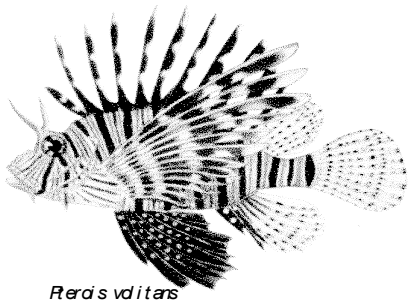
2.6 AQUARIUM FISH (Marine)

2.6.1 The Resource



Species present: Species targeted for this undertaking 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 captive environment (Pyle, 1993). Records of exports from Vanuatu indicate that some of the species (sometimes at juvenile stage) are those that form a portion 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).

A recent study, conducted by the Australian Institute of Marine Science (AIMS) on the shallow-water (<30 m) reef fishes in Vanuatu, compiled a check-list of sight records of taxa readily observed by a SCUBA diver (Williams, 1990). A total of 469 species were identified of which 25, under 6 major groups, were easily distinguishable. These include 10 species of *Pomacentridae*, 5 of *Scaridae*, 3 of *Labridae*, 3 of *Acanthuridae*, 2 *Siganidae* and 2 *Chaetodontidae*.

Distribution: Fish exploited for the aquarium trade in Vanuatu, as is done in other South Pacific islands are all wild-caught marine species from the shallow-water coral reefs surrounding the islands. No information could be obtained on the sites from which aquarium fish have been caught in Vanuatu.

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 above the substrate
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

2.6.2 The Fishery

Utilization: Recently, the smaller size, bright or gaudy coloured reef fishes, including some of the locally consumed species or their juveniles, have been a target for the aquarium export trade from Vanuatu. Exports have been made to Australia, New Zealand, U.S.A. and Japan between March 1992 and June 1993 involving, initially, the Vanuatu Marine Exports company in 1992 followed by Aqua-life Exports in 1993. Details on these companies were not available. Earlier reports indicate that the Fisheries Department has been approached on numerous occasions over the last decade to support the development of a fishery to supply the aquarium fish markets in Europe, Australia, America and Asia (Wright, 1989).

The latest application for a permit to export aquarium fish, dated June 1993, listed 41 different fish named mainly by their common English names and included: orange anthias, bicolor angels, yellow clownfish, blue damsels, clown surgeonfish, convict tang, coral beauty, lemonpeel angelfish, emperor angelfish (juvenile), false skunk clown, bird nose wrasse, assorted lionfish, pacific sailfish tang, moorish idol, longnose butterflyfish, green chromis, domino damsels, false eye toby, blacksaddled toby, olivacerous surgeonfish, *Naso literatus*, spotted unicornfish, thallassoma X, labroides X, coris X, goby X, purple anthias, jensens wrasse, bicolor chromis, melon butterfly, harlequin sweetlips (juvenile), assorted wrasse, orange axil wrasse, electric blue damsels, tailring surgeonfish, leaf fish, ptereleotris X, and black saddled leopard grouper.

Production and marketing: Actual numbers exported were impossible to collect. Wright (1989) stated that in a letter to the Department of Fisheries, a live fish exporting company quoted that it was shipping fish valued at AUS$8-9,000 monthly in 1986. In addition, over a 7-week period in 1985, live fish exports to Hawaii, valued at VT1.4 million, took place. The only recent records made available were those recorded on application forms for permits submitted by the companies prior to a shipment. Because of the numerous species involved, the tables below only records the numbers of fish and estimated value from each permit application submitted and permit granted. [Note: these figures probably differ from those actually shipped and the records may be incomplete. Value is in Vatu unless specified].

Figures from application forms submitted by the exporters for a permit to export marine products.

Date	# of fish	Value	Dest.	Date	# of fish	Value	Dest.
26/??/92	250	16,650	Aus	16/8/92	260	18,150	Aus
??/??/??	198	11,740	??	16/8/92	253	17,760	Aus
17/03/92	??*	6,985	NZ	22/8/92	285	16,810	NZ
17/03/92	151	11,985	NZ	23/8/92	164	16,700	Aus
21/03/92	395	22,060	USA	27/8/92	106	14,560	USA
02/04/92	*165	12,155	NZ	??/8/92	143	13,910	Aus
11/04/92	107	9,350	NZ	8/9/92	211	19,310	USA
25/04/92	137*	8,950	NZ	9/9/92	205	12,190	Aus
6/5/92	190*	12,425	NZ	10/9/92	116	15,060	USA
17/5/92	269	14,040	Aus	15/9/92	111	16,310	USA

14/6/92	346	23,880	Aus	16/9/92	210	11,760	NZ
17/6/92	253	15,805	NZ	17/9/92	131	21,110	USA
18/6/92	218	13,875	USA	24/9/92	110	15,860	USA
1/7/92	259	16,530	Aust	30/9/92	208	12,510	NZ
8/7/92	198	11,620	NZ	30/9/92	200	11,930	NZ
29/7/92	242	12,660	NZ	30/9/92	*208	12,510	??
6/8/92	139	13,800	Aus	??/10/92	210	14,300	Jap
12/8/92	232	11,760	NZ	24/10/92	50	7,500	??
13/8/92	350	25,300	Jap	?7/10/92	210	16,300	Jap??
				16/6/93		534.6 0[1]	Aus

*records on inspection by Fisheries. [1]=AUS$

Export figures for 1992 and the first half of 1993 extracted from Permits granted by the Fisheries Department to exporters to export marine products as follows. It is noted there are differences in these figures from those recorded in the last table.

Date	8-3-92	14-3-92	18-3-92	21-3-92	8-4-92	11-4-92	6-5-92	16-5-92	20-5-92	TOTAL
# Fish	155	229	152	395	165	383	190	190	212	2,071
Value	10,525	22,145	11,985	22,060	12,255	32,490	12,425	8,950	21,080	153,915
Date	14-6-92	14-6-92	18-7-92	19-7-92	26-7-92	29-7-92	13-8-92	16-8-92	16-8-92	
# Fish	346	218	142	339	250	142	350	160	283	2,230
Value	23,880	13,875	12,660	25,060	16,650	12,660	27,300	18,150	17,760	167,995
Date	22-8-92	30-8-92	6-9-92	9-9-92	10-9-92	12-9-92	16-9-92	17-9-92	24-9-92	
# Fish	181	143	139	205	116	232	210	131	116	1,473
Value	16,810	13,910	13,800	12,190	15,060	11,760	11,760	21,110	15,860	132,260
Date	30-9-92	30-9-92	5-10-92	8-10-92	12-10-92	15-10-92	19-10-92	24-10-92		
# Fish	208	200	210	111	210	111	210	50		1,310
Value	12,510	11,930	14,300	16,310	14,300	16,310	16,300	7,500		109,460
Date	6-6-93	27-6-93	30-6-93	18-7-93	28-7-93	4-8-93				1993
# Fish	139	317	317	369	338	338				1,818
Value (AUS$)	322.65	788.20	788.20	1,048.00	893.50	338				4,178.55

2.6.3 Stocks Status

The sites of collection for aquarium fish are not known. Williams (1990) notes that there was no strong evidence of any significant human-induced disturbance of the fish communities on their study reefs within Vanuatu. However, some reef disturbances were apparent as a result of cyclones and crown-of-thorns starfish infestation, as well as removal of mangroves and siltation from soil erosion (from logging operations). Particular areas that are rich in fish species include the south-eastern side of Cook Reef and the eastern side of Santo.

2.6.4 Management

Pyle (1993) gives a comprehensive review of literature of the different views on the effects and management strategies of the aquarium trade undertakings in different countries. In small countries like those in the South Pacific where only one operator (exporter) is 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: Fisheries Regulation 20 prohibits the export of marine fish except with the written permission of the Minister and in accordance with such conditions as he may specify. However, the permission granted under the regulation does not affect any obligation to reach any agreement with custom land owners regarding the use of land and waters for the catching of aquarium fish.

Offences under this regulation is a fine not exceeding VT100,000.

The Fisheries Act 1982 (19) prohibits the use of explosives and poisons to catch fish. Offences under this section is a fine not exceeding VT1,000,000.

Recommended legislation/policy regarding exploitation: 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.

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.

Examination of the data clearly indicates the wide range of the estimated values of fish being exported. This could be a reflection of the differences of prices offered by overseas importers or the unreliability of values submitted. There also seems to be a repetition of data for exports on different dates and the records probably do not reflect actual figures (numbers of fish and value) exported. Consistent and more accurate record keeping is highly recommended.

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

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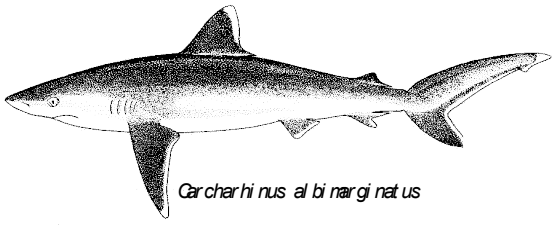
3. CHONDRICHTHYES

3.1 SHARKS

3.1.1 The Resource


Carcharhinus albimarginatus

Species: The cat shark (*Scyliorhinus torazame*), hammerhead (*Sphyrna* sp.) and shortspine spurdog (*Squalus mitsukurii*) were identified during OFCF project between 1984 and 1986. Sharks caught during several SPC deep-bottom fishing expeditions in Vanuatu also recorded *Carcharhinus albimarginatus* (silver-tip shark) and an unidentified species in the catches (Dalzell and Preston, 1992). Other species are listed in Fourmanoir and Laboute (1976).

Distribution: Smith (1992) notes that sharks occur from the reef and inshore areas through to the open oceans, at all depths.

During the OFCF project mentioned above, observations were made of many species of large size sharks in and around the entire coastal water areas of Santo, particularly around the FADs. In a lot of cases during the catch hauling operations in trolling, predation by sharks (and sometimes by barracuda) took place. *S. mitsukurii* were particularly plentiful around FADs.

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.

3.1.2 The Fishery

Utilization: Shark meat is marketed commercially in the local fish market in Port Vila. There is no information to indicate whether consumption is common in the subsistence level. A limited amount of shark fin has been exported.

Currently, shark is a by-catch of the deep-water bottomfish fishery. However, some fishermen set out a specially designed line to catch sharks either as a hobby or for commercial purposes. Records of the SPC deep-bottom fishing trials in Vanuatu indicated that shark made up a very minor portion of the catch (Dalzell and Preston, 1992).

Production: Catch composition of bottomfish catches landed by Fisheries Department vessels in 1983 and 1984 comprised of 9.6% and 16.06% of shark (by weight) respectively. During mid-water long line fishing trials for large yellowfin tuna by OFCF around FADs from October 1985 to June 1986 comprising of 30 fishing operations, 10 sharks were caught. The sharks as well as other fishes caught were preyed upon by sharks. Two sharks were caught during a mid-water vertical longline (during 57 fishing operations from November 11, 85 to July 86).

The sale of shark meat at the Natai Fish Market, which is the only source of data where shark is sold, is comparable with the sales of skipjack through that outlet as indicated in Table 3.1.1 below. The table summarizes annual fish purchases and value for the Natai Market from 1988 to 1992 (source: Fisheries Department Data Base). Between May 1983 and July 1984, 4,379 kg were purchased by Natai while only small quantity was recorded by Santofish at about the same time (Crossland, 1984).

Table 3.1.1: Annual fish purchases and value for the Natai fish market. Those for shark and skipjack are highlighted for comparison.

	1988		1989		1990		1991		1992	
Species	kg	Vatu	kg	Vatu	kg	Vatu	kg	Vatu	kg	Vatu
Coconut crab	3,261.5	1,077,573	3,493.6	1,090,867	1,521.2	469,018	231.3	138,780	1,0?94.5	762,640
Mud crab	0	0	7.5	2,550	22.5	10,625	13.6	4,760	65.5	39,300
Reef crab	51.9	7,943	22.5	4,170	8.6	2,290	11.3	2,663	0	0
Lobster	1,810	1,020,110	850.4	511,515	1,301.3	396,428	1,716.3	1,604,385	1,483.2	1,042,551
Slipper lobster	0	0	37.3	11,005	0	0	9.1	2,730	71.9	28,920
Prawn	88	70,400	422.6	336,470	271.6	657,280	136.9	90,545	67.1	49,730
Shark	**1,138.6**	**61,342**	**725.5**	**53,200**	**851.8**	**63,621**	**1,289.7**	**126,008**	**758.9**	**77,927**
Poulet	29,138.6	6,255,248	26,867.3	7,122,309	25,779.4	7,442,506	34,194.3	10,571,647	31,551.6	10,065,338
Sea perch	5,054.3	967,100	2,671.6	843,992	2,355.5	938,523	8,283.0	2,429,147	17,776.6	528,342
Loche	4,097.1	774,296	3,077.2	648,618	2,031.5	516,554	3,186.8	768,463	2,395.6	543,297
Amberjack	1,677.1	231,128	1,033.9	154,304	1,433.6	224,781	938.7	180,943	1,435.7	320,028
Bream	5,597.9	676,283	2,301.1	449,911	3,155.7	611,644	2,800.6	665,062	2,569.1	581,393
Jobfish	1,538.0	125,882	210.0	40,752	270.1	65,482	452.0	100,314	524.4	110,909
Mahi mahi	240.2	45,413	155.0	31,117	103.4	22,616	102.4	30,278	774.2	169,150
Skipjack	**564.7**	**32,125**	**381.4**	**32,746**	**669.7**	**64,215**	**195.9**	**19,280**	**1,172.5**	**119,861**
Yellow fin	1,335.7	199,685	2,487.6	372,222	2,633.0	479,990	274.5	61,530	2,122.1	503,785
Rainbow runner	173.8	20,442	41	5,690	42.7	6,534	4.6	831	20.7	3,933
Dog t/tuna	768.0	99,973	478.3	68,825	567.7	116,813	76.3	17,106	268.6	45,806
Reef-fish	34,064.0	7,708,089	6,492.4	1,086,295	12,881.6	1,973,169	20,909.1	4,993,410	24,074.2	6,137,480

Records pertaining to the export of shark fin from Vanuatu is presented in the following table. No information was obtained as to the status of this undertaking currently.

Year	Amount (t)	Value	Reference
1980	10.7	US$59,950	Nichols (1993)
1981	14.0	US$71,520	Nichols (1993)
1982	5.0	US$25,910	Nichols (1993)
1983	9.0	US$47,220	Nichols (1993)
1984	22.0	US$46,000	Nichols (1993)
1985	11.0	10,797,000 Vt	Fisheries Annual Report for 1986
(	11.0	US$70,570	Nichols (1993))
1986	5	2,282,000 Vt	Fisheries Annual Report for 1986
(	5		Wright, 1989)
(		US$15,170	Nichols (1993))
1987	-	-	
1988	3	50,000(?) Vt	Fisheries Annual Report for 1989
1989	?	14,000 (?) Vt	Fisheries Annual Report for 1989

No figures could be located for 1990 to the present.

3.1.3 Stocks Status

No information is available on the stocks of sharks in Vanuatu. However, it is believed that they are still plentiful. Observations elsewhere indicate that because of their generally slow growing, populations can be greatly reduced by heavy fishing. Randall *et al* (1990, quoted in Smith 1992) note that removal of these top level carnivores from a community such as a reef system, results in adverse effects.

3.1.4 Management

Current Legislation/Policy Regarding Exploitation: There is no existing (nor proposed) legislation concerning the exploitation of sharks in Vanuatu.

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

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4. FLORA

4.1 MANGROVES

4.1.1 The Resource

Because of the important role the mangroves contribute to the coastal fisheries resources, they are treated as a resource for these profiles.

Species present: Lal and Esrom (1990) lists 13 major mangrove tree species (in eight families) recorded in Vanuatu. They include, *Heritiera littoralis, Exocecaria aqallocha, Xylocarpus qranatum, Ceriop tagal, Rhizophora stylosa, R.. mucronata, R.. apiculata, Bruquiera gymnorhiza B. parviflora, Avicennia marina, Sonneratia caseolaris, S. alba* and *Lumnitzera littorea*.

Distribution: David (1985) estimated that mangroves cover an area of 3,000 ha (+/- 500) for the whole of the Vanuatu archipelago. Of the 80 islands in Vanuatu, only 9 have any extensive growth of mangroves and apart from Malekula, mangroves are found in small clumps scattered along low energy coastlines (Lal and Esrom, 1990). Malekula is the only island which has extensive growth of mangroves found along the shorelines protected by fringing reefs, smaller islands and peninsula protecting bays. David and Cillaurren (1989) gave the following table (Table 4.1.1) on the area distribution of the main mangroves in Vanuatu:

Table 4.1.1:

Island	Mangrove Area (ha)	Mangrove Area Percen-tage	Area of Island	Mangrove area to Island (%)
Malakula	1,975	78.0	205,300	1.0
Hiu	210	8.5	5,280	4.0
Efate	100	4.0	92,300	0.1
Emae	70	3.0	3,280	2.1
Epi	60	2.5	44,500	0.1
Vanua Lava	35	1.5	33,100	0.1
Ureparapara	30	1.0	3,900	0.8
Mota Lava	25	1.0	3,100	0.8
Aniwa	15	0.5	800	1.9
Total	2,460		391,560	0.6

Approximately 86% of the country's mangroves are located on Malekula and Hiu in the Torres group of islands. However, Emae and Aniwa islands are also well endowed since mangroves on each island represent 2% of their respective land masses (David and Cillaurren, 1989).

4.1.2 Mangrove and Associated Fisheries

Utilization: Results of a preliminary survey by Lal and Esrom (1990) indicate that mangroves play an important role in the local subsistence and semi-subsistence economy, particularly in areas

where extensive concentrations of mangroves are found. Subsistence use of mangroves for firewood, mangrove crabs and finfish is significant as shown by a survey of eleven villages situated within or in close proximity of the mangrove ecosystem in the Port Stanley on Malekula and on the adjacent islands of Uripiv, Uri and the Maskelyn. Villages actually situated within the mangroves on smaller offshore islands such as the Makelynes are almost entirely dependent of mangroves for firewood.

Mangrove dependent fisheries products are commonly harvested and villages located within and close to mangroves rely on these ecosystems for their subsistence fishing.

Production and marketing: The average consumption of firewood by villages surveyed by Lal and Esrom in 1990 is given in Table 4.2.2

Table 4.2.2: Statistics on mangrove firewood consumption during the May 3-19, 1990 survey.

Village	Number	Range (bundles per month)	Average (bundles per month)
Potnambe	3 (12)	2-12	7
Potindir	3 (10)		negligible
Litzlitz	11 (42)	2-20	8
Arbotan	3 (5)	6-10	8
Molku	3		negligible
Uri	5 (7)	8-24	15
Vilavi	8 (11)	2-8	4
Potun	4 (9)	2-3	2
Tevri	5 (17)	2-7	3
Peskarus	16 (81)	8-20	12
Pellonk	10 (40)	10-20	15
Penap	NA (18)		NA
Rambuan	NA (14)		NA

On Uliveo Island, an average of 15-24 bundles of mangrove wood per month per household is burnt as fuelwood. Using an average wet weight of 20 kg per bundle, Lal and Esrom (1990) estimated an annual consumption of mangrove wood to be 3,600-4,800 kg per household. In Port Stanley Bay region on Uri, the monthly mangrove fuelwood consumption range between 8 and 24 bundles (160-480 kg) per household.

The common finfish species targeted in the mangrove areas include mullets, rabbit fish and goat fish. In the Maskelyn islands, David (in press, quoted in Lal and Esrom, 1990) noted that 66 species of finfish were caught regularly from the mangrove areas of which 29 species were exclusively caught there. Subsistence consumption of fish products was estimated to be 10 kg per month per household (Lal and Esrom, 1990). However, the proportion from the mangrove areas was impossible to estimate. Production of the land crab, *Cardiosoma* sp. for both subsistence and for sale in the Port Stanley area is reported under the Land Crab Profile. Another important fishery, reported for the Port Stanley region and on the Maskelyne islands is the mangrove crab, *Scylla serrata*, which is often specifically caught to supply restaurants in Port Vila. One household from each of Uri and Uripiv were known to catch crabs on orders from restaurants in Vila. No production figures were available. David (1989) estimated that the annual fish production from mangroves and shelves, in numbers, is 3,963,200 as compared to 1,447,300 from the outer slope (10-400m). Productions in numbers per hectare were then estimated to be 80 and 1.5 respectively for the two areas.

4.1.3 Mangroves Status

Lal and Esrom (1990) note that the pressures on the mangrove resource from development is small due to their being distant from main urban centres. However, development for tourism has resulted in some reclamation on mangrove areas on Efate and adjacent islands and Iruiti island. Clearing of about 100 m of mangroves in Port Stanley was caused by the extension of the wharf on Malekula to accommodate the needs for a logging project. In the rural areas indiscriminate harvesting of mangroves for fuelwood, increasing village sizes and clearing for easier access to the sea present some problems. These have been noticeable in villages in Port Stanley and Crab Bay, and on Uliveo island. The entire coast of Uliveo island is believed to have had a fringe of mangroves in the 1940's. The northern side has been replaced by a sandy beach.

4.1.4 Management

Systematic management of mangroves does not exist in Vanuatu and the government relies on existing institutional mechanisms to address mangrove management issues arising from development on custom land (Lal and Esrom, 1990). Any development on custom land requires the non-owners to obtain a lease from custom land owners. Negotiation of leases on tourism development, forestry, agriculture etc. is handled by the Ministry of Lands. Proposals for physical development involving actual alienation of land for a period of time (e.g. hotel development) are deliberated by the Rural Alienated Lands Committee (RALC). Environmental Impact Assessment (EIA) is required for large-scale projects. However the EIA requirement is not currently based on any legislation. A lease is issued subject to restrictions stipulated by the Ministry of Lands and a number of covenants have been developed. Under the Land Lease Act 1983, one of the covenants included in the standard form of commercial lease is the provision that the commercial leasee agrees not to fell or otherwise destroy mangroves growing on the stated land or in the sea contiguous thereto.

Current legislation/policy regarding exploitation: Commercial harvest of mangrove forest products is totally banned (??). Even though the government does not have a formal policy on commercial logging of mangroves, the Environment Unit has adopted an informal policy of not allowing commercial logging of mangroves or large scale reclamation of mangrove areas for alternative uses (Lal and Esrom, 1990).

Recommended legislation/policy regarding exploitation: Legal back-up of the EIA requirement that is used by the Rural Alienated Lands Committee.

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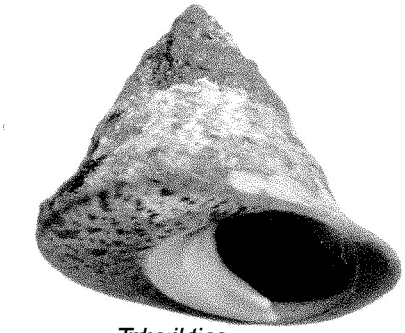
5. MOLLUSCS

5.1 TROCHUS

5.1.1 The Resource


Trochus niloticus

Species present: The top shell, *Trochus niloticus*, and *Tectus pyramis* are present.

Distribution: The natural distribution of trochus is dependent on the presence of coral reefs. It occurs in the intertropical belt between the Andaman Islands in the Indian Ocean and the islands of Fiji and Wallis in the Pacific (Bour, 1988). The edge of its natural habitat in the Western Pacific was marked by an oblique line running from Palau down to Wallis. However, with the many successful translocations and introductions, the area now inhabited by trochus extends more to the east. Within Vanuatu, *T. niloticus* is generally spread throughout reefs with suitable habitats.

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

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

Sexual maturity is reached in the second year (size 5-6 cm). Spawning occurs throughout the year in Vanuatu, at night during few days before new moon or few days after new moon. Male and female gametes are released into the sea where fertilization takes place. The fertilized eggs are covered with a thick chorion which protects the embryo. After hatching, the trochophore develops a larval shell (the protoconch) and swims towards the surface using the ciliated velum. At this stage it has become a lecithtrophic veliger. After a few days, the veliger settles on a substrate, sheds its velum and begins to crawl along on its single foot feeding on microscopic algae.

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

ovocytes (Nash, 1985). Bour (1990) sampled 596 mature females and found the following average fecundity per size class:

Average diameter (in cm)	70	80	90	100	110	120	130
Average fecundity (X 1000)	511	562	592	660	690	974	3003

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

5.1.2 The Fishery

Utilization: Collection of trochus for its protein-rich flesh has been a traditional activity on the islands for a long time. However, since the end of the 19th century, the sale of trochus shells for its pearl-shell had become apparent in Vanuatu. French settlers were reported to have harvested trochus for the shells in Vanuatu at the beginning of the 20th century. Commercial harvesting is likely to have started during the 19th century with the rise of the bêche-de-mer industry, not only in Vanuatu but also the rest of the Pacific. At present, trochus is one of the major inshore resources in the Republic generating incomes for the rural communities. The major uses are for the local production of button blanks, shell jewellery and other artefacts. Shell exports are mainly to South Korea and Japan (Kenneth, undated). World demand for pearl-shell has increased considerably since 1989.

Trochus shells are collected throughout Vanuatu, by hand on the reef by rural fishermen diving with goggles or face mask. Extraction of trochus meat is done after shell has been boiled. The extracted meat is consumed as a source of protein while the shell is sold.

The table below shows the number and percentage of households in Vanuatu that are engaged in the collection of trochus shells.

Area	No. Households fishing for trochus	% Households fishing for trochus
Banks/Torres	491	61
Santo/Malo	336	20
Ambae/Maewo	86	9
Pentecost	470	50
Malekula	643	33
Ambrym	153	21
Paama	9	20
Epi	339	27
Shepherds	164	27
Efate	392	34
Tafea	130	8
VANUATU	3213	29

T. pyramis, which is widely distributed in the Vanuatu waters, is also utilised on a subsistence level for food. The shells are sometimes sold as ornaments to the tourists.

Production and Marketing: David (1985) established the number of people engaged in fishing for

trochus for each island in Vanuatu. The main trochus fishing islands are listed below:

Island	# Trochus Fishers	% of Fishermen
Malekula	694	34
Epi	223	100
Tongoa	177	90
Efate	173	17.5

No records of trochus production at the beginning of the century are available except that 60 tonnes was quoted as the trochus export figure in 1921 (Dunbar, 1981). Export statistics on production are only available since 1969.

The table below shows exportation figures of trochus button blanks from 1986 to 1992 from Vanuatu (Amos, 1992).

Year	Trochus (tonnes)
1986	9.0
1987	26.0
1988	40.0
1989	78.0
1990	51.0
1991	67.9
1992	195.39

At present there are 5 established shell processing factories in Vanuatu. The prices offered for shells vary according to each factory but range from VT 170 to VT 300 per kg of shell.

Trochus shells are processed into button blanks for the high quality garment industry. Japanese companies are the leaders in this sector and thus set the price trends for the products. Vanuatu shell factories export their processed products to Japan, Italy, France, Hong Kong, Singapore, Taiwan and Korea.

5.1.3 Stocks Status

Experiences in other Pacific Island countries and recent history have shown that *T. niloticus* is sensitive to intensive fishing. Though the populations may be dense, they can be severely depleted in a short period of time.

The first trochus stock survey in Vanuatu was done by L.C. Devambez in 1959 which resulted in a 4-year closure on trochus fishing (Devambez, 1959). The results of this survey indicated that:

- the average age of the trochus populations of 3 years old was high
- the proportion of young shells under 3 years old was extremely low
- the density of trochus on the reefs was noticeably low, (the average take per diver/hour was 7 trochus)

A second stock survey was conducted by the same researchers in 1961. He concluded that the stocks had increased (the average take per diver/hour was 24.1 trochus). The results of this survey persuaded the Government (Condominium Government of the New Hebrides) to re-open the fishery in 1962 (Devambez, 1961).

Further stock surveys were carried out in 1990, 1991 and 1992. These surveys indicate that the stocks were rapidly declining, thus tighter management controls have to be implemented to ensure the sustainability of the resource. In early 1993 the Government introduce a quota system for the established factories. Each factory is only allowed to process 75 tonnes of raw trochus shells per year.

There are no estimated figures of the current trochus stocks but the export figures show that the level of exploitation on the trochus stocks has increased tremendously as a result of the establishment of the 5 processing factories and the competitive prices offered for the shells by each factory.

It has been estimated that a factory requires 10 tonnes of raw trochus shells to produce 1 ton of blank buttons. Thus the established factories, during the period of 1990 to 1992, processed a total of 3,142.90 tonnes of raw trochus shells as follows (Amos, 1992):

- 510 tonnes of raw trochus shells in 1990,
- 679 tonnes of raw trochus shells in 1991, and
- 1,953.9 tonnes of raw trochus shells in 1992.

5.1.4 Management

Trochus resources in Vanuatu have been managed by a variety of methods. In early 1959 the Condominium Government of the New Hebrides instigated a 4 years closed season on trochus fishing. When the fishery was re-opened in 1962, a quota was enforced. The quota system was implemented as an Export quota of 75 tonnes (whole shell weight) per year for the entire country. This system ceased to operate in 1983, when a policy was introduced by the Government to prohibit the export of whole trochus shells from the country, so that the shells could be processed into button blanks prior to export.

Current legislation/policy regarding exploitation: The Fisheries Regulations 17 prohibits the taking, harming, possessing, selling or purchasing of any trochus which is less than 9.00 centimeters in diameter when measured across the base. Exportation of whole trochus shell is illegal without the written permission of the Minister and it must comply with conditions he specifies.

Offences: Any person who contravenes any of the provision of this part shall be guilty of an offence and liable to a maximum fine of VT 100,000.

In early 1993 the Government introduced a quota system for the established factories. Each factory is only allowed to process 75 tonnes of raw trochus shells per year.

Recommended legislation/policy regarding exploitation: There does not seem to be adequate CPUE data to establish quotas that optimises the utilization of this resource. Discrete, separate quotas should be made for each specific and major area of exploitation. Rotational harvesting of the main areas is a possible way to exploit the fishery on a sustainable basis.

Time series stock assessments are required to set realistic quotas.

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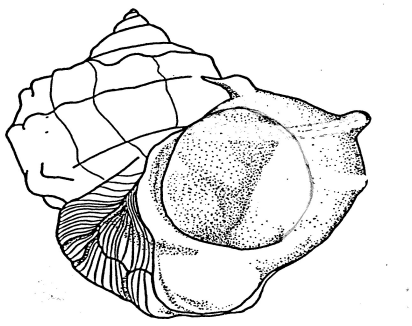
5.2 GREEN SNAIL

5.2.1 The Resource


Turbo marmoratus

Species present: *Turbo marmoratus*

Distribution: *T. marmoratus* is not widely distributed in the Pacific. It is exploited in only a few Pacific Island Countries including PNG and Solomon Islands. However it is widely distributed in the southward of Yakushima island and in some southeast Asian countries such as Burma, Indonesia and the Philippines. Recently, green snail stocks are thought to have diminished in Papua New Guinea and Indonesia due to over-exploitation. In Vanuatu, *T. marmoratus* is widely distributed throughout the archipelago.

Biology and ecology: The green snail, *T. marmoratus* (family turbinidae) is the largest of the turban snails. It has a thick shell which can exceed 20.0 cm in shell width and 3 kg in total weight. The foot of the conical shell of the adult is swollen, and that of the young, round and smooth. The green snail has a massive white operculum which has a smooth inner surface.

Green snails inhabit the seaward reef slopes in shallow water down to about 15 metres. They are nocturnal in nature and feed on algae growing on dead corals and rock surfaces.

Green snails are dioecious broadcast spawners. Male and female gametes are released into the sea where fertilization takes place. A study on sexual maturity of green snails in Vanuatu made by L.C. Devambez (Devambez, 1961) in 1961 concluded that green snails reach sexual maturity at a size between 11.0 cm and 15.0 cm in diameter.

No comprehensive study has been done in Vanuatu to determine a predictable monthly spawning schedule for green snails. However hatchery observations on green snail spawning carried out by the Vanuatu Fisheries Research Officers indicate that the snails spawn throughout the year, at night during few nights before full moon or after full moon. During the green snail spawning inductions at the Vanuatu Fisheries Department Trochus Hatchery, 5.5 million eggs were collected from a 12.0 cm size female snail. In fact, fecundity of large green snails can go up to 7 million eggs per female.

5.2.2 The Fishery

Utilization: Green snail shells are of great demand commercially. The shells are used mainly for decorative inlay work. The processing of green snail is very specialized. Machinery used for cutting and slicing of the shell is very technical and costly.

Green snails have been harvested by the local Ni-Vanuatu in large numbers since prehistoric times because of its tasty flesh as a source of protein, large size, and ease of capture.

Green snail is a vital resource for many small communities in Vanuatu. The harvesting of these snails is small but provides a significant source of revenue and employment. The sale of these gastropods is sometimes the only form of cash-crop available in some regions making the conservation of this resource of paramount importance.

The table below shows the level of households engaged in the collection green snails in Vanuatu.

Regions	No.Households looking for green snails	% Households looking for green snails
Banks/Torres	326	40
Santo/Malo	316	19
Ambae/Maewo	38	4
Pentecost	225	24
Malekula	586	30
Ambrym	153	21
Paama	9	20
Epi	210	56
Shepherds	147	24
Efate	333	29
Tafea	148	9
VANUATU	2491	23

T. setosus, a member of the Turban family, is widely distributed in the archipelago and are harvested in large amounts specifically for subsistence requirements. No figures are available on the production of this species for consumption.

Production and marketing: *T. marmoratus* is the premium commercial shell. Current FOB price for good grade green snail cuts range from 16,000 to 20,000 USD per tonne.

The major market for green snail is South Korea. The nacreous shell of green snail is a highly prized shell for inlay material of furniture lacquerware and jewellery and hence attracts a premium over all other shells in South Korea.

Green snail production in Vanuatu is small compare to trochus production. However price per kg is higher than that of trochus shells. The current price for good quality green snail shells is VT 1,700 - VT 2,000 per kg.

Export figures of green snail cuts from Vanuatu between 1986 and 1992 are shown in the following table (Source: Amos, 1992).

Year	Green Snail cuts (tonnes)
1986	15.00
1987	12.00
1988	10.00
1989	12.00
1990	10.00
1991	44.00
1992	7.35

5.2.3 Stocks Status

Green snail harvesting in Vanuatu for other than subsistence purposes has a long history. Green snail resources have been harvested mainly for export purposes since the beginning of the 19th century. It is a mature fishery, not a recent development like the deep bottom-fish fishery. Thus green snail stocks within the archipelago have been influenced by long term exploitation as well as natural phenomena.

Devambez (1956) noted that during his first survey of the southern islands of Vanuatu in 1959, it took 6 divers 45 minutes to gather 11 green snails at Anelgohat reef in Anietyum island. During his second survey in 1961 at the same site, it took 2 divers 10 minutes to collect 13 green snails (Devambez, 1961).

There have not been any comprehensive studies on the current green snail stocks, however the sharp decline from 44.00 tonnes in 1991 to 7.35 tonnes in 1992 indicates a decline of green snails in the archipelago.

5.2.4 Management

The current legislation/policy regarding exploitation: The current implemented management control that protects the green snail resources in Vanuatu is a Minimum Size Limit regulation. The legal harvesting size of green snail in Vanuatu is set at 15.00 centimeters basal length (diameter). The regulation reads:

> "No person shall harm, take, have in his possession, sell or purchase any green snail which is less than 15.00 centimeters in length when measured in its longest dimension."
>
> "No person shall export green snail except with the written permission of the Minister and in accordance with such conditions as he may specify."

Offences: Any person who contravenes any of the provision of this part shall be guilty of an offence and liable to a maximum fine of VT 100,000.

Recommended legislation/policy regarding exploitation: Assessment of the status of stocks of green snail in Vanuatu is urgently needed in order to formulate any additional regulation that might be necessary for its sustainable utilization. Such assessments would also indicate the effectiveness of the current regulation on minimum size limit.

References

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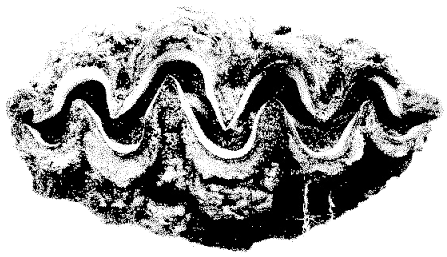
5.3 GIANT CLAMS

5.3.1 The Resource



Tridacna maxima

Species present: Four species of giant clams have been recorded in Vanuatu waters. These include *Tridacna maxima* (the elongated or rugose giant clam), *T. squamosa* (the scaley or fluted giant clam), *T. crocea* (the boring or crocus clam) and *Hippopus hippopus* (the horse's hoof, rolling clam, bear paw or strawberry clam). *T. gigas* (the Giant clam) and *T. derasa* (smooth giant clam) were recorded by Rosewater (1965) as present in Vanuatu but recent surveys indicate the rarity or absence of these two species and thus their possible local extinctions.

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. Due to over-exploitation or climatic changes the range of *T. gigas* has diminished a great deal. Several of the species, especially, *T. gigas*, *T. derasa* and *H. hippopus* have been introduced to some countries outside of their natural ranges.

The results of a survey investigating distribution and abundance of giant clams in Vanuatu, conducted at 29 sites on 13 islands, was reported by Zann and Ayling (1988). It showed that *T. maxima* is the most common species found on all islands surveyed in the archipelago. *H. hippopus* is found on almost all of the islands and most abundant on the uninhabited Cook Reef and Reef islands but absent from heavily populated areas such as Malekula. *T. crocea* was recorded only from Moso Island off Efate and Sakau Island near Malekula. The distribution of *T. squamosa* is obscure as only dead shells were recorded on only 2 islands, Aneityum and Cook Reef, during the 1988 survey and five live clams were recorded in the Malakula group during the detailed survey of the area. However, it could be on more islands as it was possible they had been included in the *T. maxima* counts. Both *T. gigas* and *T. derasa* have not been recorded on any island recently. However, Fisheries personnel indicated that the smooth clam (possibly *T. derasa*) were seen being offered for sale at the Vila public market. This was on very rare occasion and the possible source could have been the Moso or Lelepa Islands.

Biology and ecology: The giant clam family, Tridacnidae, currently has nine living species in two genera, *Tridacna* (Bruguiere) and *Hippopus* (Lamarck) and include 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 nutrient salt 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 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). Fecundity of *T. maxima* was estimated by Jameson (1974), and Munro (1993) reported that a 20 cm specimen with ripe

gonads would contain 20 million eggs. Eggs produced from 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 duration 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.

5.3.2 The Fishery

Utilization: Dalzell (1990) noted that giant clams are an esteemed food item for ni-Vanuatu who consume an average of 19.1 kg of shellfish/capita/yr, making them an important component of sea-food consumption in the subsistence sector.

The supply of giant clams to the public market in Vila has mainly been from north Efate, i.e. Moso and Lelepa Islands. On most of the islands, giant clams are collected as a subsistence food item.

Shells of giant clams, mostly *H. hippopus* are often offered for sale in Port Vila streets.

Production and marketing: No figures are available but the total annual estimated subsistence harvest in 1983 of 2,403t consisted of 33.5%, by weight, of shellfish comprising of oysters, clams and cockle families (David, 1985). Relative composition of the three families were not given.

Only on rare occasions are giant clams seen offered for sale in the public market in Vila. This is mostly on Saturdays and the species involved are *H. hippopus, T. squamosa* and sometimes *T. maxima* which are sold in baskets (Felix N'Guyen, Fisheries Research/ORSTOM Technician, 1993, *pers. comm*.).

Estimates of landings and revenue from the sales of shells is not known.

5.3.3 Stocks Status

T. gigas and *T. derasa* are believed to have become locally extinct since recent surveys did not find any specimen, even though Vanuatu was included in the distribution of these species by Rosewater (1965). However, discussion with Fisheries Officers seem to indicate that some smooth-shelled clams (possibly *T. derasa*) have been seen in the public market. This needs to be confirmed with clam divers from the Moso and Lelepa islands. *T. gigas* fossils were reported by Munro (quoted in Zann and Ayling, 1988) from Efate. Zann and Ayling (1988, and 1990) provided the following tables on the distribution and abundance of the giant clam stocks for species found in Vanuatu at sites on which rapid surveys were conducted in 1988. The areas covered were the reef slopes (< 10 m depths) and lagoon reef patches using spot dives and manta tows.

Location	Abundance (numbers per hectare)			
	T. maxima	*T. squamosa*	*T. crocea*	*H. hippopus*
Anatom				
Port Anatom	16	shells only	-	-
Inyeug Island	50	-	-	shells only
	20	-	-	10
Port Patrick	16	-	-	-
Tanna				
Leviar	5	-	-	-
Port Resolution	-	-	-	-
Erramango				
Dillon's Bay	shells only	-	-	-
Efate				
Lelepa	3	-	-	-
Malao Bay	-	-	-	shells only
Moso Island	7	-	3	3
Cook's Reef	10	shells only	-	25
	5	-	-	1
Pentecost				
Wanuru	6	-	-	9
Lontong Bay	20	-	-	-
Gaua				
Lesalau Bay	9	-	-	1
Ureparapara	shells only	-	-	-
Reef Islands	13	-	-	23
	shells only	-	-	shells only
Epiritu Santo				
Big Bay	-	-	-	-
Hog Bay	2	-	-	2
Turtle Bay	-	-	-	-

A detailed survey, using replicate belt transects, at selected locations in the Malekula Group was presented by the same authors as reproduced in the following table. No clams were found on the reef flats.

	Abundance (numbers per hectares)							
	Reef Crest				Reef slope			
	T.m.	T.s	T.c	H.h.	T.m.	T.s	T.c	H.h.
Maskelynes								
Matai/SE:exp	24	-	-	-	8	8	-	-
Sakau/SE:exp	32	-	-	-	16	8	-	-
Sakau/S:m. exp	-	-	-	-	8	8	-	-
Sakau/NW:shel	-	-	48	-	-	-	-	-
Cook Bay:v. shel	-	-	8	-	24	8	-	-
Atchin Island								
SE:exp	-	-	-	-	16	-	-	-
Malakula								
Port Sandwich								
E:exp	8	-	-	-	8	-	-	-
E:exp	-	-	-	-	-	8	-	-

T. maxima is the only species that was recorded in all of the islands surveyed. Even though *H. hippopus* was not found on all of the islands, significant populations exist in uninhabited areas, Cook's reef and Reef Island. However, this species was not found in the detailed survey in the Malekula Group which is more heavily populated. *T. crocea* is rare and was recorded only at Moso Island and off Sakau Island near Malekula. However, its abundance at Sakau/NW:shel. was high. Live *T. squamosa* were only located at five sites in Malekula with low abundance.

5.3.4 Management

Over-exploitation leading to local extinction has been well documented for giant clams. However, the effect of this on the giant clam populations in Vanuatu is not known.

Some shells of giant clams offered for sale in the Port Vila streets are far too small as far as conservation of stocks is concerned. It was not possible to confirm whether these shells have any bearing on the sizes harvested for consumption or whether those particular shells were dead when found. [A man is believed to have died in Emae as a result of eating *H. hippopus*. This resulted in the village putting a tabu on the sea area where the clam was collected. The belief is that perhaps the clam was removed from an area that was considered tabu (Mr. Moses Amos, Fisheries Biologist, Fisheries Department, Vanuatu, *pers comm*.)].

Current legislation/policy regarding exploitation: There is currently no legislation in force for the management of giant clams in Vanuatu. However, a marine reserve has been established at Crab Bay in Malekula. The area has giant clams, mostly *H. hippopus* (Mr. Moses Amos, Fisheries Biologist, Fisheries Department, Vanuatu, *pers comm*.).

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 rapid and successful progress in giant clam mariculture offers the possibility of augmenting or re-seeding depleted areas using hatchery-reared juvenile clams.

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

Zann and Ayling (1988) recommended the following for consideration:

- Government accord special protection to uninhabited Cook's reef and Reef Islands, where *H. hippopus* are common.
- reintroduce *T. gigas* and restock *H. hippopus*.

The low levels of *T. squamosa* recorded would also single out this species as needing restocking. Fairbairn (1992) concludes that prospects exist in Vanuatu for the establishment of giant clam mariculture projects, especially in certain areas on Santo, Efate, and Malakula. A project of this nature would, however, require the support of the village council and chiefs, and the landowners concerned.

Establishment of a small-scale giant clam hatchery for re-seeding purposes of the native species would seem feasible. Facility costs would be minimum as the existing hatchery for trochus/green snail can be used.

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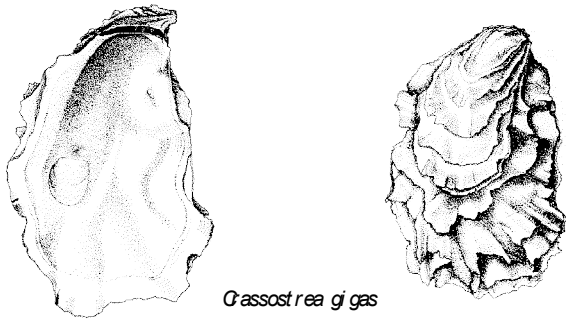
5.4 OYSTERS

5.4.1 The Resource


Crassostrea gigas

Species present: Endemic species include, *Saccostrea glomerata* (formerly *Crassostrea glomerata*) and *Crassostrea echinata*. *C. gigas* was introduced in the 1920's.

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

Very little is known about the distribution of native oysters species in the Vanuatu waters, except for oysters found near Turtle Bay (Santo) which are of the introduced species from Australia in 1920. Oysters are found in Port Sandwich (Malekula), Port Havannah (Efate), also north of Port Havannah Bay, and the inner lagoon at Erakor (Efate).

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

The soft body of the bivalves is fully enclosed in a shell and a mantle with which the shell is, so to speak, lined. There is also a gill between the mantle and internal organs. On the back edge of the body are a number of water pores through which water is drawn in to pass through the gill and thus constitute the breathing function. At the same time, the gill also functions to separate debris in the water from edible suspended matter such as plankton for the ingestive process. The volume of water thus processed by the gill in the case of "Magaki" (Pacific cupped oyster) is said to be about 10 litres per hour. Virginia oyster (American cupped oyster) filters about 5-25 litres/hour at a water temperature of 20 C°. This means that some oysters process more than 1000 times their body weight (without shell) of water every hour (Yamaha, 1989). The amount of vegetable planktons consumed by an adult oyster in one day is thought to be between 1 and 5 grams.

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

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

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

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

5.4.2 The Fishery

Utilization: Oyster culture has been practised since ancient times. The fine taste of the oyster meat itself must have prompted man to attempt the deliberate production of oysters.

The estimated annual worldwide harvest of oysters is around one million tons (weight including shell), most of which is the product of artificial proliferation and culture fisheries (Yamaha, 1989). The principal species include the Pacific cupped oyster (*C. gigas*), American cupped oyster (*C. virginica*), European flat oyster (*Ostrea edulis*) and Portuguese cupped oyster (*C. angulata*).

Like many other South Pacific island countries, oyster farming on a trial basis had been attempted in Vanuatu during the 1970's. The farming trial was not successful. At present, oyster is mainly utilised for subsistence consumption with a small portion marketed locally.

Production and marketing: The main oyster producing nations are Japan, Korea, Mexico, France, and the U.S.A. Among these the U.S.A., Japan and Korea are the major producers, each counting for between 23 and 26% of the total world production (Yamaha, 1989).

Production of oysters in Vanuatu is very small and no records exist even for the portion that is marketed locally.

Oyster culture experiments were initiated in Vanuatu in 1972. Van Pel (1956), suggested that the Philippine method of rack culture be employed. Suitable culture locations included the shallow sheltered waters of southeast Santo, southeast Malekula, in the northern lagoon of Port Vila, in the inner lagoon at Erakor, and in Port Resolution (Tanna). The protected waters in Port Sandwich was suggested as a good place for the initials trials.

The rationale for oyster culture in Vanuatu included meeting local demand and exporting surplus production (Hallier, 1977). *C. gigas* was selected for culture, in preference to the two local species for the following reasons:

- *C. gigas* is virtually the sole species existing in the South Pacific for which large supplies of spat are easily available;
- this avoids the difficulties attending the collection of native spat, a tricky matter since local stocks are never very large and little is known about their spawning period;
- *C. gigas*, a fast growing species, is very similar in appearance and taste to *C. angulata* and therefore likely to go down well with European consumers in Vanuatu and in New Caledonia (Hallier 1977).

Oyster culture experiments were conducted at the following locations:

- the Mounparap Oyster Breeding Station on the island of Santo,
- Lamap in Port Sandwich Bay farm in Malekula island, and

- the island of Efate (Erakor lagoon).

In October of 1972, 20,000 unattached spat of *C. gigas* from the hatchery of W. Budge Mariculture Farm, Pescadero, California, were planted in Mounparap Bay (Santo). During 1973, batches of 100,000 spat came in approximately every six weeks. About 600,000 *C. gigas* spat were grown in the Santo farm. This farm materialised through an association of private interests (Autrand, 1973). The venture received financial assistance from the New Hebrides Condominium in the form of long-term credit and the experiment was conducted for over a period of two years. Spats of the native rock oyster, *C. echinata*, was also collected and farmed by a private oyster farm (Doumenge, 1973).

The Port Sandwich Oyster farm was set up in April, 1973. This venture was formed by 165 islanders from five villages in the area and the operation was financed by the French Administration. 100,000 *C. gigas* seeds were imported from the same California hatchery. Continuous trials were conducted for over a period of one year. Growth rates recorded were comparable to those obtained at the Santo operation.

Results from these experiments were disappointing and the breeding of *C. gigas* in Vanuatu had to be discontinued without any definite conclusions been reached. The harmful action of the parasites, *Polydora*, and especially *Pseudostylochus*[7], were observed. High mortality rates and poor growth were observed during the hot season, which was also the period of highest rainfall.

However, a private oyster farm set in Santo in 1972 had better results. Production was 4,000 dozen/month, which was marketed in Luganville and Vila. However, the two most significant problems that remained were irregular supplies of spat and the control of the predator, *Pseudostylochus*.

5.4.3 Stocks Status

There is no consistent records of the current stocks of oysters in the Vanuatu waters and there have not been any surveys done on the very small existing stocks.

Van Pel (1956), based on his observations, reported that oysters appear to be plentiful in Vanuatu. However this is not the case at present and only limited areas would adequately support oyster growth.

5.4.4 Management

Current legislation/policy regarding exploitation: There is no legislation currently in force that deals with this resource.

Recommended legislation/policy regarding exploitation: None seems to be required except consideration could be given to the introduction of exotic species into Vanuatu.

[7]Pseudostylochus is a flat worm measuring less than 1.00 mm in thickness and reaching a maximum length of 5.0 to 6.0 cm. Its shape varies and it is capable of moving in all direction, in much the same way as an amoeba. It lives in darkness and is highly sensitive to fresh water.

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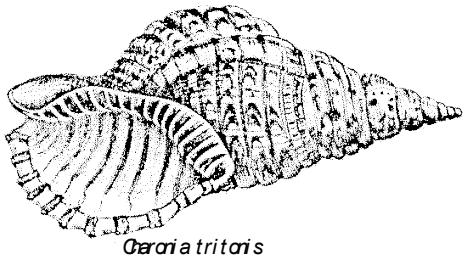
5.5 ORNAMENTAL (SPECIMEN) SHELLS

5.5.1 The Resource


Charonia tritonis

Species present: Numerous species of shells are offered for sale to tourists. They include cones, cowries, helmet, trumpet, triton, spider, giant clams, nautilus, black-lipped pearl oyster (*Pinctada margaritifera*), etc. Lewis (1985) notes that collector's shells are marine invertebrates from the classes Gastropoda (sea shells), Pelecypoda (bivalves), Scaphopoda (tusk shells) and Cephalopoda (nautilus). Wright (1989) reports that the Melanesia Shell Products Ltd (MSP) was involved in the trade of certain shells both locally and overseas and may have records for such shells as the giant triton, *Charonia tritonis*. No information was located that lists species found in Vanuatu.

Distribution: Most shellfish are habitat specific but are found in 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. No information was located on the distribution of *P. margaritifera* in Vanuatu.

Biology and ecology: *C. tritonis* shell can reach 40 cm or more in length and is usually found among corals on coral reefs and 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 and 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.

5.5.2 The Fishery

Utilization: Kay and Smalley (1989, quoted in Smith, 1992) categorises shells into five groups in the shell trade. These are ornamental shells (e.g. cones and cowries); shells used in shell craft (e.g. money cowries and helmet shells); specimen and rare shells (e.g. golden cowry); commercial shell (e.g. trochus, pearl oyster); and shells used for food. The shell trade in Vanuatu is mainly for the tourists and include shells of those collected for food (e.g. giant clams) as well as the shells collected solely for sale (e.g. cowries and cones). No specific fishery is based on *P. margaritifera* except that its use is limited to the sales of the shells in the local ornamental trade.

Shell collecting is mainly done by walking over areas of sand in lagoons or coral at low tide. They are sometimes found under rocks or by searching through areas of sand (Lewis, 1985). Fishing for shellfish species in deeper water require diving and these are sometimes picked up during spearfishing operation.

Production and marketing: The Fisheries Department does not currently collect any data on this fishery nor have there been any attempt to estimate shells that are sold on the streets in Vila. However, Wright (1989) notes that figures could be available from the MSP in their trade of shells in this category both locally and overseas.

5.5.3 Stocks Status

Information on stocks of the species involved is non-existent. Stock status information for giant clams is discussed in that Profile. A note here though is that *H. hippopus* shells seen being offered for sale in Vila consist mostly of shells that were about 3-4 inches in length. It is not clear whether this size is targeted for this species for the trade or it is a reflection of the size collected for home consumption. *C. tritonis* is listed as rare in the IUCN Invertebrate Red Data Book.

5.5.4 Management

Current legislation/policy regarding exploitation: The only regulation that covers any species in this category is that for trumpet shell, Fisheries Regulation 18. Under the regulation, trumpet shell is defined as *C. tritonis* and the taking, possessing, selling or purchasing of a shell of this species less than 20 cm in length is prohibited.

Penalty is a fine of not more than VT100,000 for any offences.

Size limit for the harvest of black-lip pearl has been proposed in the revised fisheries legislation.

Recommended legislation/policy regarding exploitation: Recommendations in other countries concerning ornamental shells trade include banning direct export, harvesting areas restriction and annual rotation, use of SCUBA or dredging. Because of the apparent detrimental effect of collection on *C. tritonis* populations in many countries, collection and export have been banned, e.g. in Fiji (Wells *et al*, 1983). Consideration to apply a minimum size limit for giant clams, including *H. hippopus*, is made under the giant clam section.

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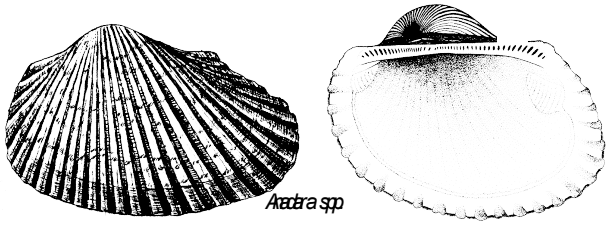
5.6 OTHER BIVALVES

5.6.1 The Resource



Species present: Clam (*Anadara* sp), cockles (*Gafrarium* sp) and mussels (*Modiolus* and *Brachiodontes*).

Distribution: These bivalve species are mostly associated with areas where mangroves thrive and thus their distribution is limited to these areas.

Biology and ecology: The biology of the locally found species as included in this section has not been studied. Cockles commonly inhabit muddy seashore and burrow only into the surface of the mud. Farmed cockles, *Anadara 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).

5.6.2 The Fishery

Utilization: Fisheries based on these species are mainly for home consumption (subsistence) in areas where they are found. Collection are done both by men and women. However, with the change to cash economy, some of the catches are being sold, e.g *Anadara*, but at very low levels. Shells are also sold to the tourists as ornaments. The native mussel species are utilized on the subsistence level only. *A. granosa* has been successfully farmed in Asia.

Production and marketing: No estimates are available on the production from these species either at the subsistence or artisanal level, even for the areas where they form an important component of the reef catch. David (1985) estimated the total village fishing production to be approximately 2,402 tonnes of which 33.5% (about 810 tonnes) consists of bivalve mollusc (clams, cockles and oyster family).

5.6.3 Stocks Status

Stocks status of the native species are unknown.

5.6.4 Management

Because of the limited level of utilization and their low level in importance as commercial species, management has not been considered.

Current legislation/policy regarding exploitation: No legislation exists concerning the exploitation of species in this section.

Recommended legislation/policy regarding exploitation: None seems necessary at this stage.

References

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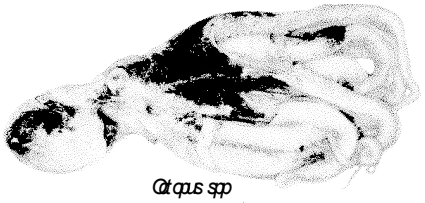
5.7 OCTOPUSES & SQUIDS

5.7.1 The Resource



Octopus spp

Species present: Octopus production is mentioned in only one reference located during the review. It does not however identify the species found within Vanuatu. Smith (1992) notes that the common octopus, *Octopus cyaneus*, is widespread in the Indo-Pacific region. There is no squid fishery known in Vanuatu.

Distribution: Octopuses generally "hide" in small holes in reefs and are found both intertidally and subtidally around reefs and rocky areas.

Biology and ecology: As in all cephalopods, sexes in octopuses are separate and 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 and they develop directly into tiny adult form (Smith, 1992). They actively predate on crustaceans and mollusc and are usually solitary.

5.7.2 The Fishery

Utilization: Traditionally, octopus fishing involves the use of a cowry decorated to look like a rat. This is also practised in some Polynesian communities. David (1985) reported that "octopus fishing is only conducted to the south and east of a line between Malo, Ambae and Ambrym" and that the number of households fishing cephalopods is closely correlated with the total number of fishermen surveyed. Half the cephalopod fishermen are concentrated on Malekula and Efate. The household survey on Malekula, Paama, Epi, Nguna/Pele, Efate and Tanna, indicated that only 9.5% of the octopus fishermen sell part of their catch. In Tanna, the octopus fishermen sold 77.5% of their catch. Details are given in the following table as was given by David (1985). The figures are those per week and represent 9.5% of the total landing as estimated by the same author.

	OCTOPUS SOLD			FISHERMEN SELLING THEIR CATCH		
Island	Number	Geographical distribution (%)	% of catch	Average sales per house-hold	% of fishermen	Geographical distribution (%)
Tanna	31	40.8	77.5	15.5	100	16.7
Malekula	15	19.8	8.0	5.0	6.0	25.0
Efate	13	17.1	19.3	4.5	13.5	16.7
Nguna-Pele	8	10.5	20.5	4.0	40.0	16.7
Epi	7	9.2	24.0	3.5	22.0	16.7
Paama	2	2.6	14.5	22.0	25.0	8.0
Vanuatu	76	100	15.5	6.5	9.5	100

Catching is mostly done using spear guns but at low tide, the fishermen simply walk over the reef and poke into the holes, suspected to "house" an octopus, using a rod.

Production and marketing: Of the total extrapolated annual fisheries village production of 2,402t in Vanuatu in 1983, 3.0% (66 t) accounted for octopuses of which 15% (10.5t), worth VAT 1.5 m, was sold (David and Cillaurren, 1989).

Data obtained by the Fisheries Department from Natai Fish Market, Santofish and the Fisheries Extension Centres in the outer islands indicate that there has been no local production of octopus going through these outlets for the last couple of years. There is however a possibility that octopus could be lumped under the "other" category due to minimal amounts. Otherwise octopus has been completely utilized on the subsistence level only. Fresh "baby octopus", imported from New Zealand were being sold at the Natai Fish Market during July 1993 at VT 1,390 per kg.

5.7.3 Stocks Status

Stocks are not known as no study has been conducted nor data collected for this particular resource.

5.7.4 Management

There does not currently seem to be any commercial demand for octopus in Vanuatu and thus exploitation is limited to subsistence. A possible threat to the resource would be the destruction of habitat (reefs).

Current legislation/policy regarding exploitation: No legislation exists regarding the exploitation of octopus in the Republic.

Recommended legislation/policy regarding exploitation: It appears that there is currently no problem with the exploitation of the resource.

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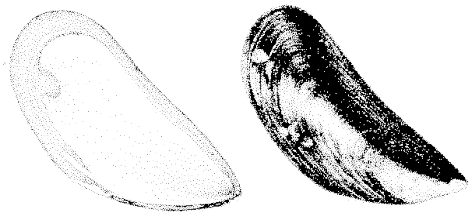
5.8 SPECIES WITH POTENTIAL FOR INTRODUCTION FOR AQUACULTURE



5.8.1 The Resource

Species: The green mussel, *Perna viridis*.

Distribution: No green mussel species exist in Vanuatu.

Two green mussel species, *P. viridis* and *P. canaliculus*, are being cultured commercially in some countries. *P. canaliculus*, the green-lipped mussel, is restricted to the temperate waters around New Zealand, whereas *P. viridis*, the Philippine green mussel, occurs widely in tropical waters throughout the Indo-Pacific region from the Persian Gulf to southern Japan and through Malaysia, Indonesia and the Philippines (Siddall, 1980). A closely related brown mussel *P. perna* is found around the African continent and in the northern half of South America (Hickman 1989).

The green mussel is not endemic in the tropical islands of the Pacific (Hickman, 1989). It has been introduced to several countries specifically for aquaculture purposes. *P. viridis* from the Philippines were introduced into New Caledonia in 1972, Fiji in 1975, Tonga in 1978 (Hickman, 1989) and from Tahiti to Western Samoa in 1982 (Bell and Albert, 1983). Mussels were transferred from New Caledonia to French Polynesia in 1978 for the development of larval rearing techniques (Uwate, *et al*, 1984).

Any attempt to farm the Philippine green mussel farming in Vanuatu would involve a species introduction. There have not been any introductions of green mussel into Vanuatu. As for the native mussel species, little is known about their distribution within the Republic.

Biology and ecology: The Philippine green mussel, *P. viridis,* inhabits estuarine or coastal waters that are rich in plankton, warm (26-32 Degree Celcius) and of high salinity (27-33ppt). Mussels can tolerate short periods of exposure to extremes of temperatures and salinity, and to high turbidity from suspended sediments.

Spawners release their eggs and sperm into the water where fertilization takes place. Fertilized eggs hatch into free-swimming larvae within 24 hours. They remain in this stage for 15-20 days, after which they are ready to settle and attach themselves to solid substrates (Valmayor, 1977). A firm substrate is required for larval settlement and for subsequent byssal attachment throughout juvenile and adult life. There must be adequate flow of current to provide sufficient food for growth, prevent build up of faecal and pseudofaecal material, and to disperse the larvae during their 3-4 weeks free-swimming phase.

Mussels are subject to predation by starfish, crustaceans and fish throughout their life span and possibly also to carnivorous molluscs and annelids as spat and juveniles. There have been few reported parasites and diseases of green mussels.

Mussels are filter feeders. They feed predominantly on phytoplankton but with some intake of detrital suspended matter. High levels of inorganic suspended matter reduce the mussel's feeding ability by "diluting" the amount of nutritionally useful material it is able to filter (Hickman 1989). As filter feeders, mussels are vulnerable to organic and chemical pollution and to natural phytoplankton blooms such as red tides.

The male mussel can be distinguished from the female by the colour of the meat. The meat or mantle of a male mussel is generally milky white to creamy, while that of a mature female is

orange to red. Sexual maturity in *P. viridis* is attained at 20-30 mm in shell length (3-4 months old).

5.8.2 The Fishery

Utilization: Mussel is a food item that could help meet the nation's need for a low-cost, high-quality protein food. Its wholesome taste plus its importance in nutrition makes it a speciality in hotels and first-class restaurants.

Commercial cropping of mussels is common in those countries where the mussels are farmed, while subsistence cropping of mussels is common in those countries where the mussels occur naturally.

Native mussel species are only utilized on a subsistence level in Vanuatu, mainly as a source of protein.

Production and marketing: Mussels are farmed extensively throughout the world. Spain, China, Holland, and Denmark each have an annual production of about 100,000 tonnes (Hickman, 1989). The vast majority of the world's annual production of 800,000 tonnes comes from the farming of blue mussels, *Mytilus edulis* and *M. galloprovincialis* with only 10% being derived from the green mussels *P. viridis* and *P. canaliculus* (FAO, 1988a).

Green mussels are farmed commercially in Thailand, the Philippines and New Zealand. New Zealand is the only country that exports significant quantities of green mussels (FAO, 1988b).

The native mussel stocks, if any, are not sufficient to meet the local demands. Vanuatu imports small quantities of New Zealand green-lipped mussels mainly for the restaurant and hotel market in Port Vila.

5.8.3 Potential Sites

The Vanuatu Fisheries Department has received expressions of interest in pursuing the possibilities of green mussel farming. Mussel farming is seen to have a potential for import substitution. The small size established market of green mussels in Vanuatu and the dubious sanitary quality of the potential mussel farming areas close to Port Vila, suggest that the development of mussel culture based on the established market is viable.

In 1989, Robert W. Hickman, FAO Consultant, carried out a case study in Port Vila, Vanuatu on the potential of farming green mussels in Vanuatu. Hickman surveyed two lagoons, the Erakor and Eratap Lagoons which are the only sites close to Port Vila considered by the Fisheries Department to have mussel aquaculture potential.

The survey results indicated that Erakor Lagoon has perhaps 120 ha of 5-10 m water depth and therefore potential for numerous longline systems. The high primary productivity, as indicated by the colour and turbidity of the water, suggests sufficient food for filter feeding bivalves.

The water quality of the Erakor Lagoon, however, poses a major constraint on its potential for aquaculture of filter feeding bivalves. The water is polluted by the septic tank seepages in the lagoon (Nerland, 1985 and Naidu and Morrison, 1988). High faecal coliforms (14-152/100 ml in the water) and elevated levels of dissolved phosphates and nitrates have been reported (Naidu and Morrison 1988) as well as depressed dissolved oxygen levels (Yuen, 1980). There is also the danger of red tide blooms possibly resulting from localised eutrophic conditions.

The Eratap Lagoon is a much smaller lagoon compared to the Erakor Lagoon. It appears to have similar characteristics to the Erakor Lagoon including a narrow entrance channel, extensive areas of shallow reef flats, and probably limited water movement. It is more sheltered from prevailing winds than Erakor Lagoon.

Hickman (1989) concluded that the mangrove oyster and the local mussel species could be used to assess intensive farming techniques, in preference to introducing a new species in the form of the tropical green mussel.

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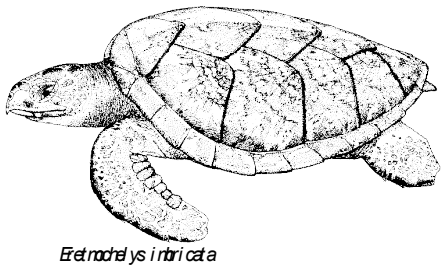

Eretmochelys imbricata

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6. REPTILES

6.1 TURTLES

6.1.1 The Resource

Species present: The main species found in Vanuatu are the green turtle (*Chelonia mydas*) and hawksbill turtle (*Eretmochelys imbricata*). Leatherback (*Dermochelys coriacea*) as well as the olive or Pacific Ridley (*Lepidochelys olivaccea*) turtles have also been observed.

Distribution: Sea turtles are marine reptiles which have inhabited the earth for over 100 million years. Seven species of turtles exist wordwide with all but one occurring in the Pacific region. The most frequently seen species in the Pacific are the hawksbill and green turtle, although the leatherback (*D. coriacea*), loggerhead (*C. caretta*) and olive or Pacific Ridley (*L. olivaccea*) turtles also occur.

Little information is available on marine turtles in Vanuatu but the hawksbill and the green turtles are the most common species of sea turtle found. The leatherback also occurs in small numbers, while the olive or Pacific Ridley, and the loggerhead are probably rare. Information collected by Dickinson (1981) indicated that turtles can be encountered almost throughout the archipelago, from Anietyum in the south, to the Banks/Torres group in the north (Groombridge and Luxmoore, 1989). The turtle most frequently encountered by divers in reef areas around Vanuatu is the hawksbill.

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 (the sites are 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 the 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).

6.1.2 The Fishery

Utilization: The major sea turtle products traded internationally are raw and worked shell, particularly from the hawksbill turtle; raw skin and processed leather, from Olive ridley and green turtles, oil for use in cosmetics and some meat products from the green turtle. The hawksbill turtle faces a special problem as its beautiful shell is the source of "tortoiseshell" which is made into jewellery and other carved items (Daly, 1989). Very little, if any, green turtle shell is traded internationally as it is very thin and does not have the physical properties of tortoiseshell, making it unsuitable for manufacturing purposes.

Pacific people have been exploiting turtles for subsistence purposes for thousands of years and the taking of limited numbers of turtles for food and traditional local use continues today. However, as with the exploitation of some other marine resources, in recent times the hunting of turtles in some areas has become more commercially motivated rather than traditional.

The hawksbill and green turtles are both exploited for meat and eggs in Vanuatu. The use of shell is thought to be minimal. In areas where they are abundant, green and hawksbill turtles have been hunted for centuries to supply the basic needs of the traditional subsistence village community, for example, food, tools, decoration and items for trade. Hunting practices which have evolved over many years represent the oral knowledge of the village relating to the turtle, where it lives, its habitats and the most efficient ways of hunting it. The complex social interactions involved in observing the many rules, rituals and traditional ownership patterns contribute to make the hunt an organised and disciplined affair and the consumption of turtles a special social event in the village. Where they occur these traditional patterns of capture and consumption have helped to regulate the exploitation of sea turtles.

The killing of turtles for consumption does not occur on all islands in Vanuatu. A questionnaire survey carried out in 1989, by the Environment Section of the Vanuatu Department of Physical Planning and Environment, showed that on some of the islands the killing of such animals is a taboo and on others, only the chief is allowed to kill or can permit such killing. On other islands marine turtles are only hunted during the yam season.

Production and marketing: From 1976 to 1988 an average of 50,000 adult hawksbill turtles were killed each year for international trade (Daly, 1989). The current major exporting countries of tortoiseshell are Cuba, Haiti and Jamaica in the Caribbean; the Maldives and Comoros Islands in the Indian Ocean and the Solomon Islands and Fiji in the Pacific. Japan is by far the major importer providing the stimulus behind the international trade in tortoiseshell although Singapore, Taiwan, Hong Kong and China also import this shell for their carving industries. In 1988, Japan imported just under 30 tonnes of tortoiseshell which represented some 28,000 adult hawksbills (Daly, 1989).

There is little information available from most Pacific nations on the extent of sea turtle product exports although it appears that only shell is currently traded internationally. The most reliable source for figures on the exports of tortoiseshell from the Pacific is the Japanese Custom Statistics (Daly, 1989). These show that during the period of 1985 to 1988, Japan imported significant quantities from both the Solomon Islands and Fiji. The Table below show export figures of tortoiseshells from the Solomon Islands and Fiji to Japan.

Year	Solomon Islands	Fiji
1985	1556 Kg	294 Kg
1986	1793 Kg	497 Kg
1987	4723 Kg	1859 Kg
1988	3911 Kg	817 Kg

The only other recorded exports of tortoiseshell to Japan from the Pacific were from Vanuatu as follows, as reported by Daly (1989):

Year	1980	1984	1985
Weight (kg)	33	25	12

McElroy and Alexander (1979 quoted in Groombridge and Luxmoore 1989) estimated the annual catch of turtles in the Maskelynes Group (Malekula), the principal turtle fishing area, to amount to 60-120 turtles, evenly split between the hawksbill and green turtles. Eggs and nesting were said to be taken whenever they were found. The hunting pressure was localised and never intense, and was not thought to have had much impact on the turtle population. The majority of the turtles are deliberately caught at sea; females are also captured on the beaches.

6.1.3 Stocks Status

There are no consistent current indices of abundance for sea turtles within the Vanuatu waters. However green and hawksbill turtles are the only known species nesting within the Republic. Information on the leatherback turtle indicate that it occurs in some parts of the group but no nesting beaches are known. The green and hawksbill turtles are common in the extensive reefs and shallow areas of the group.

The most important nesting area in the group is at south Malekula Island. Important mainland nesting of green turtles occurs at South West Bay, and particularly Lambobe beach. Small numbers of hawksbill turtles also nest here. A rough estimate of the numbers nesting each year is from 40 to 120 turtles (Groombridge and Luxmoore 1989). The Maskelynes form a group of offshore islands off the southern coast of Malekula where turtles are particularly plentiful. Regular nesting of both species also occurs within the group, particularly at Seior and Laifond islands. Sakau and 2 small islands close to Aham island are used occasionally. Other notable areas for nesting are southeast of Epi island, Emae island, and in the north amongst the Torres group. The nesting season for both species extends from September to early January.

During a recent one week turtle survey in the Maskelynes islands, south Malekula, by the Vanuatu Environment Unit in November 1992, only five turtles were tagged, 3 greens and 2 hawksbill turtles (Environment Unit, 1992.). No turtle nesting was sighted. The results of the survey seem to indicate a declining number of turtles around the Maskelynes islands.

6.1.4 Management

Current legislation/policy regarding exploitation: Vanuatu is a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (Date of entry-15 October, 1989). The convention prohibits the trade of any turtle product.

The Fisheries Regulations Order No. 49 of 1983 protects the harvesting of turtles as follows:

No person shall

(i) disturb, take, have in his possession, sell or purchase any turtle eggs;

(ii) interfere with any turtle nest; or

(iii) sell, purchase or export any turtle or the shell thereof of the species *Eretmochelys imbricata*, known as the hawksbill turtle.

Recommended legislation/policy regarding exploitation: In order to make the regulations more meaningful, consideration should be given where traditional customs are involved. In addition, protection of nesting habitats would be desirable but it may require negotiations with traditional land owners.

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6.2 CROCODILES

6.2.1 The Resource

Species present: *Crocodylus porosus.*

Distribution: The only island in Vanuatu known to have had a breeding population of the estuarine crocodile, *C. porosus*, is Vanua Lava island, one of the islands in the Banks/Torres group, north of Vanuatu.

It is thought that the crocodile population on Vanua Lava was a natural extension of the populations of the Solomon Islands (Messel and King, 1992). The crocodile populations, though small, on Nendo and Vanikoro islands in the Solomon Islands are only some 250 to 300 km to the north-west of Vanua Lava, a swimming distance for the strong and long distance swimming *C. porosus*.

Biology and ecology: Little is known about the biology and ecology of the crocodiles in Vanuatu.

6.2.2 The Fishery

Utilization: The people of Vanua Lava island strongly fear and dislike crocodiles.

Production and marketing: There is no production and marketing of crocodile skin or flesh in Vanuatu. However, in other Pacific territories, for example, Papua New Guinea there is a crocodile skin export industry.

6.2.3 Stocks Status

Little is known about the *C. porosus* population on Vanua Lava. A survey carried by David Luders, in 1983 (quoted in Messel and F.W. King, 1992) did not sight any crocodile. However Luders gathered important local information on crocodiles in Vanua Lava. He stated in his report that prior to 1972, a well known local personality, Mr. Jimmy Jones who occupied a plantation on the Selva River (Vanua Lava) for many years, reported daily sighting of crocodiles of all sizes during the 1960's basking on the sandbanks near the mouth of the river. He reportedly have shot some (the last one he shot was in 1978, 5.5 m in length). Nests were occasionally found in the Selva river area. There is little doubt that it was a breeding population, and total numbers may have ranged up to 200. In his commentary and conclusion Luders stated that it seemed certain that the 1972 cyclone reduced the crocodile population of Vanua Lava almost to nil, the bulk of the population may have been washed out to the sea and suffered an unknown fate. The habitat of the main centre of population (Selva river) was altered unfavourably.

A second survey on the Vanua Lava crocodile population, was carried out by M.R. Chambers and D. Esrom of the Vanuatu Environment Unit, Ministry of Lands, in 1989. Chambers and Esrom (1989) concluded that there were very few crocodiles remaining on the island, perhaps only two or three. However, no crocodiles were seen during the survey.

In September 1992, a third crocodile survey was conducted on Vanua Lava, headed by Professors H. Messel and F.W. King, in collaboration with the Vanuatu Environment Unit. Only two large belly slides, some days old, were seen 250 metres upstream of the mouth of Selva River.

Messel and King (1992) concluded that the crocodiles of Vanua Lava are on the verge of extinction and that only one large male *C. porosus* is remaining for certain although there might be a second animal, smaller in size. Since no juvenile crocodiles were sighted during the survey, it

was postulated that if there is a second animal then it is a second male or an immature female. There is no longer a breeding population remaining, though breeding used to occur in the past.

6.2.4 Management

Current legislation/policy regarding exploitation: No management legislation exists concerning crocodiles in Vanuatu.

Recommended legislation/policy regarding exploitation: Results of recent surveys seem to indicate that the crocodile population on Vanua Lava has become almost extinct locally. In addition, natural parameters, e.g. cyclones, are indicated as having a major part to play in the process.

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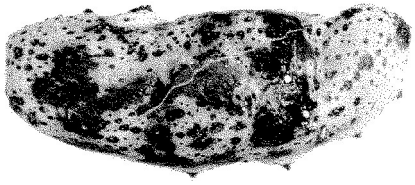
7. OTHER RESOURCES

7.1 SEA CUCUMBERS

7.1.1 The Resource



Holothuria fuscogilva

Species present: The most recent survey conducted on this resource was a project of the Australian International Development Assistance Bureau (AIDAB) conducted in 1988. Eighteen species were recorded in areas of Vanuatu and include, *Actinopyga echinites*, *A. mauritiana*, *A. miliaris*, *A. palauensis*, *Bohadschia argus*, *B. similis*, *B. vitiensis*, *Holothuria* (*Acanthotrapeza*) *coluber*, *H.* (*Halodeima*) *atra*, *H. (Halodeima*) *edulis*, *H.* (*Mertensiothuria*) *leucospilota*, *H.* (*Metriatyla*) *scabra*, *H.* (*Microthele*) *nobilis*, *H.* (*Microthele*) *fuscopunctata*, *Stichopus chloronotus*, *S. variegatus*, *Synapta maculata* and *Thelenota ananas*.

Distribution: Chambers (1990) recorded the distribution and occurrence of sea cucumber, by species, for sites visited during the above study. In addition, distribution within each location was broken down into distribution by different habitats (refer to Champers, 1990, for these details). For the purposes of this document, species occurrence (distribution) is summarised below for locations under the different islands and groups of islands, as recorded by Chambers (1990).

Location	**Species**
ANEITYUM	
Inyeug platform reef	*H.atra, B.argus, S.chloronotus*
Anelghowhat Bay	*A.mauritiana, S.maculata*
Port Patrick	*S.chloronotus*
EFATE AND OFFSHORE ISLANDS	
Moso, southwest shore	*H.atra, S.chloronotus*
Moso, east side	*H.atra, H.fuscopunctata*
COOK REEF	
Platform reef, west side	*A.mauritiana, B.argus, H.atra, H.fuscopunctata, S.chloronotus, T.ananas*
Platform reef, centre	*A.mauritiana, B.similis, H.atra, H.fuscopunctata, S.chloronotus, T.ananas*
Platform reef, northeast	*A.mauritiana, B.argus, H.atra, S.chloronotus, T.ananas*
MALAKULA AND OFFSHORE ISLANDS	
Metai	*A.echinites, A.miliaris, A.palauensis, B.argus, B.similis, B.vitiensis, H.atra, S.maculata*
Sakao, south	*B.argus, H. atra, H.nobilis, S.chloronotus*
Sakao north	*H.atra, H.edulis, S.chloronotus, S.maculata*
Cook Bay	*B.vitiensis, H.coluber, H.atra, H.edulis, S.variegatus*
Gaspard Bay	*H.atra, H.edulis, H.scabra, S.chloronotus*
Atchin	*A.mauritiana, H.leucospilota, T.ananas*
Port sandwich	*H.atra, S.chloronotus*
PENTECOST AND OFF-SHORE ISLANDS	
Wanuru	*A.mauritiana*
Banmatmat	*H.atra*
Loltong	nil
SANTO AND OFFSHORE ISLANDS	
Big Bay	nil
Hog Harbour	nil
Hog Harbour, Champagne Beach	*H.atra, H.nobilis, T.ananas*
Turtle Bay	*H.fuscopunctata, S.chloronotus, S.variegatus*
Palikulo Bay	*H.atra*
GAUA	
Lesalau Bay	*H.atra, H.edulis, S.chloronotus, S.variegatus*
Lesalau Lagoon	*H.atra, H.nobilis, S.chloronotus*

REEF ISLANDS	
Platform reef, south	*B.argus, H.nobilis*
Platform reef, northwest	*A.mauritiana*
Enwut and Watansa	*H.atra, H.leucospilota*
UREPARAPARA	
Lorup Bay, south	nil
Lorup Bay, north	*A.miliaris*
Lorup Bay, village	nil

The most diverse sites were the three sampling stations at Cook Reef (6 species each) and the intertidal reef crest and sand flats east of Metai Island in the Maskelyne Islands (7 species).

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, 1993).

Biology and ecology: Literature on the biology and ecology of sea cucumber in Vanuatu is very limited. Apart from AIDAB funded study during 1988, the only other report that touched on these subjects was that of Baker (1929, quoted in Chambers 1990). That report recorded four species of sea cucumber arranged in clear zones in the shallow fringing reef lagoon at Gaua Island. Speaking on the general results of the AIDAB survey carried out in 1988, Chambers (1990) noted that

> "overall, the beche-de-mer showed no preference for the major habitat types of reefs, lagoon or intertidal zones, with averages of 2.1, 2.5, and 2.4 species per site respectively. Within these habitats, the exposed sites may have higher diversity than the sheltered sites: lagoon - 3.0:1.3 species, intertidal - 2.6:1.8 species and reefs - 2.8:1.5. However, as the data are highly variable more sites would need to be evaluated to confirm this apparent trend".

Conand (1989) gives a review of 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 (a).

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 compound, 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 settle there.

7.1.2 The Fishery

Utilisation: Sea cucumber does not form any fishery for local consumption by Ni-Vanuatu and there is no local market for them. There is only a small export trade with harvesting concentrating on the Cook reef, the Maseklyne Islands, Atchin Island and the Port Vila lagoons (Chambers, 1990). Harvesting was reported by the same author as been carried intermittently at periods of one or more years, allowing stocks to recover and build up between successive harvest. A revival in sea cucumber fishing and processing was reported in 1973 (Baird, 1973). This indicates that processing for export had occurred earlier but abandoned until the early 1970's. Latham (1929, quoted in Dalzell, 1990) reported that bêche-de-mer was one of the principal exports of Vanuatu at the beginning of the 20th century. Dalzell (1990) reported that exports of bêche-de-mer were

officially terminated in Vanuatu after 1988 due to the consistently poor product being exported by inexperienced processors. However, after an SPC processors training course (July-August 1989) four locals were actively processing bêche-de-mer for export in 1990 (letter to SPC dated 5 June 1990). From export market permits, it seems that three shipments were made from Vanuatu between May and August 1993, involving three separate exporters.

Production and marketing: Conand (1989) classified bêche-de-mer species according to their commercial value with *H. scabra*, *H. fuscogilva* and *H. nobilis* having high value, *A. echinites*, *A. miliaris* and *T. ananas* with medium value and *H. atra*, *H. fuscopunctata* and *H. mauritiana* with low commercial value. Baird (1973) reported that this industry could well be expanded considering the extensive coastline available in Vanuatu. He reported that bêche-de-mer fishing and processing were revived by a Mr Autrand in one or two villages. Mr Autrand was reported to have successfully marketed the product "on behalf of the villages concerned" and that demand was high and prices being paid were good. No figures of production were reported, and that preserved specimen of the commercial species were to serve as indicators from villages if substantial stocks exist in their lagoons and reefs. The 1988 AIDAB funded survey recorded the presence of all the major commercial species of sea cucumber in the survey sites in the Republic. These species include: *H. nobilis*, *A miliaris, A. echinites, A. mauritiana, T. anas, H. scabra*, and *H. atra*.

The export of bêche-de-mer from Vanuatu between 1983 to 1990 are recorded in the following two tables. Exports were to Hong Kong, Singapore and Australia.

Year	Volume (t)	Value (Vatu)	Source
1983	6 (5)	3,121,000 (2,400,000)	Fisheries Department Annual Report for 1983 ad Preston (1993) Second National Development Plan (1987-1991)
1984	3	1,707,000	Fisheries Annual Report for 1984 & Second National Development Plan (1987-1991) & Preston (1993)
1985	4 (6.8) (2) (2)	2,897,000 (5,251,000) (600,000)	Fisheries Department Annual Reports for 1985. Fisheries Department Annual Reports for 1986 & 1987. Second National Development Plan (1987-1991) Preston (1993)
1986	4	2,837,000	Fisheries Department Annual Reports for 1986 & 1987 & Preston (1993)
1987	1 (1)	938,000 (203,000)	Fisheries Department Annual Reports for 1987 & 1989 & FFA. 1990. Overseas Trade. Exports 1982-1987 Part II
1988	15 (12)	3,291,000	Fisheries Department Annual Report for 1989 & Overseas Trade Part II 1985-1990 Exports Preston (1993)
1989	24 (19) (10)	9,377,000 (8,077,000)	Fisheries Department Annual Report for 1989 Overseas Trade. Part II 1985-1990. Exports. Preston (1993)
1990	2 (30)	2,229,000	Overseas Trade. Part II 1985-1990. Exports McElroy (1990 quoted in Preston, 1993, as *pers. comm.*)

Data obtained from records of Export Permits and Certificates of Origin gave an indication of

bêche-de-mer exports, species involved and amount for 1990 as follows.

Date	Species	Volume (kg)	Value per kg (US$)	Total Value
24-Apr-90	Blackfish	1,500.0		
	Greenfish	600.0		
	Black Teatfish	660.0		
	Surf Redfish	400.0		
	Sandfish	700.0		
	Prickly Redfish	60.0		
Total		3,920.0		2,442,000 Vt
7-May-90	Bêche-de-mer	300.0	12.00	US$3,600.00
Total		300.0		US$3,600.00
13-Jul-90	Sandfish	327.0	12.00	US$3924.00
	Blackfish	69.0	4.00	276.00
	Teatfish	20.0	10.00	200.00
Total		416.0		US$4,400.00
18-Oct-90	Black Teatfish	644.4	12.00	US$7,732.80
	Sand Redfish	87.6	7.00	613.20
	Prickly Redfish	8.8	9.00	79.20
Total		740.8		US$8,425.2
7-Dec-90	Black Teatfish	200.0	9.00	US$1,800.00
	Prickly Redfish	8.8	12.00	105.60
	Surf Redfish	87.6	9.00	788.40
Total		296.4		US$2,694.00
TOTAL '90		5,673.2		

The total from these records indicate an export volume of about 5.7 t in 1990, which differs vastly with the figure reported by the Statistics Office for the same year as given in the first table above. Discrepancies in data records are also found for 1983, 1985, 1987, 1989 and 1990.

No export data was located for the period between 1991 and 1992. However the following export figures were obtained from records of Permits to Export Fisheries Products between May and August 1993. During this 3-month period, 7.5 t, worth about USD 55,000 was exported.

Date/Species	Quantity (kg)	FOB per kg	Total Value (USD)
8 June 1993			

Processed bêche-de-mer	2,245	USD 7.00	15,715.00
Sub-total	2,245		15,715.00
7 July 1993			
Blackfish	694	USD 4.00	
Sandfish	543	USD 5.00	
Sub-total	1,237		5,491.00
9 August 1993			
Black teatfish	720		
Curryfish	480		
Tigerfish	1,240		
Vula	300		
Prickly redfish	240		
Surf redfish	500		
Lollyfish	400		
Sub-total	4,000		33,530.00
TOTAL	7,482		54,736.00

7.1.3 Stocks Status

Annual export figures for bêche-de-mer from Vanuatu between 1983 and 1990 were relatively low ranging from 1-6 tonnes except for 1988 and 1989 when 15 and 25 tonnes were exported respectively. About 7.5t were exported during a 3-month period in the middle of 1993. Chambers (1990) reported that "harvesting is been carried out intermittently at periods of one or more years, thus allowing stocks to recover and build up between successive harvests". Because of the lack of information on CPUE etc on this particular fishery, no meaningful estimates of level of sustainable exploitation can be made.

Baker (1929-quoted in Chambers, 1990) recorded high densities of up to 5 sea-cucumbers per square meter for *S. chloronotus* and *H. atra* in the shallow fringing reef lagoon at Gaua Island. Wright (1989) reported that a two-week survey of the archipelago was undertaken by a Fiji Fisheries Division staff in 1983. However, no report has been published but he noted that "the Draft Fisheries Management Plans prepared in September, 1983 revealed that the survey recorded that the black teatfish, (*H. nobilis*) was the most abundant holothurian encountered". Chambers (1990) found generally low densities of sea cucumber (rarely exceeding 1/100 m^2) at 8 sites in the Maskelyne Islands and Atchin Island with the exceptions of high densities of *S. chloronotus* at a site on Moso Island and *H. leucospilota* in rock pools on the north shore of Atchin Island. However, both species have no commercial value. The author noted that the low densities may be typical for much of Vanuatu except that very high densities of certain species (mostly of commercial* value) were recorded by the same author in 1987 at various sites in Port Vila Harbour and the Ekasuvat Lagoon as follows (in descending order of value):

Species	Numbers per 100 m^2
*H. scabra**	43
*A. miliaris**	785
*H. atra**	214
H. edulis	21

Densities (nos/100 m^2) of sea cucumbers at the 8 sites mentioned above were given by Chambers (1990) as follows:

Species	Metai -intertidal & reef crest	Sakao, south -intertidal	Sakao, south -reef crest	Sakao, north - intertidal	Sakao, north - reef crest	Cook Bay - intertidal	Cook Bay - reef crest	Atchin - reef crest
A. echinites	0.1							
A. mauritiana	0.1							1.6
A. palauensis	0.1							
B. argus			0.1					
B. similis	2.2							
B. vitiensis	0.1					<0.1		
H. coluber						<0.1		
H. atra	0.7	0.4		1.5	0.1	0.9	0.3	
H. edulis					0.9		0.2	
H. nobilis		0.1						
S. chloronotus			4.9		0.7			
S. variegatus							0.2	
S. maculata	0.1			0.1				
T. ananas							<0.1	

7.1.4 Management

Management of the exploitation of the sea cucumber fishery in the South Pacific countries has been very minimal. This has been partly due to the fact that the bêche-de-mer industry in the region is not an old tradition and the absence of scientific information on which to base management. As a result this particular fishery has been known to be characterised by periods of heavy exploitation followed by a resting period during which the resource is able to recover (Preston, 1993). One of the factors that has contributed to the control of harvesting is that low returns obtained on small-sized products usually spontaneously restricts fishing to large specimens (Conand, 1989).

Current legislation/policy regarding exploitation: The Fisheries Regulation of 1988 prohibits the exportation of bêche-de-mer without the written permission of the Minister and in accordance with conditions he specifies. Ministerial Order of 1991 limits the export of dried bêche-de-mer to an annual quota of 35 t.

Recommended legislation/policy regarding exploitation: Chambers (1990) recommended that:

> "the correct strategy with regard to bêche-de-mer harvesting in Vanuatu is to collect intermittently from sites which are both large enough and support sufficient densities of commercial species to be economic. Stocks should then be left for however long it takes them to recover to economic levels. There are probably few such areas in Vanuatu".

Records of annual exports of dried bêche-de-mer from Vanuatu have been consistently well below the legal quota. This seems to indicate that the quota (35 t a year) applied is very much unfounded and could well be above the sustainable level of exploitation for the fishery. The reason of the low production so far is not apparent but it can mean that the resource is not large enough to be expanded to meet the quota or there is a lack of enthusiasm by the collectors and exporters to expand.

Given the above situation, the Fisheries Department needs to conduct an assessment of the resource in order to obtain exploitable levels of the available stocks and to avoid legislating meaningless (or even damaging) regulations.

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".

(In the absence of data on which to base a reasonable minimum export quota, perhaps the minimum quantity required by market or minimum amount to make operation economically feasible could be used).

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Appendix 7.1 (a): 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, in press) 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 coefficient=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 (peak 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, in press) 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, in press). Length-weight relationship was calculated as $W=0.68\ L^{2.00}$ (correlation coefficient =0.61) (Shelley, 1982, quoted in Preston, in press).

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 specimen, 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, in press) 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, in press) 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, in press) 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, in press).

7.2 CORALS

7.2.1 The Resource

Species present: Veron (1990) gives comprehensive details of the results of the study conducted in 1988 by the Australian Institute of Marine Science (AIMS) on the hermatypic (reef-building) corals in Vanuatu. Hermatypic coral species listed as "very common" during the survey are given in the table below with some remarks made. No information is available on coral species exported from Vanuatu as "rocks". 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 (*Fungia*). Eight species of precious corals, *Corallium* sp. have been found at depths of 100m to 1,200m in Vanuatu waters (Eade, 1988, quoted in Wright, 1989).

Species	Remarks	Species	Remarks
Pocillopora damicornis	wide range of habitat	*Porites latistella*	no taxonomic differences from Philippine's colonies
P. verrucosa	on upper reef slopes	*Goniopora somaliensis*	mostly on lower reef slopes and in lagoons
Seriatopora hystrix	on upper reef slope	*G. tenuidens*	on upper reef slopes and in shallow lagoons
Stylophora pistillata	in exposed shallow upper slopes	*G. minor*	protected reef slopes and in lagoons
Montipora capricornis	at 10-20m depth	*Coeloseris mayeri*	some exposed upper reef slopes and sometimes on lower slopes
M. caliculata	more polymorphic than observed on GBR	*Pachyseris rugosa*	forms very large colonies in some lagoons
M. samarensis	reef flats	*Fungia (Pleuractis) scutaria*	no taxonomic difference from GBR coralla
M. altasepta	on protected reef flats	*Galaxea fascicularis*	protected lower reef slopes and in lagoons
M. digitata	on reef flats, no taxonomic differences from in GBR	*Lobophyllia hemprichii*	on most reef slopes
M. hispida	forms large reddish-orange colonies	*Diploastrea heliopora*	abundant on exposed upper reef slopes
M. crassituberculata	in wide range of biotopes	*Cyphastrea serailia*	in a wide range of environments
Acropora palifera	on exposed upper reef slopes	*Echinopora lamellosa*	over wide range of environments
A. formosa	in most reef habitats	*E. mammiformis*	in one station where it forms monospecific stands. Less common elsewhere
A. echinata	in some lower reef slope stations and some lagoons and may form very extensive mono-specific stands		

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).
Precious corals, *Corallium* sp. were found at depths of 100m to 1,200m in Vanuatu during the CCOP/SOPAC Precious Coral survey. Coral species utilized in the ornamental trade are those in the shallow reef areas.

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 20cm per year) while *Favia* and *Porites* grow very slowly (Lewis, 1985 and Veron, 1986). Achituv and Dubinsky (1990) notes that maximal growth usually occurs only down to 30-40% of subsurface irradiance (the irradiance immediately below the water surface) and rarely is any significant reef formation found below 10% irradiance. Reproduction is both sexual and

asexual. Harrison and Wallace (1990) records 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.

7.2.2 The Fishery

Utilization: Corals are collected to a limited extent for the local tourist trade as well as for home decorations. Some are exported together with aquarium fish as "rocks". Crossland (undated) notes that the original concern over the wreck of the President Coolidge and Million Dollar Point that led to the establishment of the area as the first national marine reserve was that certain individuals were souveniring parts of the wreck and also stripping the area of corals, mainly the colourful gorgonians and the red *Distichopora violacea*. He further notes that some of the corals were being collected on a semi-commercial basis by local divers.

Production and marketing: Marketed together with the aquarium fishes are pieces of coral marked as rocks. Records extracted from application forms for permits to export marine products from Vanuatu in 1992 show the following figures for "rocks". [Value in Vatu].

Date	# of pieces	Value	Destination	Date	# of pieces	Value	Destination
17/3/92	50	1,500	NZ	15/9/92	120	3,600	USA
11/4/92	20	1,000	NZ	16/9/92	50	1,500	NZ
8/7/92	50	1,500	NZ	17/9/92	40	3,200	USA
29/7/92	75	2,250	NZ	24/9/92	30	2,400	USA
12/8/92	50	1,500	NZ	30/9/92	50	1,500	NZ
22/8/92	75	2,250	NZ	30/9/92	70	2,100	NZ
10/9/92	30	2,400	USA	30/9/92	50	1,500	??
				??/10/92	80	2,400	Jap
TOTAL	350	12,400			490	18,200	

However, records on the permits to export marine products from Vanuatu are as follow. Of the 6 export shipments between June and August 1993, no "rocks" were included.

Date	# of pieces	Value	Date	# of pieces	Value
8/392	50	1,500	17/9/92	40	3,200
18/7/92	50	1,500	24/9/92	30	2,400
29/7/92	75	2,250	30/9/92	50	1,500
22/8/92	75	2,250	30/9/92	70	2,100
10/9/92	30	2,400	8/10/92	100	3,000
12/9/92	50	1,500	15/10/92	120	3,600
16/9/92	50	1,500			
TOTAL	360	12,900		410	15,800

7.2.3 Stocks Status

The most recent survey conducted on the corals and coral reefs in Vanuatu is that by AIMS in 1988. All information in this section is derived from results of that survey. Done and Navin (1990) observed that Vanuatu's reefs include pristine areas with no evidence of recent physical damage, and others where there have been considerable recent death and injury to corals are attributed to cyclones, sea level changes and crown-of-thorns starfish. Outstanding coral reefs valuable for the tourist industry were observed on the east side of Inyeug on Aneityum, west side of Cook Reef, entrance to Hog Harbour on Lathu Island, reef slopes adjacent to the western bay on Reef Islands and on Ureparapara. Even though the status of reefs in Vanuatu was listed as "good" by Dahl (1985, quoted in Done and Navin, 1990) the situation was assessed "poor" in 1988 even with the exceptions of some areas as stated above. It was suggested that much of the degradation had taken place since 1985 mainly from cyclones and crown-of-thorns starfish.

7.2.4 Management

Sheppard and Wells (1988) write "coral reefs rank as among the most biologically productive and diverse of all natural ecosystems, their high productivity stemming from efficient biological recycling, high retention of nutrients and a structure which provided habitat for a vast array of other organisms". Speaking of coral reefs evolution worldwide, Achituv and Dubinsky (1990) notes that corals reached their peak in the past, and at the present time they are in decline. Within Vanuatu, Done and Navin (1990) wrote that the major threats to existing healthy reefs, and to recovery of degraded reefs appear to be siltation which would accompany logging of steep watersheds, and eutrophication caused by domestic sewage discharged into reef waters. The greatest immediate threat to survival of corals however was attributed to continued crown-of-thorns starfish outbreaks.

Current legislation/policy regarding exploitation: Fisheries Regulation 19 prohibits the taking of more than 3 pieces of living coral in any period of 24 hours except with the permission of the Director and in accordance with such conditions as he may specify. In addition export of any coral is prohibited except with the written permission of the Director and in accordance with such conditions as he may specify.

Recommended legislation/policy regarding exploitation: Vanuatu is often affected by cyclones and their effects on coral reefs have been apparent in certain areas. The regulation on the taking and exporting of live corals may need to be reconsidered to limit collection to dead corals. Corals exported should be recorded as coral, not as "rocks" as is the current practise. It is probably necessary to define the size of a "piece" of coral in the regulation and identification of both species and area where collected.

Even though the current level of exploitation of corals in Vanuatu does not seem to pose a threat to the resource, however it should be safeguarded now for future direction and development. Apart from total ban on harvesting and exportation, restriction options as already practised in other countries include some combinations of the following:

- licensing collectors
- imposition of quotas
- prohibition of the use of SCUBA
- restriction of species collected
- zonation of areas for collection
- restrict number of commercial operators

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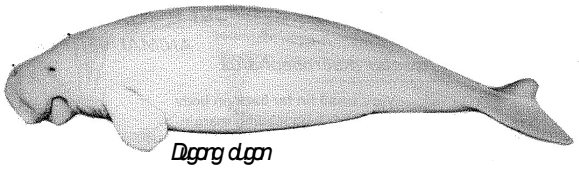
7.3 DUGONGS

7.3.1 The Resource



Species present: *Dugong dugon*

Distribution: Dugongs are widely distributed in shallow, coastal tropical and sub-tropical waters from east Africa to the southwest Pacific. In the Pacific region, they are present in large numbers in some parts of Papua New Guinea (Hudson, 1977), New Caledonia and the Solomon Islands (Nishiwaki and Marsh, 1985), Yap and Guam (Nishiwaki *et al*, 1979), and Palau (Brownell, *et al* 1981). Large populations of dugongs, perhaps the most numerous remaining in the world, are found in Australia (Anderson, 1986; Heinsohn *et al* 1978; Marsh, 1986; Prince *et al* 1981). The Vanuatu archipelago forms the easternmost limit of the dugong's distribution (Marsh, 1983) where their populations are distributed throughout the islands from Anietyum in the south to the Torres Islands in the north of the archipelago (Chambers, *et al* 1989).

Biology and ecology: Distantly related to the elephant, the dugong (*D. dugon*) is a massive but inoffensive herbivorous mammal that is restricted to the sea. It is the only existing member of the family Dugongidae (Order Sirenia). The only other member of this family, Steller's sea cow, was hunted to extinction within 30 years of its discovery in the 18th century.

Dugongs tend to occur in warm, shallow, sheltered inshore and reef areas where beds of seagrasses occur. Analysis of the stomach contents indicate that they consume a wide variety of tropical and subtropical seagrasses preferring to feed on small delicate seagrasses and dig up the whole plant including the rhizomes, making a distinctive feeding trial. Algae are also eaten.

On a recent survey of coral reefs in Vanuatu, Chambers (1990) found nine species of seagrass, all of which are reported by Nishiwaki and Marsh (1985) to be eaten by dugongs. These seagrasses include *Cymodocea rotundata*, *C. serrulata*, *Enchalus acoroides*, *Halodule pinifolia*, *H. uninervis*, *Halophila ovalis*, *Syringodium isoetifolium*, *Thalassia hemprichii* and *Thalassodendron ciliatum*.

Dugongs have a potential life span of 60-70 years (Marsh and Naika, 1983). Females bear their first calf at a minimum age of 10 years (but sometimes not until 15-18 years) after a pregnancy lasting about a year. A single calf is usually born. Although a calf begins to eat seagrasses soon after birth, it can suckle for up to 2 years and the cow-calf bond seems to be extremely well-developed. Estimates of the average interval between calves for various Australian populations range from approximately 3-7 years.

Because dugongs are such slow breeders, mortality must also be very low for a dugong population to be maintained. By analogy with other wild mammals, mortality is expected to be higher in juveniles than in adults. Adult survivorship therefore needs to be very high (of the order of 95% per year or more) for population maintenance. Thus dugongs are extremely susceptible to over-exploitation which is obviously why their status is now so vulnerable.

7.3.2 The Fishery

Utilization: Dugongs appear to be killed mainly as a source of protein. In Vanuatu they are hunted solely for food, with oil being a subsidiary reason (Chambers *et al* 1989). The flesh is taken mainly for subsistence purposes, and occasionally for ceremonial reasons. In other Pacific countries, for example, Papua New Guinea, dugongs are used to supply teeth for ornaments and

jewellery, bones for utensils, spears and clubs, skin for earrings and amulets, and the skull and whiskers for display in the men's meeting house in some regions.

In most localities in Vanuatu where dugongs are killed, hunting can take place at any time of the year, and is not apparently governed by any custom or tradition. Where such controls do operate, they are mostly related to the yam seasons which are events of great significance in Vanuatu. Many localities within Vanuatu do not consider the dugong an important animal either in terms of food or culture.

A survey on the status of the dugongs in Vanuatu by Chambers, Bani and Barker-Hudson in 1989 indicated that dugongs are killed by a variety of methods, but the common method is by spearing. The table below gives relative usage of methods by which dugongs are reportedly killed in Vanuatu (Chambers *et al* 1989).

Method	Number of people reporting this method
Spear	30
Blocking the nostrils	6
Setting nets	5
Gun	5
Dynamite	2
Axe	2
Accident - nets	2
Accident - Boats	1
Stone wall	1
Spear gun	1
Knife	1

Many people mentioned that dugongs were often caught in shallow water, particularly when stranded in pools by the receding tide.

Production and marketing: There are no production records as well as records of dugong flesh being sold in the markets in Vanuatu. In Papua New Guinea the meat is freely marketed in some areas (Hudson 1977). In New Caledonia, dugong tusks are sold at US$60 each (Chambers, personal observation, 1988).

7.3.3 Stocks Status

Dugong numbers have greatly reduced in the recent past and in many areas it is now extinct or greatly reduced in numbers. Declines have been caused by overhunting, accidental mortality from boats and fishing nets, pollution and loss of the seagrass beds which provide its stable food (Chambers *et al* 1989).

In Micronesia (Yap, Guam and Palau) dugongs are rare and must be considered in danger of extinction. In Melanesia (PNG, Solomon Islands, New Caledonia and Vanuatu) dugong numbers have decreased in recent years and the long-term prospects of the dugong in Papua New Guinea must be considered as uncertain unless the hunting rate is reduced (Chambers *et al*, 1989). In New Caledonia and Solomon Islands the status of the dugong is not known, but it is hunted in both countries.

So far as is known at present, Vanuatu has the Pacific region's only reasonable dugong numbers that are not subjected to any great pressures that could lead to a marked decline in their numbers although it is not possible to make an accurate estimate of their numbers in Vanuatu. The survey conducted by Chambers, Bani and Barker-Hudson in 1989 indicated that dugongs are reported to be present in nearly all the 100 localities in the survey areas. Some major islands, where dugongs have been reported from many of their local localities, include Efate, Santo and Malekula. Other islands such as Tanna and Erromango, had a few localities where they have been reported from. Most of the dugongs sighted were of single or pairs of animals with an average number reported from each locality of about 2 or 3.

Three islands were reported to have no dugongs. They are Futuna, Buninga and Mere Lava. In addition, dugongs were reportedly absent from the Dillon's Bay area of west coast Erromango and Wusi on west coast Santo.

7.3.4 Management

Current legislation/policy regarding exploitation: Throughout its range, dugongs are considered an endangered species (IUCN,1982). In many countries the dugong is legally protected. In Vanuatu, the dugong is protected by the Fisheries Act of 1982, which prohibits the capture of mammals in its waters.

Recommended legislation/policy regarding exploitation: Existing regulations seem to be adequate.

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