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Vanuatu fishery resource profiles

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Abbreviations and Acronyms

ACIAR	Australian Centre for International Agricultural Research
AIDAB	Australian International Development Assistance Bureau
AIMS	Australian Institute of Marine Science
CITES	Convention on the International Trade in Endangered Species of Wild Fauna and Flora
CMT	customary marine tenure
CPUE	catch per unit of effort
DWFN	distant water fishing nation
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	environmental impact assessment
FAD	fish aggregation device
FAO	Food and Agriculture Organization of the United Nations
FFA	Pacific Islands Forum Fisheries Agency
GEF	Global Environment Facility
GRN	goods received note
ICLARM	International Centre for Living Aquatic Resources Management
ICOD	International Centre for Ocean Development
ITSL	International Tuna Services Limited
IUCN	International Union for the Conservation of Nature
JAMARC	Japan Marine Fishery Resources Research Centre
JICA	Japan International Cooperation Agency
LGC	local government councils
MSG	Melanesian Spearhead Group
MSY	maximum sustainable yield
OFCF	Overseas Fishery Cooperation Foundation
ORSTOM	French Scientific Research Institute for Cooperative Development
PNG	Papua New Guinea
PWD	Public Works Department
SPADP	South Pacific Aquaculture Development Programme
SPC	Secretariat of the Pacific Community
SPFC	South Pacific Fishing Company Ltd.
TL	thoracic length
UNCLOS	United Nations Convention on the Law of the Sea
WCPO	western and central Pacific Ocean
OFP	Oceanic Fisheries Programme of the Secretariat of the Pacific Community
TAC	total allowable catch
USD	US dollars
VMS	vessel monitoring system
VFIL	Vanuatu Fishing Investment Limited
VUV	Vanuatu vatu

Preface

The International Waters Project (IWP) is funded by the Global Environment Facility (GEF), implemented by the United Nations Development Programme (UNDP), and executed by the Secretariat of the Pacific Regional Environment Programme (SPREP) in conjunction with the governments of 14 participating independent Pacific Island countries. IWP was requested to provide assistance for the review and update of the "Republic of Vanuatu Fisheries Resource Profiles", originally prepared by Lui A.J. Bell and Moses J. Amos in 1993. The purpose of the original profiles was to:

- provide information to the government on the level of freshwater and marine resources available for appropriate development planning, and for initiating regulatory controls for resource conservation and management;
- facilitate the dissemination of information and data required by government and local communities, as well as regionally and internationally; and
- facilitate the provision of concise and timely information required by potential investors.

The terms of reference for the updated review are to:

- undertake library research to collate and assess all existing documentation, data, images, etc. that will provide information relating to resource identification, abundance, distribution, exploitation, marketing, and current management measures in Vanuatu;
- provide and update the list of freshwater and marine resources, and include their identity, abundance and local distribution;
- describe the utlisation of resources, including exploitation and marketing information for each resource; and
- describe current management practices (including proposed management plans) for each resource described.

This report provides an overview of the major marine resources identified as being important to the commercial, artisanal and subsistence fisheries sectors within Vanuatu. It also covers numerous freshwater resources.

Each fisheries resource[1] includes:

- a brief description of the resource (species present, distribution, biology, and ecology);
- an overview of the fishery (utlisation, production, and marketing);
- a discussion on stock status; and
- a list of management concerns (current legislation and policies regarding exploitation and recommended management options). In some cases, a resource involves more than one species.

The assistance and level of understanding provided by staff members of the Department of Fisheries and the Environment Unit, particularly Mrs Leah Nimoho, was greatly appreciated. The author also acknowledges the assistance provided by Ms Beverleigh Kanas Liu for editing the profiles.

The author assumes full responsibility for the content of this report. Opinions, where

[1] Because of the inclusion of profiles for non-marine resources, the term "fisheries resources profiles" is used, which is more reflective of the contents of the report.

expressed, are his alone and in no way reflect the policy of the International Waters Programme, the Vanuatu Department of Fisheries, the Environment Unit, or the Government of Vanuatu.

Executive summary

The Republic of Vanuatu consists of over 80 mountainous islands, mostly of volcanic and coralline origin, extending over an area of over 12,200 km^2. Of this total area, 5,500 km^2 is considered arable land. The area of inner reefs and lagoons is approximately 448 km^2, with mangroves covering an area of 25 km^2.Vanuatu's exclusive economic zone (EEZ) covers an area of 680,000 km^2, but resolution regarding the ownership of Matthew and Hunter Islands (EEZ of about 190,000 km^2) would increase Vanuatu's EEZ considerably. Vanuatu's projected population in 1991 was 165,260 people, while in 1989 it was 142,630. The intercensal population growth rate between 1979 and 1988 was 2.4%.

The Fisheries Department is the sole agency responsible for the control (regulation), development and management of fisheries resources within Vanuatu, but the impacts of development on the natural environment falls under the jurisdiction of the Environment Unit within the Ministry of Natural Resources. There is a possible overlap of responsibilities between the two agencies in areas such as assessment and species conservation.

Vanuatu's First National Development Plan (DP1-1982-1986) concentrated on diversifying the economy in order to reduce the country's dependence on copra sales. In the Second Development Plan period (1987–1991), efforts focused on maximizing the various economic sectors' contribution to the expansion of income-earning and employment opportunities with export possibilities. The development of a small, locally based ocean tuna fishery was envisaged.

The South Pacific Fishing Company was established in 1957 on Espiritu Santo as a cold storage and fishing support base for longline vessels fishing in the southwest Pacific for tuna (for canneries). The company ceased operations 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 1970s, Vanuatu-based longliners took only a small portion (500–2,000 tonnes/year) of their catch (up to 15,000 t/year) within Vanuatu waters. At this time, Japanese pole-and-line fishing vessels also took only modest quantities of skipjack (300–1,600 t/year). Under an agreement with the Government of Vanuatu, Russian purse-seiners claimed to have caught a total of 12 t of tuna within Vanuatu waters during the agreement period. A fee of US 1.5 million dollars was paid to fish during this agreement period.

By December 2003, 132 longline vessels were licensed to fish within Vanuatu waters. Vanuatu is a party of the Multilateral Fisheries Treaty with the United States. Research conducted on the bait fishery in Vanuatu indicates 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, mainly for offshore bottom fishing. The project was estimated to have met 80% of local requirements for fresh, high quality fish for urban populations; therefore, it has been successful in significantly reducing the amount of imported fish. Several studies have been conducted on Vanuatu's offshore bottomfish resources, and indications so far indicate that the current level of exploitation has not reached the estimated maximum sustainable yield of about 730 t/year. All of the catch from this fishery is marketed locally via several avenues. The Provincial Fisheries Extension Centres in the outer islands, the Santo fish market, Au Bon Marche in Port Vila, and the LTP fish market in Port Vila are the main marketing channels of fisheries products. However, direct sales to restaurants and stores, especially those in Port Vila, are increasing due to better prices offered to fishermen.

Fishing has always been considered secondary to agriculture in Vanuatu. However, a village subsistence fishing survey conducted in 1983 indicated that over 50% of the country's rural population engaged in fishing. Apart from the collection of trochus and green snail for the production of button blanks in local factories, most fishing within the reefs and lagoons has been at the subsistence and artisanal levels. Reef and lagoon fish, as well as non-finfish marine animals such as lobsters, are becoming increasingly important at the artisanal level. The current decreasing trend in the number of boats engaged in bottomfishing is a possible indication of the likely increased pressure on the inshore resources. Exports of beche-de-mer and aquarium fish have been relatively small and erratic in the past. Recently, however, they have become some of the major marine export products, particularly for the aquarium fish trade. At present, trochus is one of the major inshore resources in Vanuatu, generating income for rural communities. Although green snail harvesting is done on a smaller scale, higher prices are offered for this mollusk.

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 people on the more remote islands.

In an effort to develop aquaculture in Vanuatu, two animal species have been introduced: the marine Pacific oyster, *Crassostrea gigas*, and the giant Malaysian freshwater prawn, *Macrobrachium rosenbergii*. 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 trials conducted on Santo, but predation and irregular spat supply were problematic. No information could be found on the failure of the *Macrobrachium* project, but indications are that it may have been caused by high mortality and slow growth rates, and possibly land disputes.

Recently, the Department of Fisheries has begun studies on freshwater resources. Preliminary observations indicate that there is potential for the development of aquaculture using freshwater indigenous fish species. In 2004, the Department of Fisheries began research on farming imported Nile tilapia from the Fiji Fisheries Research Station. Aquaculture research on tilapia is currently being undertaken at Erapo on Efate Island. Aquaculture research on *Macrobrachium lar* is being undertaken on Sarate, in south Santo. The Department of Fisheries' future intention is to diversify and to include the importation of *Macrobrachium rosenbergii* from the Fiji Fisheries Research Station in Suva.

Vanuatu was one of the countries included in the 1989 joint Food and Agriculture Organization of the United Nations and South Pacific Aquaculture Development Programme study on the potential of green mussel aquaculture. The study indicated potential sites within Vanuatu, particularly Erakor Lagoon, but water quality (pollution) was noted to be a problem. The Department of Fisheries currently operates a small-scale hatchery for three native mollusk groups: trochus (*Trochus niloticus*); green snail (*Turbo marmoratus*), and giant clams (*Tridacna crocea* and *T. maxima*). Hatchery work on these species is for re-seeding purposes.

Vanuatu's Fisheries Act (1983) is currently under review. This process will hopefully lead to changes that seem necessary in the Fisheries Regulations currently in force. There is clearly a need for coordination with other agencies in this area in order to define responsibilities and to avoid conflict and overlap in work programmes.

PART 1: VANUATU OVERVIEW

1 Country, economy, fisheries management agencies

1.1 Land

Vanuatu was first visited by Europeans in the early 17th century. James Cook explored the islands in 1774, giving them the name "New Hebrides", which lasted until independence on 30 July 1980. The first European settler was a cattle rancher who arrived in 1854. He was soon followed by cotton growers from Australia, and later by the French, who outnumbered the British three to one by the mid-1880s.

The Republic of Vanuatu comprises an archipelago of over 80 islands, of which 67 are inhabited. The islands lie between latitude 13°S and 20°S, and between longitudes 166°E and 172°E.The archipelago is approximately 850 km long 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. Because of Vanuatu's location on the margin of the Indian and Pacific Plates, tectonic uplift and subsidence of islands periodically occurs.

The total land area is 12,200 km^2 of which 5,500 km^2 (45%) is considered potentially arable. The areas of inner reefs and lagoons have been estimated to be approximately 448 km^2 and mangroves 25 km^2. The climate varies from tropical in the north to subtropical in the south, and annual rainfall ranges from 1,700 mm in the south, to almost 3,000 mm in the north. Cyclones occur, on average, twice per year.

1.2 Sea

The ocean surface currents in the vicinity of Vanuatu are variable in direction and rate, but are moderate: the maximum current velocity is 40 cm/s or 0.75 kt. The westward flowing northern branch of the South Equatorial Current is the strongest current in the South Pacific, but does not affect the Vanuatu fishing zone. The westward flowing southern branch of the South Equatorial Current is evident north of 20°S and appears strongest from July to October. The South Equatorial Counter Current is evident from 5°S–10°S during November to April.

Vanuatu claims sovereignty over Matthew and Hunter islands and a large EEZ around them; however, this claim is disputed by France. It is the Government of Vanuatu's stated policy that its EEZ includes those waters around the islands of Matthew and Hunter. In order to facilitate resource management and to remove ambiguity, Vanuatu needs to promote rapid and equitable resolution of its EEZ boundaries with Fiji, Solomon Islands, New Caledonia, and France.

In the short term, prior to resolution of boundaries with its neighbours, it is important for Vanuatu to develop a clear definition of the exact boundaries of its EEZ (including the Matthew and Hunter zone) so that these boundaries can be included in licensing terms and conditions, and can be used for management purposes. This may require an amendment to the Maritime Zones Act.

In Vanuatu's EEZ, the ocean surface is warmest (27°–29°C) during January and February, and coolest (24°–27°C) during July and August. The thermocline, a region where temperatures decrease from 27–15°C is from 75–350 m within Vanuatu's EEZ. On average, the thermocline in Vanuatu is slightly deeper than in the Solomon Islands. Dissolved oxygen concentrations are generally high in the EEZ and do not limit the

vertical distribution of tuna. These subsurface oceanographic conditions are likely to influence longline fishing performance, where the thermal and oxygen profile effectively determines the extent of yellowfin and bigeye tuna habitat fished by the longline gear. Both primary and secondary productivity within oceanic waters near Vanuatu are low to moderate. However, although Vanuatu's EEZ has lower productivity than Papua New Guinea's or that of the Solomon Islands, there is high localized production around several of Vanuatu's islands.

1.3 People

The indigenous people of Vanuatu, or ni-Vanuatu, are Melanesians. About 7–8% of the population are immigrants or descendants from Europe, Asia and countries in the Pacific Islands region. The ni-Vanuatu are culturally heterogeneous, a fact that is reflected in the large number of languages spoken in the country. With over 100 distinct tongues for its relatively small population, Vanuatu is thought to be the most linguistically diverse country (per capita) in the world. Vanuatu's national language, Bislama, is a form of Pidgin-English. Besides Bislama, the country's two official languages of government are English and French.

About 80% of Vanuatu's people live in rural areas, and they depend on agriculture for their livelihood. The urban population has increased by 4.2%, which is considerably faster than the overall rate of increase. The proportion of the population below 15 years of age is 41.5%, while those below 25 years make up 59.3%.

A recent population count in 2004 puts Vanuatu's population at 215,000 (SPC 2004). The annual growth rate of 2.7%, and the calculated population density is 18/km^2. Average life expectancy is 69 years (SPC 2004).

1.4 Government

Prior to independence in 1980, Vanuatu was known as the New Hebrides and had been governed for 74 years by a joint Anglo-French Condominium. 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. The independence of the sovereign state of Vanuatu was celebrated on 30 July 1980, and the country 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 52 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 13 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 presidents of provincial governments. There is a National Council of Chiefs that is mainly an advisory body to the government and is comprises custom chiefs elected by their peers sitting in the Island Council 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, value added tax–VAT, licenses, export permits, company registration, land registration, other taxes, public enterprises, interest and rent, fees and fines, etc.), foreign borrowing (soft loans) and direct investment.

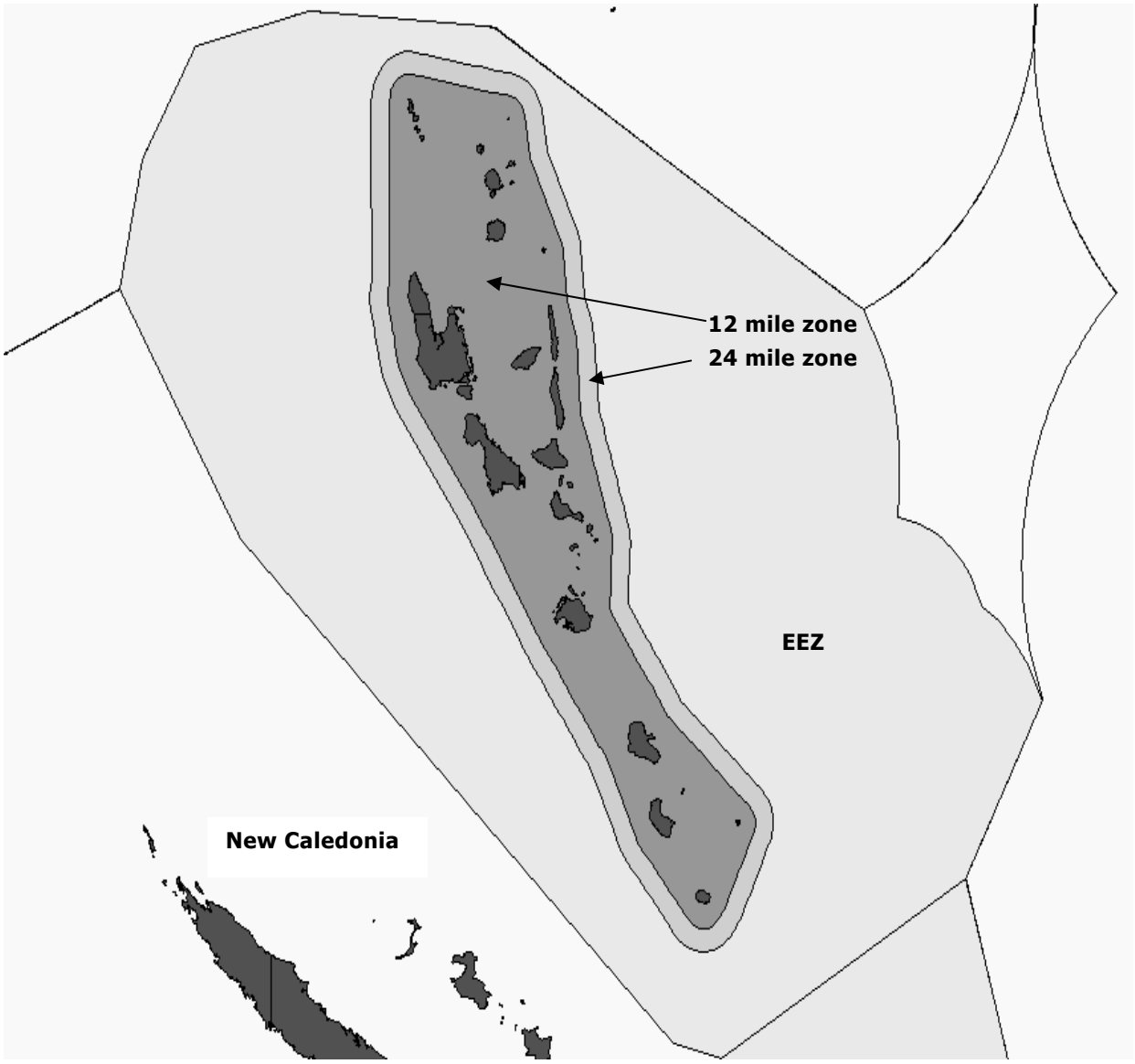


Figure 2: Vanuatu's EEZ, and 12- and 24-mile zones

1.5 Economy

Agriculture accounted for 18% of total the gross domestic product (GDP) in 1999 at constant 1983 prices and 16% at current prices. Subsistence agriculture made up some 51% of the total contribution of agriculture to GDP at both current prices and constant prices. Agriculture, fisheries and forestry combined account for 23% of GDP.

Table 1: Production of major commodities (in tonnes)

Commodities	1999	2000	2001	2002	2003
Copra	27,723	48,337	14,258	7,338	10,620
Coconut oil	-	1,812	8,733	9,856	7,725
Beef veal	1,577	1,361	815	685	976
Cocoa	1,104	1,536	538	756	1,506
Shells	85	106	39	19	23
Cowhides	258	347	272	235	289
Kava	334	555	935	456	491
Coffee	10	-	8	81	-

Primary agriculture products, mainly copra, beef, cocoa, coconut oil, cowhides and kava, along with timber and shells, account for the bulk of merchandise exports. Copra is still the largest export earner in value terms.

Table 2: Export values of major commodities, million VUV

Commodities	1999	2000	2001	2002	2003
Copra	1,381	1,096	323	174	282
Coconut oil	-	126	362	471	382
Beef veal	404	380	239	194	287
Cocoa	148	147	64	143	295
Shells	76	107	95	50	45
Timber sawn	363	415	334	197	249
Cowhides	27	47	39	28	36
Kava	379	478	503	230	228
Coffee	2	-	5	1	-
Other Products	124	418	338	438	797
Total	2,904	3,214	2,302	1,928	2,600

Figure 3 depicts the annual exports per year per commodity. Since 2001, copra exports have declined while coconut oil exports have increased. Vanuatu's dependence on a few commodity exports renders the country highly vulnerable to shifts in world commodity prices. The lack of growth in agriculture does not reflect the potential for the sector. About 45% of the total land area in Vanuatu is cultivable, characterized by good quality soils and favorable agro-climatic conditions.

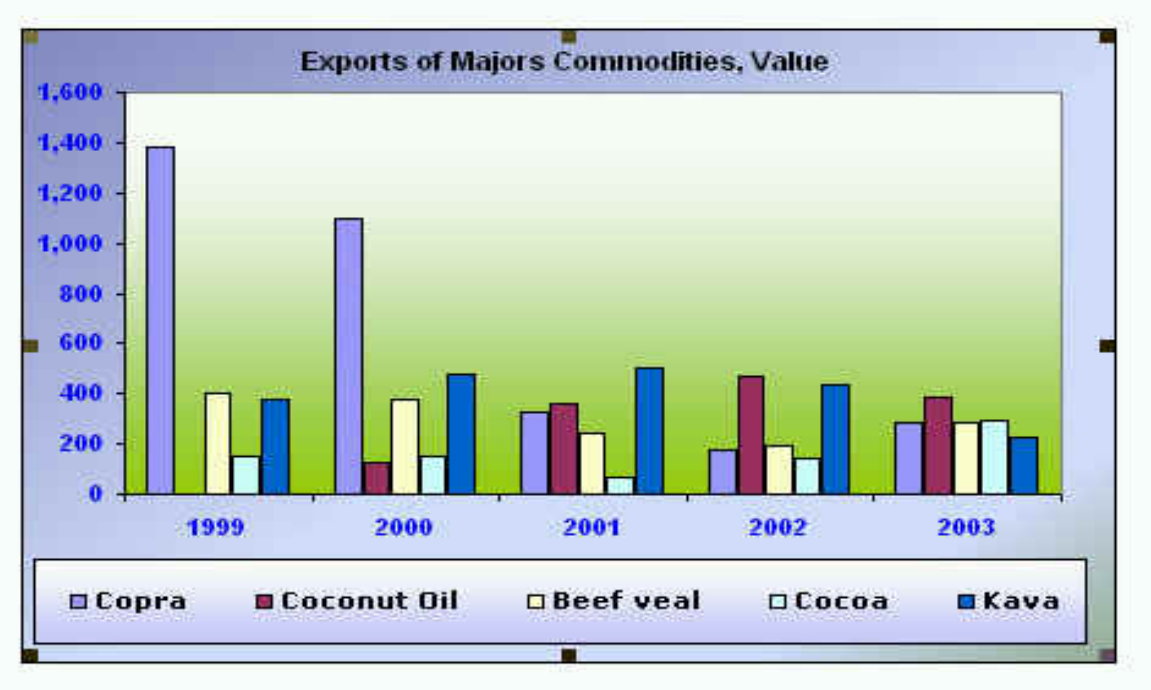


Figure 3: Export values of major commodities from Vanuatu, 1999-2003, in million VUV

The European Community and Australia have been the primary importers of manufactured Vanuatu commodities. Vanuatu has experienced serious trade imbalances since independence. The proportion of exports to imports has varied from 20–38% over the past decade. The further trade liberalization that will occur under trade agreements such as the Melanesian Spearhead Group Trade Agreement will make it increasingly difficult for Vanuatu to improve or even maintain its current trade balance, unless new, more effective development strategies are adopted, particularly for the agricultural sector but also for fisheries and forestry.

Table 3: Total exports from Vanuatu to major countries, by value (mllion VUV)

Major countries	1999	2000	2003	2001	2002
European Community	1,275	587	495	187	228
Japan	565	387	248	273	228
Australia	80	194	529	524	621
New Caledonia	126	188	235	125	192
South Korea	48	28	9	38	4
New Zealand	56	103	36	89	72
Bangladesh	154	690	213	199	104
Other countries	603	1,036	835	867	682
Total	2,907	3,214	2,600	2,302	2,170

2 National Development Plans

The First National Development Plan (DP1) covered the period 1982–1986. This was mainly a period of reconstruction and transition. The primary objectives were diversification and strengthening and expansion of the productive economic base, especially the reduction of dependence on copra (National Planning Office, undated). Major natural resource-based projects were initiated, including the establishment of cocoa and coffee projects, a copra rehabilitation programme, village-based fisheries

programmes, and the expansion of tourism infrastructure.

The broad focus of the Second National Development Plan (DP2, 1987–1991) shifted to sustaining and enhancing the achievements made in DP1 through a greater emphasis on manpower development and improved management (National Planning and Statistics, undated). The national development objectives for the DP2 period 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 was adopted under the following five broad strategies:

- 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.

The developmental strategies for the fisheries sector are listed under six sectors as follows.

Subsistence Fisheries

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

Small-scale Commercial (Coastal) Fisheries

- Continue to assist the formation of small-scale coastal fishing enterprises throughout the archipelago; and
- 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; 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 overexploited reef areas.

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 on them;
- Develop improved techniques for the harvesting of the sector's resources; and
- Provide the scientific basis for aquaculture development.

Administration, Training and other Departmental Support Activities

- Develop a cadre of qualified personnel within a Fisheries Development and Capture Division 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.

In the Third National Development Plan (DP3, 1992–1996), the Environment Unit is

listed as being "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 environmental master plan to guide future development activities;
- review the organisational structure of the Environment Unit with a view to upgrading its status to a full Department to monitor environmental changes, enforce environmental legislation, continue environmental awareness and educational programmes, and continue 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.

3 Institutions/agencies governing marine resources

3.1 Fisheries Department

Administration and management of the fisheries sub-sector lies with the Fisheries Department within the Ministry of Agriculture, Quarantine, Forestry and Fisheries. The Fisheries Department is tasked with the responsibility of monitoring the fishery and implementing development projects.

The Fisheries Department headquarters are in Port Vila with a regional office in Luganville, and smaller provincial centers in each of Vanuatu’s six provinces. The Fisheries Department is headed by a Director, and has five functional divisions: Research and Aquaculture, Management and Policy, Licensing and Compliance, Development and Capture, and Administration.

The overall policy objectives of the fisheries sector are to:

- develop the exploitation of marine resources in order to achieve the potential of fisheries 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; and
- increase the sector's contribution to government income available to support other areas of social and economic development.

3.2 Environment Unit

The Environmental Unit, which was established initially under the (then) Ministry of Lands, Energy and Rural Water Supply, became operational in September 1986. The Second National Development Plan (1987–1991) (DP2) noted that the proposed work of the Environment 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 environmental and conservation issues and to oversee and coordinate environmental and conservation issues. The objectives, as laid out in the Development Plan are to:

- increase study and knowledge of the natural environment and its wildlife resources;
- study and recommend procedures for the rational and wise development of natural resources and wildlife;
- initiate relevant legislation as necessary;
- increase the awareness of conservation and environmental issues within the government and other agencies; and,
- provide technical expertise to the government and other agencies as required.

The establishment of the Environment 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 that 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 the government and other agencies concerned with environmental issues;
- promotion of environmental education among government personnel and the country as a whole;
- development of contacts and cooperation with international environmental agencies; and
- recruitment and training of ni-Vanuatu to participate in, and take over and develop, the above strategies.

4 Fisheries resource management

Management of fisheries in Vanuatu is understood to mean the exercise, by some authority, of control over access to fishery resources that ultimately limits, redistributes or otherwise modifies the type or amount of fish or seafood being caught, and thus the economic or other returns deriving from it.

Fisheries management in Vanuatu is based on a number of legal instruments that:

- establish a wide range of national level rules and regulations governing, *inter alia*, foreign access, vessel licensing, Vanuatu participation in international agreements, prohibited fishing methods, size limits, exports licensing, marine reserves, and the deployment and use of fish aggregation devices;
- empower provincial government councils to pass bylaws making “rules and regulations governing fishing and conditions relating to the issuing of fishing licenses covering six nautical miles as from the low tide foreshore of all islands making up the provincial regions”;
- uphold the principles of customary marine tenure, whereby customary landowners also own the foreshore and fringing reefs and the resources those habitats contain.

The Department of Fisheries, Ministry of Agriculture, Quarantine, Forestry and Fisheries, is responsible for the control, development and management of fisheries resources. The main piece of legislation dealing directly with the management of inshore fisheries is the Fisheries Act 1982 [CAP. 158], and subsequent amendments. Other relevant instruments include the Decentralization and Local Government Regions Act (1994), laws relating to the issue of Business Licenses (CAP 173), the Maritime Zones Act (1981), and various land laws. Vanuatu is also a party nation to a number of international conventions and treaties, including the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), and the United Nations Convention on the Law of the Sea (UNCLOS).

4.1 Customary marine tenure

Customary marine tenure (CMT) is the general term given to the various systems of ownership or control of marine spaces, or the resources they, contain by indigenous tribes, clans or communities. CMT has been traditionally practiced in most Pacific Island countries and continues to exist in various forms throughout the region.

There is no single system of marine tenure in Vanuatu. In many places, land and sea tenure rights are inherited through the male side of a family, but in some cases it passes down through the women. CMT not only survives throughout Vanuatu, but is going through a phase where exercising the right to exclude outsiders and regulate one's own groups' activities on the fishing ground is intensifying.

Ownership of marine resources creates opportunities not only for resource management, but also for dispute. Considerable population movement in Vanuatu over the past century was associated with coastal land alienation for plantations and by churches for their settlements. Customary laws were never written down, and this has resulted in poorly remembered histories of traditional ownership of land and associated fishing grounds in some areas. Occasionally, a request for the identification of customary owners reopens old disputes that have been dormant for many years; or, the desire for money can lead to claims that have little foundation in true custom.

In Vanuatu, as in many Pacific Island countries, land tenure is the most contentious and widespread legal issue. By formally identifying customary owners, and determining their traditional rights, the government gives priority to land that is the subject of dealings under law (e.g. leases, logging contracts, declarations of public land). The legal framework for dealing with these problems remains inadequate. And, because nearshore marine resources have seldom been subject to such government laws, the development of formal government procedures for dealing with CMT has lagged behind those dealing with land tenure.

Vanuatu's various land laws provide for customary ownership of land based on the concept that all land in Vanuatu is the inalienable property of the ni-Vanuatu people. This concept is enshrined in the Constitution, which states (Chapter 12, Article 71) that, "all land in the Republic belongs to the indigenous customary owners and their descendants". And "land" includes "land extending to the seaside of any foreshore reef but no further" under the Land Reform Act (Cap. 123). Government laws concerning land often pertain to tenured marine areas. The Land Leases Act stipulates that customary owners cannot lease their reefs as they can with their land.

Customary ownership of land extends to the outer limits of coastal or fringing reefs. The marine resources in these areas are essentially the property of the landowners who may exploit or restrict access to them as they see fit. Resources such as trochus, green snail and beche-de-mer, which are found and exploited principally in shallow inshore waters,

are thus particularly affected by customary marine tenure practices.

One of the virtues of customary tenure is its flexibility. When such local customs and laws are precisely defined and fixed legally they tend to freeze tradition, leaving villagers less flexible in their responses to demographic changes, changes in technology, or other developments that require adjustments in local resource use patterns and controls.

There were formerly a number of different traditional marine management measures practiced in Vanuatu, and these practices varied among the numerous different cultural groups found throughout these islands. Some of these practices are still found today, others have survived only through oral history.

An example of a practice that is found throughout Vanuatu is the placement of a taboo — for varying lengths of time — on fishing activities of a particular reef area, which allows the resources within the reef area to recover from fishing efforts, and to rebuild stocks. In most cases, the leaves of certain plants that are specific to the cultural group are erected to indicate clearly that the area is under a taboo.

Vanuatu's experience suggests that some strategies and conditions would favour the success of government-supported, village-based management of small-scale fisheries in other Pacific islands. These strategies include:

- Publicizing (in coastal communities) the government's willingness to collaborate with villagers on management issues, and inviting requests for assistance from interested villages.
- Starting small, not with a comprehensive plan to address many types of fisheries or many villages.
- Concentrating initially on villages where local marine tenure and local authority are strong and the community is cohesive.
- Concentrating initially on villages where fishing ground geography facilitates effective village surveillance.

4.2 Tuna Management Plan

In 2000, the Department of Fisheries developed a National Tuna Management Plan. The plan sets out the procedures for developing the domestic tuna industry. The Tuna Management Plan was developed to meet four key objectives, which are to:

- ensure that the exploitation of the tuna resources that are found in and pass through Vanuatu waters is compatible with the sustainability of the stocks throughout their range;
- ensure — within the limits of the sustainability objective — the harvest is taken in a way that maximizes the long-term economic and social benefits received by the peoples of Vanuatu;
- contribute to the food security of ni-Vanuatu; and
- meet regional and international responsibilities for tuna management.

The scope of the Tuna Management Plan covers all highly migratory tuna species including albacore, yellowfin, bigeye, and skipjack tunas, and all other fish species taken in the course of fishing for tuna.

The Tuna Management Plan covers all Vanuatu waters, including the consideration of the area of the Vanuatu EEZ around Mathew and Hunter Islands and Vanuatu flagged tuna fishing vessels wherever they fish.

5 Marine resource legislation

5.1 Constitution of the Republic of Vanuatu

The 1980 Constitution touches on natural resources or the environment. It imposes for every ni-Vanuatu a fundamental duty to himself and his descendants and to others "to protect the Republic of Vanuatu and to safeguard the national wealth, resources and environment in the interests of the present generation and future generations".

5.2 Maritime Zones Act 1981 [CAP. 138]

The Maritime Zones Act (1981) establishes a series of archipelagic baselines around the islands of Vanuatu and uses them as a basis for the definition of a territorial sea and other maritime zones, as follows.

5.2.1 Internal waters

Includes rivers, lakes and the intertidal zone down to the low-water mark, as well as the interior parts of bays and other semi-enclosed waters.

5.2.2 Archipelagic waters

Comprise all waters inside the archipelagic baselines, other than internal waters.

5.2.3 Territorial sea

Comprises all waters outside the archipelagic baselines, up to a limit of 12 nautical miles.

5.2.4 Contiguous zone

Waters outside the archipelagic baselines, up to a limit of 12 nautical miles, but excluding the territorial sea.

5.2.5 Continental shelf

Comprises the seabed and subsoil of the submarine areas that extend beyond the limits of the territorial waters throughout the natural extension 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.

5.2.6 Exclusive economic zone

Comprises areas of the sea, seabed, and subsoil that are beyond and adjacent to the territorial sea, measured to 200 nautical miles from the baseline.

The main relevance of the Maritime Zones Act to inshore fishery management is the fact that foreign fishing vessels are normally not licensed to fish inside archipelagic or internal waters.

5.3 Fisheries Act 1982 [CAP. 158] (currently under review)

Although it was passed by Parliament in 1982, the Fisheries Act only took effect in 1983, at which time the Fisheries Act No. 22 of 1983 also annulled certain pre-existing statutes relating to fishery management. Subsequently, the Fisheries (Amendment) Act No. 2 of 1989 made additional provisions, mainly to facilitate the adoption of regional fisheries treaties by the Government of Vanuatu. Other minor amendments, additional regulations,

and ministerial guidelines have also been issued from time to time.

The Fisheries Act of 1983 (Revised Edition 1988) provides "for the control, development and management of fisheries and matters incidental thereto" and empowers the Minister for Fisheries to make a wide range of judgments and decisions relating to the issue of fishery licenses, fishery conservation and management measures, as well as to grant exemptions from an many of the provisions and regulations contained in the Fisheries Act.

Section II of the Fisheries 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 Fisheries Act, empowers the Minister to make regulations to be consistent with the Act for the implementation of its purpose and provisions.

5.4 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 Licences
Part II	Local Fishing Licences
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

5.5 Foreshore Development Act [CAP. 90]

The Foreshore Development Act (No. 31) of 1975 regulates the carrying out of works along the foreshore. This Act is administered by the Minister for Internal Affairs, and so 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 the mean high water mark and the bed of the sea within the territorial waters including lagoons.

Until early 2003 there were no statutory requirements for environmental impact assessments (EIAs) to be submitted prior to any ministerial consent for development on the foreshore. The Environment Management and Conservation Act, subjects all such developments to mandatory EIAs, unless such activity is exempt under the Act.

5.6 Environment Act

Government policy on environmental and conservation issues is to provide an affordable framework of environmental protection and compliance within Vanuatu. This is realized through the enactment of the Environment Management and Conservation Act No. 12 of 2002, which went into effect on 9 March 2003. This is the only legislation governing environmental protection of all natural resources in Vanuatu. The Environment Act requires mandatory EIAs be carried out for all development projects affecting the environment before any local or national authority gives consent to developers and project proponents.

The Environment Act has established a Bioprospecting Advisory Committee, which vets all applications to carry out bioprospecting activities in Vanuatu. The Environment Act is currently implemented by the Vanuatu Environment Unit, although a Director of Environment is not yet appointed.

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

Vanuatu became a party nation to CITES on 15 October 1989. Trade in species listed on Appendix 1 of the CITES treaty is prohibited, while trade in those species listed on Appendix 2 requires the authorization of the appropriate national authority which, in Vanuatu's case, is the Environment Unit of the Ministry of Lands and Natural Resources. Marine species currently listed on Appendix 2 of CITES include all six species of giant clam thought to be present in Vanuatu, as well as corals.

5.8 Decentralization Act

The Decentralization and Local Government Act of November 1994 replaced the earlier Decentralization Act (CAP 127) with a new instrument, which gives more extensive powers and authorities to local government councils (LGCs) in six newly-defined provinces within Vanuatu. LGCs are also referred to as provincial governments.

The significant of this Act for inshore fisheries management is the extensive powers it conveys to LGCs to pass bylaws affecting marine resource use. The Act entitles LGCs to pass bylaws consistent with existing legislation in order to make "rules and regulations governing fishing and conditions relating to the issuing of fishing licenses covering six nautical miles as from the low tide foreshore of all islands making up the LGC region". LGCs are also empowered to pass bylaws in relational to local economic development policies and plans, environmental protection zones, business licensing, infrastructure development, and various other issues that may impact on marine resource development.

6 Fisheries sector overview

As a signatory to the United Nations Commission on the Law of the Sea (UNCLOS), Vanuatu claims sovereignty over a 200-mi EEZ, enclosing some 710,000 km^2 of ocean. Vanuatu's fisheries sector is an important provider of employment, food and income. Fisheries resources are exploited at the subsistence, artisanal and industrial levels. As is the case in many Pacific Islands, fish resources provide the principal source of animal protein for ni-Vanuatu communities, especially those living in the country's many remote islands.

Vanuatu's fisheries resources are divided into three main groups: 1) various species of tuna, 2) deep-water bottom fish generically referred to as "poulet", and made up of primarily of snappers and related species, and 3) reef fish that inhabit the coastal waters inside the reefs. Current fishing activities in Vanuatu can be classified into the following broad categories:

- **Subsistence**: nearshore reef fishing activities that target reef associated and lagoon fish, and shellfish and small pelagic fish, reef gleaning, and shell collecting;
- **Artisanal**: small-scale commercial fishing activities that principally target shallow and deep- water bottom snapper (poulet) species, and FAD associated pelagics using trolling and longlining techniques. Also includes collection of sessile organisms such as trochus, green snails, and beche-de-mer;
- **Big game/sports fishing**: commercial charter boat sport fishing for tourists. This fishing activity targets billfish, tunas and large coastal pelagic fish species. Some vertical droplining for deep-water bottom fish is also included;
- **Locally based longliners**: pelagic longline fishing for albacore and yellowfin tunas, plus some bottom set longlining for snappers and groupers; and,
- **Foreign access industrial fishing**: which primarily includes longlining, but also some multilateral purse seining.

Subsistence fishing is an important aspect of village life and is second only to agriculture. Annual catches of fish and shellfish from reefs and lagoons were estimated at around 1,360 t/year in 1983, 93% of which was for subsistence consumption. Estimates of fish production and consumption patterns, and the importance of nearshore fishing activities to the lives of rural people and the national economy in Vanuatu, are not reliable.

Traditional management practices have been used to conserve stocks, although with

advances in fishing techniques and equipment, and increasing pressure for financial rewards from fishing, customary methods of fishing have declined in some areas. Although in some communities, village level management methods are reportedly making a comeback.

Commercial fisheries focus on the exploitation of high value tuna and deep-water bottom fish. Such fisheries currently make a small, but important, contribution to the national economy and to the generation of other socioeconomic benefits. Demand for fish in urban centers such as Port Vila and Luganville has increased in recent years. Offshore oceanic fish resources are considered modest in comparison to other island states of the western and central Pacific. Tuna, in particular, are highly seasonal in their availability, and are presently only lightly exploited.

7 Physical geography

7.1 Geological structure and bathymetry

Three ridges dominate the geological structure of Vanuatu: an ancient western range (23–11 million years before present-MaBP), which includes the Torres Archipelago, Santo and Malekula islands; a more recent eastern range (11–3.2 MaBP), with Maewo, Pentecost, and part of Epi and Efate; a recent central range with active volcanoes, which from north to south encompasses the Banks Archipelago, Ambae, Ambrym and part of Epi and Efate islands, along with the Shepherds, Erromango, Tanna and Aneityum islands. The upper emerged parts of these ridges (1,000 m and 500 m isobaths) are not continuous (i.e. they are several distinct entities separated by deep channels). The largest includes all of the central and central northern islands of the archipelago — a V-formation with Santo at the northwestern point, Maewo the northeastern point, and Efate at the base. Generally, the reef slopes of islands located on the eastern and western ridges of the island arc are steeper than the slopes of islands of the central ridge.

7.2 Reefs and mangroves

Due to the archipelago's recent geological history, there are no lagoons and no barrier reefs. The shoreline of Vanuatu's high islands is generally quite uniform, with few peninsulas, and bays that open widely to the ocean. Port Sandwich Bay, located on the southeastern point of Malekula Island, is the only inlet along the coast that is wide enough and deep enough to harbour vessels.

Vanuatu's fringing reefs are generally no more than 100 m wide and a few metres thick. There are 44,800 ha of fringing reef in Vanuatu, and 53% of this reef is along the coasts of Malekula (10,100 ha), Efate (8,070 ha) and the Banks-Torres Islands (5,370 ha, excluding Reef Island).Throughout the coastal area, coral reefs, along with river mouths and mangroves, are the biotopes with the highest species diversity in terms of fish, crustaceans and shellfish.

Coral structures develop as a result of a symbiotic relationship between coral polyps and the unicellular photosynthetic algae that they harbour in their tissues. These zooxanthellae require light in order to produce organic matter, which is utilized by coral polyps for their growth. Below 50–60 m, there is not enough light for photosynthesis to take place, and therefore stony, reef-building corals generally do not extend beyond this depth.

River mouths and mangroves are easily accessible fishing areas. Throughout the country, 288 rivers have mouths that are large enough to be considered a fishing area, and have a high enough discharge rate to fertilize the coastal zone — half of all rivers are located on Santo and Malekula islands, where 63% of the 3,000 ha of mangroves in Vanuatu are

also located.

Mangroves, which are located at the interface between the land and the sea, buffer the land from violent storm waves and winds, and provide critical habitat for many species of fish and invertebrates. Mangrove root systems (buttress roots and pneumatophores) hamper the erosive impact of waves and promote sedimentation of suspended particles derived from soil erosion. The roots capture these sediments, which would otherwise smother the coral reefs. The aerial roots, which are exposed at high tide, provide excellent sites for the attachment of molluscs and many small species of algae and benthic microalgae. These root systems also provide a protected environment for juvenile and adult fish and crustaceans that take shelter from oceanic and estuary predators. In addition, the breakdown of organic material enriches the nearby marine environment.

Coastal areas that encompass reef flats, mangroves and river mouths, gives only a partial indication of the importance of these ecosystems with respect to subsistence fisheries development; the ratio of these parameters to coastline length provides a much better indicator. In this regard, the following two islands show the highest fishing potential: Aneityum, with 43 ha of reef flats per km of coastline, and Malekula with 4.2 ha of mangroves per km of coastline. Efate and satellite islands form the most uniform group, where the number of reefs, mangroves and rivers per kilometre of coastline, are higher than anywhere else in Vanuatu. In contrast, the coastal zones of three volcanic islands — Ambrym, Ambae and Paama (Lopevi) — are not suitable for fishing activities as there are very few reef flats on these recently formed islands, and no mangroves or rivers.

8 Climate

A southeasterly trade wind regime prevails throughout most of the year in Vanuatu. The trade winds are easterly in southern and central Vanuatu, and southerly in the far north where there is a clear equatorial climatic influence. Hence, in northern Vanuatu, there is a high percentage of periods (mainly in summer) of calm weather and mild breezes.

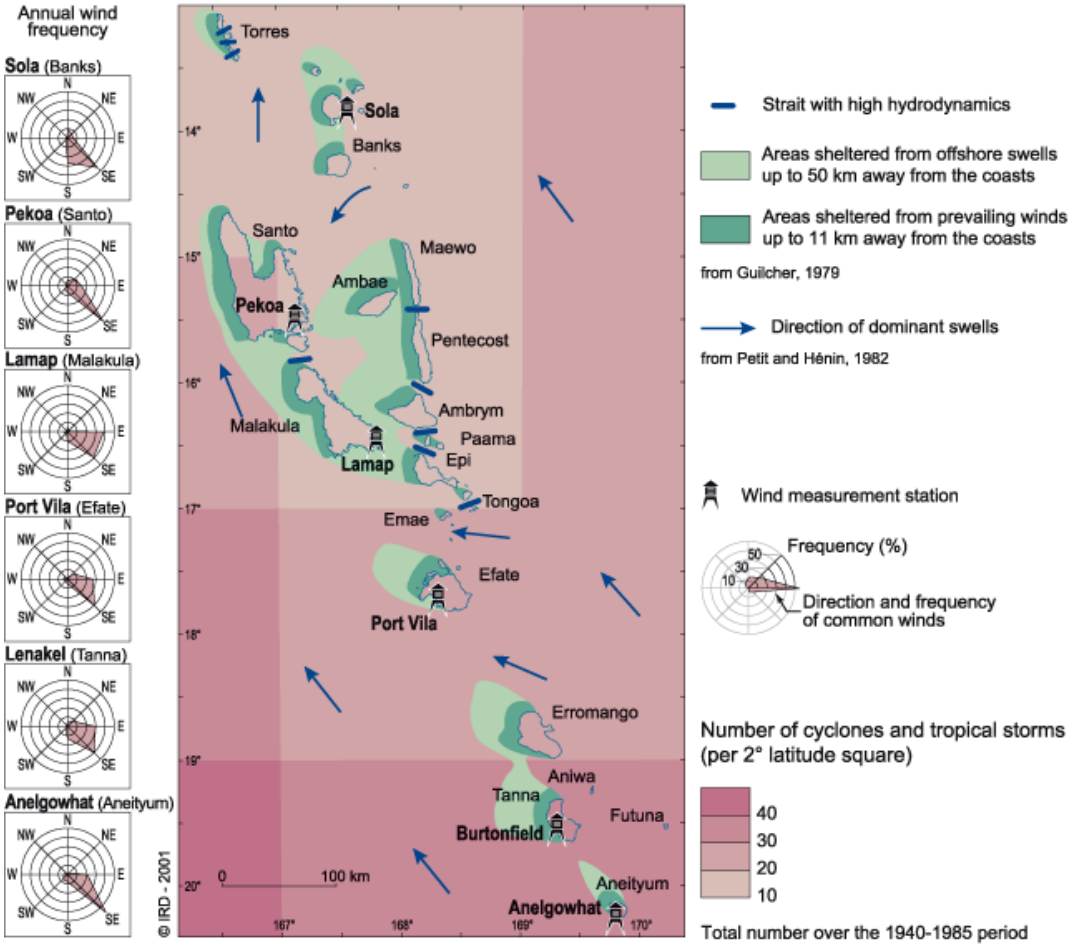
At Vanua Lava, there is a six-month calm period from November to April, while at Aneityum Island it is generally only calm during February. There is also a latitudinal zonation to Vanuatu's climate: the southern part of Vanuatu is quite windswept and the ocean is often very rough, particularly for small fishing boats; the northern islands are less exposed to winds and are therefore more suitable for fishing activities.

Another type of zonation relates to the extent of exposure to trade winds. The windward coasts, which are hit by oceanic waves, are less practical for fishing than the leeward sides of islands. The sheltered zones correspond to the boundary limit for fishing and navigating conditions for small fishing boats. These zones extend up to 50 km away from the coasts; over this distance, 15 and 12 knot winds can form 0.6 m and 0.9 m high waves (respectively), if blowing for 5 h.

The navigational limit under good weather conditions is around 10 km from the coasts (distance required for 10 knot winds blowing for 2 h to form 30–35 cm high waves). Hence, the "leeward sea" between Santo and Malekula islands to the west, and Maewo, Pentecost, Ambrym and Epi islands to the east, is an ideal fishing area that is sheltered from southeasterly swells. The straits between the islands are characterized by high hydrodynamics, with refracted swells and tidal currents.

Tropical cyclonic phenomena are meteorologically classified as follows: tropical cyclones, characterized by wind speeds of 63 knots (kt) or more; severe tropical storms, with winds of 48–63 kt; and tropical storms, with maximum wind speeds of 34–47 kt. From 1940 to 1985, 58 severe tropical storms and cyclones affected Vanuatu, 65% of which occurred in January and February.

Climatically, northern Vanuatu is most suitable for fisheries development (milder trade winds, long calm periods, few devastating cyclones). Conversely, southern Vanuatu is better for setting up infrastructures associated with fish preservation techniques, which require ventilation, and good relative humidity for fish salting and drying.



PART 2: FISHERIES RESOURCE PROFILES

9 Crustaceans

9.1 Coconut Crab

9.1.1 Species present

Coconut or robber crab, *Birgus latro*

9.1.2 Distribution

The coconut or robber crab is widely distributed in the tropics 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 and Fielder 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 declines and local extinctions.

Within Vanuatu, coconut crabs are distributed over a wide area and are present on most islands of the archipelago. The main coconut crab population areas in Vanuatu are in the north, mainly the Banks/Torres islands, Santo/Malo, and Maewo islands; and in the south, mainly on Erromango Island.

9.1.3 Biology and ecology

The 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, and the fruits from *Pandanus*, *Canarium*, *Cycas*, *Terminalia, Barringtonia*, and *Artocarpus*. Coconut crabs are slow-growing and Vanuatu stocks take at least 10 years to reach legal marketable size (9.0 cm, cephalothoracic length, CTL=43 mm). Fletcher et al. (1991) estimated the longevity of coconut crabs to be between 40 and 60 years and the asymptotic thoracic length 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. To escape predation and to minimize the risk of dehydration, coconut crabs burrow or hide in small crevices that provide the same conditions as burrows, prior to moulting. The moulting process takes from one to two hours to complete while the time between moulting and emergence from the burrows is about one month for small crabs and up to three months for the larger individuals (Fletcher et al. 1991).

Mature crabs mate on land during the summer months when the shell of both sexes are hard; fertilization, however, may require seawater. Egg laying is assumed to take place soon after copulation because females do not possess seminal receptacles. Females carry fertilized eggs attached to their pleopods for approximately one month before migrating to the sea to release them. Eggs are released by one of four methods that are closely associated with the type of coastline present.

1) On cliffy coastlines with narrow or no inter-tidal shelf, the berried crab climbs over

the cliff edge and reorients itself so that it faces uphill 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, and thus exposing the entire egg mass. If there is not a sufficient amount of wave splashes, the crab moves farther down the cliff until it is washed over by a wave, which results in the rapid hatching of the mature eggs and washing away of the newly eclosed zoea larvae.

2) On coastlines with an inter-tidal shelf, the berried female crab 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 eventually lowers it into the water with rapid backward and forward jerking movements that facilitate the release of eggs.

3) The third method involves coastlines such as that mentioned in method 2, but the eggs are not released into a pool splashed by waves, but rather in a saltwater "steam" that drains the shelf.

4) On coastlines with a sand or coral rubble beach, the method of egg release is similar to that in method 2. The crab moves down the beach into the water until it is swamped by a wave. In each method, egg hatching/larval release begins by exposing the eggs to moving water, usually waves.

Mature eggs hatch immediately into the first zoea stage upon release into the ocean. The hatched eggs undergo four planktonic zoeal stages in approximately three weeks, and the crabs (new recruits) emerge from the water as glaucothoe that inhabit shells. The glaucothoe inhabit the wrack area above the high sea mark and are hard to find and difficult to distinguish from other related coenobinids (Reese 1987). The glaucothoe subsequently metamorphose into juvenile crabs that maintain the shell carrying habit for one to two years (Brown 1989).

9.1.4 The Fishery

Utilisation

Because of its large size and terrestrial habit, and the delicate flavour of its flesh, *Birgus* is a highly valued food item. Coconut crabs are a vital resource for many small communities in Vanuatu, for both commercial and subsistence purposes. The collection and sale of coconut crabs is sometimes the only income earning possibility for the inhabitants of some of the remote islands.

Coconut crabs are readily captured using methods that require no capital investment in equipment. In most cases the crabs are caught by hand, having first been attracted to a staked bait, often a split coconut (Brown et al. 1991). Capture methods have evolved as a result of declining crab populations. For example, in the Torres region, the bait originally used was an entire coconut with only a small circular hole cut into it. The bait was usually set only an hour before dark and checked shortly after dark. If the coconut was opened entirely or left for too long before checking, the bait would be entirely consumed or taken. Usually the coconut is split into two and three pieces and the bait is not checked until after 11 pm, to allow a long enough time period for the crabs to come out find it (Fletcher 1992).

Production and marketing

Coconut crabs are the only major potential cash crop for remote areas such as Torres Island, due to the drastic drop in prices of agricultural products, especially copra. Ninety-five percent of the total crab production in Vanuatu originates from Santo and Banks/Torres regions.

Coconut crabs are exported to the urban markets in Port Vila and Santo that target hotels and restaurants. A smaller portion comes directly from the collectors on those islands. The level of exploitation for all of Vanuatu, both for subsistence use and commercial sales, is unknown. Production data collected by the Department of Fisheries is scarce and only dates back to 1983.

Table 4: The total estimated coconut crab production for the Santo and Torres regions, 1983-1990

Years	Santo	Banks/Torres - Hiu & Tegua
1983–1984	705 kg	4,662 kg
1987	37,600 crabs	122,000 crabs
1988	3,261.5 kg	-
1989	3,493.6 kg	-
1990	1,521.2 kg	-
1991	8, 854 crabs	97,440

In 1991, an estimated 12,000–15,000 crabs, mostly from either Santo or the Torres regions, were sold to Port Vila restaurants. In 1992, an estimated 20,000 crabs equivalent to a total weight 25,600 kg were harvested in Torres, mainly from Hiu and Tegua islands, and only a small percentage from Loh and Toga islands; while 5,960 crabs, equivalent to a total weight of 4,836 kg were harvested from Santo.

During the 2001–2002 harvest season, 1,797 crabs (valued at VUV 1,636,200) from Torres and 2,000 crabs from the Santo/Malo region were harvested. The crabs are sold at VUV 850 per kilogram. This compares to an average price of VUV 500–600 in 1991. In the open municipal markets in Santo and Port Vila, the crabs sell for VUV 500–2,500/crab. The actual value paid to crab collectors varies, depending on whether collectors sell directly to restaurants, or through a wholesaler, where payments might be reduced because of airfreight costs.

Given these limitations, it is likely that most collectors are getting less than VUV 500/kg, and some only VUV 400/kg. This is not substantially more than they were receiving 10 years ago at VUV 350/kg.

The total number of crabs purchased by restaurants in Port Vila is estimated to be approximately 1,500/month, which equates to 18,000/year. In Santo, 2000 crabs are sold locally, making a grand total of 20,000 crabs sold per year; only slightly less than the 25,000 estimated in 1991.

9.1.5 Stock status

The expanding tourist industry and the decline in local copra-based economies has resulted in a significant increase in the socioeconomic value of the coconut crab, which in turn has led to an increase in exploitative pressures on local coconut crab populations. Substantial reductions in population sizes have been noted. The collection and sale of these crabs is sometimes the means for communities in remotes islands to earn cash, which makes the conservation of this resource of paramount importance. This need was highlighted in Australian Centre for International Agricultural Research (ACIAR) and

the Australian International Development Assistance Bureau (AIDAB)-funded studies conducted between 1985 and 1992. The studies revealed that the crabs had a slow growth rate, recruitment of juveniles may not be large, and that the numbers of adult crabs in an area could be reduced very quickly. At the conclusion of these initial projects, a series of recommendations were provided to the Vanuatu Government to assist with the development of a management strategy to protect the remaining crab stocks. This resulted in a set of management restrictions in July 1991, which included the use of closed seasons and restrictions on the number of crabs that could be taken each year from key areas (i.e. Santo and Torres regions). These controls were in addition to the minimum legal size and protection of berried crabs that had been in force since 1983, but had been ineffective in halting the decline in crab stocks. In many areas, stocks suffered from growth overfishing and potentially recruitment overfishing.

In 2003, given the seriousness of the declining crab populations, ACIAR funded another study to re-examine coconut crab stocks in Vanuatu to determine if the management arrangements introduced 10 years ago had been sufficient to conserve the remaining stocks. The status of coconut crab stocks was assessed by field sampling, which utilised the same methods as detailed in Fletcher and Amos (1994). The results of the 2003 stock assessment surveys are outlined below.

Sanma Province

Overall, the number of crabs found in the 2003 surveys in Sanma Province was similar to or lower than the last survey period in 1991/1993 (Table 5). Some Sanma sites had more crabs (Matantas, Thion), some had similar numbers (Hog Harbour), and some sites had substantially fewer crabs (Kole). Most sites had catch rates less than 0.5 crabs per bait, with few legal size crabs (catch per unit of effort – CPUE <0.15). Thus, most areas can be classified as growth over-fished and the entire province is rated as overfished; therefore, the total quota should not increase beyond the current official quota of 2,000 crabs/year.

Table 5: CPUE (number of legal size crabs per bait) for sites within the Sanma Province during each survey period (Fletcher 2003)

Site	1985	1986	1987	1991	1993	2002
HOG HBR						
A	0.1	0.05	0.05	0	0	0
B	0.2	0.1	0.05	0	0	0
Ocean		0.1	0.05	0.04	0.14	0.11
Point		0.5	0.05		0.05	0.07
Cham. Beach					0.05	
Hill					0.05	
KOLE						
Close	0.05	0	0.03	0.06	0.07	0
Far	0.25	0.05	0.05	0.03	0.13	0
PORT OLRY						
Thion		0.02				0.09
MATANTAS						
Hill			0.04			0.35
Beach						0.25

Torba Province

The status of stocks varied among the islands in Torba Province (Table 6). Tegua and Hiu (Torres group) still has substantial quantities of crabs (mean CPUE >2); with many sites having higher catch rates than was found 10 years ago. However, crab abundance in

some locations in Torba Province has declined, especially Moto Lava in the Banks; and in Loh there are indications of growth overfishing.

Table 6: CPUE (number of legal size crabs per bait) for sites within the Torba Province during each survey period (Fletcher 2003)

Site	1985	1986	1987	1991	1993	2002
TORRES						
Hiu						
Flatstone	4.8	3.2	1.82	1		1.96
Yurtawa			0.55	0.35		0.2
Tegua						
Site 1	4	2.5	0.7	0.4		0.87
Site 3			1.2	0.6		2.1
Site 4		0.8	1.8			0.68
Loh						0.02
BANKS						
Moto Lava						
Site 1				0.3		0.075
Site 2				0.1		0

Tafea Province

An assessment survey carried out in 2002 suggests that there are healthy stocks of coconut crabs on Erromango Island. However, around the Ipota area on the eastern side of the island, there is considerable exploitation pressure, resulting in the initial signs of local depletions. The current harvest of coconut crabs is approximately 1,500 crabs per year on the east side.

Penama Province

An initial survey in Penama Province (Maewo) suggests that the level of harvesting in this region may be too great because the catch rates in some areas are relatively low.

9.1.6 Management

The current regulations stipulate that only 5,000 crabs can be collected in the Torres/Banks region, with a further 2,000 from the Santo/Malo region, leaving a very large (13,000 crabs) discrepancy with the total numbers sold (20,000). These "extra" crabs must either have come from collections in non-quota locations such as Maewo and Erromango, or from “illegal” captures in the regions already under quota. Initial estimates from Maewo indicate that approximately 2,500 crabs were removed in 2003 while the collections from Erromango were between 1,500 and 2,000.

Current legislation/policy regarding exploitation

Fisheries Act CAP 158

Chapter 158. The Fisheries (coconut crabs) Regulation No. of 1991.

Closed season Santo/Malo region: 31 October–1 April

Torres/Banks group: 31 August–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 the capture of coconut crabs carrying eggs, and any crab less than 9 cm in length when measured along the carapace from immediately behind the rostral horn to the rear edge of the carapace in the mid-line. The removal of eggs from a coconut crab, or possessing and/or taking crabs from which eggs have been removed, is 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 VUV 100,000.

Ban on the collection of crabs from Sanma Province

A three-year temporary ban on the collection of all crabs within the Sanma Province region was enacted by way of a regulation in 2004. The purpose of the ban is to stop further stock declines in some areas of the province.

Recommended legislation/policy regarding exploitation

Sanma Province

It is recommended that the quota for Sanma regions be divided into small, regionally based quotas as specified below. The quotas specified should be applied within each area. The quotas have been determined by assuming that all areas are available for capturing crabs.

Region	Maximum quota
North Santo (Port Olry/Cape/Queros/Loran)	700
Hog Harbour	350
Kole	150
Shark Bay/Mavea	200
South Santo	300
Malo/Aore	300
TOTAL	2,000

Torba Province

It is recommended that the quota for Torba Province be regionalized. The suggested levels for each region are detailed below.

Site	Proposed quota
Torres	
Hiu	1,500
Tegua	1,500
Loh	500
Toga/Metoma	200
Banks	
Moto Lava	400 (or lower)
Gaua	400 (or lower)
Other	500 (or lower)
Total	5,000 (or lower)

Other proposed measures

- An initial quota of 2,000 coconut crabs should be implemented for Tafea Province. This number should be allocated as follows: 1,500 from the Ipota (eastern) side, and 500 from the Dillion Bay (western) side. A closed season should be implemented for Tafea Province (and all southern provinces) between January and March to protect spawning in these regions.
- The quota for Maewo in Penama Province should be reduced slightly from its current level to 1,500 crabs per year, with a closed season occuring at the same time as that in Sanma Province.
- There should be a trigger point of 500 crabs per year for any other province/island, which, if exceeded, would trigger the requirement for specific surveys and management to be introduced.
- The Director of Fisheries should have the power to halt the collection of crabs at any time if there are indications of over harvesting.
- The collection of information on the numbers of crabs being harvested needs to be improved. A more accurate means of recording the numbers of crabs sent to Port Vila from each regional airport, particularly Santo, should be instituted.
- There should be regular three- or four-month surveys of the main restaurants and markets for crabs in Port Vila.
- Complete yearly/biyearly stock assessment surveys should be conducted using local fisheries staff at each of the main sites to monitor the performance of the management arrangements.

9.2 Lobsters

9.2.1 Species present

Three species of rock lobsters are present in Vanuatu: pronghorn spiny lobster, *Panulirus pencillatus*; painted spiny lobster, *P. versicolor*; and longlegged spiny lobster, *P. longipes femoristriga*. The slipper lobster, also known as the Caledonian mitten, *Parribacus caledonicus*, is also present.

9.2.2 Distribution

Panulirus pencillatus is the most widespread species of the spiny lobsters and is commonly found in the Indo-West Pacific and Eastern Pacific regions, from the Red Sea, East and South Africa to Japan, Hawaii, Melanesia, 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 is present in the Indo-Western Pacific region from the entire Red Sea and east coast of Africa, southern Japan, Micronesia, Melanesia, northern Australia and Polynesia.

P. longipes femoristriga is found in Japan, the Mollucca Islands of Indonesia, Papua New Guinea, Vanuatu, eastern Australia, New Caledonia and French Polynesia.

Parribacus caledonicus is found throughout the Indo-Western Pacific region in Queensland, Australia; New Caledonia and the Loyalty islands; Vanuatu; Fiji and Samoa.

Within the Vanuatu archipelago, *Panulirus pencillatus* and *Parribacus caledonicus* inhabit the "weather" sides (east and south) of the islands. *Panulirus pencillatus* is found around Anietyum, Futuna, Tanna, Erromango islands, the south and east of Efate, the Shepherd islands, Cooks Reef, Ambrym, Pentecost, Maewo and south and east coast of Malekula and Espiritu Santo islands. *P. longipes femoristriga* has been reported to be present on Tanna and in the northern region and on Maskelyne Island, Malekula and along the west coast of Espiritu Santo; *P. versicolor* is found in abundance in the northern islands as well as around Efate, Tanna and other southern islands.

9.2.3 Biology and ecology

Spiny lobsters are considered opportunistic and omnivorous scavengers that prey on gastropods, crustaceans, echinoderms, seagrass and algae (Philips et al. 1980 in Pitcher 1993). Rock lobsters are nocturnal and are not gregarious (Holthuis 1991). They reach sexually maturity at 7–10 years of age. Once breeding begins, it is continuous throughout the year, but is reduced in cooler months. Mating in most aquatic decapods occurs shortly after female moulting and the sexes are attracted to each other by pheromones before or after moulting (Ruppert and Barnes 1994). The female carries the eggs under its tail for one month before tiny phyllosoma larvae are released (Pitcher 1993). The larvae remain in the ocean for 4–12 months before moulting into the puerulus stage. At this stage they are about 50 mm long, and resemble a colourless miniature adult. As puerulus they undergo a transition from the oceanic to the benthic environment, where they settle in or near the adult habitat, quickly moulting into pigmented juveniles (Philips and Sastry 1980, in Pitcher 1993). Because of the widespread dispersal of *Panulirus pencillatus* phyllosoma larvae, and because of there are a number of unexploited reefs to provide recruitment to exploited reefs, this species is probably resilient to recruitment overfishing.

Panulirus pencillatus is the main rock lobster species harvested by coastal rural communities in Vanuatu. It occupies the same habitats as *Parribacus caledonicus* (i.e. the "weather" sides of islands), within the surf zone, surge channels and undercut *Porolithon* reef where there is good water circulation and the water ranges in depth from 2–6 metres. *P. pencillatus* often hide in crevices and marine caves during the day time, often attached to the ceilings of caves. The ideal habitat includes the spurs of reefs that run offshore.

P. longipes femoristriga are smaller than *P. pencillatus* and live in deeper waters up to 122 metres. *P. longipes femoristriga* favours compact reefs, particularly those receiving moderate but regular surf action with small blowholes through the narrow fringing reef flats. These reef types are common around Malekula Island and the west coast of Santo.

P. versicolor is the largest of the three rock lobster species and inhabits quiet, turbid or clear waters down to 37 metres. It also lives in silty, quiet lagoon waters, often near stream mouths, or in deeper water on the outside face of reefs that receive moderate to high wave action.

9.2.4 The Fishery

Utilisation

The exploitation of rock lobsters in Vanuatu is widespread, both for subsistence and as a source of income for rural coastal communities. The lobsters are harvested by hand while free diving (using mask and snorkel) on moonless nights. A torch is used to find them. Lobsters are also sometimes harvested during the day. A small experimental fishery was initiated at Tanna and other southern islands, using two- to three-foot wide beehive cane or wicker pots baited with chitons or sea urchins. The pots were set on the reef edge in reasonably sheltered pools or crevices, often covered with stones, and out beyond the reef in depths of at least 122 m. 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).

Production and marketing

Main commercial markets are located in Port Vila, Efate and Luganville, and Santo. In 1983, an estimated production of 490 t of lobsters were harvested, of which, 45% was sold at Port Vila markets, earning an estimated amount of VAT 122 million (David and Cillaurren 1992).

Baird (1973) reported a CPUE of two to three "sacksfull" a night in Santo and Lamap (south Malekula island), with an estimated weight between 50 and 100 kg. Value per kilogram of crab was AUD 1.00 (equivalent to VUV 80).

The artisanal lobster harvest for 1983 was estimated to be approximately 20.5% (490 t) of the subsistence harvest of 2,402 t of marine organisms annually (David 1985), and worth an estimated value of more than USD 1 million. Of the total harvest of marine species, approximately 555 t were produced for sale, of which, 45% consisted of crayfish and 42% of fish. The estimated market value was VUV147 million, of which, 83% was attributed to rock lobsters. Of all the crustaceans in Vanuatu, lobsters are the only ones that are actively marketed, with half of the catch going 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 shown in Table 7.

Table 7: Quantity of lobsters and slipper lobsters landed at Natai Fish Market

	May 1983-July 1984	**1988**	**1989**	**1990**	**1991**	**1992**
Lobster (kg)	3,306	1,810.0	850.4	1,301.3	1,716.3	1,483.2
Value (VUV)		1,020,110	511,515	396,428	1,604,385	1,042,551
Slipper Lobs		0	37.3	0	9.1	71.9
Value (VUV)		0	11,005	0	2,730	28,920

Source: Department of Fisheries database, and Crossland 1984; lobsters purchases between July 1983 and July 1984 at Santofish amounted to 120 kg (Crossland 1984).

From 1990 to 1992, the fisheries extensions centres purchased lobsters, but the data are mixed together with those of coconut crabs under "other species". Even though the species in this category seem to have comparatively small inputs into extension centre purchases, these species are important to other sectors within the country at the subsistence, artisanal and commercial levels (see Table 8).

Table 8: Purchased lobsters recorded as "other species"

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

Source: Department of Fisheries database

In 2003, the Department of Fisheries banned the issue of Fish Establishment Export Licenses for overseas bound rock lobsters. This was because the status of rock lobster stocks was not healthy. However, the harvesting of lobsters was still allowed, but only for domestic market consumption. Exports figures for the years 1999 to 2003 are summarized in Table 9.

Table 9: Quantity of lobsters exported

Year	Quantity (kg)	Value (VUV)
1999	70	42,000
2001	3,494	3,403,650
2002	758	838,772
2003	10	2,000

Source: Fisheries export permits

9.2.5 Stock status

Assessment surveys carried out by the Department of Fisheries indicate that rock lobster stocks in Vanuatu are in danger of being overfished. The exploitation level is determined by access to urban markets in Port Vila and Luganville, and the population size of the island or coastal communities.

Populations of rock lobsters vary from island to island, and population size is determined by reef habitat. Some islands appear to have high populations of a particular lobster species compared with other islands. For example, surveys carried out on the Shepherd islands (Buninga, Makira, Emae, Tongariki and Mataso) indicate that double-spined and blue-spot rock lobsters are the predominant species, and that Makira and Mataso islands had the highest occurrence of lobsters. Very few slipper lobsters were recorded during the assessment survey, implying that slipper lobster stocks are near depletion. Assessment surveys carried out around Malekula Island, however, indicate that the predominant species there is the painted spiny lobster (*Panulirus versicolor*). The absence of blue-spot lobsters from the survey sites may be due to its high commercial value and the ease with which the lobster can be sold or freighted out from Malekula to either Port Vila or Luganville.

The assessment surveys concluded that Erromango, Aneityum, and the islands of the Torres/Banks group had very high numbers of rock lobsters.

9.2.6 Management

Current legislaion/policy regarding exploitation

The fisheries regulation under the Fisheries Act CAP 158 of 1982, prohibits taking, possessing, selling or purchasing of any rock lobster carrying eggs; or any rock lobster that is less than 22 cm in length when laid flat and measured from immediately behind the rostral horns to the rear edge of the telson; or any lobster whose carapace is less than 7.5 cm when measured along the mid-line from immediately behind the rostal horns to the rear edge.

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

For the slipper lobster, *P. caledonicus*, the above regulation applies, except that the minimum length is 15 cm measured from the front edge of the carapace to the rear of the telson. Penalties for violation of these regulations is a fine of up to VUV100,000.

Recommended legislation/policy regarding exploitation

Given the high exploitation levels of lobsters, it is recommended that the Department of Fisheries should 1) carry out a thorough rock lobster stock assessment; 2) place a closed season for harvesting of rock lobsters, especially during the period when female lobsters are carrying eggs; and 3) allocate quotas for each provincial region.

9.3 Freshwater prawns

9.3.1 Species present

The main endemic species commonly found in rivers, streams or lakes in Vanuatu is *Macrobrachium lar*. However, there are several species of freshwater shrimp that are present Vanuatu but are not in sufficient quantities to be able to sustain an industry.

In the late 1970s, the culture of the giant Malaysian fresh water prawn, *Macrobrachium rosenbergii* was tested in Vanuatu but failed due to high mortality rates.

9.3.2 Distribution

Freshwater prawns are found throughout Vanuatu, particularly on islands where there are rivers, streams or lakes. Stock abundance has been identified on Santo, Malekula, Maewo, Erromango, Efate, Epi and Anietyum islands.

9.3.3 Biology and ecology

The biology of the freshwater prawn *Macrobrachium rosenbergii* is well known. Larval cycles during the hatchery phase as well as the species growout performance in aquaculture are documented in numerous articles. However, little is know about the biology and its larval cycle of *Macrobrachium lar*, although it has been reported to have a very slow growth rate and is capable of wandering off from, thus making it unsuitable for aquaculture farming.

9.3.4 The Fishery

Utilisation

Local freshwater prawns are harvested for subsistence use and for sale. In islands such as Pentecost, and particularly Maewo, taro farmers rear local freshwater prawns in their irrigated taro patches. Draining these taro patches is another way of harvesting the *Macrobrachium lar*. In subsistence use, prawns are caught with a spear, but for commercial purposes, prawns are caught using traps so that their appearance is maintained, thus guaranteeing a better financial return.

Current purchasing price per kilogram of local freshwater prawn from harvesters is VUV 500–1,000. Retail price is VUV 1,500/kg. Freshwater prawns are normally brought in from the islands and rural inland areas of Santo and Efate and are sold to middlemen buyers or directly to restaurants and hotels.

To date, there has been no major aquaculture farming of freshwater prawns. However, in the late 1970s a local company initiated a trial freshwater prawn farm, but due to rearing difficulties and a lack of technical expertise, the farm was terminated in the early 1980s.

Given the high demand for freshwater prawns at the domestic markets, the Department of Fisheries, as part of its 2004 development activities, initiated research studies on the possibilities of farming *Macrobrachium rosenbergii*. The purpose is to introduce this freshwater prawn species into Vanuatu from Fiji, where successful trials have been achieved.

With funding assistance from ACIAR, the Department of Fisheries Research and the Aquaculture Division began farming trials of *M. lar* at Sarate, in south Santo. Juveniles are netted or collected from the wild and reared in impounds (4 m x 6 m) with stocking densities of 5 prawns per 1 m^2. The purpose of this research is to determine the socioeconomic viability of farming this native freshwater prawn.

Production and marketing

In 1983, it was estimated that the annual production of *M. lar* was 18 t, representing 0.7% of the annual rural fishing production, was determined for Vanuatu. In 1986, the Japan International Cooperation Agency (JICA) reported a freshwater prawn yield of 12 t for Vanuatu in 1984.

From 1988 to 1992 the government owned Natai Fish Market (now liquidated), and production figures for prawns are shown in Table 10.

Table 10: Production figures for 1988-1992

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

Most of the prawn catch is consumed at the subsistence level. Yields from freshwater areas for subsistence purposes have been estimated to be about 56 t/year (Government of Vanuatu, Second National Development Plan 1987–1991).

9.3.5 Stock status

To date no stock assessment surveys has been directed towards estimating or assessing the stocks of the *Macrobrachium lar* in Vanuatu. However, fresh water prawns are continually being harvested and are sold directly to either the restaurants or the hotels at an average price per kilogram of VAT 1,000.

9.3.6 Management

Current management regimes for this resource are self-regulation, even though freshwater prawns are a commercially marketed resource.

Current legislation/policy regarding exploitation

There is no current legislation regarding the exploitation of this resource.

Recommended legislation/policy regarding exploitation

The following options should be considered as possible management measures:

- Prohibit or ban the use of all chemicals to catch or harvest this resource by collectors;
- Develop criteria to manage such economic developments as cattle farming, habitat destruction, deforestation, irrigation, aquaculture, etc., that may have detrimental impacts on the resource; and
- Develop criteria for introduction of fresh water exotic species into the river

systems.

9.4 Land crabs

9.4.1 Species present

Three species of land crabs, all belonging to the genus *Cardisoma*, are found in Vanuatu (Lal and Esrom 1990).

9.4.2 Distribution

Land crabs occur throughout Vanuatu but abundance is only restricted to a number of islands such as Malekula, Santo, Emae and Efate.

9.4.3 Biology and ecology

Lal and Esrom (1991) reported that the *Cardiosoma* spp. is caught on the edges of mangrove areas and along the sandy strand bordering *Rhizophora* mangroves. Adults appear to live in inland areas among ground cover vegetation or in underground burrows, mainly around swamp areas, and come at night to feed.

Gravid females carry their dark blue coloured eggs until they hatch. They are often observed eating leaves, and go to the seaside to release the larvae.

Around two days before a full moon, especially during the summer months, the crabs emerge at dusk and undertake mass migrations to the sea. The larvae are released from the eggs into the sea by vigorous flapping of the abdomen. A berried female is able to release up to 425,000 larvae.

Release of larvae at spring tides presumably maximizes dispersal along the coast. It has been reported that the spawning migration in Vanuatu occurs during a new moon (i.e. on dark nights).

Typical *Cardisoma* habitat in Vanuatu is normally associated with inland mangrove areas and swamps.

Cardisoma hirtipes

9.4.4 The Fishery

Utilisation

In the past, the collection of land crabs was mainly for home consumption; however, nowadays this resource has a commercial value. Crabs are sometimes caught at night during their migration to spawn, but are normally caught at around dusk. On islands where the crabs are abundant, such as on Emae and Uri islands, collection occurs at any time during the day. Given the recent commercial value of the crabs, rural communities

on other islands of Vanuatu are now collecting and exporting the crabs, via air freight or trading vessels, to Luganville and Port Vila municipal markets for sale.

In areas where crabs are abundant, they are offered for sale in bundles or small baskets. On Emae Island, crabs are offered for sale at the Aromai airport to airplane passengers at VUV 200 a basket. In Siwo village on Emae Iisland, members of neighbouring communities pay a collection fee of VUV 700 per person before they can collect land crabs on areas of land owned by the Siwo community. In Port Stanley, on Malekula, *C. hirtipes* is regularly caught for subsistence as well as for sale. Lal and Esrom (1990) reported 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 air freighted to Port Vila, via middlemen buyers.

Production and marketing

There are no records in Vanuatu of land crab production, except some estimates made for Norsup market on Malekula. Crabs sold on Efate come mostly from Erakor and Eton, although probably also from northern Efate. At the open market in Port Vila, a basket — estimated to contain 10–20 crabs — is sold for VUV 500. Crabs are also sold in bundles or strings at VUV 50 per crab.

Lal and Esrom (1990) estimated that about 17,680 kg of land crabs, worth VUV 850,000, are marketed via Norsup market annually. Some of these were bought by individuals who airfreighted them to Port Vila where they were sold for VUV 250–300 for a bundle of five crabs.

9.4.5 Stock status

There is no data on land crabs. However, observations made in locations where there are abundant land crab populations — such as Crab Bay on Malekula, and on Siwo and Vaitini on Emae Island — indicate a reduction in the overall land crab population.

9.4.6 Management

Current legislation/policy regarding exploitation

There is no legislation concerning the exploitation of land crabs. However, Crab Bay has now been declared a reserve in order to allow such resources as land crabs to propagate.

Recommended legislation/policy regarding exploitation

There does not seem to be any need to regulate the resource at present. However, if exploitation becomes too great in areas such as Port Stanley or Emae Island, it may become necessary to limit or ban the export of crabs to Port Vila. However, in order to see any sort of trend, it would be necessary to begin collecting data.

9.5 Deepwater shrimp

9.5.1 Species present

Seven species of the caridean shrimps are found in Vanuatu at depths between 229 m and 650 m. All belong to the family Pandalidae and at least three genera: *Heterocarpus*, *Plesionika* and *Parapandalus*.

The species listed by King (1986) 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).

9.5.2 Distribution

Heterocarpus is found in the in the Indian Ocean, as well as the Pacific Islands from Palau to French Polynesia (King 1993). This species occupies particular depths but has overlapping ranges with the smaller shrimp (e.g. *P. serratifrons* and *P. edwardsii*), and is widely distributed in shallower waters (<400 m). The medium-sized *Heterocarpus*, *H. sibogae* and *H. ensifer* predominate catches from depths greater than 400 m; while *H. laevigatus*, one of the largest species, is common in depths of more than 500 m.

King (1980) found that within Vanuatu, catch weights 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 m and 500 m consisted almost exclusively of this species. Catches of *H. laevigatus* increased with greater depth, while catches of *H. ensifer* decreased with depth. Table 11 shows species composition by weight expressed as a percentage of the total shrimp catch at each depth. In the shallowest depth sampled (229 m), *P. serratifrons* accounted for 31% of the total catch.

Table 11: 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

9.5.3 Biology and ecology

Deepwater caridean shrimp have separate sexes (King 1993). Biological parameters for four species of deepwater shrimp are given in Table 12. Female sexual maturity of *H. laevigatus* is attained between 4 and 4.6 years (40–43 mm carapace length); spawning appears to occur in the winter months. Growth parameters for some other species are also given and are reproduced below.

Table 12: Some biological parameters of a few deepwater shrimps (King 1993)

Species	L∞ (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			

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. * = figures for Fiji.

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

9.5.4 The Fishery

Utilisation

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

There has been no fishery in Vanuatu that has been based on deepwater shrimp, even though this resource can be utilised for speciality food items in local restaurants and possibly export.

In parts of the world where carid shrimps are commercially exploited, various types of trawls are used as the main method of harvesting. But as noted by Crossland (undated), this method is of little use in the South Pacific region because apart from the Gulf of Papua in Papua New Guinea, there are no areas of continental shelf. Most of the potential fishing grounds in the Pacific Islands consist of uneven or sloping bottoms, which are unsuitable for trawling.

Production and marketing

During a survey, *H. ensifer* was the only species that occurred over the entire depth range and catches of individual species varied with depth. In addition, dominant species in a particular depth range differed. When the catch data was grouped into 100 m depth ranges, it was estimated that the total mean catches were low in shallow water but increased with dept, reaching a maximum in depths of 500–600 m (King 1980). The mean catch rate was calculated to be 2.83 kg per trap. Shrimp abundance seemed to decrease beyond this range. King, however, noted that the important factors for consideration when contemplating a fishing strategy included the catch weight and size of individual shrimp.

In 1982, the Department of Fisheries and the former ORSTOM (now the Institute de Recherche pour le Développement, IRD) conducted a survey at depths between 400 m and 700 m. The most abundant catches of shrimp were obtained from depths between 450 m and 500 m (Wright 1989). This survey also averaged 1.0 kg per trap, with *H. sibogae* and *H. laevigatus* making up the majority of the catch. 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. King (1986) provided a table of catch rates and optimum depths of caridean shrimp from different countries.

Table 13: Catch rates and optimum depths of caridean shrimps from different countries

Location	Catch rates (kg/trap)	Optimum Depth (m)	Comments & References
Hawaii's Northwestern group	2.9	550–600	Catch of *H. ensifer* and *H. laevigatus* combined (Gooding 1984)
Guam's 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)

Location	Catch rates (kg/trap)	Optimum Depth (m)	Comments & References
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 commercially exploiting deepwater shrimp in Vanuatu.

9.5.5 Stock status

The resource is not exploited and information on standing stocks is not known. More detailed assessment research is needed. Ralston (1986, in King 1993) reported a drastic decline in catch rates, from 3.3–1.8 kg/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).

9.5.6 Management

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

Current legislation/policy regarding exploitation

There is no current legislation regarding deepwater shrimp.

Recommended legislation/policy regarding exploitation

Legislation of deepwater shrimp is unnecessary until the resource stock is assessed and utlisation initiated.

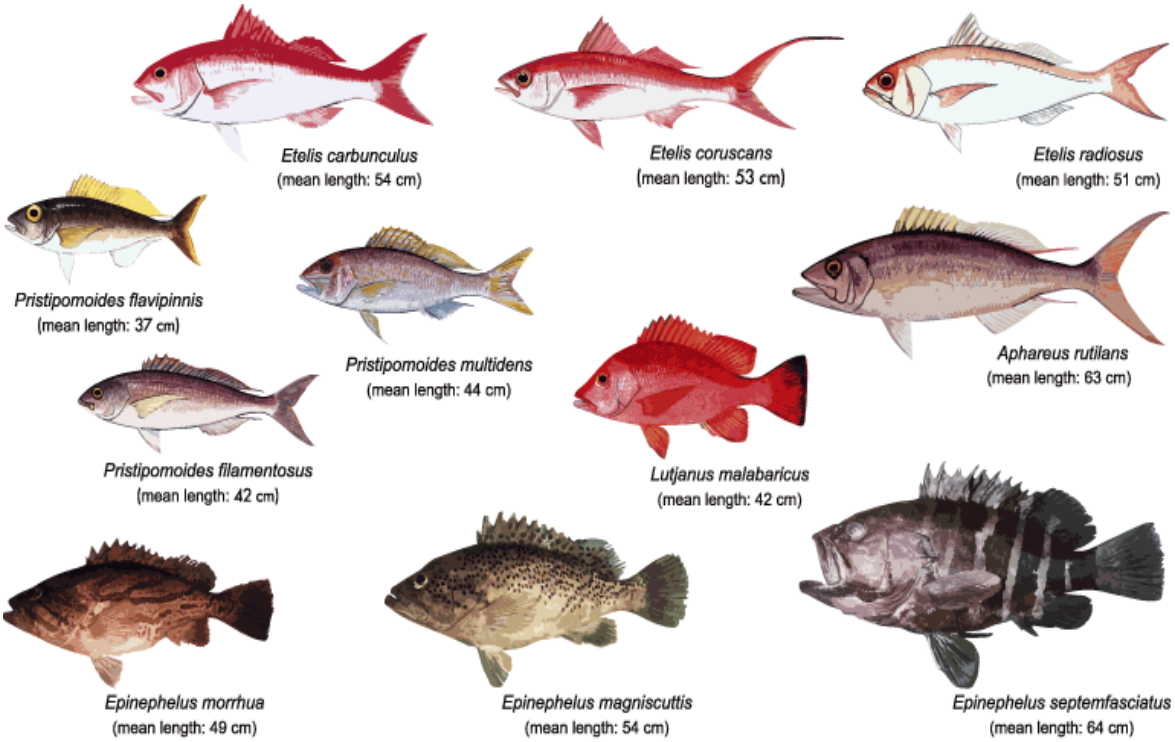
10 Finfish (Osteichthyes)

10.1 Deepwater bottomfish

10.1.1 Species present

Over 100 species of bottomfish were recorded by Brouard and Grandperrin (1985) with the most represented families being Lutjanidae (subfamilies Etelinae, Lutjaninae and Apsilinae), Serranidae (subfamily Epinephelinae) and Lethrinidae.

The 11 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, Lutjanus gibbus, L. bohar, L. rufolineatus, L. argentimaculatus, L. timorensis, Lethrinus variegatus, Lethrinus miniatus, Paracaesio kusakarii and T. zonatus.



Source: FAO Species Catalogue, Vol 6 and 16, Rome, 1985, 1993

10.1.2 Distribution

Throughout the South Pacific, snappers and groupers constitute the greatest proportion of the deepwater fish catch, in terms of total landing and value. Most of the species in these two families are widely distributed throughout the central, western and South Pacific. Species richness, however, tends to decline with distance from the Indo-Pacific faunal center, so that areas such as Hawaii have 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. Many species, particularly members of *Aphareus, Aprion, Etelis, Lutjanus, Macolor, Paracaesio, Pinjalo* and *Pristipomoides* have broad distributions that encompass 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 distributions 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.

Deepwater bottom-fish inhabit outer reef slopes at depths ranging from 100–400 m (Brouard and Grandperrin 1985; Schaan et al. 1987). In Vanuatu, this area has been estimated by region (Table 14) to be over 750,000 ha (David 1985).

Table 14: 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

Area	Surface 100–400 (ha)	Percentage of total	Area	Surface 100–400 (ha)	Percentage of total
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
Malekula	101,344	13.4	Aneityum	14,816	2.0
Ambrym	26,650	3.5			
			Vanuatu Total	754,685	100

This, however, does not indicate areas that are potentially rich in bottom-fish. Brouard and Grandperrin (1985) gave depth ranges for 84 different bottom-fish species in Vanuatu. Classification of species by three depth zones of maximum concentration (as recorded during deep bottom-fishing in Vanuatu) was also given. These data are shown in Table 15.

Table 15: 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*
	A. rutilans	*T. zonatus*
	L. argentimaculatus	
	E. magniscuttis	
	G. mossambicus	
	E. chlorostigma	
	E. areolatus	
	L. rufolineatus	
	P. kusakarii	

The vertical distribution of fishing effort shows two peaks — located between 150 m and 200 m and between 250 and 300 m depths — with a subsequent sharp decline to a minimum at around 400 m. Fishing yields (weight) increase steadily from the surface and reach a maximum at 400 m depth. There is almost no fishing effort below 500 m.

The vertical distribution of fish species shows clear habitat stratification. *Pristipomoides* spp. and *Lutjanus malabaricus* inhabit the water layer between 25 m and 300 m. *Etelis* spp. are the main fish caught below 200 m, and *E. carbunculus* is caught at the deepest levels. Groupers (*Epinephelus* spp.) and *Aphareus rutilans* are the most common species in the intermediate waters between 100 m and 350 m, although these fish do not seem to be very depth-specific.

The two main *Etelis* species, *E. carbunculus* and *E. coruscans*, are mainly fished near islands that are exposed to southeasterly winds. *E. radiosus*, the third species of the group, seems to be widely distributed, but with maximum yields recorded at Tongoa and Tanna islands. Especially high yields were recorded at Maewo and Paama for *E. carbunculus* and at Maewo for *E. coruscans*.

As noted for *Etelis* spp., the three *Pristipomoides* species seem to be widely distributed

around many islands, but there are similarities with respect to the geographical distribution reported for *E. radiosus*. The highest CPUE for *P. multidens* was recorded at Tongoa, while very high yields of *P. filamentosus* were recorded at Tanna. The *Epinephelus* group is mainly caught in Ambrym, Pentecost and Tanna. Catches of *L. malabaricus* have declined throughout Vanuatu. *A. rutilans* catches are specifically localized around Maewo.

The largest fishing grounds within the country are off the east coast of Santo. Around Efate, fishing effort during 1987-1988 seemed to have concentrated in the northeast Efate region, Emao and Forari (Cillaurren 1989).

10.1.3 Biology and ecology

Benthic fish and crustaceans form an important dietary component for deepwater snappers and groupers, and pelagic urochordates are important prey items for many species of *Pristipomoides* (Moffitt 1993). Deepwater snappers are serial spawners, capable of spawning several times over a prolonged breeding season. Reproduction takes place in the summer months: 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 are usually 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 (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 out in Santo for 656 *P. multidens* individuals, giving a male to female ratio of 1:18. The same authors hypothesized — using results from microscopic examinations of fresh gonads for different stages of maturation — that shallower water species have maximum breeding activity in summer, although they are capable of spawning all year round, while deepwater species do not have such a marked cycle. In all species, intense sexual activity in October and November seems to be very common. Length at sexual maturity (L_m) was calculated by the same authors for 26 deepwater species, without any sex distinction, as presented in Table 16. 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[2]) and maturation stages 5, 6 and 7. 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 from 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.

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

Table 16: Minimum sexual maturity sizes recorded and calculated sexual maturity sizes(Lm) using Lm=0.576 mean Lmax (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 that occur on the outer reef slopes of Vanuatu seem to be very low, lower even than for the more deeper water species such as *E. carbunculus* and *E. coruscans* than for shallower water species such as *P. flavipinnis* and *P. multidens*. Brouard and Grandperrin (1985) gave the following table (Table 17) and notes for the Von Bertalanffy parameters, total mortality index (Z) and natural mortality index (M) for six major species of the outer reef slopes in Vanuatu.

Table 17: Some biological parameters for six major species of the outer reef slope in Vanuatu

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. carbunulus	0.07	94	4.2	3.42	57	28	0.07	0.089	0.149
E. coruscans	0.128	82	5.99	4.71	55	30	0.107	0.136	0.237
L. malabaricus	0.310	60	7.65	4.47	44	32	0.447	0.401	0.545
P. flavipinnis	0.356	58	8.06	4.39	35	27	0.648	1.006	0.602
P. filamentosus	0.295	60	7.28	4.26	41	31	0.467	0.587	0.527
P. multidens	0.244	64	7.01	4.53	44	34	0.375	0.460	0.448

K=1000/W, W=aLmb (a, b obtained by means of the length/weight relationship; meanL=mean maximum lengths, Lc=(L100 +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.

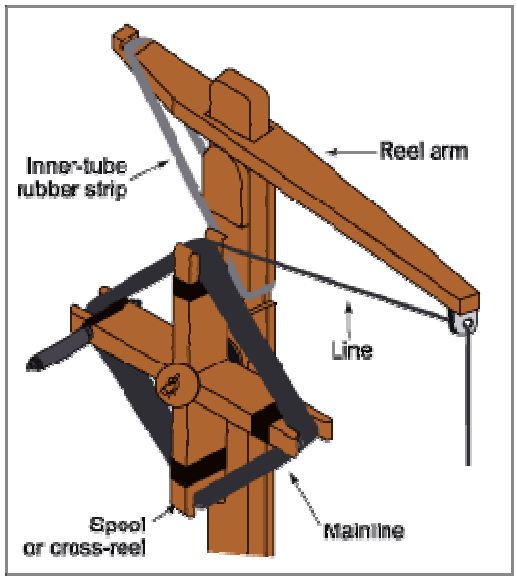
Carlot (1988) estimated growth and mortality parameters (L_∞ and K) of *E. carbunculus* in Vanuatu to be 132.4 cm and 0.22 $year^{-1}$ respectively using ELEFAN I. Brouard and Grandperrin (1985) estimated the same parameters for the same species, using otoliths, to be 94.0 and 0.07^{-1} respectively.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

10.1.4 The Fishery

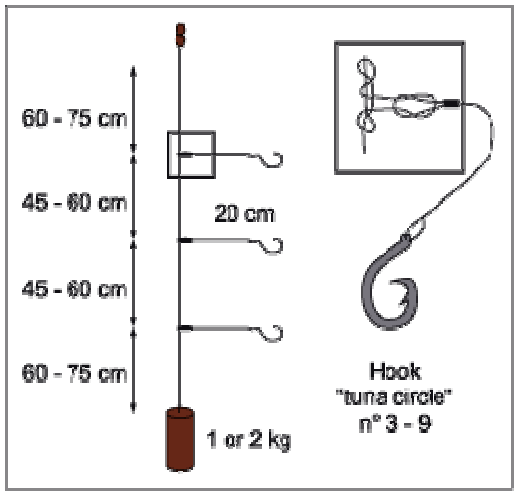
Fishing technique

Up until the late 1980s, most deepbottom fishing was done with a manual wooden reel, monofilament line fitted with a metal leader, three hooks, and a weight, as shown in the diagram at right.

Fishing reel (Western Samoa model)



Leader



The manual wooden fishing reel is a homemade device developed by FAO in 1976, and which has been widely adopted in the Pacific Islands (Guldbransen 1977). In Vanuatu, this device replaced the bicycle pedal mechanism and is generally used on powerboats, but sometimes on traditional dugout canoes. The fishing line on these reels is used for trolling and deepsea fishing. In this latter case, it descends vertically from the fishing boat with the motor off. Three hooks, set at about 50 cm intervals, are baited with skipjack tuna or sardines. The line is only fitted with a small weight as it remains in the water for a very short amount of time.

Fishing is done during the day or at night, usually drifting. Very little deepwater mooring with a grab anchor is practised (Guldbransen 1977; Crossland and Grandperrin 1980). Deep longline fishing was only a marginal technique until the 1990s when it was gradually adopted by independent fishermen and some associations. Reel and lines are also used for troll fishing, mainly for tuna, around FADs and on the way to deepsea fishing grounds. Fishing trips are rarely longer than two days, and most are less than 12 hours long.

Utilisation

The deepwater bottomfish fishery targets the high, commercially valuable snappers ("poulet" or chicken fish), which are locally sold to fish markets, hotels and restaurants. Some enter the subsistence economy at the village level (Dalzell 1992).

The first datasets available on deepsea fishing were obtained by the South Pacific Commission (now the Secretariat of the Pacific Community – SPC) exploratory expeditions in Vanuatu (Humes 1975, 1976; Fusimalohi 1979). The initial surveys by the SPC Deep Sea Fisheries Development Project — between 1974 and 1981 —concluded that deepwater bottomfish resources were virtually unexploited. In 1981, after the formally structured Department of Fisheries was established, the Village Fisheries

Development Programme (VFDP) was launched to promote the intensive development of small-scale deepsea fishing. Hand-reels, developed for deepwater bottom handling in Western Samoa, were used, and were mounted on 8 m catamarans or 5 m dories powered by 25 hp outboard motors. Trial fishing efforts for bottomfish, initiated by SPC, were continued by the Department of Fisheries from 1981 to 1982.

The fishing trials used several types of catamarans and mono-hulls: the 8.6 m alia catamaran, 5.0 m and 5.6 m Hartley half-cabin launches were chosen, with a marked preference for the Hartley type (Schaan et al. 1987).

Trap fishing, using Z-type traps, were tried by the Department of Fisheries 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 deepwater resources initiated the establishment of the VFDP by the in 1982. This soon led to the creation of more than 200 fishermen's associations throughout the archipelago. The activities of 119 of these associations were monitored by VFDP and ORSTOM (now the Institut de recherché pour le développement) to determine their fisheries potential and management parameters. The geographical distribution and temporal development patterns of the studied associations clearly reflect the patterns of all of the fishermen's associations, and the length of time these associations lasted was found to vary from island to island.

By 1988, a total of 180 fishing projects were registered under the VFDP, although not all of these were directly involved in fishing; some concentrated on marketing while others focused on establishing ice machine centers in 10 locales.

Following the completion of the EU-funded Fisheries Extension Project in 1995, the ice machine centers, due to a lack of operational funds, were not sustainable. In 1996, all ice machine centers managed by the Department of Fisheries were placed on public tender as a privatization scheme. By 1998, no more ice machine centers were operational, resulting in the decline of many artisanal fishing projects. The closure of all ice machine centers affected rural sector fishing of deepwater fish, and reduced — almost to zero in some areas — rural economy turnover based on fishery products. In areas such as Tanna, Efate and Santo, where access to local markets and preservation facilities is available, fishing projects were only slightly affected.

In 2000, the government — through a policy decision — agreed to reactivate commercial rural fishing activities through the development of provincial ice machine centers as a mean to boost rural sector economic development. The Department of Fisheries, through its Development and Capture Division, re-established a community-based ice machine project in 2001, funded by the Government of Vanuatu. The project completed its first phase in 2003, which was the establishment of the Tafea (Lenakel, Tanna) and Shefa (Tunika, Emae) provincial ice machine and marketing centers. The aim of the project is to establish an ice machine and fish processing and market center at each provincial zone.

Duty exemption privileges are made available to individual fishermen and to fishing projects that provide the Department of Fisheries with details of fishing activities and catches. Provision of in-kind subsidies by the government became the incentive that sustained the development of the bottomfish fishery. A summary of operating projects by area and year, under the VFDP between 1982 and 1986, is given by Schaan et al. (1989). Table 18 provides the number of provincial artisanal fishing projects that were in operation, and which provided data to the Department of Fisheries between 1982 and 2003.

Table 18: Number of operated fishing projects for 1982 to 2003

Province	'82	'83	'84	'85	'86	'96	'97	'98	'99	'00	'01	'02	'03
Tafea	1	1	2	2	8	9	9	23	20	14	21	21	22
Shefa	1	4	6	12	10	33	33	21	17	22	33	29	32
Malampa	2	3	3	14	19	23	15	3	3	16	22	17	17
Penama	0	0	5	8	11	2	0	0	0	8	10	2	4
Sanma	2	2	5	15	17	15	19	34	33	16	16	8	13
Torba	0	0	0	1	3	1	3	7	4	1	1	1	1
Total	6	10	21	52	68	83	79	88	77	77	103	78	89

Production and marketing

Catch rates from various SPC bottom fishing trials in Vanuatu were given in Dalzell and Preston (1992). Based on 80kg/trip and 160 trips/year, Crossland (1984) estimated an annual production of 320,000 kg (VUV 32 million) per project.

The advent of the deepwater fishery also established a marketing scheme. Originally, the Natai Fish Market in Port Vila, operated by a government-owned company called Port Vila Fisheries Limited, received all catches from fishing projects from around Vanuatu, including those based on Efate between 1982 and 1997.

Transportation to Port Vila was all by air using large coolers, fish boxes and fish bags. Due to increased production, a second marketing operation, Santofish, was established in 1983 at Luganville which purchased fish caught along the east coast of Santo (largest fishing grounds) and outer islands.

Fisheries extension centres on the outer islands (seven total: one each on Tongoa/Sheperd, Malekula/Lakatoro, Banks/Sola, Ambae/Lolowai, Epi, Santo and Efate/Tafea) purchased and re-sold fish between 1987 and 1993. 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.

However, because of better prices offered, bottom-fish increasingly went directly to the restaurants and supermarkets in Vila. The total catch (kg) landed and the average catch per trip (kg), by area and year, under the VFDP fishing operation between 1982 and 1986 is recorded below (adapted from Schaan et al. 1987):

Table 19: Catch per trip for the years 1982-1986

Area	1982	1983	1984	1985	1986
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	-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	-28.8	-27.7

Area		1982		1983		1984	1985	1986
Ambrym	-		-			3,515	7,033	4,383
(C/trip)	-		-			-41.8	-27.9	-20.1
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		-22.9		-27	-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	-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 the production of the bottomfish 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 fish landed under the VFDP between 1982 and 1986. The results are shown in Table 20.

Table 20: Estimated weight by species

Species	Est. weight (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 bottomfish 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.

Annual patterns concerning fishing effort, yields (total catch weights and fish numbers), and mean catches are presented in Figure 2. As of 1983, there was a steady rise in the overall fishing effort, as shown by the regular increase in the number of fishermen's associations. As of 1989, this trend was reversed because there were too many associations for the market volume and local outlet potential. Many associations were therefore disbanded due to a lack of sufficient income.

Deepwater bottomfish production by Department of Fisheries Extension Centres (1990-1992)

Fisheries Department Extension centers played a significant role in purchasing deepwater fish from fishermen. Most of the fish bought from fishermen were re-sold, with surpluses being freighted to either Santofish or Natai Fish market in Port Vila. Combined catch

landings at the Fisheries Extensions from 1990 to 1992, by species, are given in Table 21.

Table 21: Deepwater bottomfish landed (kg) at all the outer islands fisheries extensions centres

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**

Source: Department of Fisheries database

Table 22: Natai Fishmarket deepwater fish purchases (kg) between 1988 and 1992

Species	1988	1989	1990	1991	1992
	weight(kg)	weight (kg)	weight (kg)	weight (kg)	weight (kg)
Poulet	29,138.6	26,867.3	25,779.4	34,194.3	31,551.6
(Value VUV)	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
(Valu)	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

Source: Department of Fisheries database

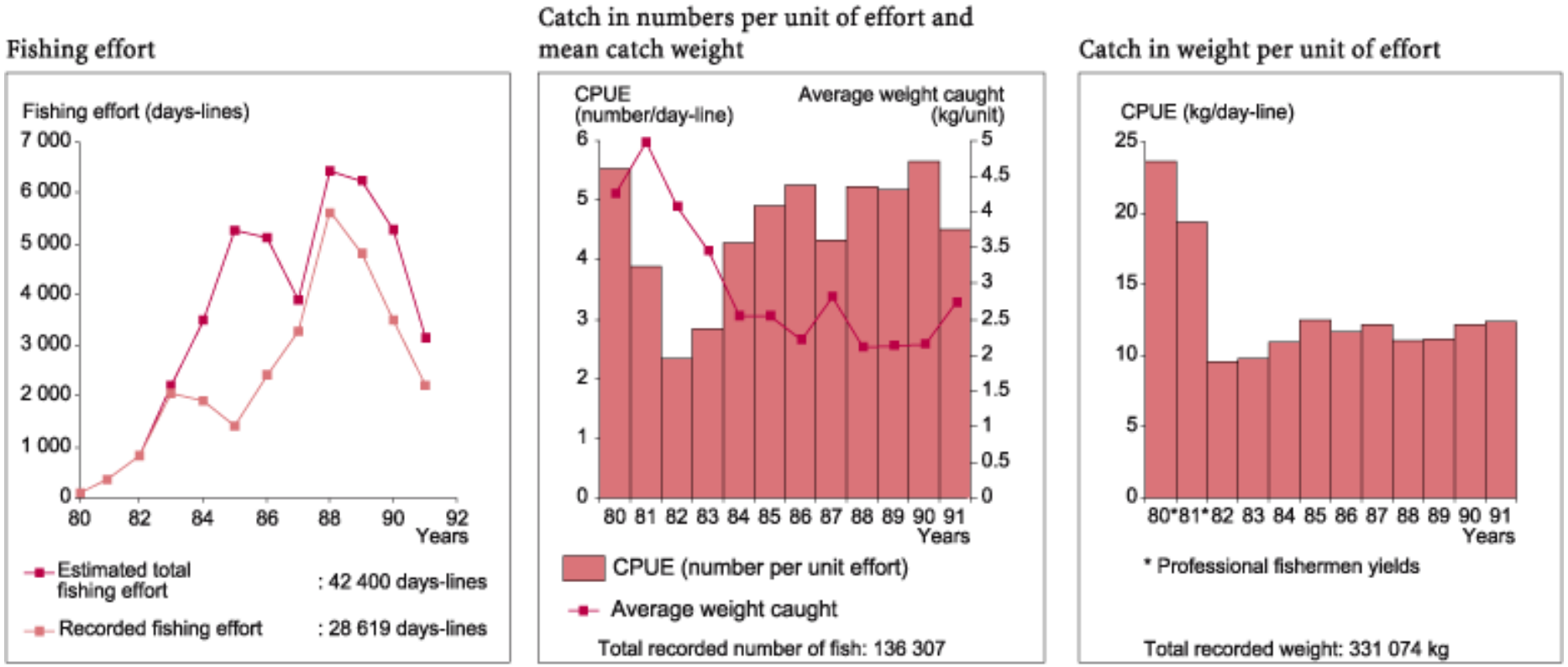


Figure 2: Annual overall fishing effort, catch patterns per unit of effort and mean weight from 1980-1991

Table 23: Sales of bottom fish through Santofish from 1989 to 1992

Species	1989	1990	1991	1992	Total
	weight (kg)	weight (kg)	weight (kg)	weight (kg)	weight (kg)
Poulet[3]	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**

Source: Santofish database

Table 24: Deepwater bottomfish production by province

Year	Tafea	Shefa	Malampa	Sanma	Penama	Torba	Total	Value
1993	3,205	33,308	19,773	no data submitted	4,346	678	61,310	8,296,930
1994	7,063	26,563	5,814	no data collected	1,682	no data submitted	41,122	10,563,363
1995	5,691	23,477	11,670	no data submitted	4,715	no data submitted	45,553	10,958,750
1996	4,731	34,983	7,088	20,608	2,494	2,352	72,255	18,993,237
1997	5,886	30,468	5,286	19,198	527	745	62,109	17,000,425
1998	147	13,376	925	6,562	1,205	435	22,667	6,396,996
1999	no data submitted	13,684	656	4,839	no data submitted	no data submitted	19,178	6,156,521
Total	28,805	211,550	74,662	51,207	25,198	10,454	324,195	78,366,222

Weights are in kg and values in vatu. Source: Department of Fisheries GRN database.

Because excess fish are sent to Natai fish market in Port 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 in Port 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.

Exports of deepwater bottomfish

In 1996, an export market was established which resulted in exports of deepwater bottom fish overseas. Summarized below are quantities of poulet fish exported from Vanuatu.

[3]Note: 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*

Table 25: Quantities of poulet fish exported from 1996 to 2003

Year	Total quantity (kg)	Value (VUV)
1996	635	136,269
1997	75	225,000
1999	4,818	3,264,416
2001	6,685	4,369,075
2003	5,273	3,244,200

Source: Department of Fisheries export permits

GRN catch sales records[4]

Summarized below are records of deepwater bottom fish caught by fishing projects and sold on the domestic market for the years 2000, 2001, 2002 and 2003.

Table 26: GRN catch sales records of deepwater bottom fish for the 2000

Species	Total quantity (kg)	Value (VUV)
Amberjack	679	473,300
Loche (*Ephinelus* spp.)	1,583	791,500
Large eye bream	6,359	3,179,500
Green jobfish	933	466,500
Red jobfish	438	306,600
Short tail poulet	12,460	8,722,000
Long tail poulet	6,351	4,445,700
Other sp	4,584	2,292,000
TOTAL	34,324	21,145,600

Table 27: GRN catch sales records of deepwater bottom fish for 2001

Species	Total quantity (kg)
Long tail poulet	4,055
Short tail poulet	3,086
Large eye bream	203
Stripped bream	257
Loche	974
Red jobfish	101
Amberjack	420
Other sp	123
TOTAL	9,219

Table 28: GRN catch sales records of deepwater bottom fish for 2002

Species	Total quantity (kg)	Value (VUV)
Amberjack	18	5,430
Bm. striped loche	4	1,300
Kusakars snapper	3	900
Large eye bream	34	10,200
Large scaled jobfish	27	12,150
Short tail poulet	203	86,000
Red silver jaw	54	14,110

[4] Since 1989–1990, fisheries extension centres have used a receipt system — the goods received note, or GRN — designed to provide information on catch, effort and catch composition.

Species	Total quantity (kg)	Value (VUV)
Sea perch	28	8,400
Spotted loche	51	15,150
TOTAL	1,373	484,020

Table 29: GRN Catch sales records deepwater bottom fish for 2003

Species	Total quantity (kg)	Value (VUV)
Amberjack	281	100,270
Bm. striped loche	112	35,950
Kusakars snapper	18.5	7,000
Large eye bream	455	142,310
Large scaled jobfish	270	145,445
Pink tail jobfish	279	125,650
Red short tail poulet	3,627	1,568,635
Red long tail poulet	2,321	907,626
Red silver jaw	944	456,720
Silver jaw	22	9,670
Sea perch	357	130,370
Spotted loche	229	77,565
Seven banded loche	46	18,015
Stripped bream	7.5	3,000
White poulet	92	18,000
Yellow Jobfish	679	232,968
TOTAL	21,836	7,334,197

10.1.5 Stock status

Eleven species of deepwater bottomfish, belonging to two families (*Lutjanidae* and *Serranidae*), account for more than 80% of Vanuatu's fisheries production. Almost half of the production identified are *Etelis* spp., a third are *Pristipomoides* spp., and the rest includes *Epinephelus* spp., *Lutjanus malabaricus* and *Aphareus rutilans*. Mean sizes are represented by modal lengths determined during experimental fishing trips (Brouard and Grandperrin 1985). Village fisheries catch sizes range from 20–100 cm for *Etelis* spp., and *Aphareus rutilans* spp. (jobfish); 16–120 cm for *Epinephelus*; and 25–80 cm for *Pristipomoides* spp. and *Lutjanus malabaricus*. Some large-sized fish were recorded for certain species such as *Etelis carbunculus*.

The vertical distribution of fishing effort shows two peaks located between 150 m and 200 m, and between 250 m and 300 m, with a subsequent sharp decline to a minimum at around 400 m. Fishing yields (weight) increase steadily from the surface and reach a maximum at 400 m. There is almost no fishing effort below 500 m.

The vertical distribution of fish species shows clear habitat stratification. *Pristipomoides* spp. and *Lutjanus malabaricus* inhabit the water layer between 25 m and 300 m depth. *Etelis* spp. are the main fish caught below 200 m depth, and *E. carbunculus* is caught at the deepest levels. Groupers (*Epinephelus* spp.) and *Aphareus rutilans* are the most common species in the intermediate waters between 100 and 350 m depth–these fish do not seem to be very depth-specific.

Two groups of species are the main targets of fishermen: *Pristipomoides* spp. and

Lutjanus malabaricus within the 100–250 m layer, and *Etelis* spp. in the 200–400 m layer. These species seem to be much more gregarious than *Epinephelus* spp., which is considered to be a solitary territorial fish (Moffit 1993). Groupers seem to be bottom feeders and *Lutjanidae* species may also seek food close to the seabed. For all bottomfish species, larval and juvenile forms are pelagic, preferentially colonizing coastal waters, and nycthemerally migrating vertically, surfacing only at night (Parrish 1987).

Vertical fishing effort distribution patterns differ little between the islands. Generally, the highest fishing yields do not correspond to maximum fishing efforts. The most commonly caught species (*Etelis* spp. and *Pristipomoides* spp.) are found around all of the islands. A few catch trends have been noted: *Etelis* spp. are preferential targets in the eastern part of the archipelago, and there is higher *Pristipomoides* production in the western and southern sectors. Note also that *Lutjanus malabaricus* nearly completely disappeared in southern Vanuatu.

Cillaurren (undated) estimated that 74% of the 1987–1988 catch comprised *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 frequency analysis.

Examination of catch data for the 1982–1988 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 Nguyen (1989). The results indicated that, overall, the catch per unit of effort (CPUE) generally declined slightly as the number of boats increased. CPUE 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 suggests moderate exploitation of the stocks of these species, given limitations of the data. 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 stocks were at that time underexploited.

Carlot and Nguyen (1989) also calculated optimum fleet size for the bottomfish fishery in Vanuatu using two methods, those of Gulland 1971 and Pauly 1984. The Gulland method yielded an optimal fleet size of 138 vessels, while that of Pauly gave 55 vessels. Based on different assumptions and calculations, Brouard and Grandperrin (1985), estimated that 120 boats would generate the maximum sustainable yield (MSY).

The most recent and accurate MSYs for the entire archipelago are provided by Cillaurren, David, and Grandperrin (2001). The authors estimated a total MSY deepwater bottom fish for Vanuatu to be 535 t/year, with a fishing zone between 100 m and 500 m. Calculations of CPUE and MSY are based on catch data for the period 1981–1991. A summary of the estimates are provided Table 30.

Table 30: Estimated MSYs for islands in Vanuatu

Island	Estimated 100–500 m isobath surface area (ha)	CPUE (kg/day-line)	Estimated maximum sustainable yield (tonnes per year)
Torres	34,286	13.6	21
Banks	66,122	20.0	40
Maewo	25,277	<12.0	15
Ambae	18,525	<12.0	11
Pentecost	30,644	<12.0	19
Santo	152,528	12 - 26	92
Malekula	135,851	15	82
Ambrym	72,305	15	44
Paama	Total for Paama, Epi, Emae & Shepherd Islands is 171,700	No estimate	13
Epi		No estimate	56
Emae		No estimate	25
Shepherd islands		No estimate	9
Efate	117,456	9 – 13	71
Erromango	53,658	No estimate	54
Tanna & Aniwa	61,914	16	37
Aneityum	14,816	No estimate	15

10.1.6 Management

The MSY figures are rough estimates, although they should, nevertheless, assist development planners in choosing their objectives. The bottomfish resources of the outer reef slopes are, as it turns out, rather limited, which means that the fishery must be managed with great care.

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. From both the catch and effort and length frequency analysis there is evidence to suggest that the fishery is still under- exploited though there are slight declines both in mean length and the larger fish (the 95th 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 caution should be taken, as there might be some locations where the effort has reached its optimum level.

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 and 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. However, current government policy reserves the exploitation of this resource only for local fishing enterprises owned by citizens and natural citizens of Vanuatu.

Recommended legislation/policy regarding exploitation

Given the commercial value of this resource and the need for sustainable utlisation, the Department of Fisheries should develop a management plan for the deepwater demersal fishery that would place a limit on boat numbers and establish quotas in specific fishing areas in Vanuatu.

In order to give the management plan legal back up, the minister responsible for the fisheries sector — using powers accorded under the Fisheries Act — should make regulations that impose limits on fishing craft numbers, fishing gear, size of hooks, and establish provincial demersal fishery quotas based on calculated MSYs.

Table 31: 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 vascularization.
3	Flattish testicle; pinkish white colour; does not run after cutting	Opague ovary with strong vascularization 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 vascularization 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 vascularization.	Spent ovary with strong vascularization; red colour, early in this isolation oocytes can still found after cutting.

Table 32: Length-weight relationships for some deepwater bottomfish species as calculated by Brouard and Grandperrin (1985), where $W = aFL^b$ 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

10.2 Tunas

10.2.1 Species present

The commercially important 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*). Bigeye (*T. obesus*) and frigate tuna (*Auxis thazard*) have also been recorded.

10.2.2 Distribution

Tunas found in Vanuatu are generally believed to migrate throughout the region at various times of the year. The same fish found in Vanuatu may, depending on the season, also be found in the waters of other Pacific Island countries, such as the Solomon Islands, Fiji and Australia, as well as in the high seas areas. Stocks are, therefore, regional tuna stocks rather than belonging to any one country. Distribution of tunas is summarized below.

Skipjack tuna

Skipjack tuna exhibit a strong tendency to school in surface waters and are abundant and widely distributed throughout the world's oceanic surface waters, except in the Black Sea. Surface-schooling, adult skipjack tuna (>40 cm fork length, FL) are commonly found in tropical and subtropical waters of the Pacific Ocean. Skipjack in the western and central Pacific Ocean (WCPO) are considered to be a single stock for assessment

purposes.

In the western Pacific, warm, poleward-flowing currents near northern Japan and southern Australia extend this tuna's distribution to 40ºN and 40ºS. These limits roughly correspond to the 20ºC surface isotherm.

A substantial amount of information on skipjack migration and movement is available from tagging programmes. In general, skipjack movement is predominantly from east to west in the WCPO but is highly variable due to environmental events. During warm El Niño events, the warm pool (oceanic area with sea surface temperature >28ºC) and part of the skipjack stock are displaced eastward towards the EEZs of the Marshall Islands, Nauru and Kiribati. Conversely, during La Niña, or cool events, the warm pool compresses and skipjack are concentrated towards the western Pacific near Papua New Guinea and the Federated States of Micronesia

Yellowfin tuna

Yellowfin tuna are abundant worldwide in tropical and subtropical seas, particularly in the Pacific Ocean. Juveniles commonly school in surface waters in the WCPO with skipjack and, to a lesser extent, bigeye tuna. Adult yellowfin in the WCPO are located in deeper waters but are usually above the thermocline, a zone of rapidly changing water temperature.

The population ranges between 40°N and 35°S in the western Pacific, and 35°N and 33°S in the eastern Pacific. Restricted mixing between the western and eastern Pacific based on genetic and tagging data suggests that there are two stocks in the Pacific. Unlike skipjack tuna, adult yellowfin (>100 cm FL) are found in warm surface waters of the tropical Pacific, as well as in cooler subsurface waters.

Bigeye tuna

Bigeye tuna are distributed worldwide in tropical and temperate seas, but are absent from the Mediterranean. Juveniles and small adults may school at the surface with other bigeye tuna or with yellowfin and/or skipjack. Adult bigeyes inhabit greater depths than the other tropical tunas and are often associated with the thermocline.

Adult bigeye tuna (>100 cm FL) inhabit the tropical and temperate waters of the Pacific Ocean between northern Japan (40°N) and northern new Zealand (40°S) in the west, and from about 40°N to 30°S in the east, except near waters of Central America between 5° and 20°N. Overall habitat is limited by temperature and dissolved oxygen concentration. Within these limits, food supply is probably the major determinant of distribution.

Albacore tuna

Albacore distribution is quite different from the three tropical tunas. Juvenile albacore concentrate in temperate areas where food is abundant, commonly at the ocean surface along frontal zones. Their distribution includes 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.

Mature albacore gradually disperse to subtropical areas and inhabit deeper waters within the thermocline.

Mackerel tuna

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

Dog-tooth tuna

Dog-tooth tuna inhabit waters of the tropical Indo-West Pacific from the Red Sea and East Africa, eastwards to Japan, the Philippines, Papua New Guinea, and Australia and out into the islands of Oceania.

Frigate tuna

Distribution is probably throughout warm oceanic waters but there are only a few documented occurrences in the Atlantic Ocean

Skipjack, yellowfin, bigeye and albacore tunas are present year round in Vanuatu's waters (Bigelow 2001). The skipjack resource is considerable, given the adjacent fisheries in Fiji and the Solomon Islands. Most of Vanuatu's waters lie in areas where albacore are more prevalent, that is, albacore tunas inhabit cooler waters to the south of 20ºS. Aerial surveys for 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 greatest numbers 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's waters, except that fewer tuna were found between April and November.

The most recent and up to date scientific assessment of the status of the stocks is undertaken by fisheries scientists from the Oceanic Fisheries Programme (OFP) of SPC in Noumea. OFP carries out stock assessments and related analyses of highly migratory tuna stocks and publishes results in a number of formats including:

- National Fisheries Assessments for each country;
- The OFP Tuna Fishery Yearbook; and
- The OFP Regional Tuna Bulletin.

Up to date information and publications can also be obtained from the SPC Oceanic Fisheries Programme website at: www.spc.int/oceanfish.

10.2.3 Biology and ecology

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

Skipjack tuna

Skipjack commonly grow to a length of 80.0 cm FL and a weight of 8–10 kg. Growth is similar to yellowfin and bigeye tuna in the first year and slower thereafter, although significant differences occur between individuals. Skipjack longevity is about five years as the longest period at liberty for a tagged skipjack 4.5 years. Reproductive maturity is reached at 40–45 cm, corresponding to an age of one year or less.

Skipjack reproduction is especially frequent in an equatorial band between 10°N and 10°S. Spawning has been known to occur in both the WCPO and to some extent in the eastern Pacific, if the water temperature is >25°C. Spawning occurs throughout the year in equatorial and tropical waters, but only during summer months at higher latitudes.

Data analysis obtained during the SPC (October 1977–August 1978) assessment indicated that by maturity, skipjack populations are dominated by females. The presence of female skipjack with recovering gonads in Vanuatu in December 1977 and January 1978 indicated that annual spawning occurs in Vanuatu waters during the period between December and January. Data suggests that skipjack spawning in Vanuatu waters exhibits seasonal periodicity. The typical diet of skipjack in Vanuatu waters includes squid, juvenile tuna (several species in the family Scombridae), surgeonfish (Acanthuridae) and the alima stage of stomapods.

Yellowfin tuna

Yellowfin commonly grow to a length of 150 cm FL and are relatively fast growing. Yellowfin tuna attain reproductive maturity at 105 cm, probably before the age of two years. Spawning occurs throughout the year within 10 degree of the equator. Spawning is progressively confined to summer months at higher latitudes when sea surface temperatures are >24°C. Spawning usually occurs at night with a mean spawning interval of approximately two days. Reproductively active fish are vulnerable to troll, purse seine, and shallow handlines and longlines, whereas deeper longlines catch mature, but reproductively inactive fish.

Tagging studies for the western Pacific indicate extensive movements between 120^0E and 170^0W longitudes, with distinct stocks in the eastern Pacific and WCPO. Juvenile yellowfin often occur in mixed schools with skipjack of the same size, but as they grow they begin to inhabit deeper, cooler waters. Available data suggest that yellowfin tend to increase in size from west to east.

Bigeye tuna

Bigeye tuna commonly grow to a length of 180 cm FL with a maximum length of over 200 cm. Bigeye are believed to be significantly longer lived than yellowfin. Several tagged bigeye have been recaptured in excess of eight years at liberty (the longest period at liberty is currently 8.2 years). These fish were aged between two and three years at release, which suggests that significant numbers of fish survive at least until 10 years of age. Bigeye mature at a size of 100–300 cm probably during their third year of life.

The distribution of bigeye larvae suggests that they spawn in the western Pacific between 30°N and 20°S, and in the eastern Pacific between 20°N and the equator. Similar to yellowfin tuna, bigeye spawning occurs at night with a spawning frequency of ~2 days; however, the duration of the spawning season for individual bigeye is not known.

Albacore

Albacore commonly grow to a length of 60–100 cm with a maximum length of 130 cm. Growth is relatively slow and the lifespan relatively long compared with the three tropical tunas. Albacore grow at a rate of approximately 8 cm per year from ages two to five, with slower growth thereafter. Significant numbers of albacore probably reach an age of 10 years or more and the longest period at liberty for a tagged and recaptured albacore is 11 years.

Albacore reach reproductive maturity by 82 cm, which corresponds to an age of at least five years. In contrast to the tropical tunas, albacore larvae are rare in the equatorial Pacific. Adult albacore tuna (>80cm FL) in the South Pacific spawn in tropical and subtropical waters between 10°S and 25°S from November to February. The main spawning area for albacore in the South Pacific is from 15–25°S in summer months. Albacore are also found in the North Pacific, though the northern and southern stocks are generally considered to be separate.

Albacore are distributed Pacific-wide, with juveniles concentrated in the sub-tropical zone between 35–40°S from east of New Zealand to 130^0W. Adults tend to concentrate around 15–30°S.

10.2.4 The Fishery

History of Vanuatu's tuna fishery

Foreign and International Involvement

Vanuatu tuna resources are exploited at the industrial, artisanal and subsistence level. The following Vanuatu summary is largely based upon the studies of coastal fisheries in the Pacific (Dalzell et al. 1996) and the Republic of Vanuatu Tuna Management Plan.[5]

Since the mid-1950s, commercial fishing for tuna within Vanuatu's EEZ has occurred at a low level (Wright 1989). Japanese longliners were the first to arrive, but were replaced by Korean vessels around 1967, and by Taiwanese vessels after 1975 (Habib 1984). Albacore was the principal target species for canning in the USA, Japan and other countries.

Vanuatu's involvement in commercial tuna fishing began in 1957 with the establishment of the South Pacific Fishing Company Limited (SPFC) based at Palekula, on Espiritu Santo Island. SPFC was established by the Japanese Mitsui and Company, with the objective of conducting tuna transshipment operations of longline vessels. The facilities established at the Palekula Base were large and occupied some 24 ha of relatively flat land, which had been initially developed by the US Navy during World War II.

The SPFC complex consisted of a main wharf, slipways (one 500 GRT and one 50 GRT), cold storage, two bait freezers (5,000 cartons of bait in 10 kg boxes/room), two quick-freeze rooms, unloading area, engine room, large brine block ice makers with crusher, a loading facility, housing and workshops.

In 1974, much of the plant was upgraded, with a new cold storage facility replacing the old one. The new cold storage unit was in three rooms, each holding from 500–600 t of frozen fish. A new engine room was also installed with three large Yanmar diesels with alternators for power, and four large compressors for the ammonia refrigeration system. The bait freezers and quick-freeze rooms were retained. The ice facility was abandoned with ice made by filling plastic bags with water and placing them in the quick-freeze rooms. A new "T" section was added to the existing main wharf, so that larger carrier vessels could come alongside to load. In addition, a new fuelling wharf was installed at this time, which was also used for vessels to tie up to, as well as two large fuel storage tanks and a pump house with pumping equipment.

Over the years, many longliners from different countries worked out of the Palekula Base. Unfortunately, the transshipment side of the base's operation closed in 1986, when the remaining vessels relocated to American Samoa to take advantage of incentives

[5] The Republic of Vanuatu Tuna Management Plan – A National Policy for the Management of Tuna Fisheries was produced in April 2000 and subsequently adopted by the government in 2001. Additional details are available at http://www.fao.org/fi/fcp/en/VUT/body.htm.

offered by processors there. At this time, the facility was turned over to the Government of Vanuatu. The slipways were still operational and the government continued using them until 1998, when financial problems with SPFC caused their closure.

In 1987, a Russian purse seiner paid a reported USD 1.5 million to access the Vanuatu fishing zone. It only reported a catch of some 12 t of tuna during the short period of operation.

Also in 1987, the *Treaty on Fisheries between the Governments of Central Pacific Island States and the Government of the United States of America*, administered by FFA, entered into force. The Treaty allows US purse seiners licensed under the Treaty to fish in Vanuatu waters. This has occurred on only four occasions in 1999 with very small catches.

Vanuatu's next major experience with tuna fishing was with the development of a Bilateral Agreement between the Government of Vanuatu, through SPFC, and the Kaohsiung Fishermen's Association of Taiwan in 1989. Under this agreement, an unlimited number of vessels could fish in Vanuatu waters, with the license fee set at USD 5,000 per vessel. There were no minimum terms and conditions under this agreement and it is still in force today with varying numbers of vessels taking out licenses annually. The government intends to re-negotiate this agreement to bring it in line with national and international requirements and standards as they apply to Vanuatu.

In the mid-1990s, two tuna fishing enterprises were established, each managing vessels in Vanuatu. The first, International Tuna Services Limited (ITSL), operated two purse seiners and one longliner. The purse seiners were Korean, although the vessels were Vanuatu flagged. The company was 51% Vanuatu owned, which at that time allowed the vessels to be licensed as local fishing vessels, with an annual fee of VAT 500,000 per vessel. Unfortunately, in March 2000, low prices world-wide for canning-grade tuna forced these vessels to stop fishing until the economic climate improved.

TOHO Vanuatu Limited operated a single freezer tuna longliner, which was Japanese owned and licensed under a trial/experimental arrangement in Vanuatu, paying a fee of VAT/month 20,000 (VAT/year 240,000). The operation started in late 1995, making 20 day trips and landing 15–20 t/trip. The vessel transshipped its catch from Noumea, where it also took on fuel and provisions. This venture operated for only four months.

During 1999 and 2000, the government negotiated with four Fijian-based companies. Tuna Pacific Agencies Limited and CKR Fisheries Limited signed agreements for up to 16 vessels each to fish in Vanuatu waters. The other two companies, Tuna Pacific Company Limited and Jiko Fishing Company Limited, signed agreements that allocated up to 16 vessels each.

The licensing fees for all Fijian companies has been set at USD 8,000 per vessel (license fee of USD 7,000 and an observer fee of USD 1,000). The vessels are able to fish in Vanuatu waters and only need to provide entry and exit reports with a faxed copy of the log sheets. All catch is landed to processors back in Fiji. Under the agreements, a vessel monitoring system is required.

Domestic and locally based development

Domestic interest in catching tunas did not begin in Vanuatu until the early 1980s, when the VFDP was established under the European Development Fund (EDF) in 1982. Canadian volunteers were involved in the VFDP, setting up commercial fishing enterprises at the village level around Vanuatu. The focus was to develop a fishery based on exploiting deepwater snappers, using wooden handreels and boats supplied as part of the project.

A supporting component of the VFDP was the construction and deployment of fish aggregating devices (FADs) in selected areas. The purpose of the FADs was to provide a fishing location where boats could go to catch small tunas, mainly skipjack and juvenile yellowfin, which could be used as bait for fishing deepwater snappers. Several FADs were deployed off Port Vila in late 1982 and early 1983, and the Department of Fisheries promoted their use by local fishermen. These FADs were also used by charter sportfishing vessel operators working out of Port Vila, to increase the potential of catching fish for their paying customers.

Also during 1983, the Department of Fisheries, with technical assistance from the (then) South Pacific Commission, conducted experimental fishing trials around the Port Vila FADs. These trials included the use of vertical longlines, single-hook drifting lines and gillnets, as well as normal trolling techniques. Trolling catches from around the FADs were quite high at 9.0 kg/line-hour, with the occasional lure and fish lost to sharks. Sharks were the main catch from the gill net fishing trials, with the nets being badly damaged.

FADs were deployed in other locations around Vanuatu, in the vicinity of VFDP centres where there were bait shortages and there was a suitable location for a FAD. The FADs also provided an alternative protein source to villagers, especially in the rural areas.

As part of the VFDP, two fish markets were established in 1983, one in Port Vila and the other in Luganville. The marketing strategy for the village projects was that each centre would sell catch locally, usually the lower value species, with the higher value species transported to one of these centres for either local or export sale. In fact, it was a requirement of the VFDP that all fish, apart from those sold locally in rural areas, had to be sold to the two government-owned fish markets. The problem with this arrangement was that the two fish markets would not normally purchase tunas, which meant that unless the tunas caught around FADs could be sold locally in the rural areas, there was no market available in the main centres. This marketing approach greatly restricted any development in small-scale tuna fishing.

The use of FADs continued into the 1990s, after the conclusion of the VFDP. The Department of Fisheries had materials received under the EDF as well as Japanese aid in goods and services. The location of the FADs was gradually restricted to the two main centres, Port Vila and Luganville. This was due to the dwindling materials available, the lack of funds to purchase new materials, and the fact that the main users were the charter sportfishing operations and some local fishermen in these areas. In fact, the charter sportfishing operators and small-scale fishermen using the FADs in the mid and late 1990s purchased some of the materials to complement those still held by the Department of Fisheries. The charter sportfishing operators then used their own vessels to deploy several FADs off Port Vila.

In November 1995, Vanuatu Fishing Investments Limited (VFIL) was established as a locally incorporated company owned by New Zealand interests. VFIL's agreement included the leasing of the Port Vila fish market set up under the VFDP (which had been operating at a reduced level for several years) to use for their fishing venture. The fish market was known as Natai. VFIL was required to restore the equipment in Natai (chillers, freezers, ice plants, etc.) to an operational condition, plus sell domestic market products, including a range of imported seafood products.

VFIL was granted four locally based foreign fishing licenses at the time of signing the agreement, and had access to another 10 such licenses if required. In July 1996, VFIL had four vessels licensed, although only one actually came to Vanuatu to fish, F/V *Marine Princess* (64 GRT). This vessel was set up for both tuna and demersal longlining, with most trips lasting around six days using a mix of both gears. Unfortunately, this venture pulled out of Vanuatu in December 1997. The reasons for this were not clear,

however, it is thought to be was a mix of inexperience at fishing in Vanuatu, mixing fishing techniques, low catch rates, and varying prices for both export and domestic sales.

Since the failure of VFIL, no other locally based commercial tuna fishing has taken place. The Natai fish market has been sold to private interests, who bulldozed the premises in early 2000 to build a supermarket with a fish display and a take-away food section. However, charter sportfishing operators continue their operations with a great reliance on FADs to increase their fishing prospects for tunas and billfish. In July 2000, there were eight charter sportfishing vessels operating from five different companies in Port Vila, and one vessel working out of Luganville.

Recent development of the Vanuatu tuna fishery

Local vessels

Unlike in years past, tunas currently form an important component of the local artisanal and commercial fisheries. Catches are made by trolling mostly around FADs using small (~5^{+} m in length) outboard powered vessels. Most catches are sold locally but skipjack forms the major bait of the deepbottom fishery for "poulet" (deepwater snappers, *Etelis* and *Pristipomoides* species).

Locally based foreign vessels

As a trial, in 2003 the government — through the Department of Fisheries — issued up to eight locally based foreign fishing licenses. The licenses expired in October 2004. Seven of the locally based foreign fishing vessels were of Chinese Taipei origin chartered by a local fishing company known as the “Sound Fishing Group”. The eighth vessel was a Russian fishing boat chartered by another local fishing company known as “Sushi Fresh”. Three of the vessels sunk in Port Vila harbour as a result of a cyclone in 2004, leaving only five vessels in operation.

The vessels were allowed to fish up to nine nautical miles measured from the Vanuatu base lines. As a condition, the vessels were required to offload all their catch in Vanuatu for re-export overseas and for local consumption.

Foreign fishing vessels

The number of foreign fishing activities has increased from 14 in 1999 to 137 in 2003. This increase is a result of bilateral fishing agreements the Government of Vanuatu signed with nine different foreign fishing companies.

Only one out of the nine foreign fishing companies has a local agent based in Port Vila, while the other eight are based in Fiji. The foreign fishing vessels were licensed by the Department of Fisheries to fish for tuna and tune-like species in Vanuatu waters. The vessels were prohibited to fish in territorial waters.

Table 31 lists the number of licensed foreign, locally based foreign, and local fishing vessels that fished in Vanuatu waters for the period between 1996 and 2003.

Table 31: Number of licensed fishing vessels, 1993–2003

Year	Foreign fishing vessels	Locally-base foreign fishing vessels	Local fishing vessels
1996	34	1	7
1997	26	0	1
1998	15	0	3
1999	14	0	4
2000	63	0	9
2001	54	0	6
2002	105	0	6
2003	137	8	9

Production and marketing

The Vanuatu-based Taiwanese vessels harvested up to 15,000 t/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 t/year during the 1970s) of their catches in Vanuatu waters" (Government of Vanuatu Second National Development Plan, 1987–1991). 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).

Table 32: The combined tuna catch (in numbers of fish) for 1967–1977

	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.

Table 33: Combined catches (t) by Japanese and Taiwanese fleets in Vanuatu waters from 1972–1976

Catch	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

Source: Habib 1984

The Japanese pole-and-line fishing vessels, operating in the 1970s in the northern part of

Vanuatu's EEZ, took only modest quantities (300–1,600 t/year) of skipjack (Government of Vanuatu Second National Development Plan, 1987–1991). The monthly summary catch by the Japanese pole-and-line vessel operation within Vanuatu's EEZ from 1974 to 1979 is presented in Table 34, below (adapted from Habib 1984). The data give a catch range by pole-and-line of about 5–8 t/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 are summarized in the same table but marked*.

Table 34: Monthly catches by the Japanese pole-and-line vessels between 1974 and 1979 within Vanuatu's EEZ

	1974		**1975**		**1976**		**1977**		**1978**		**1979**	
Month	Days	Catch (mt)	Days	Catch (mt)	Days	Catch (mt)	Days	Catch (mt)	Days	Catch (mt)	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 35. These figures, however, do not reflect the proportion caught in Vanuatu waters or the catch rates.

Table 35: South Pacific Fishing Company (SPFC) Landings by Longline Vessels at Palekula, Espiritu Santo.

Year	**No. of Vessels**	**Albacore**	**Yellowfin**	**Bigeye**	**Others**	**Total (t)**	**Total Fish Re-exported (t)**	**Value of Re-exports**
1969	24					8,450	Data not available	Data not available
1970	26					9,240	Data not available	Data not available
1971	45					13,403	Data not available	Data not available
1972	55					15,054	Data not available	Data not available
1973	57					14,310	Data not available	Data not available
1974	67					12,704	Data not available	Data not available

Year	No. of Vessels	Albacore	Yellowfin	Bigeye	Others	Total (t)	Total Fish Re-exported (t)	Value of Re-exports
1975	46					6,314	Data not available	Data not available
1976	28					4,956	Data not available	Data not available
1977	55					10,063	Data not available	Data not available
1978	48					9,478	9,182	USD 14,376,143
1979	50					7,887	7,724	USD 13,929,587
1980	53	4,734	1,659	503	407	7,304	4,523	USD 9,348,498
1981	27	3,384	858	252	296	5,121	4,840	USD 9,348,498
1982	28	2,981	614	193	273	3,876	3,881	VUV 688,931,000
1983	19	4,178	369	204	280	5,030	4,541	VUV 794,869,000
1984	18	3,132	309	173	292	4,050	3,945	VUV 710,302,000
1985	12	3,058	516	222	136	4,032	3,962	VUV 760,830,000
1986	12	829	219	59	79	1,186	2,492	VUV 373,494,000

T = metric tonnes. Source: Department of Fisheries Annual Reports (for 1983, 1984, 1985, 1986, 1987, 1989); Habib 1984; Government of Vanuatu Development Plans (first 1982–1986 and second 1987–1991).

Catches from trolling trials conducted by the Department of Fisheries between September 1980 and April 1982 comprised skipjack (61%), yellowfin (23%), and other species (16%). The results of the 1980–1981 aerial surveys indicated that surface schools comprised 40% skipjack, 26% yellowfin, 13% mixed skipjack and yellowfin, and the rest indeterminate.

All tuna catches by the small-scale fishery during the years 1988–1992 were marketed locally. Some of the catch was sold on site with most fish sold to the former fisheries extension centres where proper ice and freezer facilities were located. In cases of over-supply on the outer islands, the excess fish were sent to the Natai Fish Market in Port Vila. The tunas landed at the Natai Fish Market as well as those purchased by the fisheries extension centres between 1988 and 1992 are shown in Table 36. The value of fish landed at Natai are also given.

Table 36: Value of fish landed at Natai Fish Market during the period 1988-1992

Species/	1988	1989	1990	1991	1992	1990	1991	1992
Value	Natai	Natai	Natai	Natai	Natai	Fisheries Ext	Fisheries Ext	Fisheries Ext
Skipjack	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			
Yellowfin	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			
Dog-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			
Albacore						39.2	69	1,227.9
Value								
Total wt (kg)	**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 (VUV)	**337,783**	**473,793**	**661,018**	**97,916**	**669,452**	No data	No data	No data

The tunas landed at the Natai Fish Market stabilized at around two tonnes per year while those going through the fisheries extension centres had increased tremendously from one tonne in 1990 to almost ten tonnes in 1992.

Summaries of tuna sales, by species, at the Santofish market between 1989 and 1992 are recorded in Table 37. An increase is also shown from about half a tonne in 1989 to almost three tonnes in 1992. Table 37 also contains catch by the Overseas Fisheries Cooperation Foundation (OFCF) fishing trials in southern and eastern coastal areas and around FADs off Santo Island during 1985–1986.

Table 37: Summaries of tuna sales by species (in kg)

Species	1985	1986	1989	1990	1991	1992
Skipjack	1,109.3	208.5	12.4	219.6	272.8	718.8
Dogtooth	-	-	486.9	666.1	815.6	487.2
Yellowfin	1,212	738	72.7	146.8	256.7	1,740.7
Mackeral tuna	139.8	499.8	8.0	546.8	0.9	0
Total	2,461	1,446	580.0	1,579.3	1,346.0	2,946.7

Total tuna landings in the three outlets were 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.

Following the closure of the fisheries extension centre-operated ice machines in 1995, and the liquidation of both Santo Fish and Natai Fish Markets in 1999, it was difficult for the Department of Fisheries to collect accurate data. The closure of the government-operated centres and the urban fish markets also affected the operation of many fishing projects. Up to 95% of the fishing projects ceased operating due to lack of preservation facilities in rural areas and transportation to the unban markets, such as restaurants and hotels. However, from 2000 onwards, fishing activities by rural fishing projects began to increase again. Summarized below (Table 38) are figures tuna caught by artisanal fishing projects.

Table 38: Summaries of tuna catch (kg) by species by artisanal fishing projects in 2000, 2002, and 2003

Species	2000	2002	2003
Skipjack	1,766	437	2,439
Dogtooth	601.2	79	111
Yellowfin	779.3	197	1,979
Mackeral tuna	-	-	230
Albacore	12	-	6
Total	3,159	713	4,765

The above figures are not representative of the total data provided by artisanal fishing projects. Data are only those provided by some fishing projects to the Department of Fisheries.

US Treaty purse seiners

Under the FFA Member Countries' Multilateral Treaty with the United States of America, the following tuna catches were recorded in Vanuatu's EEZ by American purse seiners from 1989 to 2004.

Table39: Catch (tonnes) by US Treaty purse seiners between 1989 and 2004

Tuna	1989	1990	1997		2001		2002		2004	
	Wt	Wt	Wt	USD	Wt	USD	Wt	USD	Wt	USD
Skipjack	692	39	10.89		271		63.5		176.5	
Yellowfin	97	0	7.26		0		0		40.7	
Albacore			0		0		0		0	
Total	789	39	18.142	2,230	271	35,585	63.5	8,276	217.2	58,565

Source: Forum Fisheries Agency

Catch in Vanuatu waters by Licensed Foreign Fishing Vessels

Annual catches (in metric tonnes) of albacore (ALB), yellowfin (YFT), bigeye (BET), billfish (B/fish) and skipjack (SKJ) made by distant-water longline and pole-and-line fishing vessels (Japan, Korea and Taiwan) in the Vanuatu EEZ or in the vicinity of the of the Vanuatu EEZ (15°–20°S, 165°–175°E) between 1979 and 2003 is summarized in the Table 40, below.

Table 40: Catch by licensed foreign fishing vessels in Vanuatu waters

	62	63	64	65	66	67	68	69	70	71	72	73	74	75
ALB	1,111	507	848	99	427	622	356	169	231	106	416	728	317	294
YFT	493	213	372	25	106	158	114	99	50	73	148	293	140	137
BET.	96	45	90	5	25	89	36	17	18	13	18	89	53	7
B/fish	467	270	406	14	82	62	38	6	35	38	41	27	7	10
SKJ	-	-	-	-	-	-	-	-	-	-	-	-	13	148
Total	2167	1035	1716	143	641	931	544	292	334	230	623	1137	531	595

	76	77	78	79	80	81	82	83	84	85	86	87	88	89
ALB.	514	566	1,241	1,107	558	1,057	837	1,006	1,071	423	273	1,751	2,024	947
YFT	166	109	229	339	139	134	105	84	119	87	119	201	468	132
BET	63	36	31	70	32	51	35	21	64	15	14	16	25	22
B/fish	51	39	46	63	38	71	34	27	48	14	18	26	32	33
SKJ	87	644	50	446	536	0	0	0	0	0	0	0	0	0
Others	0	0	0	0	0	4	1	3	7	2	0	0	4	1
Total	890	1394	1597	2025	1330	1317	1012	1140	1308	541	424	1994	2552	1135

	90	91	92	93	94	95	96	97	98	99	00	01	02	03	Total
ALB	1,430	630	10	1617	1771	5705	2561	2342	1253	3036	2672	1445	2022	1810	47,910
YFT	153	137		57	308	370	448	340	180	290	466	252	515	791	9,156
BET	30	13		20	31	121	77	51	63	75	82	57	153	211	2,080
B/fish	74	33		30	147	212	94	51	45	132	122	0	0	0	2,983
Others	0	2		0	0	0	0	0	0	0	230	102	306	346	2,910
Total	1688	815	10	1723	2257	6408	3180	2784	1541	3532	3572	1856	2996	3159	46,457

Source: Unraised logsheet data held by SPC; Data covers fleet from Vanuatu, Fiji and Taiwan. Figures for 1992 are incomplete (Source: SPC, Country Report No.15).

Albacore

Although subject to year to year fluctuations, albacore catches in the South Pacific have remained stable since the 1980s at around 30,000 to 40,000 tonnes per year. Taiwanese longliners generally account for approximately half of this catch with Japanese and Korean longliners and the New Zealand troll fleet accounting for most of the remainder.

Stocks are generally considered to be in good condition with moderate exploitation levels although recent assessments indicate that fishing mortality may have increased significantly since the mid 1990s.

Yellowfin

Yellowfin tuna are an important component of tuna fisheries throughout the WCPO. The yellowfin resource is harvested by a range of fisheries, from small-scale artisanal fisheries in the Pacific Islands and Southeast Asia, to large distant water longliners and purse seiners that operate widely in equatorial and tropical waters, using a range of gear types.

From 1994 to 1999, annual catches of yellowfin in the WCPO have varied between 398,000 and 457,000 t/year. Approximately 54% is taken by purse-seine vessels, catching the surface swimming fish in equatorial waters. Around 16% is taken by longline vessels, targeting the adult fish in deeper waters.

Catch per unit of effort for the longline yellowfin fishery is highest in the equatorial zone where the catch rate is 1–1.5 fish per 100 hooks. In the south, between 10°S and 40°S, there has been a recent increase in catch rates to 0.5-1.0 fish per 100 hooks from a low prior to the 1980s. Vanuatu, which is located within this southern zone, is just south of the prime yellowfin longline area.

Bigeye

Bigeye tuna are an important component of tuna fisheries throughout the Pacific. They are the principal target species of the large distant-water longliners from Japan and Korea, and of the smaller fresh sashimi longliners based in several Pacific Island countries. Prices paid for both frozen and fresh bigeye on the Japanese sashimi market are the highest of all the tropical tunas.

Since 1980, the Pacific wide catch of bigeye has varied between 88,000 and 163,000 t. Japanese longline vessels contribute over 80% of the catch. The catch in the WCPO has fluctuated between 41,000 and 68,000 t.

Skipjack

Skipjack are primarily caught by purse seine and pole-and-line gear. Catches in the WCPO have increased steadily over the past two decades, more than doubling since 1980 with a peak catch of 1.1 million tonnes in 1998. In the 1990s, catches fluctuated between 900,000 and 1,100,000 t. Skipjack catches increased during the 1980s due to growth in the international purse-seine fleet, combined with increased catches by domestic fleets from the Philippines and Indonesia.

10.2.5 Stock 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 (now IRD) 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).

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. That is, sustainability of the status of tuna stocks in Vanuatu waters is determined by the overall exploitation tuna and tuna like species within the Central and Western Pacific Ocean. A lot of scientific studies have been carried out to determine the overall western and central Pacific Ocean tuna stocks, the recents stock assessments were carried out in 2003 and 2004 providing the following summarized results:

Bigeye tuna

Since about 1994, a rapid increase in purse seine catches of juvenile bigeye has created increased uncertainty regarding the sustainability of the current levels of exploitation. Bigeye is the least well understood of the four principal tuna species in the Pacific and there are serious deficiencies in understanding of basic biological parameters for the stock. Consequently the assessment of bigeye is quite uncertain and it is not possible to confidently estimate the current status of the stock.

Recent assessments carried out in 2003 and 2004 indicates that over fishing of the western and central Pacific Ocean bigeye tuna stock was occurring, i.e. F(current/F(msy)>1. The assessments further indicated that current level of fishing mortality F(current) carry high risks of over fishing, with a 67% probability of this occurring.

Yellowfin tuna

Recent assessments carried out in 2003 and 2004 indicates that the yellowfin stock in the WCPO is probably not being overfished, [probability (F(current)/F(msy) > 1; ranged from 15 – 40%]. The studies emphasized that stock is not in over-fished state. However, the 2004 assessments estimated the stock is likely to be nearing exploitation and any further increase in F(current) would move the yellowfin stock to an overfished state.

Skipjack tuna

Stocks are generally considered to be in good condition with moderate exploitation levels although recent assessments indicate that fishing mortality may have increased significantly since the early 1990s. However, recent assessments carried out in 2003 by OFP indicated that the WCPO stock is not being overfished. High levels of recruitment into the fishery were observed.

South Pacific albacore

Assessments carried out in 2002 and 2003 by OFP estimated low impact of fishing on total biomass. However, the impact of fishing on longline exploitable biomass (i.e. the largest albacore) has now reached 30% (i.e. the current longline exploitable biomass is 30% less than it would be in the absence of fishing. The overall stock is unlikely to be over fished. Observed declines in CPUE in some Pacific island fisheries (including Vanuatu) in recent years may be as a consequence of changed oceanographic conditions and observed high levels of localized fishing effort impacting on the CPUE.

10.2.6 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 gillnetting, 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 EEZs through bilateral 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.

The harvest of tuna resources in Vanuatu waters is currently managed by a National Tuna Management Plan, developed in 2000 and approved by the Council of Ministers for implementation in 2004.

The Tuna Management Plan has been developed to meet four key objectives:

- To ensure that the exploitation of the tuna resources that are found in and pass through Vanuatu waters is compatible with the sustainability of the stocks throughout their range.
- Within the limits of the sustainability objective, to ensure the harvest is taken in a way that maximizes the long term economic and social benefits received by the peoples of Vanuatu.
- To contribute to the food security of ni Vanuatu.
- To meet regional and international responsibilities for tuna management.

The scope of the Management Plan covers all highly migratory tuna species including: albacore, yellowfin, bigeye, skipjack and all other species taken in the course of fishing tuna. The Plan covers all Vanuatu waters, including the consideration of the area of the Vanuatu EEZ around Matthew and Hunter Islands and Vanuatu flagged tuna fishing vessels wherever hey fish. Detailed below are the changes made by the Management Plan.

Foreign tuna fishing vessels	
Past Situation	Changes
A fleet of mostly Taiwanese vessels fishes in the Vanuatu EEZ - they rarely come close to land	A limit will be set on the maximum number of licenses for Foreign vessels
36 Foreign vessels are currently licensed to fish	License fees will be increased from $5,000 to $11,000 per vessel per year for most tuna longliners
They pay $5,000 per vessel per year to fish	Must fish outside of a 24 mile zone
They must fish outside of the Territorial Sea - a 12 mile zone around the archipelago	No fishing on sea mounts by foreign vessels
	Must carry satellite locators
	Observers will be placed on some vessels
	By-catch will be monitored
	Increased enforcement activities
Vanuatu flagged Foreign tuna fishing vessels	
Past Situation	Changes
For a fee, foreign vessels are allowed to fly the Vanuatu flag	Vanuatu flagged tuna fishing vessels will be required to pay a fee, initially set at $5,000, to cover management costs
85 Vanuatu flagged fishing vessels operate around the world - may be many more soon	Vanuatu will participate in relevant international conventions and commissions
Currently little is known about their operations	

If these vessels violate international agreements it can result in embargoes and retaliation by other countries against Vanuatu This could damage future fish exports from Vanuatu	Vanuatu government will be involved in access agreements with foreign countries Vessels will be required to provide information on their activities or face penalties
Local tuna fishing vessels	
Past Situation	Changes
Vessels less than 10 metres are not required to be licensed Charter game fishing vessels sell their catch without regulation Duty exemptions are provided to commercial fishermen with and without licenses but not game fishing vessels Authority within 6 mile provincial zone unclear	Only licensed vessels will be eligible for duty exemptions on fuel and fishing equipment Vessels 8 metres or more will be required to be licensed, smaller vessels may license to obtain exemptions Charter game fishing vessels that sell their catch will require a commercial license and then be eligible for duty exemptions License fee will be VUV 20,000 plus VUV 5,000 per metre over 8 metres "Local" vessels must be locally owned Fisheries Division will be the final authority for tuna conservation and management within 6 mile zone Local vessels larger than 20 metres may be required to: Carry an observer Have a satellite locator (ALC) on board File Telex Reports for entry and exit to EEZ and weekly catches Local vessels larger than 20 metres will not be allowed within the 12-mile zone or on sea mounts
Coordination and management	
Past Situation	Changes
Resources for managing tuna fisheries are limited No forum for strategic planning Limited operational coordination between the different agencies involved including: Fisheries Division, Vanuatu Maritime Authority, Police Maritime Wing	A Fisheries Management Account external to general government revenues that will collect a portion of foreign and local license revenues Fisheries Management Account will finance: Observers on foreign vessels, Local development activities, Better management of foreign fishery. Permanent Tuna Management Advisory Committee to coordinate and plan. Tuna Management Coordinator position
Local tuna fishery development	
Past Situation	Changes
Small scale tuna fishing mainly being carried out by charter game fishing vessels and small vessels trolling around the Fish Aggregating Device (FAD) Only one FAD currently in operation and placement and maintenance are by donation Currently no export of tuna although there is interest and has been in the past	Monies from the Fishery Management Account will be used to place and maintain FADs around Vanuatu to encourage small scale fishing and local sale of tuna Plan will promote necessary health and sanitary regulations to facilitate future tuna exports Promotion of foreign investment in local tuna fishery

Limits on license numbers

The National Tuna Management Plan determines the maximum number of licenses that can be issued in each fishing category with *tuna* or *tuna like species* as a target species; the fishing category and license limits are listed below.

Fishing Category	Vessel/license limit
A. Tuna longline	100
B. Tuna purse seine	10
C. Tuna pole-and-line	10
D. Other	100
E. Research fishing	No Limit
F. Exploratory and test fishing	2

Total allowable catch

The importance of sustainable management of the tuna resources within the Vanuatu EEZ, meant that the Management Plan has to set out total allowable catches (TACs) for the major tuna species. Total TAC for Vanuatu waters is 17,000 t. The total TAC comprises albacore, yellowfin, bigeye and skipjack tuna (see below).

TACs for major tuna species

Species	Total allowable catch/year
Albacore	10,000 metric tonnes
Yellowfin	3,000 metric tonnes
Bigeye	1,000 metric tonnes
Skipjack	3,000 metric tonnes

Fees

The management plan also details the amount of fees for the different fishing categories, as can be seen below. All fees are in US dollars unless specifically indicated.

Foreign vessel fees

Fishing Category	GRT	Foreign (USD)	Locally based foreign (USD)
A. Tuna longline	<100	$9,000	$4,500
	>=100	$11,000	$5,500
B. Purse seine	-	$25,000	$12,500
C. Pole-and-line	-	$3,000	$1,500
D. Other methods		$3,000	Based on length see Schedule
E. Research fishing		$500	$500
F. Exploratory and test fishing		Standard rate for method, prorated for shorter period if appropriate	Standard rate for method, prorated for shorter period if appropriate

Fees for locally based foreign vessels fishing using "D, other methods"

Vessel Category	License Fee (VUV)
<= 8 Meters	40,000
> 8 Meters	40,000 + 10,000 per metre over 8 metres

Fees for local vessels (all fishing methods)

Vessel Category	License Fee (VUV)
<= 8 Meters	20,000
> 8 Meters	20,000 + 5,000 per metre over 8 metres

Fees for authorizations for Vanuatu flagged vessels to fish under regional agreements

Regional Agreement	Authorization Fee (USD)
IATTC	$5,000
MHLC	$5,000
CCSBT	$5,000
IOTC	$5,000
ICCAT	$5,000

Fees for reefer/carriers

Item	Fee (USD)
Reefer/Carrier License (valid 12 months)	$700
Transshipment fee: Sashimi grade tuna	$12.50/ tonne
Transshipment fee: Cannery grade tuna	$2.00/ tonne

Current legislation/policy regarding exploitation

The Department of Fisheries is responsible for the management of Vanuatu's tuna resources under the Fisheries Act 1983. Following the endorsement of the National Tuna Management Plan by the government, the development and management of tuna resources in Vanuatu waters is based on the Tuna Management Plan.

Recommended legislation/policy regarding exploitation

The newly drafted Fisheries Act must be passed by Parliament as soon as possible. The enactment of the new Fisheries Bill will further strengthen the development of the domestic tuna industry.

In order for Vanuatu to obtain greater benefits for its tuna resources, it is highly essential that the government facilitate the development of a shore-based facility, whereby foreign fishing vessels operating in Vanuatu waters are subjected to off load their catch for re-export overseas.

10.3 Billfish

10.3.1 Species present

The billfish species found in Vanuatu waters are the black marlin (*Makaira indica*), blue marlin (*Makaira mazara*), striped marlin (*Tetrapturus audax*), broadbill swordfish (*Xiphias gladius*), and sailfish (*Istiophorus platypterus*).

10.3.2 Distribution

Generally, billfish are primarily epipelagic, inhabiting tropical and temperate waters, as well as the cold waters of all oceans. They are usually confined to the water layers above the thermocline but some may occur at greater depths.

Makaira indica (black marlin)

Black marlins are distributed throughout the tropical and subtropical Indian and Pacific Oceans. Like the sailfish, black marlins are more closely associated with land masses than either the blue or striped marlin.

Tagging studies have indicated a single black marlin stock, which migrates between the eastern and southwestern Pacific during El Niño years. Black marlins are highly mobile. Major seasonal concentrations occur in the northwest Coral Sea (September–December), the northeastern Indian Ocean (November–March), the eastern Banda Sea west of Irian Jaya (January–April), and the East China Sea between Taiwan and Japan (June–November). There are strong indications that the distribution and movements of male and female black marlin may differ.

Makaira indica (blue marlin)

Makaira indica are the most tropical of all marlins but are found throughout the tropical and subtropical regions of the Indian and Pacific Oceans; a single stock is assumed for each ocean. Like the striped marlin, they are rarely encountered in shallow nearshore waters,.

Blue marlins occur in equatorial waters year round, although part of the stock makes seasonal migrations to the north and south during the respective summer seasons in each hemisphere. It is believed that these summer migrations are primarily by “shoals” of mature males between 35 kg and 75 kg, and that year-to-year variability in the catch rates of blue marlins away from the equator are strongly influenced by the number of migrating males. Good catch rates occur when large numbers of males migrate.

Tetrapturus audax (striped marlin)

Striped marlins are found in the tropical, subtropical and temperate waters of the Indian and Pacific Ocenas. They are a truely oceanic species, rarely found in shallow coastal waters.

Xiphias gladius (broadbill swordfish)

Broadbill swordfish are found in tropical, temperate and sometimes cold waters of all oceans. They are restricted to oceanic waters, and are rarely found in waters less than 20 metres in depth.

Istiophorus platypterus (sailfish)

Sailfish have a tropical distribution that extends into subtropical waters of the Indian and Pacific Oceans. In the western Pacific they are found between 27ºS and 40ºN, and in the

east between 5ºS and 25ºN. Peak concentrations in the Pacific occur around Papua New Guinea, Irian Jaya, the Micronesia (Caroline Islands), Solomons Islands, and the East China Sea.

The distribution of billfish in Vanuatu is likely to be highly seasonal. Although the occasional black marlin may be caught, most billfish caught are blue or striped marlin. Blue marlins are present in significant numbers from November through March. They may be more abundant from Espiritu Santo north than farther south. Striped marlins are likely to be caught around the southern half of Vanuatu from September to December, with a distinct peak in October and November. Because Vanuatu is towards the southern limit of the normal range of blue marlins and towards the northern end of the range of striped marlins, high year-to-year variability in the relative numbers of the two species might be expected as oceanic conditions vary.

Good years for one species are likely to be poor years for the other, as in Hawaii, and may relate to the southward extent of the South Equatorial Counter Current. Years with warmer water temperatures may result in higher catch rates of blue marlin while years with cooler temperatures may result in higher catch rates of the striped marlin.

10.3.3 Biology and ecology

Makaira indica (black marlin)

Females grow in excess of 700 kg, whereas males rarely exceed 200 kg. Available information on age indicates that female black marlins may reach 15 kg in their first year, and 30 kg in their second. A 450 kg female is over 10 years old. Males probably reach similar ages as females, but with slower growth rates.

Like other fish in the family Istiophoridae, the black marlin is an extremely fast swimmer. Its food consists largely of other large fast swimming fish such as tunas, mackerels, trevallies, and swordfish. Less important foods include other fish, squid, and large crustaceans. Analysis of stomach contents indicates that the black marlin uses its bill to slash prey before it swallows it.

Makaira indica (blue marlin)

Blue marlins are sexually dimorphic in size with females reaching 900 kg while males may weigh up to 170 kg. Males reach maturity between 30 kg and 40 kg, and females between 47 kg and 80 kg, although substantially larger females may not have reached sexual maturity. Males live to be about 21 years and females to at least 28 years. Blue marlins grow rapidly over 3–4 years to 80 kg. With the onset of sexual maturity, male growth rates decrease, whereas female growth rates continue to increase.

Spawning is believed to occur year-round in equatorial waters but is limited to summer months at higher latitudes. Peak activity may be centered about the eastern Caroline Islands and the Marshall Islands (Micronesia) in the western Pacific, and French Polynesia in the east.

Tetrapturus audax (striped marlin)

Striped marlins mature at 27–40 kg, and while there appears to be little sexual dimorphism in size, in the eastern Pacific the percentage of females tends to increase with the size of the fish. Striped marlins grow to a maximum of 260 kg in at least 10 years.

Xiphias gladius (broadbill swordfish)

Age and growth rates of broadbill swordfish are poorly understood, particularly in the

Pacific and Indian Oceans. After about two years of age, females grow faster than males, reaching a larger maximum size (about 540 kg), and potentially living longer than males. Males mature at two to three years (about 20 kg) and females at four to five years (around 75 kg).

Istiophorus platypterus (sailfish)

Sailfish spend a considerable amount of time in nearshore coastal waters, presumably to take advantage of the seasonal abundance of baitfish schools. There are no external features to distinguish the sexes, and while it is generally believed that males and females reach equivalent weights, the larger fish are usually females. Sailfish grow to 100 kg with an average size between 25 kg and 40 kg. Males are not mature until they reach at least 20–25 kg and females closer to 30–35 kg.

No study has been conducted for these species within Vanuatu waters, however, Smith (1992) notes that all billfish are predators of mostly fish and squid. Some biological information for billfish is given in Nakamura (1985). Sexes are separate, but both are active and voracious predators, although they are occasionally preyed upon by larger oceanic fish such as tunas, wahoo, and dolphinfish, particularly when the sailfish are in their younger stages. Young sailfish are sometimes also taken by adult billfish. Smith (1992) also notes that billfish are solitary, while other species tend to form small- to medium-sized schools. Migrations associated with spawning are known for billfish and dolphinfish.

10.3.4 The Fishery

Utilisation

It is assumed that billfish species do not form an important component of the household fish consumption. However, recent developments of the village fishing programme for offshore fishing has led to the utlisation of these resources on all levels (i.e. village, artisanal and commercial). The majority of the catch is sold to customers at the landing sites, fish markets in Port Vila and Luganville, or directly to restaurants (including hotel restaurants).

The pelagic resources support the sport fishing industry in Vanuatu. Large quantities of the species are caught by game fishers, which are also sold to local markets for domestic consumption. Large catches are made by small fishing enterprises around FADs.

Production and marketing

Details of catches by 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 summarized for the period 1967 to 1977 in Table 41.

Table 41: Catch of billfish in Vanuatu waters by Japanese and Taiwanese vessels 1967–1977

	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

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
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: Catch figures are expressed in numbers of fish, and effort in thousands of hooks. These figures only constitute 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 from 1985–1986, the following data were recorded.

Table 42: Billfish catch for years 1985-1986 (kg)

Species	1985	1986
Marlin	38.5	670.6

Billfish data collected by the Department of Fisheries from 1987 to 2003 is incomplete because game fishing vessels that normally target this resource were not forthcoming with the provision of their catch data. Artisanal fishing projects target mainly the deepwater bottom and catch billfish as bycatch. The quantity of billfish caught by small-scale rural fishing projects is very small and often not reported. In 2000, the Department of Fisheries recorded a total weight of 324 kg of marlin caught by artisanal fishing projects located on Efate. Summarized below are production sales of billfish by Sanma Fish Market.

Table 43: Billfish sales by Sanma Fish Market

	2001		2002	
Species	kg	VUV	kg	VUV
Blue marlin	1,063	300,515	-	-
Swordfish	412	123,600	302	90,600

Most accurate billfish data are those provided by foreign fishing vessels licensed to fish in Vanuatu waters. Table 44 summarizes catch data submitted by Vanuatu licensed foreign fishing vessels for 2001. More detailed catch data can be obtained from the Secretariat of the Pacific Community Tuna Fishery Year Book for 1999–2003.

Table 44: Billfish catch by Vanuatu licensed foreign fishing vessels (2001)

Species	Quantity (kg)
Striped Marlin	4,401
Blue Marlin	7,001
Black Marlin	906
Swordfish	3,048
Sailfish	265
TOTAL	15,621

10.3.5 Stock status

No assessment work on oceanic species has been conducted in Vanuatu. In the past, no fishery specifically targeted billfish. Billfish tended to be the bycatch of troll fishing for tunas, and local market demand for billfish was very limited except for dolphin fish which had a high value close to that of poulet (deep bottom snapper).

However in the recent past the demand for the oceanic pelagic species by the local markets has increased. This demand is fueled the steady increase in the urban population. There is no indication of over-exploitation of these resources.

An Australian Centre for International Agricultural Research (ACIAR) study conducted by the Australian Institute of Marine Science (AIMS), examined the development of gamefishing tourism, with an emphasis on billfish, in Papua New Guinea, 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 believed to be found in significant numbers from November–March (Williams, undated-draft document).

10.3.6 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 utlisation would fall under bilateral agreements for distant-water fishing nations to fish in Vanuatu's EEZ.

Recommended legislation/policy regarding exploitation

Legislation does not seem necessary at present, although given the flourishing gamefishing industry in Vanuatu, a system of collecting catch data from this development urgently needs to be formulated and administered by the Department of Fisheries.

11 Other oceanic pelagic fish

11.1 Dolphinfish, rainbow runner, wahoo and barracuda

11.1.1 Species present

The main species include dolphinfish (*Coryphaena hippurus*), rainbow runner (*Elegatis bipinnulatus*), wahoo (*Acanthocybium solandri*), and barracuda (*Sphyraena* spp).

11.1.2 Distribution

These species are typically distributed in varying abundance throughout the world's oceans. Their distribution is determined mostly by food availability. They are often associated with FADs, and in Vanuatu's deep coastal waters, they constitute a good portion of the bycatch from various fishing methods that target big tunas.

11.1.3 Biology and ecology

There has been no research on these species within Vanuatu waters. Smith (1992) notes that the above mentioned species are predators that feed mostly on fish and squid. They are active and voracious predators but are occasionally preyed on by large oceanic fish, particularly during their younger stages. Sexes are separate.

11.1.4 The Fishery

Utilisation

A survey of village subsistence fishing, conducted in Vanuatu in 1983, indicated the fishing for deepsea fish did occur, but there was no indication of how important these offshore pelagic fish were to household consumption. Recent developments of the village fishing programme for offshore fishing has led to the utilisation of these resources on all levels (i.e. village, artisanal and commercial). The majority of the catch is sold to customers at the landing sites, fish markets in Port Vila and Luganville, or directly to restaurants (including hotel restaurants).

The pelagic resources support Vanuatu's sport fishing industry. Large quantities of these species are caught by game fishers, and are also sold at local markets for domestic consumption. Large catches are made by small fishing enterprises around FADs.

Production and marketing

Crossland (1984) reported the following purchases (in kg) of wahoo and mahimahi — by both former Natai and Santofish markets — for a one-year period between 1983 and 1984.

Table 44: Purchases by former Natai and Santofish markets

	wahoo	**mahimahi**
Natai (May 1983–July 1984)	2,011	1,918
Santofish (July 1983–July 1984)	325	743

Those sold to the once operating island fisheries extensions, the Natai Fish Market and Santofish between the periods 1988 and 1992 are listed in Table 45. The values of the pelagic fishes were only available from the former Natai Fish market sales records.

Table 45: Pelagic fish purchases by Natai, Santo Fish, and fisheries centres

	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

Source: Department of Fisheries and Santofish databases

Data recorded during the OFCF fishing trials in southern and eastern coastal areas and around FADs off Santo Island from 1985–1986 are shown in Table 46.

Table 46: Pelagic fish catch (in kg) by OFCF fishing trials

Species	1985	1986
Dolphinfish	1,374.7	642.9
Rainbow runner	146.5	149.2
Other	13.0	30.5
TOTAL	1,534	823

One of the reasons for poor data submission is because artisanal fishing projects typically do not target pelagic fish. Pelagic fish are generally caught as bycatch, and so their numbers are often not recorded and submitted to the Department of Fisheries. A few artisanal fishing projects, however, do target pelagic fish. The fish are sold directly to restaurants and hotels. These fishing projects are on Efate Island and have access to FAD deployed 7 miles off Devils point. Even data collection from these fishing projects is very poor. Summarized below are pelagics caught and sold at the Port Vila Urban Markets.

Table 47: Catch data for 2000, 2002 and 2003

	2000		2002		2003	
Species	**KG**	**VUV**	**KG**	**VUV**	**KG**	**VUV**
Mahimahi	258	64484	6	2200	350	139,019
Rainbow runner	273	78200	5	1100	6.1	1590
Wahoo	1347.9	436718	92	36300	4683	923940
Barracuda	-	-	-	-	34	12700

The above data are not complete, and the figures are not representative of the overall total pelagic fish production by small fishing projects in Vanuatu. Local fish markets have not cooperated in submitting their production figures.

11.1.5 Stock status

No assessment work on the oceanic pelagic species has been conducted in Vanuatu. In the past no fishery specifically targets these except they tend to be bycatch from the troll fishing for the tunas and local market demand for these species was very limited except for dolphin fish which had a high value close to that of poulet (deep bottom snapper).

However in the recent past the demand for the oceanic pelagic species by the local markets has increased. This demand is fueled by the steady increase in the urban population. There is no indication of over-exploitation of these resources.

11.1.6 Management

Current legislation/policy regarding exploitation

There is no specific national legislation that deals with the harvesting of these pelagic fish resources. However, the Fisheries Act empowers the Director of Fisheries to draft management plans to control exploitation levels of the resource.

Recommended legislation/policy regarding exploitation

The Department of Fisheries needs to improve its data collection procedures to ensure that sufficient data can be collected. The following recommendations should be considered:

- Given the flourishing gamefishing industry in Vanuatu, a system of collecting catch data from this development urgently needs to be administered by the Department of Fisheries.
- The Department of Fisheries urgently needs to improve its statistics division and provide appropriate training for its statistician.
- All artisanal fishing projects should pay a fishing license fee.
- Fish market outlets should be obligated by way of a policy to provide data.

11.2 Baitfish (small pelagics)

11.2.1 Species present

The SPC 1977 and 1978 skipjack and baitfish resources assessment in Vanuatu waters identified 60 baitfish species caught in bouki-ami hauls. The dominant species included *Spratelloides delicatulus*, *Stolephorus indicus*, *S. devisi, Hypoatherina ovalaua*, *Herklotsichthys punctatus* (*quadrimaculatus*), *Apogon (Rhabdamia) cypselurus, Pterocaesio pisang,* and *Pterocaesio* spp. Other common species include: *Benthosoma fibulatum, P. diagramma, Selar crumenphthalmus, Decapterus macrosoma, Priacanthus* spp., *Xiphasia setifer* and *Archamia lineolata*. The only information available on the 1982 joint survey of the

baitfish resource by the Department of Fisheries and the South Pacific Fishing Company Ltd. (SPFC) is a diary of activities (Blackburn 1982). The dominant species of fish caught by stick-held dip nets using night lamps (as conducted by OFCF in 1985) were baitfish catches of *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).

11.2.2 Distribution

Some available information on the distribution of small pelagics in the South Pacific can be found in Dalzell 1993. 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 Vanuatu's coastal lagoons and 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 distribution of fusiliers (*Caesio* and related genera) is determined largely by the extent of coral cover, which is associated with shallow coastal water (<30 m depth). The mackerels (*Rastrelliger* spp.) are found farther offshore, whereas roundscad (*Decapterus* spp.) are found between the neritic and oceanic areas, with flying fish inhabiting both inshore waters and the open ocean (Dalzell and Lewis 1988).

In 1984, several bays in Vanuatu were surveyed using purse seine, dip net and trap nets. The results were very poor. The survey concluded that areas of high baitfish concentrations could be absent in Vanuatu due to the lack of suitable wide coastal shelves, which are characteristic of good baitfish environments (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 nets were conducted in 1982. Results from both methods compared favourably with those of the Skipjack Programme from other parts of the Pacific (Habib 1984).

The OFCF/ Department of Fisheries 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 baitfish. Baitfishing trials were carried out in 12 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 baitfishing was prohibited. Adult baitfish of these two species were only observed for short periods of time (Anon 1987).

The SPFC/Fisheries Department baitfish survey of 1982 also conducted surveys within Palekula Bay, Hog Harbour, Port Olry, Shark Bay, Turtle Bay, Aore and Malo Islands, Tangoa and Tangice Islands and Tasmalum.

11.2.3 Biology and ecology

Most studies on the small pelagic fish in the Pacific have concentrated on the species that are important to the pole-and-line fishery, such as 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 fish 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 fish into three groups as shown in Table 48.

Table 48: Biological parameters of small tropical pelagic fish

Group	Life cycle	Size	Growth	Age sexual maturity	Spawn	Batch fecundity
One Species: stolephorid anchovies (*E. heteroloba*, *E. devisis*, *E. punctifer*), sprats (*S. gracilis*, *S. delicatulus*, *S. lewisi*) and silverside (*Hypoatherina ovalau*)	1 year	7 - 10 cm max	Rapid	3-4 months	extended period	500-1500 oocytes/grm of fish
Two Species: herring and sardines (*Herklotsichthys* spp., *Amblygster* spp., *Sardinella* spp.), larger anchovies (*Thrissina* spp., *Stolephorus* spp), sharp-nosed sprats (*Dussumieris* spp.)	1 to 2 years	10-24 cm max	-	towards end first year	restricted seasonal	300-500 oocytes/grm of fish
Three Species: roundscads (*Decapterus* spp.), bigeye scads (*Selar* spp.), small mackerels (*Rastrelliger* spp.), flyingfish (Exocoetidae), half beaks (Hemiramphidae)	2-5 years	20-35 cm max	-	-	restricted seasonal	400-600 oocytes/grm of fish (50-100 for flying fish)

Dalzell (1993) gave a summary table for the growth, mortality and maturity parameters for a number of small pelagic fish species in the South Pacific (Table 49).

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

Although there are suitable fishing grounds — along the eastern and southern coasts of Santo Island — the absence of atolls, which act as nursery grounds for baitfish fry, seems to have an effect on the abundance of baitfish. 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 Palekula Bay, are all liable to be influenced by trade wind and are often turbid.

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

Table 49: 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_∞
Encrasicholina heteroloba	PNG	7.9	2.6	4.9	1.0	5.1	0.65
Stolephorus waitei	PNG	10.9	1.7	3.4	1.5	7.3	0.67
Spratelloies delicatulus	Fiji	7.3	4.6	6.9	0.4	4.0	0.55
Atherinomorus lacunosus	New Caledonia	11.4	2.5	4.1	1.2	8.5	0.75
Herklotsichthys quadrimaculatus	Fiji	12.6	2.0	3.5	1.6	9.5	0.75
Amblygaster sirm	New Caledonia	22.9	1.5	2.4	2.0	15.0	0.66
Decapterus russelli	New Caledonia	24.9	1.3	2.1	3.0	18.0	0.72
Selar crumenophthalmus	Hawaii	27.0	2.57	3.4	2.0	23.0	0.85
Rastrelliger kanaurta	New Caledonia	23.7	3.0	3.7	1.0	20.0	0.87

11.2.4 The Fishery

Utilisation

Over 75% of the total catch from the OFCF baitfish survey consisted mainly of *H. ovalis*, *S. melanosticta*, *Allenetta* spp., and only a few specimens of *H. ovalis*, *S. melanosticta* and *S. delicatulus* were found and used as live baitfish. Other species were unsuitable due to their size and poor survival rate. During the SPC skipjack and baitfish assessment in Vanuatu, the blue sprat, *S. delicatulus* was the dominant species by number and weight. This particular fish is regarded to be excellent skipjack bait and is easily attracted to lights around which it forms surface aggregations. The second most abundant species was *S. indicus*, but because of its large size and extremely delicate body, 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 skipjack baitfish.

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 gear. 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 the former Santofish market on Santo and the once operable fisheries extensions on the outer islands.

Excess small pelagic fish, like other marine products from the outer islands, is normally sent to the urban fish markets in port Vila and Luganville. Sardines and mackerel are also sold in the supermarkets (e.g. Bon Marche in Port Vila).

Production and marketing

The total baitfish catch from 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 baitfish. It was noted that the results were similar to those executed during the Japan Marine Fishery Resources Research Center 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.

Table 50: Catches by the OFCF fishing trials

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 Department of Fisheries. A 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; 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, consisting mainly of the sardine *H. punctatus*, a species that 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 was 14.2 kg, a figure much less than the beach seine and bouki-ami catches in Vanuatu.

During the SPFC/Department of Fisheries survey in 1982, the potential bait catches were estimated by Japanese experts to be two and five tonnes per haul in Hoghabour and Turtle bays (Santo), respectively (Blackburn 1982). Night baitfishing trials in September of that year, however, 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).

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 are usually caught using nets and spears.

Yearly data (weights in kg) of small pelagic fish sold to the Fisheries Extensions (1990–1992) on the outer islands are as follows.

Table 51: Small pelagic fish purchases by fisheries centres

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

Source: Department of Fisheries data

A summary of inshore pelagic fish sales at Santofish on Santo between 1989 and 1992 is presented in the following table.

Table 52: Inshore pelagic fish sales by SantoFish

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

Source: Santofish database, Santo

In 1992 it was estimated that one tonne of fish (some of which included sardines and mackerel) was sold through the Au Bon Marche supermarket in Port Vila.

The most recent production data (2001) collected by the Department of Fisheries was from a fish market in Luganville, Santo.

Table 53: Inshore pelagic sales by Sanma Fish market

	2001		2002		2003	
Species	**KG**	**VUV**	**KG**	**VUV**	**KG**	**VUV**
Mangru	206.5	49,390	1788	369,090	415.5	41375
Sardine	24.5	2940	-	-	38	8600

11.2.5 Stock status

No study has been done to assess the stocks of small pelagic fish in Vanuatu, and there is currently no baitfishing for pole-and-line tuna fishing. The high catch of the sardine, *H. punctatus*, from one of the lampara hauls does not reflect its abundance. Although this species is a good baitfish for skipjack, it 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 constitute the baitfish for the pole-and-line fishery. Subsistence and artisanal levels of exploitation of the small pelagic fish in Vanuatu, 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 indicate 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).

11.2.6 Management

The SPC surveys suggest that the supply of live baitfish may present problems for the commercial operations of a pole-and-line tuna fishery within Vanuatu. Thus, stocks would not be able to sustain and support any commercial harvesting of tuna. In addition, species show seasonality in occurrence. Because of the lack of information on the species caught locally in the subsistence and artisanal fisheries, management strategies are difficult to devise. This is particularly so with species that have a short lifespan and high mortality rates where high fishing could be advantageous because many of the fish 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 (two to four years) lifespan.

Biological data are 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 of baitfish and the management of commercial baitfishing, or small pelagic fishing, for subsistence and artisanal purposes.

Recommended legislation/policy regarding exploitation

Net mesh size for capturing *Selar* and *Rastrelliger* spp. should be considered. Smaller mesh size nets should be banned.

Any attempt to commercially exploit the baitfishery should proceed only after detailed research on the fishery is completed.

11.3 Aquarium fish (marine)

Between 1.5 and 2 million people worldwide are believed to keep marine aquaria. This trade, which supplies this hobby with live marine animals, is a global multi-million dollar industry, worth an estimated USD 200–330 million (UNEP-WCMC 2003) annually, and operates throughout the tropics.

11.3.1 Species present

Species targeted for the aquarium trade are small and have bright or ornate colours. Other important species' characteristics include non-restrictive diets and overall adaptability to a captive environment (Pyle 1993).

A total of 1,471 species of fish are traded worldwide, with the best estimate of annual global trade ranging between 20 and 24 million individuals. Damselfish (Pomacentridae) make up almost half of the trade, with species of angelfish (Pomacanthidae), surgeonfish (Acanthuridae), wrasses (Labridae), gobies (Gobiidae) and butterflyfish (Chaetodontidae) accounting for approximately another 25–30%. The most traded species are the blue-green damselfish (*Chromis viridis*), clown anemonefish (*Amphiprion ocellaris*), whitetail dascyllus (*Dascyllus aruanus*), sapphire devil (*Chrysiptera cyanea*), and the threespot dascyllus (*Dascyllus trimaculatus*).

Records of exports from Vanuatu indicate that some species also 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 include Acanthuridae (surgeonfish and tangs*),* Balistidae and Monacanthidae (triggerfish and filefish), Blenniidae and Gobiidae (blennies and gobies), Chaetodontidae (butterflyfish), Cirrhidae (hawkfish), Labridae (wrasses), Pomacanthidae (angelfish), Pomacentridae (damselfish) and Serranidae (groupers and basslets).

A checklist of taxa of shallow water (<30 m) reef fish in Vanuatu, conducted by the Australian Institute of Marine Science (AIMS) (Williams 1990), was compiled. A total of 469 species were identified; of these, 25 fell under 6 main family groups, including 10 species of Pomacentridae, 5 of Scaridae, 3 of Labridae, 3 of Acanthuridae, 2 Siganidae and 2 Chaetodontidae.

11.3.2 Distribution

Ornamental marine species (e.g. corals, other invertebrates, and fish) are collected and transported mainly from Southeast Asia, but also increasingly from several island nations in the Indian and Pacific Oceans, to consumers in the main destination markets: the US, the European Union, and to a lesser extent, Japan. Fish exploited for the aquarium trade in Vanuatu, as is done in other South Pacific islands, are all wild-caught marine species from shallow water coral reefs.

11.3.3 Biology and ecology

Reef fish exhibit a wide variety of reproductive strategies. Some, such as many of the butterflyfish (Chaetodontidae), form monogamous mated pairs. Others, such as the pygmy angelfish (Pomacanthidae, genus *Centropyge*), form polygamous harems consisting of a single male and several females. Still others, such as surgeonfish and tangs (Acanthuridae), spawn in mass aggregations.

Daily, monthly, and annual periodicity in peak spawning times has been demonstrated for many species of reef fish (Thresher 1984, in Wright 1993). Spawning tends to occur at dusk or dawn, during full or new moon, and with some amount of seasonal variation. Specific times and strategies vary between different species, and sometimes between populations of the same species in different localities. Actual spawning usually occurs quite rapidly, and fertilization virtually always takes place externally.

There are two basic strategies employed by reef fish with respect to eggs: parental care, and no parental care. Reef fish, which devote parental care to their eggs, are usually either demersal egg-layers (such as the damselfish, Pomacentridae) and gobies (Gobiidae), or mouth brooders (such as cardinalfish, Apogonidae). By providing parental care for the eggs, these fish are able to enhance their offspring's survival rate; however, extra time and energy are expended and clutch sizes are smaller.

Most species of coral reef fish forgo any parental care and spawn pelagic eggs. Gametes are released in the water column, and the fertilized eggs drift as plankton for some time before hatching. Although the eggs are more vulnerable to predation, greater numbers of them are spawned and no energy is expended by the parent in caring for the clutch.

Pyle (1993) gives some biological and ecological characteristics of the main families in the marine aquarium trade from the South Pacific.

Table 54: Biological and ecological characteristics

Family	Feeding strategy	Reproductive strategy	Habitat
angelfish (Pomacanthidae)	herbivore/omnivore	harem-forming/pair-forming; some species protogynous; spawn at dusk; pelagic eggs	shallow to deep reef; rubble/coral
butterflyfish (Chaetodontidae)	omnivore/plantivore/ corrallivore	pair-forming/school-forming; pelagic eggs	shallow to deep reef; coral and ledges
surgeonfish 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
damselfish (Pomacentridae)	herbivore/plantivore/ omnivore	harem-forming/aggregate-forming; spawn in morning; demersal eggs	shallow reef coral/rubble; *Amphiprion* inhabit sea anemones

Family	Feeding strategy	Reproductive strategy	Habitat
triggerfish and filefish (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
hawkfish (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

11.3.4 The Fishery

Utilisation

Recently, the smaller, brighter or more ornate reef fish, including some of the locally consumed species or their juveniles, have been the target for Vanuatu's aquarium export trade.

Exports have been made to Australia, New Zealand, the US, 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 Department of Fisheries 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, the US and Asia (Wright 1989).

Production and marketing

Proper data records of aquarium fish exports commenced in 1992 via application forms for permits submitted by companies prior to shipment. Because of the lack of proper data collection procedures, the numerous species involved were only recorded as numbers of fish and estimated value from each permit application submitted and permit granted. In 1992, 7,590 aquarium fish were exported overseas, of which 35.3% were exported to New Zealand, 32.8% to Australia, 18.4% to the US, and 13.5% to Japan. Total value for all aquarium fish exported in 1992 was 556,110.00 Australian dollars (AUD). There were very little export data in 1993. One reason for this was the effect of the 1993 civil servant nationwide strike, which resulted in the poor delivery of many services by the Department of Fisheries. The effects of the strike spilled over into 1994, when 4,500 aquarium fish were exported.

Collection is done by companies through agreements with traditional fishing rights owners. The aquarium trade appears to be the only industry that has continuously exported live fish for the last 10 years, surviving the high freight and operating cost in Vanuatu. Aquarium fish exports increased to 70,000 fish, comprising 300 species from 17 families. The 2003 exports dominate overall fisheries exports in terms of quantity and value. The export of live rocks and invertebrates also increased while giant clam exports declined. About 70% of fish exported originated from the company, Sustainable Reef Supplies. The estimated contribution the industry made to the local economy is USD 1 million, making it the biggest domestic fisheries industry. Table 55 summarizes export data from 1992 to 2004.

Table 55: Aquarium fish export figures for 1992 to 2004

Year	Quantity (# individuals)	Value
1992	3,000	750,000
1993	4,000	1,000,000
1994	4,500	1125000
1995	1,850	26,060

Year	Quantity (# individuals)	Value
1996	5,555	906,153
1997	16,608	747,133
1998	33,945	594,104
1999	29,363	-
2000	12,490	1,856,574
2001	10,051	1,528,754
2002	20,749	5,803,346
2003	70,000	41,522,371
2004	129,793	24,214,932

Table 58 lists the common fish species that are collected purposefully by local divers and aquarium trade operators for the aquarium export. Angelfish (Pomacanthidae) are the most traded family with flame angelfish (*Centropyge loriculus)* being the main exported species, followed by wrasses (Labridae), gobies/blennies (Gobiidae/Blenniidae), damselfish (Pomacentridae), butterflyfish (Chaetodontidae) and tangs (Acanthuridae). Angelfish are the most valued species, contributing 42% of the export value followed by wrasses, others (rare and unusual species), damselfish, and tangs.

Table 56: The number of fish species per family (in Vanuatu) that are targeted by local aquarium industries.

Families	Common Name	Number of species
Acanthuridae	Tangs	18
Balistidae	Triggers	16
Blenniidae	Blenny	19
Chaetotontidae	Butterfly fishes	21
Cirrhitidae	Hawkfish	6
Gobiidae	Goby	8
Labridae	Wrasses/Hogfishes	80
Lutjanidae	Snappers	7
Monacanthidae	Filefishes	7
Mullidae	Goatfishes	2
Pomacanthidae	Angel fishes	25
Pomacentridae	Clowns/Damsels/Chromis	24
Scaridae	Parrot fishes	2
Scopaenidae	Lion fishes	11
Serranidae	Anthias/Croupers/Bass	17
Siganidae	Rabbit fishes	1
Tetraodontidae	Puffer fishes	15

Table 57: Total invertebrate aquarium exports from Vanuatu (1997–2003)

Year	Invertebrates
1997	230
1998	1200
1999	3000
2000	5000
2001	8000
2002	5000
2003	11000

11.3.5 Stock status

Efate Island has been the main collection location for aquarium fish products since the establishment of the export business in the early 1990s. Collection sites around Efate frequented by divers are outlined on the map below.

Williams (1990) notes that there was no strong evidence of significant human-induced disturbance of fish communities on study reefs within Vanuatu. However, some reef disturbances were apparent as a result of cyclones and crown-of-thorns starfish infestations, as well as the cutting of mangroves and siltation from soil erosion (from logging operations).

Recent assessment surveys by the Secretariat of the Pacific Community in collaboration with the Department of Fisheries in 2004, indicate that only two sites on Efate (Tuktuk II and Hat Island) were affected by the collection of aquarium fish by exporting companies. The remaining islands within the archipelago have healthy aquarium fish stocks.

Efate and offshore islands. Main collection sites for aquarium products.

11.3.6 Management

Pyle (1993) provides a comprehensive literature review of the effects and management strategies of the aquarium trade in different countries. In small countries such as those in the South Pacific where often only one operator (exporter) is involved, exploitation guidelines seem to be sufficient.

Apart from the removal of fish, habitat damage is a major concern. This can result from the breaking up of corals, either incidentally (anchorage, divers' fins or walking on them), or deliberately to extract a valuable fish hidden in a coral head. The greatest concern is 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 agreement with customary land owners regarding the use of land and waters for catching aquarium fish.

Offences under this regulation are punishable by a fine not exceeding VUV 100,000. The Fisheries Act 1982 (19) prohibits the use of explosives and poisons to catch fish. Fines under this section are not to exceed VUV 1,000,000.

In 2000, the government banned exports of the giant clam *Tridacna crocea*. The ban also prohibited the harvesting of all species of giant clams on Efate Island for the aquarium trade.

Recommended legislation/policy regarding exploitation

Recommendations include:

- Operators exporting live fish should be licensed and limited to a single operator giving the sole operator a 12-month period of grace.
- Operators should be of a high international repute with a proven record in the trade.
- resource custodians Involvement of in the collection process should be to the maximum extent practicable. There should be a training component in this process.
- The use of chemicals or poisons for collection should be prohibited.
- Conservation guidelines should be formulated by the Division of Fisheries in consultation with the operator. A ceiling on the total number of fish exported per year to be set, taking into account the area to be fished.
- Efforts should be made to ensure that collection activities do not conflict with other uses (e.g. tourist diving).
- The Department of Fisheries should consider reserves, closed-seasons, and other conservation measures.
- A quota should be placed on each fish species exported for aquarium purposes.
- Strict management and monitoring mechanisms should be established to ensure compliance with quotas and data reporting.

Table 58: Fish harvested for the aquarium export trade

Fish Species	Fish Species
Acanthurus lineatus (Clown Tang)	*Chaetodon equippum* (Saddle Butterflyfish)
Acanthurus nigricans (Power Gray)	*Chaetodon mertensii* (Mertensii Butterflyfish)
Acanthurus olivaceous	*Chaetodon ornatissimus*
Acanthurus olivaceous, juv	*Chaetodon pelewensis*
Acanthurus pyroferus	*Chaetodon rafflessi* (Lattice Butterflyfish)
Acanthurus strigata	*Chaetodon ulietensis*
Acreichthys radiatus	*Chaetodon ulietensis* (Falcula Butterflyfish)
Amanses scopas	*Chaetodon unimaculatus* (Teardrop Butterflyfish)
Amblygobius phalaena	*Chromis* sp. (Black Chromis)
Amphiprion chrysopterus	*Chromis viridis* (Green Chromis)
Amphiprion chysopterus	*Chrysipter* sp.(Elect Gregory)
Amphiprion clarkii	*Chrysiptera* sp. (Black Cap Damsel)
Amphiprion melanopus	*Chrysiptera starcki* (Starcki Damsel)
Amphiprion perioderon (Pink Shunk)	*Chrysiptera taupou* (Blue Devil)
Anampses neoguinensis	*Chrysiptera tricineta* (Tricinta Damsel)

Fish Species	Fish Species
Apolemichithyys trimaculatus	*Cirrhilabrus exquisitus* (Exquisite Wrasse)
Arothron hispidus (White Spot Pufferfish)	*Cirrhilabrus pylei*
Arothron meleagrisl (Guinea Fow)	*Cirrhilabrus rhomboidalis* (Rhomboid Wrasse)
Arothron nigropunctata, xanthic Phase (Dogface Goldfish *)*	*Cirrhilabrus rubromarginatus* (Ruby Wrasse)
Arothron nigropunctatus	*Cirrhilabrus scottorum* (Scott Wrasse)
Arothron stellatus (Stellatus Pufferfish)	*Cirrhilabrus* sp. (Black Fin)
Balistapus Undulatus (Undulate Triggerfish)	*Cirrhilabrus* sp., Hooded wrasse
Balistoides conspicillum	*Cirrhilabrus* sp.? Vila Fairy wrasse
Balistoides viridescens (Titan Triggerfish)	*Cirrhitichthys falco* (Spotted Hawkfish)
Balisttoides conspicillum (Clown Triggerfish)	*Cirripectes stigmaticus*
Bodianus anthioides (Lyretail Hogfish)	*Cirripectes stigmaticus* (Indian Blenny)
Bodianus axillaris	*Coris gaimard* (Red Coris)
Bodianus axillaris (Coral Hogfish)	*Corythoichthys intestinalis* (Pipefish)
Bodianus bimaculatus (Candy Hogfish)	*Ctenochaetus tominiensis* (Tominini Tang)
Bodianus diana (Diana Hogfish)	*Cyprinocirrhites polyactis* (Pixy Hawkfish)
Bodianus loxozonus (Black Fin Hogfish)	*Dascyllus aruanus* (Three-Stripe Damsel)
Bodianus mesothorax	*Dascyllus trimaculatus* (Domino)
Bodianus perdito (Banana Hogfish)	*Dendrochirus zebra*
Bothus sp.	*Epinecephalus urodeta*
Callopplesiop altovelis (Marine Betta)	*Escenius bicolor*
Cantherines sp.	*Forcipiger flavissimus*
Canthigaster bennetti (Bennetti Pufferfish)	*Forcipiger Flavissimus* (Longnose Butterflyfish)
Canthigaster coronata	*Geniacanthus wanatabe*
Canthigaster solandri (Blue Dot Pufferfish)	*Genicanthus melanopilos* female
Canthigaster sp. (Deepwater Pufferfish)	*Genicanthus melanopilos* male
Canthigaster Valentini (Valentini Pufferfish)	*Genicanthus melanospilos*
Centropyge aurantius	*Genicanthus watanabe,* female
Centropyge bicolor	*Gomphosus variu* (Brown Bird)
Centropyge bispinosis	*Gomphosus varius*
Centropyge flavicuda	*Halichoeres chrysus*
Centropyge flavissimus	*Halichoeres melanurus*
Centropyge flavissimus x, smoky phase	*Halichoeres ornatissimus* (Ornamental Wrasse)
Centropyge heraldi (Herald's Angelfish)	*Halichoeres prospeion*
Centropyge loriculus	*Heniochus acuminatus* (BW Heniochus)
Centropyge multifaciatus	*Heniochus varius*
Centropyge nox	*Hoplolatilus starcki* (Blueface Coby)
Centropyge vrolki, Vanuatu golden Var.	*Labroides bicolor*
Centropyge tibicen	*Labridae Family* (Assorted Wrasse)
Cephalapholis miniata (Miniata Grouper)	*Labroides dimidatus* (Cleaner Wrasse)
Cephalopholis miniata	*Labroides pectoralis* (Multi Cleanerfish)
Cephalopholis urodeta (Vee Tail Grouper)	*Labropsis alleni*
Chaetodon auriga (Auriga Butterflyfish)	*Labropsis xanthonota*
Chaetodon ephippium	*Lepidozygus tapeinosoma*
Macropharynogodon negroensis	*Macolor niger* (Niger Dogfish)
Melichthys vidua (Pink Tail Triggerfish)	*Macropharynogodon meleagris* (Leopard Blue)
Naso Lituratus (Naso Tang)	*Thalassoma lutescens,* MD Banana
Naso maculatus	*Thalassoma quinquivattum* (Rainbow Wrasse)
Naso vlamingii (Vlamingii Tang)	*Valenciennea strigata*
Neocirrhites armatus	*Valenciennea strigata* (Sleeper Goby)
Novaculichthys taeniourus	*Variola albimarginata* (Lyre Grouper)
Novaculichthys taeniourus (Dragon Wrasse)	*Xanthichthys auromarginatu* (Blue Jaw)
Odonus niger (Niger Triggerfish)	*Zanclus canescens*
Paracanthurus hepatus (Indo Pacific Blue Tang)	*Zebrasoma scopas*
Paracheilinus sp. Flasher wrasse	*Zebrasoma scopas* (Scopas Tang)

Fish Species	Fish Species
Paracirrhites arcatus (Yellow Grouper (Arc Eye Hawkfish))	*Zebrasoma veliferum* (Sailfin Tang)
Paracirrhites forsteri	*Thalassoma lutescens,* LG Super Male
Paracirrhites forsteri (Freckled Hawkfish)	*Pseudanthias tuka*
Paraluteres prionurus (Mimic File)	*pseudobalistes fuscus*
Parupeneus barberinoides (Bicolor Goatfish)	*Pseudocheilinus evanidus* (Striated Wrasse)
Parupeneus cyclostomus (Yellow Goatfish)	*Pseudocheilinus hexataenia* (Sixline Wrasse)
Plectorhinchus chaetodonoides	*Pseudocheilinus octotaenia*
Plectorhinchus vittatus	*Pseudocheilinus sextaenia*
Pomacanthus imperator	*Pseudochromis porphyreus* (Purple Baslet)
Pomacanthus imperator, adult	*Ptereleotris evides* (Scissortail)
Pomacentrus sp. (Blue Chromis)	*Ptereleotris Sp.* (Redfin Goby)
Pomocanthus semicirculatus	*Ptereleotris zebra*
Priacanthus sp.	*Ptereleotris zebra* (Bar Goby)
Protoreater nodosus	*Pterois antennata* (Ragged Finned Firefish)
Pseudanthia pleurotaenia	*Pterois radiata* (Radiata Lionfish)
Pseudanthias lori	*Pterois volitans* (Volitans Lionfish)
Pseudanthias parvirostris	*Pygoplites diacanthus*
Pseudanthias pleurotaenia	*Rhinecanthus aculeatus* (Humu Humu)
Pseudanthias sp.(tri-color)	*Rhinecanthus lunula* (Lunula Triggerfish)
Scorpaensis sp. (Scorpionfish)	*Rhinecanthus rectangulus*
Sufflamens bursa	*Rhinecanthus verrucosa*
Sufflamens chrysoptera	*Richardsonicthys leucogaster* (Waspfish)
Synanceia verrucosa (Stonefish)	*Scarus* sp. (Assorted Parrotfish)
Thalassoma lunare (Lunare Wrasse)	*Thalassoma lutescens* (Lime Wrasse)
Thalassoma lutescens (Banana Wrasse)	

11.4 Shallow water reef fish

11.4.1 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 are 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 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).

11.4.2 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 kilometres 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 400 m.

Table 58: Area distribution of reefs in Vanuatu down to 400 m

	SURFACE AREA (ha)				
ISLANDS	**Land**	**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
Malekula	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

11.4.3 Biology and ecology

Ecological characteristics of some of the fish families in this category are given in Pyle (1993) as follows.

Table 59: Ecological characteristics of reef fish families

Family	Feeding strategy	Reproductive strategy	Habitat
Acanthuridae (surgeonfish and tangs)	herbivorous	school-forming; spawn at dusk in large groups; pelagic eggs	all habitats depending on species
Labridae (wrasses)	hebivorous	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).

11.4.4 The Fishery

Utilisation

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 gears 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. Local fishermen prefer spear gun particularly for night diving especially when spear-fishing for parrot-fish.

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 archipelago, Malekula, the Banks group, Efate, Santo, Pentecost and Tanna constitute the major fishing population centres. In describing the 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.

Up to the late 1980s and early 1990s fishing in the reef zones in Vanuatu was 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. Fishing boats used in these zones were mostly traditional canoes with paddles. The reef flats were easily reached on foot. The collection of mollusc was normally done by the women. Fishing methods used included; assegai or spears, bows and arrows, cast nets, fish fences and traps, fishing reel, gill nets, handlines, poisoning using leaves and under-water spearguns (David 1990).

During the mid 1990s there was a dramatic change in rural fishing methods. There were more boats powered by either 15 or 25 Hp outboard motors. Prefered fishing methods included; cast nets, gill nets, under-water spear guns, fishing reels, and handlines. Fin-fish catches from the reefs became a common commodity in the fish markets. Fin fish which used to be caught for mainly subsistence are now caught for commercial purposes. This change is driven the cost of living and the need to generate rural income to cover such costs as school fees, school uniforms, etc.

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:

Table 60: Village fishing sector production

Item	Percentage
fish	42.5
shellfish	33.5
lobster	20.5
octopus	3.0
freshwater 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.

Table 61: Details of the 1983 survey results

	TOTAL PRODUCTION		PRODUCTION SOLD			
Product	**Number**	**Weight (tonnes)**	**Number**	**Weight (tonnes)**	**% total production**	**Value 10^6 VUV**
Deepsea 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
Freshwater 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 shellfish (baskets)	202,600	810	13,400	53.5	6.5	1.6
Freshwater 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 former Fisheries Department Extensions Centers on the outer islands for the period from 1990 to 1992 were given as "mixed reef fish" and is shown in Table

62. 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 62: 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

The "mixed reef fish" sold through the Natai Fish Market from 1988 to 1992 were made up mostly of parrot-fish (recorded as "blue fish"), a few surgeon-fish (Acanthuridae) and goatfish (*Parupeneus*) which were sold at VUV 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 63 below. Mullet is composed almost exclusively of *V. seheli*. The combined records show increasing totals from this component of the total fish landing. (Figures are in kg.).

Table 63: Reef fish sales at Santofish (1989–1992)

	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 purchased reef crabs and mud crabs as shown below for the 1988–1992 period (source: Fisheries Department Data Base).

Table 64: Reef crab and mud crab sales, 1988– 1992

	1988	1989	1990	1991	1992
Reef Crab (kg)	51.9	22.5	8.6	11.3	0
Value (VUV)	7,943	4,170	2,290	2,663	0
Mud Crab (kg)	0	7.5	22.5	13.6	65.5
Value (VUV)	0	2,550	10,625	4,760	39.300

Au Bon Marche super market was the only other commercial outlet in Port Vila that sold fish from the early 1980s until present. In 1992 an estimated 1,000 kg of reef fish, including sardines and mackerel, were sold via this supermarket during.

Following the closure of both Santo fish and Natai fish markets, in 1997, data collection of reef fish production has been very poor. The Department of Fisheries only concentrates on collecting pelagic and deepwater bottom fish data, which are provided by fishing projects via the GRN forms. Reef fish data records from the Department's data collection base are incomplete. Summarize below are reef fish sales for the years 2001 to 2003 by Sanma Fish

Market.

Table 64: Reef fish sales, 2001–2003

	2001		2002		2003	
Species	**kg**	**VUV**	**kg**	**VUV**	**kg**	**VUV**
Mix reef fish	627.3	153,484	96	19,330	635	208055
Mullet	24	4800	34	6800		
Rabbit fish	-	-	5	1250		

Even though data collected by the Department indicated that reef fish production to be very small, due to poor data collection, the reality is that reef fish production is increasing every year, given its commercial at the urban markets. Production by fish outlets such as LTP, and Au Bon Marche indicates an increase in reef fish production, particularly of rabbitfish, parrotfish, snappers and mullet.

Table 65: Local fish market sales of reef fish for 2004

Species	**KG**	**VUV**
Mix reef fish	15,767	3,012,495
Sardine	46.5	6,975
Loche	5	750
Trevally	28.2	4,275
Parrotfish	151.9	30,300
Mangru	64	13,056
Total	**16,062**	**3,067,851**

Note that the 2004 figures are not complete because some fish markets refused to supply data regularly to the Department of Fisheries, but even when they do, the figures are under reported. A possible reason could be that fish markets do not want the Department of Fisheries to know how much money they are making through the retailing of reef fish and fish in general.

It is important to note that given transportation difficulties, reef fish caught by rural fishermen and fisherwomen are often sold at urban municipal markets in fish boxes. Data from these catches are not collected. It is envisaged that with the re-establishment of community-based ice machine projects, fish data can be collected much more readily. An example is the Emae ice machine project, which began in 2004. Since its operation — from September 2004 to December 2004 —2,738 kg of reef fish were purchased from Emae rural fishermen and fisherwomen, and transported to Port Vila for sale, resulting in an infusion of VUV 451,770 into the rural communities around Emae.

Artisanal fishing projects are found throughout the islands of Vanuatu, especially on offshore islands closer to and including Efate and Santo. These projects contribute immensely to rural economies. Table 66 lists fish caught by artisanal fishing projects in 2004 by quantity and value. The data, however, are incomplete because some fishing projects were not able to send in their catch data sheets, and because the Department of Fisheries has not yet completed entering the 2004 data sheets supplied by artisanal fishing projects.

Table 66: Artisanal production in 2004

Species Name	Quantity (kg)	Value (VUV)
Wahoo	206	72700
Yellowfin	1106	166535
Skipjack	1059.5	285400
Mahimahi	15	7500
Dogtooth tuna	67	13400
Rainbow runner	17	3460
Marlin	43	13000
Red short tail	1596	515475
Red long tail	485	271475
Red silver jaw	74	33900
Large-scaled jobfish	360	202000
Yellow jobfish	751	337950
Pink tail jobfish	142	63900
Spotted loche	10	1800
Brown striped loche	33	8250
Large eyebream	17	5100
Kusakars snaper	36	10800
Amberack	109.5	31550
Sea perch (snapper)	45	13530
Silver jaw	139	62550
White poulet	62	13640
Snapper	20	4400
Other	13	2600
Total	6,406	2,140,905

Source: Department of Fisheries

11.4.5 Stock status

There has been no attempt to assess any reef fish stocks in Vanuatu. Compilation of data by the Department of Fisheries makes it impossible to trace trends of individual species. Williams (1990) found no significant human-induced disturbance to fish communities in those reefs that were studied. However, most reefs examined showed evidence of major disturbances by cyclones and/or crown-of-thorns starfish.

Given the recent population increase, particularly in the rural areas, and the need to generate income to meet the current high cost of living, fishing pressure on reef fish resources has increased, especially on Efate, Santo and Malekula. This is due, in part, because of easy access to urban markets.

11.4.6 Management

On rare occasions, 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. The increased use of more efficient fishing gears is apparent, and the decline in fishing effort for the deepwater fishery could result in a shift of fishing pressure to shallow water fish.

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 about the unregulated use of gillnets, especially in reef areas. Consideration should be given to setting minimum mesh size limits. The use of spear guns and underwater flashlights at night is believed to be very effective for catching certain species, especially parrotfish.

The following recommended policies for immediate implementation should be considered:

Gillnet mesh sizes should be regulated,

Night diving using spear guns and underwater flash lights should be banned,

Provincial governments, in collaboration with the Department of Fisheries and the Environment, should identify and establish marine reserves.

11.5 Chondrichthyes

11.5.1 Sharks

Species present

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

11.5.2 Distribution

Smith (1992) notes that sharks are found from the reef and inshore areas to the open oceans, at all depths.

During the OFCF project, sharks were observed in and around the coastal waters of Santo, particularly around FADs. Often during hauling operations in trolling, predation by sharks (and sometimes by barracuda) was reported. *S. mitsukurii* were particularly plentiful around FADs.

11.5.3 Biology and ecology

Compagno (1984) provides some information about habitat, distribution, biology and ecology of known shark species worldwide. In reproduction, 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.

11.5.4 The Fishery

Utilisation

Shark meat is sold commercially at the local fish market in Port Vila. Shark consumption is common at the subsistence level. A limited amount of shark fin has been exported.

Currently, shark is a bycatch of the deepwater bottomfish fishery. However, some fishermen purposefully set specially designed lines to catch sharks, either as a hobby or for commercial purposes. Records of the SPC deep-bottom fishing trials in Vanuatu indicate that shark constituted a very minor portion of the catch (Dalzell and Preston 1992).

In October 2003, the Department of Fisheries issued six fishing licenses for six locally based foreign fishing vessels to fish for sharks in Vanuatu waters. The licenses were valid for 12 months.

Production and marketing

Catch composition of bottomfish catches landed by Department of Fisheries vessels comprised 9.6% and 16.06% of shark (by weight) in 1983 and 1984, respectively. From October 1985 to June 1986, mid-water longline fishing trials for large yellowfin tuna around FADs caught 10 sharks.

From 1988 to 1992, the sale of shark meat at the Natai Fish market was the only source of data where shark was sold. Table 67 summarizes annual shark purchases and value for the Natai market from 1988 to 1992. Between May 1983 and July 1984, 4,379 kg of shark were purchased by Natai, while only a small quantity was recorded by Santofish at about the same time (Crossland 1984).

Table 67: Annual shark purchases and value for the Natai fish market, 1988–1992

1988		1989		1990		1991		1992	
kg	VUV	kg	VUV	kg	VUV	kg	VUV	kg	VUV
1,138.6	61,342	725.5	53,200	851.8	63,621	1,289.7	126,008	758.9	77,927

Source: Fisheries Department Data Base

Data for years 1993–1995, 1998–1999, and 2002 are not complete because catch data for sharks for these years were included as part of "mixed-reef fish" data records. Table 68 summarizes catch records by artisanal fishing projects for the years 1996–1997, 2000–2001, and 2003.

Table 68: Shark production by artisanal fishing projects, 1996, 1997, 2000–2003

1996 (kg)	1997 (kg)	2000 (kg)	2001 (kg)	2003 (kg)
190	586.3	750.8	11,307	1,102

Following the shark fishing operations of the six locally based foreign fishing vessels in October 2003, three transshipments were made by these vessels between October 2003 and August 2004.

Records pertaining to shark fin exports from Vanuatu are presented in Table 69.

Table 69: Shark fin exports from Vanuatu, 1980–1989

Year	Quantity (kg)	Value
1980	10,700	USD59,950.00
1981	14,000	USD71,520.00
1982	5,000	USD25,910.00
1983	9,000	USD47,220.00
1984	22,000	USD46,000.00
1985	11,000	USD70,570.00
1986	5,000	VUV2,282,000
1987	Data not available	-
1988	No data records	VUV50,000
1989	No data records	VUV14,000

The high number of shark fin exports from the early to mid-1980s is attributed to the operation of the South Pacific Fishing Company in Palekula, Santo. From the 1990s onwards, there were no significant exports of shark fins. Summarized below are recent records of shark fin exports.

Table 70: Shark fin exports (2001–2004)

Year	Quantity (kg)	Value (VUV)
2001	12	-
2002	22	147,160
2003	478	1,786,316
2004 (January-July)	15	50,460

In 2001, 686 pieces of shark teeth were also exported.

11.5.5 Stock status

No information is available on Vanuatu's shark stocks. However, catch data provided by locally based foreign fishing vessels seem to indicate that the shark populations in Vanuatu are still plentiful.

Observations elsewhere indicate that because they are generally slow growing, populations can be greatly reduced by heavy fishing. Randall et al. (1990, in Smith 1992) noted that the removal of these top level carnivores from a reef system can result in adverse effects.

11.5.6 Management

Current legislation/policy regarding exploitation

There is no existing legislation concerning the management or exploitation of sharks in Vanuatu.

Recommended legislation/policy regarding exploitation

Given the quantity of shark trunks transshipped by six locally based foreign fishing vessels, and the importance of sustainably managing sharks, it is critical that the Department of Fisheries develop management guidelines for this resource.

A policy banning commercial fishing of sharks is urgent needed. This ban should remain in effect until the Department of Fisheries, in collaboration with other relevant government and private sector agencies, develops a sound management plan for the shark fishery.

14 Flora

14.1 Mangroves

14.1.1 Species present

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

Lal and Esrom (1990) list 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.

14.1.2 Distribution

David (1985) estimated that mangroves cover an area of 3,000 ha (+/- 500) for the whole of Vanuatu. Of Vanuatu's 80 islands, only 9 have extensive mangrove growth, and apart from Malekula, mangroves are found only in small clusters scattered along low-energy coastlines (Lal and Esrom 1990). Malekula is the only island that has extensive growth of mangroves found along the shorelines protected by fringing reefs, smaller islands and peninsula protecting bays. David and Cillaurren (1989) provided the area distribution of the main mangroves in Vanuatu (see Table 71).

Table 71: Distribution of mangroves in Vanuatu

Island	Mangrove Area (ha)	Percentage	Area of island	Mangrove area to island (%)
Malekula	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 Vanuatu's mangroves are located on Malekula and Hiu islands in the Torres group. However, Emae and Aniwa islands are also well endowed, and mangroves on each island represent 2% of their respective land masses (David and Cillaurren 1989).

14.1.3 Utilisation

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, and for catching mangrove crabs and finfish is important, as revealed by a survey of 11 villages near mangrove ecosystems in Port Stanley on Malekula, and on the adjacent islands of Uripiv, Uri and the Maskelynes (Table 72). Villages actually situated within the mangroves on smaller offshore islands such as the Maskelynes are almost entirely dependent on mangroves for firewood.

14.1.4 Production and marketing

The average consumption of firewood by villages surveyed by Lal and Esrom in 1990 is given in Table 72.

Table 72: Statistics on mangrove firewood consumption in May 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

Village	Number	Range (bundles per month)	Average (bundles per month)
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 burned 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 the Port Stanley Bay region on Uri, the monthly mangrove fuelwood consumption ranges between 8 and 24 bundles (160–480 kg) per household.

The common finfish species targeted in mangrove areas include mullets, rabbitfish and goatfish. In the Maskelyne islands, David (in Lal and Esrom 1990) noted that 66 species of finfish were caught regularly from mangrove areas, and 29 species were caught exclusively there. Subsistence consumption of fish products was estimated to be 10 kg per month per household (Lal and Esrom 1990). However, it was impossible to estimate the proportion that came from mangrove areas. The collection of land crabs, *Cardiosoma* spp. for both subsistence and sale in the Port Stanley area, is reported under the Land Crab Profile. Mangrove crabs, *Scylla serrata*, are another important resource from the Port Stanley region and on the Maskelyne islands, and they are often specifically caught to supply restaurants in Port Vila. One household each from Uri and Uripiv were known to catch crabs for restaurants in Port Vila, however, no production figures are available. David (in Lal and Esrom 1990) estimated that the annual fish production from mangroves and coastal shelves, in numbers, is 3,963,200 as compared with 1,447,300 from the outer slope (10–400 m). Production in numbers per hectare for the two areas were estimated to be 80 and 1.5, respectively.

14.1.5 Mangrove status

Lal and Esrom (1990) note that the pressure on mangrove resources from development is small because of mangroves' distance from main urban centres. However, development for tourism has resulted in some reclamation of mangrove areas on Efate and adjacent islands, and on Iruiti Island. The extension of the wharf on Malekula — to accommodate the needs for a logging project — necessitated the clearing of about 100 m of mangroves in Port Stanley. In rural areas, indiscriminate harvesting of mangroves for fuelwood, an increasing population, and clearing for easier access to the sea, present 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 1940s, although the northern side has been replaced by a sandy beach.

14.1.5 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 customary 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. An environmental impact assessment (EIA) is required for large-scale projects, although 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

The following recommendations should be considered by relevant institutions.

- There should be a ban on harvesting mangroves in Vanuatu.
- Developers should be banned from destroying mangrove areas to build hotels.
- An assessment survey of Vanuatu's mangroves should conducted.

15 Molluscs

15.1 Trochus

15.1.1 Species present

The top shells, *Trochus niloticus* and *Tectus pyramis* are present in Vanuatu.

15.1.2 Distribution

Trochus niloticus is found in the tropical and subtropical waters of the eastern Indian and western Pacific Oceans. Its natural distribution extends from Sri Lanka in the west (Rao 1936) to Wallis Island in the east (Gillett 1986a). The edge of its natural habitat in the western Pacific is marked by an oblique line running from Palau down to Wallis. The northern limit of its range is the Ryukyu Islands of southern Japan (Hedley 1917), while its most southerly extent is New Caledonia (Bour et al. 1982) and the Swain Reefs complex at the southern end of the Great Barrier Reef in Australia (Moorhouse 1933).

Translocations of *T. niloticus* to areas where they do not naturally occur have, in many cases, been remarkably successful. An example is the successful translocation of trochus to a pass on the windward side of Tahiti in 1957, when 40 out of 1,200 trochus survived the journey from Vanuatu (Gillett 1986). These stocks were not fished for 17 years. On the basis of an estimated biomass of 2,500 tonnes in 1971 (Yen 1985), it was estimated that the initial population of 40 increased by an average factor of 2.3 annually between initial transplant and first harvest (Nash 1985).

In Vanuatu, *T. niloticus* occur naturally and are generally found on reefs with suitable habitats.

15.1.3 Biology and ecology

Trochus niloticus Linnaeus, 1767 is a member of the family Trochidae, a large family of marine gastropod mollusks that include several hundred species. The family Trochidae is itself a member of the Archaeogastropoda, the most primitive order of the prosobranch Gastropoda. It shares this order with the turban shells (family Turbinidae) and the abalones *(*family Haliotidae). These families share many life history features: all are herbivores, feeding on

either turf or fleshy algae; they release their gametes (eggs and sperm) directly into the sea, where fertilization occurs; the eggs are lecithotrophic (contain yolk); and the plantonic larval phase is short (no more than a few days).

T. niloticus occurs in two different growth forms, which have at times been considered two separate species (Allan 1947, in Wright and Hill 1993). The shell in one form is conical, with straight sides and flat base. In the second form, the final whorl of the shell expands greatly to form a wide basal flange. The conical form has been described as *Trochus maximus* Koch and the flanged form as *T. niloticus* Linnaeus (Dodge 1958).

T. niloticus has a large, thick and heavy conical shell that is pinkish with dark, reddish brown blotches. It is the largest species in the genus, and may exceed 15 cm in basal length. Trochus inhabit shallow, sunlit waters, and is rarely found deeper than a few metres. The maximum densities of trochus suitable for harvesting are found on the first metres 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 foraminifera on dead coral and rock surfaces, with a radula. A trochus radula is estimated to comprise of about 150 teeth that enable the trochus to graze. In the stomach content of 20 trochus specimens, ranging from 60–75 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 females, and milky white in males. 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 usually contains 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). In Vanuatu spawning occurs throughout the year, 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 occurs. The fertilized eggs are covered with a thick chorion, which protects the embryoes. After hatching, the trochophores develop a larval shell (the protoconch) and swim 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 released by a female trochus depends on the size of the shell (basal length). Heslinga (1981) estimates that one female, 10-cm in diameter, can release up to 2 million ovocytes, while Nash (1985) states that females in the 8.6–10.0 cm 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.

Table 74: Average fecundity per trochus size

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

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

15.1.4 The Fishery

Utilisation

The collection of trochus for its protein-rich flesh has been a traditional activity in the islands for a long time. However, since the end of the 19th century, the sale of trochus shells for its shell has become apparent in Vanuatu. French settlers were reported to have harvested trochus 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 beche-de-mer industry, not only in Vanuatu, but the rest of the Pacific as well. At present, trochus is one of the major inshore resources in Vanuatu that generates income for the rural communities. The major uses are for the local production of button blanks, shell jewelry and other items Shell exports are mainly to South Korea and Japan (Kenneth, undated). World demand for pearl shell has increased considerably since 1989.

Throughout Vanuatu trochus shells are collected by hand on the reef by fishermen diving with goggles or face masks. The 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.

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

Production and marketing

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 product. Vanuatu shell factories export their processed products to Japan, Italy, France, Hong Kong, Singapore, Taiwan and Korea.

David (1985) established the number of people engaged in fishing for trochus for each island in Vanuatu. The main trochus fishing islands in 1985 are listed below.

Table 75: Number of people engage in trochus fishing

Island	No. of trochus fishers	% of fishermen
Malekula	694	34.0
Epi	223	100
Emae	177	90.0
Efate	173	17.5

The only record of trochus harvesting at the beginning of the century is a report of 60 tonnes as an export figure for 1921 (Dunbar 1981). Export statistics have only been available since 1969.

The abundance supply of trochus resulted in an increase in number of button blank processing factories established in Port Vila and Santo during the late 1980s. The number increased from one factory in 1986 to five factories in 1993. It is estimated that it takes 10 tonnes of raw, whole trochus shells to produce 1 tonne of button blanks. Table 76 shows exports of trochus button blanks from 1986 to 1992 from Vanuatu (Amos 1992).

Table 76: Button blank export figures, 1986–1992

Year	Estimated quantity of raw shells processed (tonnes)	Quantity of button blanks exported (tonnes)
1986	90.0	9.0
1987	260.0	26.0
1988	400.0	40.0
1989	780.0	78.0
1990	510.0	51.0
1991	679.0	67.9
1992	1,953.9	195.39

In 1993, five established shell processing factories operated in Vanuatu. Prices offered for shells vary according to each factory but generally range from VUV 170–300 per kg of shell. By 1996, only two processing factories were operating. The number of established processing factories increased to three in 2001, but by 2003, only one factory was operating. The closure of two other factories was due to an insufficient supply of raw trochus shells. The table below contains export figures for 1996–2003.

Table 77: Processing and export figures for two trochus shell processing factories (1996–2003)

Year	Raw shells processed (t)	Button blanks exported (t)	Trochus scraps exported (t)	Raw shells exported (t)	Total value
1996	263.17	26.32	57.90	No exports	USD994,970.00
1997	306.39	30.64	34.10	11.64	USD847,841.00
1998	476.43	47.64	9.420	No exports	USD700,638.47
1999	279.00	27.90	No exports	No exports	USD697,000.00
2000	286.90	28.69	42.50	No exports	USD222,895.00
2001	305.97	30.60	56.416	No exports	USD806,900.00
2002	114.00	11.40	42.35	No exports	USD260,109.00
2003	157.60	15.76	-	No exports	USD493,200.30

Table 78: 2004 trochus export figures

Commercial export item	Quantity (kg)	Value (VUV)
Trochus scrapes	7,480	867,680
Trochus button blanks	17,250	32,381,400
2nd Quality shell blanks	2,900	894,824
Shell materials	8,000	1,002,240
Total	35,250	35,146,144

15.1.5 Stock status

Experiences in other Pacific Island countries have shown that *T. niloticus* is sensitive to intensive fishing. Although 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, and resulted in a four-year closure on trochus fishing (Devambez 1959). This survey indicated that the:

- average age of the trochus population — 3 years — was high;
- proportion of young shells under three years old was extremely low; and
- density of trochus on the reefs was noticeably low (the average take per diver/hour was seven trochus).

A second stock survey was conducted by the same researchers in 1961. This survey concluded that trochus stocks had increased (the average take per diver/hour was 24.1 trochus). The results of this survey persuaded the then 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 indicated that the stocks were rapidly declining, and thus tighter management controls needed to be implemented to ensure the sustainability of the resource. In early 1993, the government introduced a quota system for the established factories. Each factory was only allowed to process 75 tonnes of raw trochus shells per year. The quota system was difficult to monitor, and it was hard to ensure that the quota allocated to each factory was respected. The result was that some factories processed more than their allocated annual quota.

Export figures indicate that the level of exploitation of trochus stocks has increased tremendously as a result of the establishment of the five processing factories in 1993. The highest quantity of raw shells — 1,953.9 tonnes — was processed in 1993. This figure has since been reduced to 114 tonnes in 2002.

In 2004 there was only one factory operating with roughly 13 cutting machines. The closure of four factories and the reduction of raw shell supplies could indicate that current stocks are not in a healthy state.

In 1996, the Department of Fisheries began an extensive trochus research project aimed at scientifically investigating ways to increase replenishing wild stocks with hatchery reared juveniles.

The trochus reseeding project was funded by the Australian Centre for International Agricultural Research.

This project has been successful in communicating the importance of sustainable management, and encouraging rural communities to participate in managing their marine resources, particularly *Trochus niloticus* resources. The implementation of the project involved restocking using hatchery reared trochus juveniles and adult trochus translocation in areas badly affected by uncontrolled exploitation by locals and very poor observation of proper management measures. Locations within the following islands were either reseeded with juvenile or adult trochus; Efate, Emae, Mataso, Makira, Nguna, Pele, Moso, Ifira, Hideaway, Malekula, Aniwa, Anietyum, and Tanna. The current status of trochus, prior to reseeding is not very healthy, however, by 2010, following restocking trochus stocks for the reseeded locations should recover to a very healthy state.

15.1.6 Management

Trochus stocks 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 semi-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 cm 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 VUV 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 utlisation 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.

The following proposed new policies have been drafted by the State Law Office particularly to control the level of exploitation of the trochus resource and should be signed and garzetted in 2004 for implementation:

Fisheries Subregulations 17(2) & (4)

"(2) A person must not take, harm, have in his or her possession, sell or purchase a trochus shell that is less that 9.0 centimetres or more than 13.0 centimetres in length".

"(4) The maximum amount of trochus that can be exported from Vanuatu in a year is 55 tonnes".

Regulation 24
Repeals the existing regulation, and is substituted with:

24 Offences
A person who contravenes any provision of this Part is guilty of an offence and is punishable on conviction by a fine not exceeding:

- in the case of an individual

(i) VUV 50,000 for a first offence; (ii) VUV 100,000 for a second offence; (iii) VUV 200,000 for a third or a subsequent offence; and

- in any other case

(i) VUV 250,000 for a first offence; (ii) VUV 500,000 for a second offence; (iii) VUV 1,000,000 for a third or subsequent offence."

15.2 Green snail

15.2.1 Species present

Turbo marmoratus

15.2.2 Distribution

T. marmoratus is not widely distributed in the Pacific. It is exploited in only a few Pacific Island countries, including Papua New Guinea and the Solomon Islands. However, it is widely distributed southward of Yakushima Island (Japan) and in some Southeast Asian countries such as Burma, Indonesia and the Philippines. 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.

15.2.3 Biology and ecology

The green snail, *T. marmoratus* (family Turbinidae) is the largest of the turban snails. It has a thick shell that can exceed 20 cm in width and 3 kg in total weight. The foot of the adult conical shell is swollen, and that of the young, is round and smooth. The green snail has a massive white operculum that has a smooth inner surface.

Green snails inhabit shallow water seaward reef slopes down to about 15 metres. They are

nocturnal and feed on algae growing on dead corals and rock surfaces. The marine snails are dioecious broadcast spawners, and male and female gametes are released into the sea where fertilization occurs. A study on the sexual maturity of green snails in Vanuatu — made by Devambez in 1961 — concluded that they reach sexual maturity when their shells reach between 11 cm and 15 cm in diameter.

Hatchery observations on green snail spawning carried out by the Vanuatu Fisheries Research Division indicate that snails spawn throughout the year, several nights before or after a full moon. During the green snail spawning inductions at the Vanuatu Fisheries Department Trochus Hatchery, 5.5 million eggs were collected from a 12 cm size female snail. Fecundity depends on size: for large green snails (greater than 12 cm in basal diameter) the number of eggs released per female can reach 7 million.

15.2.4 The Fishery

Utilisation

Green snail shells are in 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 the shell is very technical and costly.

Green snails have been harvested in large numbers by ni-Vanuatu since prehistoric times because of the snail's tasty flesh (which is a source of protein), large size, and ease of capture. Like *Trochus niloticus*, the harvesting of green snails is small but provides a significant source of revenue and employment for coastal communities. The sale of these gastropods is sometimes the only source of income in some regions, making the conservation of this resource of paramount importance.

Table 79 shows the level of households in Vanuatu that are engaged in the collection green snails.

Table 79: The number of households engaged in green snail collection

Regions	Households involved in harvesting green snails	
	Number	%
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 is harvested in large amounts specifically for subsistence. No figures are available on the production of this species for consumption.

Production and marketing

Current FOB price for premium grade green snail cuts ranges from USD 30,000–35,000/tonne. The major market for green snail is South Korea. The nacreous shell of green snail is a highly prized shell for inlay of furniture, lacquer ware, and jewelry.

Green snail production in Vanuatu is small compared with trochus, although price per kg is higher for green snail than for trochus. The current price for good quality green snail shells ranges from VUV 1,700–3,000/kg.

Table 80:Export figures of green snail cuts from Vanuatu between 1986 and 2003

Year	Green snail cuts export (tonnes)	Value
1986	15.00	
1987	12.00	
1988	10.00	
1989	12.00	
1990	10.00	
1991	44.00	
1992	7.35	
1993	51.03	
1994	1.07	
1995	.350	
1996	2.67	USD 79,720.00
1997	3.90	USD 30,000.00
1998	1.06	USD 860,692.50
1999	.600	-
2000	No exports	-
2001	No exports	-
2002	No exports	-
2003	.694	USD 348,000.00

Source: Department of Fisheries annual reports

15.2.5 Stock status

Green snail resources have been harvested mainly for export purposes since the beginning of the 19th century. Green snail stocks in Vanuatu have been influenced by long-term exploitation as well as natural environmental events.

Devambez (1959) 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 at Aneityum Island. During his second survey in 1961, at the same site, it took 2 divers 10 minutes to collect 13 green snails (Devambez 1961).

Green snail stocks have been greatly reduced throughout Vanuatu. Assessment surveys carried out by the Department of Fisheries from 1998 to 2001 all indicate that green snail stocks have been exploited to near depletion in the following islands: Efate, the Shepherds group, Epi, Santo, and Ambrym. The increased exploitation level during the early 1990s is fueled by the high commercial value of the resource. The only islands that appear to have some green snail stocks are Aneityum, Malekula, and the Banks group.

The presence of green snails in these islands is the result of strict adherence to community-based management practices.

As shown in Table 80, there have been no exports of semi-processed green snail cuts since 1999. Two factors are responsible for this: the unavailability of the resource from the main supplying islands, and the observance of closed seasons in the form of "taboos" (placed by the community leaders) to control harvesting.

Given the need to investigate ways to repopulate depleted reefs with green snail seeds, the Department of Fisheries has been allocated funds totaling VUV 4,000,000 in 2004 to carry out extensive research on hatchery production of green snail juveniles, and the rearing of juveniles to sizes large enough to avoid predation. The research project is expected to be completed in 2007.

15.2.6 Management

Current legislation/policy regarding exploitation

The current implemented management control that protects green snail resources in Vanuatu is a minimum size limit regulation. The legal harvesting size in Vanuatu is 15 cm 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 centimetres 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 VUV 100,000.

Given the scarceness of the resource throughout the archipelago, and given the urgent need to put into place a strict management system, the Department of Fisheries (in close collaboration with the State Law Office) have drafted a new regulation to repeal the above Regulation 16.

Recommended legislation/policy regarding exploitation

The Department of Fisheries must ensure that the 10 years fishing ban on green snail resources is strictly observed. To ensure that future green snail stocks are sustainably utilised, the Department must develop a management plan that includes the following:

- reference points,
- set harvest quotas per provincial area,
- set a quota on number of investors/factories, and
- closed seasons.

A new proposed management regulation has been drafted and will be referred to as Fisheries Regulation 16 which now reads:

(1) In this regulation “green snail” means a mollusk of the species *Turbo marmoratus.*

(2) Subject to subregulation (3), a person must not take, harm, have in his or her possession, sell or purchase any green snail during the period starting on 1 January 2005 and ending on July 2015.

(3) A person may take or have in his or her possession a green snail for the purpose of carrying out research or for breeding the species during the period mentioned in subregulation (2).”

15.3 Giant clams

15.3.1 Species present

Five species of giant clams have been recorded in Vanuatu. 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), *T. derasa* (smooth giant clam) and *Hippopus hippopus* (the horse's hoof, rolling clam, bear paw or strawberry clam). *T. gigas* (the giant clam) was recorded by Rosewater (1965), but recent surveys indicate the rarity or absence of *T. gigas* species, and therefore, local extinctions are likely.

15.3.2 Distribution

Giant clams, tridacnids, are restricted to the Indo-Pacific region and are well adapted to clear tropical waters such as those that favour coral growth. Munro (1993) gives brief geographical distributions of each of the nine species of giant clams found world wide. Due to overexploitation or climatic changes, the range of *T. gigas* has greatly diminished. Several species, especially, *T. gigas*, *T. derasa* and *H. hippopus*, have been introduced to countries outside of their natural ranges.

The results of a survey investigating the distribution and abundance of giant clams in Vanuatu — conducted at 29 sites on 13 islands — were reported by Zann and Ayling (1988). The survey 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 is 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 two islands, Aneityum and Cook Reef, and five live clams were recorded in the Malekula group. However, it may occur on more islands as it was possible they were included in the *T. maxima* counts. Both *T. gigas* and *T. derasa* have not been recorded on any island recently. However, Department of Fisheries personnel indicated that the smooth clam (possibly *T. derasa*) has been seen for sale at the Port Vila public market. This was on very rare occasion and the possible source could have been the Moso or Lelepa Islands.

15.3.3 Biology and ecology

The giant clam family, Tridacnidae, currently has nine living species in two genera, *Tridacna* (Bruguiere) and *Hippopus* (Lamarck), and includes the largest bivalve molluscs known. A unique characteristic of the giant clams is their symbiotic relationship with zooxanthellae algae that live in the tissue of the brightly-coloured mantle (Munro undated). (Giant clams acquire their symbiotic algae at age 7–15 days). The clams receive photosynthetic sugars and oxygen from the algae, while the algae receive 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 restrict clams to shallow waters where light penetrates.

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 the release of eggs 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 lasts between 5 and 15 days. Soon after the larvae settle on the bottom, they metamorphose into juvenile clams. Recruitment is low and erratic. Growth parametres for most giant clam species in several localities are given in Munro (1993). Overall, for the first few years, growth rates range between 3.5 and 10 cm per year depending on species. Natural mortality is low.

15.3.4 The Fishery

Utilisation

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/year. The supply of giant clams to the public market in Port 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. Giant clam shells, mostly *H. hippopus*, are often offered for sale in Port Vila streets.

It was not until 1998 that giant clams became a lucrative commodity in the aquarium trade business. The most highly sought after species are *T. maxima* and *T. crocea.* From 1998–2000 large quantities of *T. maxima* and *T. crocea* were harvested from north Efate, particularly from Moso and Lelepa islands by the locals and sold to aquarium traders based in Port Vila.

Production and marketing

No figures are available, but the total annual estimated subsistence harvest in 1983 of 2,403 t consisted of 33.5%, by weight, of shellfish comprising oysters, clams and cockle families (David 1985). Relative compositions 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*. Estimates of landings and revenue from the sales of shells are not known.

Summarized in the table below is the number of clams harvested from north Efate and from the surrounding offshore islands of Lelepa, Moso, Pele, and Nguna, mainly for the aquarium trade exports. Ninety per cent of the total giant clams exported were *T.crocea*.

Table 81: Total giant clams exports from Vanuatu, 1997- 2003

Year	Giant Clams
1997	350
1998	16160
1999	11835
2000	26746
2001	13496
2002	4057
2003	2000

15.3.5 Stock status

T. gigas and *T. derasa* are believed to be locally extinct because recent surveys have not found any specimens, even though Vanuatu was included in the distribution of these species by Rosewater (1965). However, on rare occasions Fisheries Officers have recorded smooth-shelled clams (*T. derasa*) being sold in the public municipal market. This may be an indication that small populations of these clams still exist but only in some islands, mainly the Moso and Lelepa islands. *T. gigas* fossils were reported from Efate by Munro (quoted in Zann and Ayling 1988). Zann and Ayling (1988, 1990) provide tables on the distribution and abundance of giant clam 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.

Table 82: Summarized results of the 1988 giant clam survey

	Abundance (numbers per hectare)			
Location	***T. maxima***	***T. squamosa***	***T. crocea***	***H. hippopus***
Aneityum				
Port Aneityum	16	shells only	-	-
Inyeug Island	50	-	-	shells only
Port Patrick	16	-	-	-
Tanna				
Leviar	5	-	-	-
Port Resolution	-	-	-	-

Location	Abundance (numbers per hectare) *T. maxima*	*T. squamosa*	*T. crocea*	*H. hippopus*
Erromango				
Dillon's Bay	shells only	-	-	-
Efate				
Lelepa	3	-	-	-
Malao Bay	-	-	-	shells only
Moso Island	7	-	3	3
Cook's Reef	10	shells only	-	25
Pentecost				
Wanuru	6	-	-	9
Loltong Bay	20	-	-	-
Gaua				
Lesalau Bay	9	-	-	1
Ureparapara	shells only	-	-	-
Reef Islands	13	-	-	23
Epiritu Santo				
Big Bay	-	-	-	-
Hog Harbour	2	-	-	2
Turtle Bay	-	-	-	-

A detailed survey, using replicate belt transects at selected locations in the Malekula Group, was presented by the same authors and the results are reproduced in Table 83. No clams were found on the reef flats.

Table 83: Summarized results of the Malekula group survey

	Abundance (numbers per hectares) Reef Crest				Reef slope			
	T. maxima	**T. squamosa**	**T. crocea**	**H. hippopus**	**T. maxima**	**T. squamosa**	**T. crocea**	**H. hippopus**
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 was the only species recorded in all of the islands surveyed. Although *H. hippopus* was not found on all islands, significant populations exist in uninhabited areas, Cook 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. Its abundance at Sakau/NW, however, was high. Live *T. squamosa* were only located at five sites in Malekula with low abundance.

Stock assessment surveys by the Department of Fisheries from 1998–2000 were conducted at 57 sites on the islands of Anietyum, Erromango, Tanna, Efate, Emae, Mataso, Makira, Malekula, Gaua, Vanua Lava, Mota Lava, Ureparapara and Torres. The average density of all giant clams (calculated as numbers per 100 m^2) was generally low in all survey sites, as can be seen in Table 84. Slightly high populations were recorded in the Banks Group sites, which is expected as the fishing pressure is relatively low. Analyses of survey results indicate that a very low density of giant clams exist throughout Vanuatu. In the Shepherd Island sites, the average density of all clams in the sampled areas was less than 1 clam per 100 m^2, 1.5 clams per 100 m^2 for sample sites in Tafea Province, 3 clams per 100 m² for Torba Province, and 1.3 clams per 100 m² for sites in Malampa Province.

Table 84: Number of giant clams per sampled area

Survey Location	Abundance							
	Reef crest/Lagoon				Reef slope			
	T. maxima	T. squamosa	T. crocea	H. hippopus	T. maxima	T. squamosa	T. crocea	H. hippopus
Gaua - Losolava	6	1	0	1	5	0	0	3
Vanua Lava – Vureas Bay	0	0	0	0	44	0	0	0
Pakea Island	0	0	0	0	31	1	0	0
Ravenga -West	0	0	0	0	41	0	0	2
- North	0	0	0	2	66	1	0	2
Mota Lava -Ra	0	0	0	0	20	0	0	0
Reef island – N.West	0	0	0	0	178	8	0	0
-West	4	0	0	0	126	0	0	2
Ureparapara-Lagoon	0	0	0	0	97	0	0	2
Hiu-Picot Bay	0	0	0	0	153	0	0	0
Metoma	0	0	0	0	0	1	0	0
Tegua-South	0	0	0	0	19	1	0	2
Loh	0	0	0	0	7	0	0	0
Malekula -Sakau	7	3	7	3	0	0	0	0
- Lamap	71	5	4	2	0	0	0	0
- Uri	19	3	0	1	0	0	0	0
- Tedka	37	17	5	2	0	0	0	0
- Pinalum	27	4	0	0	0	0	0	0
- Vao	26	14	3	0	0	0	0	0
- Port Stanley	0	3	6	0	0	0	0	0
- Litz Litz	16	12	4	0	0	0	0	0
- Lambubu	37	14	0	0	0	0	0	0
- Crab Bay	1	1	0	0	0	0	0	0
- Avok	25	7	0	2	0	0	0	0
Emae - Marae	0	0	0	0	80	5	0	0
- Sulua	0	1	0	1	100	2	0	1
- Worarana	1	0	0	0	0	0	0	0
- Makatea	1	0	0	0	0	0	0	0
- Siwo	8	2	0	2	0	0	0	0
- Vaitini	0	0	0	0	24	6	0	0
Cooks Reef – West Lagoon	14	6	0	2	0	0	0	0
-North Flat	1	0	0	4	0	0	0	0
Makira	1	0	0	0	1	0	0	0
Mataso-Na'asang	1	1	0	0	0	0	0	0

Survey Location	Abundance							
	Reef crest/Lagoon				Reef slope			
	T. maxima	T. squamosa	T. crocea	H. hippopus	T. maxima	T. squamosa	T. crocea	H. hippopus
-South	0	0	0	0	10	1	0	0
Mistery Island – East reef flat	65	25	0	1	0	0	0	0
-North lagoon	0	0	0	0	15	0	0	0
Aneityum – Anelgouhat-east	0	0	0	0	102	5	0	0
-Port Patrick-central	19	0	0	0	0	0	0	0
Port Patrick-south	15	2	0	0	0	0	0	0
Tanna-Port resolution-east	10	0	0	0	0	0	0	0

Survey results indicate that the most abundant giant clam species is *Tridacna maxima,* followed by *Tridacna* squamosa. *Tricdacna crocea* and *Hippopus hippopus* populations appear to be fished out in all surveyed locations.

Significant populations of *T. maxima* were observed on Anelgouhat Reef on Aneityum island, Dillons Bay reef on Erromango Island, Vao and Labubu on Malekula, Cooks Reef on Emae, and Reef Island in the Banks Group. *T. crocea* was observed in abundance at Moso Reef (Tassiriki side of Tranquility Reserve area), also on Lelepa Island and Ifira and Malapoa Point areas. The survey observed a significant population of *T. crocea* on giant clam reserve areas owned by Tranquility Island Resort on Moso Island.

H. hippopus stock has been heavily fished in all the coastal reefs except on remote reefs and small community-protected giant clam reserves. The survey figures clearly indicate the scarcity of this particular clam species in Vanuatu. A stock assessment is an ongoing activity for the Department of Fisheries.

15.3.6 Management

Although the overexploitation of giant clams has been well documented in many areas, it has not been well researched and recorded in Vanuatu.

Some giant clam shells for sale in Port Vila's streets are far too small, as far as conservation of stocks is concerned. But it is difficult to confirm whether these shells indicate the sizes that are harvested for consumption, or whether or not they were dead when found.

Current legislation/policy regarding exploitation

There is currently no legislation in force for the management of giant clams in Vanuatu. However, PART II Sections (20), subsection (1) and (2) of the Fisheries Act CAP 158, provides the Minister with the authority to declare an area within Vanuatu waters to be a marine reserve. A marine reserve has been established at Crab Bay in Malekula, and the area has giant clams, mostly *H. hippopus.*

In 2000, the government passed a policy to ban the harvesting of wild giant clams on Efate and neighbouring islands for the aquarium trade. The ban prohibits the harvesting of *T. maxima* on Efate Island, although it can still be harvested from the offshore islands and shipped into to Port Vila for the aquarium trade. *T. crocea* is banned from all aquarium exports.

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 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.

Although the establishment of reserves has not proven to increase recruitment in depleted areas, it will at least play a role in conserving the genetic pool of remaining stocks. The rapid and successful progress in giant clam mariculture offers the possibility of augmenting or reseeding depleted areas using hatchery-reared juvenile clams.

The following recommendations should be considered by the Government of Vanuatu:

- accord special protection to uninhabited Cook's Reef and Reef Islands, where *H. hippopus* are common;
- reintroduce *T. gigas* and restock *H. hippopus*; and
- introduce size limitations for all species of giant clams in Vanuatu.

The low levels of *T. squamosa* recorded singles out this species as needing restocking. Fairbairn (1992) concluded that prospects exist in Vanuatu for the establishment of giant clam mariculture projects, especially in certain areas on Santo, Efate, and Malekula. Such a project would, however, require the support of village councils and chiefs, and landowners.

Establishment of a small-scale giant clam hatchery for reseeding native species would seem feasible. Facility costs would be minimal as the existing hatchery for trochus and green snail could be used.

15.4 Oysters

15.4.1 Species present

Endemic species include *Saccostrea glomerata* (formerly *Crassostrea glomerata*) and *Crassostrea echinata*. *C. gigas* was introduced in Vanuatu in the 1920s.

15.4.2 Distribution

With the exception of the Arctic and Antarctic regions, oysters are found in all the sea areas of the world.

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. Approximately 200 species of oyster are known to exist in the world.

Very little is known about the distribution of native oyster species in Vanuatu. Some oysters found near Turtle Bay (Santo), Oyster Island (Santo), were introduced from Australia in 1920. Oysters are found in Port Sandwich (Malekula), Port Havannah (Efate), north of Port Havannah Bay, and the inner lagoon at Erakor (Efate).

15.4.3 Biology and ecology

Among the varieties of shellfish found worldwide, the most prolific are the conch (Gastropoda) and bivalve (Pelecypoda) families. There are about 85,000 species of conches, and 25,000 species of bivalves. Conches actively search for food on the ocean floor with eyes and feelers, while 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 bivalves is fully enclosed in a shell and a mantle that lines the shell. There is also a gill between the mantle and internal organs. On the back edge of the body are a number of pores through which water is drawn in to pass through the gill and aid in breathing. At the same time, the gill also functions to separate debris in the water from edible suspended matter such as plankton. The volume of water thus processed by the gill in the case of the Pacific

cupped oyster is about 10 litres/hour. The 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 1,000 times their body weight (without shell) of water every hour (Yamaha 1989). The amount of phytoplankton 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 environmental 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.

15.4.4 The Fishery

Utilisation

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 1970s. The farming trial was not successful. At present, oyster is mainly utilised for subsistence consumption with a small portion marketed locally. The Masklyne Islands appear to be main supplier of mangrove oysters for the Port Vila market.

Production and marketing

The main oyster producing nations are Japan, Korea, Mexico, France, and the USA. Among these the USA, 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 water 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. About 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*[6], 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 per month, which was marketed in Luganville and Port Vila. However, the two most significant problems that remained were irregular supplies of spat and the control of the predator, *Pseudostylochus*.

15.4.5 Stock status

There are 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 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. The only area that has substantial stocks of oysters would be the Oyster Island Resort in Santo.

15.4.6 Management

[6]Pseudostylochus is a flat worm measuring less than 1 mm in thickness and reaching a maximum length of 5–6 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.

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. However, consideration could be given to the introduction of exotic species into Vanuatu to farm for consumption at the local markets. Current imported New Zealand oyster is sold at VUV 3,000 per half a kilogram.

15.5 Ornamental (specimen) shells

15.5.1 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 Produts Ltd (MSP) was involved in the trade of certain shells including the giant triton, *Charonia tritonis* both locally and overseas. There is currently no information on lists species found in Vanuatu.

15.5.2 Distribution

Shellfish are found in every type of marine habitat, from coral reefs and sand to silt and mud (Smith 1992); most are habitat specific. They occur worldwide, 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. Currently there is no information on the distribution of *P. margaritifera* in Vanuatu.

15.5.3 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.

15.5.4 The Fishery

Utilisation

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 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 Department of Fisheries 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 Port Vila. However, the Department of Fisheries issues souvenir permits to tourists or shell collectors on an *ad hoc* basis when it is requested. The quantity of shells taken out of the country as souvenirs is very small.

15.5.5 Stock status

Information on stocks of the species involved is non-existent. Stock status information for giant clams is discussed in this profile. A note here though is that *H. hippopus* shells seen being offered for sale in Vila consist mostly of shells that were about three to four 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.

15.5.6 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 VUV 100,000 for any offences.

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 in Fiji (Wells et al. 1983). The Department of Fisheries should consider enacting a policy to ban harvests or collection of *C. tritonis*.

15.6 Other bivalves

15.6. Species present

Clams (*Anadara* spp.), cockles (*Gafrarium* spp.) and mussels in the genuses *Modiolus* and *Brachiodontes*).

15.6.2 Distribution

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

In Vanuatu, the bivalves species can only be found in certain islands such as Malekula, Emae, Efate, Banks group, Santo, particularly islands where there are mangrove populations.

15.6.3 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).

15.6.4 The Fishery

Utilisation

Fisheries based on these species are mainly for home consumption (subsistence) in areas where they are found. Collections are done both by men and women. Main collection area on Efate Island is the Erakor Lagoon. 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 utilised 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).

15.6.5 Stock status

Stocks status of the native species is unknown.

15.6.6 Management

Because of the limited level of utlisation 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:

Given the increase collection pressure on the cockle stocks in the Erakor Lagoon by locals for both subsistence and as a source of income, the Department of Fisheries should consider carrying out an assessment stock survey of the lagoon to determine the stock status of the cockles and consider placing a ban for up to 3 years on collection of the resource.

15.7 Octopuses and squids

15.7.1 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.

15.7.2 Distribution

Octopuses generally "hide" in small holes in reefs and are found both in the intertidal and subtidal zones around reefs and rocky areas. Distribution of octopuses is wide spread through all islands of Vanuatu.

15.7.3 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.

15.7.4 The Fishery

Utilisation

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.

Table 85: Number of Fishermen/Fisherwomen per island

	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 2,402 t in Vanuatu in 1983, 3.0% (66 t) accounted for octopuses of which 15% (10.5 t), worth VUV 1.5 m, was sold (David and Cillaurren 1989). Data obtained by the Department of Fisheries from Natai Fish Market, Santofish and the Fisheries Extension Centres in the outer islands indicate that there was no local production of octopus going through these outlets.

There is however a possibility that octopus could be lumped under the "other" category due to minimal amounts. Otherwise octopus has been completely utilised on the subsistence level only. Fresh "baby octopus", imported from New Zealand were being sold at the Natai Fish Market during July 1993 at VUV 1,390 per kg.

Recent data production of octopus is nonexistent even though the resource is still harvested for subsistence use and also sold at the Port Vila urban markets.

15.7.5 Stock status

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

15.7.6 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 Vanuatu.

Recommended legislation/policy regarding exploitation

It appears that there is currently no problem with the commercial exploitation of the resource. However, exploitation for subsistence purposes needs monitoring and some form of management control by the Department of Fisheries.

16 Species with aquaculture potential

16.1 The resource

Green mussel, *Perna viridis*.

16.2 Distribution

There are no native green mussel species in Vanuatu. Two green mussel species, *Perna 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 throughout 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).

Green mussels are not endemic to the tropical Pacific islands (Hickman 1989), although they have been introduced to several countries specifically for aquaculture purposes. *P. viridis*, from the Philippines, was introduced into New Caledonia in 1972, into 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).

There have been no introductions of green mussel into Vanuatu. With regards to native mussel species, little is known about their distribution within Vanuatu.

16.3 Biology and Ecology

The Philippine green mussel, *P. viridis,* inhabits estuarine or warm (26–32^{0}C) coastal waters rich in plankton, and highly saline (27–33 ppt). Mussels can tolerate short periods of exposure to extremes of temperatures and salinity, and to high turbidity from suspended sediments.

Spawning mussels release their eggs and sperm into the water where fertilization occurs. Fertilized eggs hatch into free-swimming larvae within 24 hours. They remain in this stage for 15–20 days, after which they settle and attach themselves to solid substrates. A firm substrate is required for larval settlement and for subsequent basal attachment throughout juvenile and adult life. There must be adequate flow of current to provide sufficient food for growth, to prevent build up of faecal and pseudofaecal material, and to disperse the larvae during their three to four- week free-swimming phase.

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

Mussels are filter feeders, feeding predominantly on phytoplankton but with also intaking 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 its 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 shell length (three to four months old).

16.4 The Fishery

16.4.1 Utilisation

Although green mussels do not naturally occur in Vanuatu, there is potential for introducing them for aquaculture. Mussels could potentially help meet Vanuatu's need for a low-cost, high-quality protein food. Commercial cropping of mussels is common in those countries where mussels are farmed, while subsistence cropping of mussels is common in those countries where mussels occur naturally.

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

16.4.2 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 farming the blue mussel, *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).

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

16.5 Potential farming sites

The Vanuatu Department of Fisheries has received expressions of interest in farming green mussels. Mussel farming is seen to have a potential for import substitution. The small size of the established market for 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, may not be viable.

In 1989, Robert W. Hickman, a consultant with FAO, carried out a case study in Port Vila on the potential of farming green mussels in Vanuatu. Hickman surveyed the Erakor and Eratap lagoons, which are the only sites near Port Vila that, according to the Department of Fisheries, have potential for mussel aquaculture.

The survey results indicate that Erakor Lagoon has around 120 ha of water 5–10 m deep, and so has potential for numerous longline systems. The high primary productivity, as indicated by the colour and turbidity of the water, suggests there the lagoon has sufficient food for filter feeding bivalves. The water quality of Erakor Lagoon, however, poses a major constraint to farming filter feeding bivalves. The water is polluted by septic tank seepages in the lagoon (Nerland 1985; Naidu and Morrison 1988). High faecal coliform (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.

Eratap Lagoon is much smaller than Erakor, and is more sheltered from the prevailing winds. Eratop appears to have similar characteristics to Erakor Lagoon, including a narrow entrance channel, extensive areas of shallow reef flats, and probably limited water movement. Hickman (1989) concluded that the mangrove oyster and 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.

17 Reptiles

17.1 Turtles

17.1.1 Species present

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

17.1.2 Distribution

There are seven species of turtles throughout the world, and all but one occurs in the Pacific region. The most frequently seen species in the Pacific are the hawksbill and green turtle, although leatherback (*D. coriacea*), loggerhead (*Caretta caretta*) and olive or Pacific Ridley (*L. olivaccea*) turtles also occur. Leatherback turtles in the Pacific are highly endangered and there are suggestions that they may be on the verge of extirpation (Spotila et al. 2000). Nesting females have declined precipitously in Malaysia (Chan and Liew 1996) and Costa Rica (Spotila et al. 2000).

Little information is available on marine turtles in Vanuatu but the hawksbill and the green turtles are the most common species turtles found. Information collected by Dickinson (1981) indicates 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).

Leatherback turtles occur in small numbers. Archival data reviews and interviews of knowledgeable coastal residents by George et al. (2004) indicate that leatherback turtles are known throughout many islands of Vanuatu. They are often seen at sea as they migrate to nesting areas. There are several vernacular names for leatherback turtles. For example, on Aneityum the leatherback is known as “naho yau”, which translates as “whale turtle”, referring to its size. On Akhamb Island off southern Malekula, they are known as “nev marmaj”, which translates as “devil turtle”. It is said that in this area, leatherbacks are avoided and not eaten due to their unusual appearance, and a belief that they are bad spirits.

17.1.3 Biology and ecology

The hawksbill turtle feeds invertebrates, sponges and soft corals. The green turtle, by contrast, is mainly herbivorous, feeding on seagrass and algae. Because seagrass beds often do not occur close to suitable breeding beaches, green turtles may migrate from a resident habitat to breeding beaches and back at intervals. Loggerheads and olive Ridleys are also carnivorous and, like the hawksbill, do not appear to migrate to the same extent as the green turtle, although some long distance movement has been recorded (Pickering 1983). The movements of olive Ridley turtles are particularly poorly known. Loggerheads nest mainly outside the tropics on subtropical and warm temperate coasts.

While green turtles often nest together in large numbers (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 on 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 densities are low throughout their 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).

A review of archival data, unpublished reports, interviews with key informants from coastal communities, and a nesting beach survey (see Petro et al 2005) indicates that leatherback turtles nest on a number of Islands, including Pentecost, Ambrym, Malekula, Epi and Efate. A number of other islands including Gaua, Ambae, Tanna, Aneityum and Santo also reported regular nesting activity up until about 20–30 years ago. It is possible that these areas are still occasionally used for nesting by small numbers of leatherbacks (George et al. 2004).

On Efate Island adjacent to Port Vila, one or two females nest, but not every year. The nesting beaches are in the Mele Bay area (adjacent to Port Vila) and in Teouma Bay, south of the captital. The Mele Bay nesting beaches are in areas that have been developed for real estate, a tourist resort, and a golf course.

Epi Island appears to have the largest number of nests, with two nesting areas. The southwest-exposed coasts in the Votlo area probably have as many as 20–30 nesting females (George et al. 2004). A smaller number appear to nest on the east coast around Big Bay. Malekula appears to have the greatest number of nests after Epi. Malekula also appears to be the only island where leatherbacks are still consumed. All nests are on black sand beaches often associated with rivers. Tabulated below are survey results of leatherback nesting sites at Votlo, south Epi by George et al. (2004).

Table 86: Nesting beach survey at Votlo, southern Epi

Activity	Green	Hawksbill	Leatherback	Grand total
False crawls	10	3	5	17
Nesting	15	2	31	46
Grand Total	25	5	36	63
Number tagged	2	0	9	11

(Refer to Appendix 4 for summarized information on leatherbacks in Vanuatu)

17.1.4 The Fishery

Utilisation

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; and oil used 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 jewelry 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.

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 is becoming more commercially motivated.

Hawksbill and green turtles are both exploited for meat and eggs in Vanuatu, and the use of their shells 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 traditional subsistence villages, for example, food, tools, decoration and trade items. 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 carried out in 1989, by the Environment Section of the Vanuatu Department of Physical Planning and Environment, showed that on some islands, the killing of certain animals is taboo and on others, only the chief is allowed to kill or can permit such killing. On other islands, such as the Masklynes, marine turtles are only hunted during the yam season.

Their large size makes leatherbacks nearly impossible to harvest (when they are found swimming at sea) because they are too huge to be hoisted into canoes or small fishing craft. For those local communities that consume leatherbacks, such as the Malekula coastal communities, leatherbacks are harvested when they are found on nesting beaches.

Production and marketing

From 1976–1988 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, representing some 28,000 adult hawksbills (Daly 1989).

Little information is available from most Pacific Island nations regarding 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 1985–1988, Japan imported significant quantities from both the Solomon Islands and Fiji.

Table 87: Export figures (in kg) of tortoiseshells from the Solomon Islands and Fiji to Japan

Year	Solomon Islands	Fiji
1985	1,556	294
1986	1,793	497
1987	4,723	1,859
1988	3,911	817

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

Table 88: Exports of turtle shells from Vanuatu to Japan

Year	1980	1984	1985
Weight (kg)	33	25	12

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

At present, turtle killings by coastal communities is minimal, given the amount of awareness work carried out by the Environment Unit, the Department of Fisheries, and "Wan Smol Bag", a theater group. There are now turtle monitors on all islands in Vanuatu, and they meet every year to discuss turtle conservation issues.

17.1.5 Stock status

Currently, there are no consistent indices of sea turtle abundance in Vanuatu. However, green and hawksbill turtles are the only known species nesting within the country. Information on the leatherback turtle indicate that it occurs in some parts of Vanuatu. Only one or two nesting beaches are known. Green and hawksbill turtles are common in the extensive reefs and shallow areas of Vanuatu's islands.

The most important nesting area in the Vanuatu archipelago is at south Malekula Island. Important mainland nesting areas for 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 40–120 turtles (Groombridge and Luxmoore 1989). Turtles are particularly plentiful in the Maskelynes islands off the southern coast of Malekula. Regular nesting of both species also occurs within the group, particularly at Seior and Laifond islands. Sakau and two small islands close to Aham Island are used occasionally. Other notable nesting areas are southeast of Epi Island, Emae Island, and in the north among the Torres Group. The nesting season for both hawksbill and green turtles is from September to early January.

During a one-week turtle survey in the Maskelynes in November 1992 by the Vanuatu Environment Unit, only five turtles were tagged: three greens and two hawksbills. No turtle nesting was observed. The results of the survey seem to indicate a declining number of turtles around the Maskelynes.

17.1.6 Management

The Department of Fisheries — having recognized the urgent need for conservation of the marine turtles and the need to increase their populations — established several turtle nurseries in collaboration with some private sector investors. The nurseries were able to rear up to 200 juvenile turtles, mainly hawksbills. The intent is to increase survivability rates for juvenile turtles. The three nurseries successfully released over 300 tagged turtles in total. Two of the nurseries are now closed. Only one nursery is still in operation and is managed by the Congula Cruises 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. The Department of Fisheries, in consultation with relevant institutions, should develop a management plan for all species of marine turtles in Vanuatu. The management plan should establish a quota system, and a closed season for harvesting turtles, as well as a ban on killing leatherback turtles.

17.2 Crocodiles

17.2.1 Species present

Crocodylus porosus.

17.2.2 Distribution

The only island in Vanuatu known to have had had a breeding population of the estuarine crocodile, *C. porosus*, is Vanua Lava Island, one of the islands in the Banks/Torres groupGroup, in northern 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 northwest of Vanua Lava, a swimming distance for the strong and long distance swimming *C. porosus*.

17.2.3 Biology and ecology

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

17.2.4 The Fishery

Production and marketing

There is no production and marketing of crocodile skin or flesh in Vanuatu, although in other Pacific Island countries, such as Papua New Guinea, there is a crocodile skin export industry.

17.2.5 Stock status

Little is known about the *C. porosus* population on Vanua Lava. A survey carried by David Luders in 1983 (in Messel and King 1992) reported no crocodiles. However, Luders gathered important local information on crocodiles in Vanua Lava. He stated in his report that prior to 1972, a well known local, 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 1960s basking on the sandbanks near the mouth of the river. He reportedly had shot some (the last one he shot was in 1978, and was 5.5 m long). 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 to nearly nil, and the bulk of

the population may have been washed out to the sea and suffered an unknown fate. The habitat of the main population (Selva River) was altered unfavourably.

A second survey of the Vanua Lava crocodile population was carried out by Chambers and Esrom of the Vanuatu Environment Unit, Ministry of Lands, in 1989. Chambers and Esrom (1989) concluded that very few crocodiles remained 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 Messel and 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 male or an immature female. There is no longer a breeding population.

17.2.6 Management

Current legislation/policy regarding exploitation

There is no management legislation regarding crocodiles in Vanuatu.

Recommended legislation/policy regarding exploitation

Survey results seem to indicate that the crocodile population on Vanua Lava has become almost extinct. In addition, natural events such as cyclones are indicated as having a major role in the disappearance of crocodiles.

18 Other resources

18.1 Sea cucumbers

18.1.1 Species present

The most recent survey conducted on sea cucumbers was an Australian International Development Assistance Bureau (AIDAB) project conducted in 1988. Eighteen sea cucumber species were recorded in Vanuatu: *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*.

18.1.2 Distribution

Chambers (1990) recorded the distribution and occurrence of sea cucumbers by species for sites visited. In addition, distribution within each location was broken down into distribution by different habitats. For the purposes of this document, species occurrence (distribution) is summarised below (Table 89) for locations under the different islands and groups of islands, as recorded by Chambers (1990).

Table 89: Species distribution

Island	Location(s)	Species
Aneityum	Inyeug platform reef	*H. atra, B. argus, S. chloronotus*
	Anelgohat Bay	*A. mauritiana, S. maculata*
	Port Patrick	*S. chloronotus*
Efate & offshore islands	Moso, southwest shore	*H. atra, S. chloronotus*
	Moso, east side	*H. atra, H. fuscopunctata*
Emae – Cooks 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*
Malekula 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 offshore islands	Wanuru	*A. mauritiana*
	Banmatmat	*H. atra*
	Loltong	*nil*
Santo and offshore islands	Big Bay	*nil*
	Hog Harbour	*nil*
	Champagne Beach	*H. atra, H. nobilis, T. ananas*
	Turtle Bay	*H. fuscopunctata, S. chloronotus, S. variegatus*
	Palekula 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 (six species each) and the intertidal reef crest and sand flats east of Metai Island in the Maskelyne Islands (seven

species).

Bacteria constitutes the major nutritional component for most holothuroids. Therefore "the complex relationship between bacterial populations and sediment structure may have a major influence on the distribution of holothuroids" (Preston 1993).

18.1.3 Biology and ecology

Sea cucumbers belong to the phylum Echinodermata, which contains 17 classes, 12 of which are extinct. There are four subphyla (Homalozoa extinct) which include sea lollies and feather stars (Crinozoa), starfish, brittle stars and basket stars (Asterozoa), and spiny-skinned (as most members have defensive spines on the outside of their bodies) (Campbell 1985).

There are 900 echinoderms known as beche-de-mer, or sea cucumbers, belonging to the class Holothuroidea. The body of the holothuriod is not drawn out into arms and the mouth and anus are located at different ends of the body. The class is distinguished from other echinoderms by the reduction of the skeleton to microscopic ossicles, and by the modification of the buccal podia into a circle of tentacles around the mouth (Ruppert and Barnes 1994).

Most sea cucumbers are dioecious (separate sexes) and all species can reproduce sexually. Spawning occurs in spring or summer in the tropics. During spawning, eggs are caught by the tentacles and transferred to the sole or the dorsal body surface for incubation. The eggs pass from the gonads into the coelom where they are fertilized (Ruppert and Barnes 1994). Development begins to take place within the coelom and the young leave through a rupture in the anal region. The embryo then becomes planktonic. There are two larval stages. On the third day of development the larval stage called auricularia is reached. The second stage is a barrel-shaped larva, called doliolaria, where the ciliated band has become broken up into three to five ciliated bands.

Sea cucumbers live for 5–10 years, maturing after 3 years, depending on the species. Predators include tritons, starfish, lobsters, rays, and humans.

Sea cucumbers are deposit and suspension 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 settles there.

Literature on the biology and ecology of sea cucumbers in Vanuatu is very limited. Apart from the AIDAB-funded study in 1988, the only other report was that of Baker (1929, 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 about the biology of the main species of holothurians exploited commercially in the South Pacific. Additional information is provided in Preston (1993).

18.1.4 The Fishery

Utilisation

Sea cucumbers do not form any fishery for local consumption by ni-Vanuatu, and there is no local market for them. 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 1970s. Latham (1929, in Dalzell 1990) reported that beche-de-mer was one of Vanuatu's principal exports at the beginning of the 20th century. Dalzell (1990) reported that exports of beche-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 beche-de-mer for export in 1990 (letter to SPC dated 5 June 1990).

There are at present five licensed local companies involved in exporting dried beche-de-mer products. Main harvesting areas have concentrated on Emae Island, the Banks Group, Efate Island, Cook Reef, the Masklyne Islands, Epi, and Atchin Island.

Production and marketing

Conand (1989) classified beche-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* having medium value; and *H. atra*, *H. fuscopunctata* and *H. mauritiana* having low commercial value. Baird (1973) reported that this industry could well be expanded, considering Vanuatu's extensive coastline. He reported that beche-de-mer fishing and processing had been revived by a Mr Autrand in one or two villages. 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 production figures were reported.

The export of beche-de-mer products from Vanuatu — to Hong Kong, Singapore and Australia — between 1983 and 1989 are recorded in Tables 90 and 91.

Table 90: Beche-de-mer exports from Vanuatu (1983-1989)

Year	Quantity (tonnes)	Value (VUV)	Source
1983	6	3,121,000	Fisheries annual report for 1983; Preston (1993)
1984	3	1,707,000	Department of Fisheries annual report for 1984; Second National Development Plan (1987–1991); Preston (1993)
1985	6.8	5,251,000	Department of Fisheries annual reports for 1986 & 1987.
1986	4	2,837,000	Department of Fisheries annual reports for 1986 & 1987; Preston (1993)
1987	1	938,000	Department of Fisheries annual reports for 1987 & 1989; FFA 1990.
1988	15	3,291,000	Department of Fisheries annual report for 1989; Overseas Trade Part II 1985–1990 exports
1989	24	9,377,000	Department of Fisheries annual report for 1989

Data obtained from records of Export Permits and Certificates of Origin gave an indication of beche-de-mer exports, species involved, and amount for 1990.

Table 91: Beche-de-mer exports, 1990

Date	Species	Quantity (kg)	Value/kg (USD)	Total Value
24 April 1990	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		VUV 2,442,000
7 May 1990	Beche-de-mer	300.0	12.00	USD 3,600.00
13 Jul 1990	Sandfish	327.0	12.00	USD 3924.00
	Blackfish	69.0	4.00	276.00
	Teatfish	20.0	10.00	200.00
Total		416.0		USD 4,400.00
18 Oct 1990	Black teatfish	644.4	12.00	USD 7,732.80
	Sand redfish	87.6	7.00	613.20
	Prickly redfish	8.8	9.00	79.20
Total		740.8		USD 8,425.2
7 Dec 1990	Black teatfish	200.0	9.00	USD 1,800.00
	Prickly redfish	8.8	12.00	105.60
	Prickly redfish	8.8	12.00	105.60
	Surf redfish	87.6	9.00	788.40
Total		296.4		USD 2,694.00
TOTAL 1990		5,673.2		USD 37,719.2

No export data were 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 three-month period, 7.5 tonnes, worth about USD 55,000 was exported.

Table 92: Beche-de-mer exports, May 1993-August 1993

Date	Species	Quantity kg)	FOB/kg	Total Value (USD)
8 June 1993	Processed beche-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

Table 93: Beche-de-mer exports, 1996–2004

Year	Quantity (kg)	Value (VUV)
1996	1,771	-
1997	38,100	8,352,874
1998	19,086	7,828,280
1999	18,220	5,079,170
2000	25,500	4,181,604
2001	47,694	17,609,324
2002	8,402	5,122,676
2003	25,069	11,906,346
2004	14,094	13,934,242

18.1.5 Stock status

The 1988 AIDAB-funded survey recorded the presence of all the major commercial species of sea cucumber in the survey sites in Vanuatu, including *H. nobilis*, *A. miliaris, A. echinites, A. mauritiana, T. ananas, H. scabra*, and *H. atra*.

Annual export figures for beche-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 7.5 tonnes were exported during a three-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 catch per unit of effort on this particular fishery, no meaningful estimates of sustainable exploitation can be made.

Baker (1929, in Chambers 1990) recorded densities of up to five sea cucumbers/m^2 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 member in 1983. Although no report was published, 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) generally found low densities of sea cucumbers (rarely exceeding 1/100 m^2) at eight sites in the Maskelyne Islands and at 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.

Table 94: Density of beche-de-mer by species in Port Vila Harbour at Ekasuvadt Lagoon (in descending order of value)

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

Table 95: Densities (no./100 m^2) of sea cucumbers at the eight sites reported above by Chambers (1990)

Species	Metai Intertidal & reef crest	Sakao south intertidal	Sakao south reef crest	Sakao north intertidal	Sakao north reef crest	Cooks Bay intertidal	Cooks 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	

Stock assessment surveys of beche-de-mer carried out by the Department of Fisheries at the Shepherd Outer Islands from September–October 1998 indicated that Emae Island has a stock density great enough to sustain commercial harvesting, however, this would need to be carefully managed to ensure the sustainability of the resource. The overall predominant species is lollyfish, which occurs in highest densities on the northeastern side of Emae Island. Lollyfish has a very low commercial value. The smaller islands of Buninga, Mataso and Tongariki do not have densities that can withstand harvesting above subsistence levels.

In 2003, the Department of Fisheries carried out an intensive sea slug survey around Epi Island. The following sites were surveyed, Lamen Island, Nuvi, Nikaura, Valesdir, Mavelau, Burumba, Maso, Ponkovio, and Alak. The results of the survey showed that Epi has a healthy stock of sea slugs, with the predominant species being lollyfish and greenfish.

The overall status of sea slug stocks in Vanuatu is at a very critical stage, whereby, sustained fishing pressure can result in depletion of the stocks. Fishing pressure is a direct result of monetary needs of rural communities throughout Vanuatu.

18.1.6 Management

Managing the exploitation of the sea cucumber fishery in South Pacific countries has been very minimal. This has been partly due to the fact that the beche-de-mer industry in the region is not an old tradition and there is an absence of scientific information on which to base management decisions. As a result, this particular fishery has been characterised by periods of heavy exploitation followed by a recovery period (Preston 1993). One of the contributing factors in 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 beche-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 beche-de-mer to an annual quota of 35 tonnes.

Recommended legislation/policy regarding exploitation

Chambers (1990) recommended that:

> "the correct strategy with regard to beche-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 beche-de-mer from Vanuatu have been consistently well below the legal quota. This seems to indicate that the quota (35 tonnes/year) applied is very much unfounded and could well be above the sustainable level of exploitation for the fishery. The reason for the low production thus far is not apparent but it can indicate 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 Department of Fisheries 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. Only three companies should be allowed to operate and process beche-de-mer in Vanuatu.

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 beche-de-mer, with corresponding total wet length and weight at first sexual maturity, have been calculated for some commercially valuable species. These can then be used as a basis for setting a legal size on the processed product (Conand 1989). However, Conand (1989) notes that "these are minimal 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 the minimum amount to make an operation economically feasible could be used.

18.2 Corals and sponges

18.2.1 Species present

Veron (1990) gives comprehensive details of the results of the a 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 96 below with some remarks made. There is no information is available on coral species exported from Vanuatu as "rocks".

Smith (1992) lists coral species sought for ornamental or curio purposes including, 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 100–1,200 m in Vanuatu (Eade 1988, in Wright 1989).

Table 96: Coral species found in Vanuatu

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		

Although they are not well documented, there are healthy populations of soft corals and common sponges in Vanuatu. Sponges are primitive multicellular organisms, and over 5,000

species have been described to date. In 2000, research carried out by the Coral Reef Research Foundation around Efate Island and Espiritu Santo Island alone identified at least 158 species of common sponges of the Phylum: Porifera and Class: Demospongia. As regards to soft coral, a total of at least 106 species were identified as belonging to the Phylum: Cnidaria, Class: Hyrozoa and Class: Anthozoa, Subclass: Octocorallia.

18.2.2 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. No reefs develop in areas where the annual minimum temperature is below 18°C (Achituv and Dubinsky 1990).

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

18.2.3 Biology and ecology

Coral growth is optimal only within a fairly narrow range of water temperatures and salinities, and so varies considerably from area to area. Some *Acropora* grow fast (up to 20 cm per year), while *Favia* and *Porites* grow very slowly (Lewis 1985; Veron 1986). Achituv and Dubinsky (1990) note 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) note that sexual reproduction patterns include hermaphroditic or gonochronic species with broadcast spawning or brooding modes of development; hermaphroditic broadcast spawners are the dominant group.

Several asexual reproductive processes 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 midnight.

Sponges are exclusively sessile animals with large goblet-shaped structures and are divided into three organizational types – asconoids, syconoids, and leuconoids. The simplest are the asconoids sponges. Asconoid sponges have but one large chamber or atrium lined with flagellated choanocytes. Because of their simple structure and organization, these sponges grow no larger than 8 mm. The second more advanced type of sponge is the syconoid sponge. Folds in the body wall give rise to cup-shaped structures called radial tubes. Sponges with this structure have a maximum length of 4 cm. The majority of sponges, icluding all large sponges, belong to the third group, the leuconoid sponges.

Sponges undergo sexual as well as asexual reproduction (budding). Gametes are not produced in particular organs, but throughout the body of the sponge. Most sponges are hermaphrodites. Sperm cells, which are released into the open wate, fertilize the amoeboid egg cells of conspecific sponges. Sponges have an exceptional capacity of regeneration. Small pieces can grow into new sponges. Even when several species of sponges are minced, scrapped, mixed, and pressed through a sieve, they regenerate into complete organisms. Sponges thrive in a variety of habitats, even in dark locations avoided by many animals, such as grottos, caves and overhangs. Their natural enemies include a few snails, nudibrachs, free-living worms, crustacea (crabs), fishes and turtles with diet centered on sponges.

18.2.4 The Fishery

Utilisation

Corals are collected to a limited extent for the local tourist trade as well as for home decoration. Some corals are exported with aquarium fish as "rocks". Crossland (undated) notes that the original concern over the wreck of the President Coolidge at Million Dollar Point, which led to the establishment of the area as the first national marine reserve, was that certain individuals were stealing 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 corals were being collected on a semi-commercial basis by local divers.

The demand for live corals for the aquarium trade is huge. This led to the Department of Fisheries issuing licenses for cultured coral in 2000. In 2004, the Department of Fisheries revoked all licenses for exporting live cultured corals on the basis that some exporters were removing live *Acropora* spp. coral from the wild and exporting it as cultured coral. The Department of Fisheries, however, allows the export of live “rocks” for the aquarium trade industry.

With regards to sponges, multiple chemical compounds have been isolated from sponges and are now synthesized worldwide. Antibiotics, hormones, and even some compounds able to halt the growth of certain types of tumors are among them.

Production and marketing

Pieces of coral are marketed together with aquarium fish. Live rock is also exported for the aquarium industry. Records extracted from application forms for permits to export marine products from Vanuatu in 1992 show that 840 pieces of "rocks" worth VUV 30,600 were exported to New Zealand, the United States and Japan.

Table 97: Coral and live rock exports, 1997-2004

	Coral		Live rock	
Year	**Pieces**	**VUV**	**KG**	**VUV**
1997	373	-	23,350	-
1998	722	-	15,370	-
1999	75	-	13,160	-
2000	4,013	-	23,630	1,596,839
2001	7,000	922,521	19,195	2,278,931
2002	780	328,474	26,950	3,734,349
2003	2,185	1,020,445	25,889	14,225,901
2004 (Jan–July)	Ban	-	36,600	3,355,300

Given the economic viability of the sponges, there has not been are exports of sponges overseas from Vanuatu. The Department of Fisheries does not issue permits for harvest of wild sponge populations for export purposes.

18.2.5 Stock status

The Australian Institute of Marine Science conducted a survey of corals and coral reefs in Vanuatu 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 other areas where there has been considerable death and injury to corals from cyclones, sea level changes, and crown-of-thorns starfish. Outstanding coral reefs were observed on the east side of Inyeug on Aneityum, on the west side of Cook Reef, the entrance to Hog Harbour on Lathu Island, the reef slopes adjacent to the western bay on Reef

Island, and on Ureparapara. Although the status of reefs in Vanuatu was listed as "good" by Dahl (1985, in Done and Navin 1990), they were assessed as "poor" in 1988, even with the exceptions of some areas as stated above. It was suggested that considerable degradation had taken place since 1985, mainly from cyclones and crown-of-thorns starfish.

In 1998, the Department of Fisheries initiated a Coral Reef Monitoring Program, with funding support from the South West Pacific Node at the Marine Studies Programme, University of the South Pacific. Ten sites were selected to be regularly monitored, eight of which were on Efate Island, one site on Iapuna, Epi, and another site on Aore Island. Monitoring results showed that the main causes of stress to corals in Vanuatu are from natural disasters (e.g. bleaching, cyclone damage, and crown-of-thorns, *Acanthaster planci*, predation). The most recent bleaching in 2000/2001 caused coral deaths around west Efate from Port Vila Harbour, Mele Bay and Erakor Island. Coral bleaching was observed at all monitoring sites.

Coral gardens around Aore Island and Million Dollar Point on Santo were severely damaged due to predation by crown-of-thorns starfish. This led the Department of Fisheries to initiate a crown-of-thorns starfish eradication and awareness program for Aore Island. A joint effort comprising Santo Fisheries staff, the Vanuatu Moblie Force, Santo Dive operators, youth and village communities began a cleanup campaign in May 2004, with funding support from the Biodiversity Project. In September 2004, a second cleanup campaign was held, with funding support from the Foundation of the People of the South Pacific. A total of 1,187 crown-of-thorns starfish were eradicated. Damage by crown-of-thorns predation is also recorded from reefs at Aneityum, Epi and Malekula.

Cyclones have also significantly damaged corals in Vanuatu. Cyclone Danny in 2003 damaged 80% of live corals on exposed reefs on southwest Efate from Malapoa, Devils Point, Pango, Hat Island and Lelepa. Floods (rivers and streams) caused by cyclone Danny also brought considerable amounts of silt and mud onto the coastal waters causing high mortality of corals.

Earthquakes also contribute to coral deaths in Vanuatu. In 1999, the northern part of Ambrym Island was forced upward by an earthquake. This resulted in a 10 m tsunami that hit south Pentecost (killing 11 people, injuring 50, and displacing over 100 others) and caused servere damage to coral reefs.

There has not been any stock assessment surveys carried out to determine the status of stocks of sponges through out Vanuatu, nor has there been any comprehensive scientific assessment to document all species of sponges in Vanuatu waters.

18.2.6 Management

Sheppard and Wells (1988) state that "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 provides habitat for a vast array of other organisms". Writing about coral reef evolution worldwide, Achituv and Dubinsky (1990) note 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 the recovery of degraded reefs, appears to be siltation, which accompanies the logging of steep watersheds, and eutrophication caused by domestic sewage discharged into reef waters. The greatest immediate threat to the survival of corals however was attributed to continued crown-of-thorns starfish outbreaks.

Recent threats have been high seawater temperatures, which is the main cause of coral bleaching throughout the archipelago. Exports of live coral for the aquarium trade can also be a threat if they are not monitored and managed strictly by the Department of Fisheries.

Current legislation/policy regarding exploitation

Fisheries Regulation 19 prohibits the taking of more than three pieces of living coral in any 24-

hour period, except with the permission of the Director and in accordance with such conditions as he may specify. In addition, the 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 taking and exporting live corals may need to be reconsidered, and limited to the collection of dead corals only.

Although the current level of exploitation of corals in Vanuatu does not seem to pose a threat to the resource, it should be safeguarded now for future direction and development. Apart from a 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.

18.3 Dugongs

18.3.1 Species present

Dugong dugon

18.3.2 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 Aneityum in the south to the Torres Islands in the north (Chambers et al. 1989).

18.3.3 Biology and ecology

Distantly related to the elephant, the dugong (*Dugong dugon*) is a massive but inoffensive herbivorous sea mammal. 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 be found in warm, shallow, and sheltered inshore and reef areas where beds of seagrasses occur. Analysis of stomach contents indicate that dugongs consume a wide variety of tropical and subtropical seagrasses, preferring to feed on small delicate seagrasses, digging up the whole plant, including the rhizomes, making a distinctive feeding trail. 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 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 seagrass soon after birth, it can suckle for up to two years, and the cow-calf bond is extremely well-developed. An estimate of the average interval between births for various Australian populations ranges from about three to seven 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 (on the order of 95% per year or more) for population maintenance. Thus, dugongs are extremely susceptible to over-exploitation which is why their status is now so vulnerable.

18.3.4 The Fishery

Utilisation

In Vanuatu dungongs are hunted mainly 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 Island countries, such as Papua New Guinea, dugongs are used to supply teeth for ornaments and jewelery, 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 takes 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 dugongs in Vanuatu by Chambers et al. in 1989 indicates that dugongs are killed by a variety of methods, but the most common method is spearing.

Table 98: Identified 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

Dugongs have recently become a major tourist attraction in Vanuatu, due to their behavior which makes them easy to be tamed. There are reports from some islands in the archipelago of

coastal communities feeding and swimining with the dugongs. In Epi (Lamen Bay) and Tanna (Port Resolution) tourists are able to swim with dugongs.

Production and marketing

There are no production records or 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 USD 60 each (Chambers pers. observ. 1988).

18.3.5 Stock status

Dugong numbers have greatly been 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 seagrass beds that 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 (Papua New Guinea, 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 hunting is reduced (Chambers et al. 1989). In New Caledonia and the 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 et al. in 1989 indicated that dugongs are reported to be present in nearly all 100 localities in the survey areas. Major islands where dugongs have been reported from many locales, include Efate, Santo and Malekula. Other islands such as Tanna and Erromango had a few localities where dugongs had been reported. Most of the dugongs sighted were a single animal or pairs of animals with an average number reported from each locality of about two or three.

Futuna, Buninga and Mere Lava islands reportedly have no dugongs. Dugongs were also reportedly absent from the Dillon's Bay area on the west coast Erromango, and Wusi on the west coast of Santo.

18.3.6 Management

Current legislation/policy regarding exploitation:

Throughout its range, *Dugong dugon* is 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 Vanuatu waters.

Recommended legislation/policy regarding exploitation

Existing regulations seem to be adequate.

19 Endemic freshwater resources

This section covers both the edible and non-edible freshwater fish and crustaceans of Vanuatu. Much of the information is obtained from Nimoho 2000.

19.1 Freshwater ecosystems

Vanuatu's freshwater ecosystems comprise rivers, streams, volcanic lakes, ephemeral lakes and swamps. The distribution of the various freshwater ecosystems is patchy throughout the archipelago, covering only 1.0% of the total land area of approximately 14,763 km^2.

Freshwater ecosystems on Vanuatu's larger islands, (e.g. the Jordan River on Santo, Cooks River on Erromango Island, and Pankumo River on Malekula Island) have greater discharges, which form cascades, rockfaces, pools, and tidal reaches, and are often characterized as having extensive flood planes. Smaller islands ecosystems on the other hand only have streams, which are often ephemeral.

19.1.1 Importance of Freshwater Ecosystems

Rivers, streams and lakes provide water for day-to-day living in rural communities, and for irrigation of land to grow staple root crops. Freshwater ecosystems provide habitat for important sources of protein, such as fish, eels, birds and invertebrates, and for terrestrial wildlife, including birds, reptiles and frogs.

19.1.2 Freshwater Fauna Composition

The dominant freshwater fauna in Vanuatu are fish, gastropods and crustaceans. Nimoho (2000) reported 62 fish species within 20 families, 7 species of prawns within one family, and 1 crab species.

19.2 Carcharhidae

19.2.1 Species present

Carcharhinus leucas (bull shark)

Distribution

The bull shark is also called the river shark, freshwater whaler, estuary whaler, and swan river whaler. It can live in a wide range of habitats, including coastal marine and estuarine areas, to freshwater streams.

It has been recorded from the surf zone down to a depth of at least 150 m. It is the only species of shark that is known to live for extended periods in freshwater. It has been reported nearly 4000 km from the sea in the Amazon River system, and is known to breed in Lake Nicaragua in Central America. The bull shark is common in Papua New Guinea and has been reported to inhabit inland river systems 130 km from the coast. In Australia, the bull shark occurs from Perth, Western Australia, around the northern coastline and down the east coast to Sydney, New South Wales. This species has a widespread distribution in tropical and warm temperate waters of the world. In Vanuatu, bull sharks have been reported within the upper reaches of the Pankumo River, which is the largest river on Malekula Island.

19.2.1.2 Biology and ecology

The bull shark is recognized by a combination of physical features, including a stout body, short blunt snout, triangular serrated teeth in the upper jaw, and no fin markings as an adult. This species has a second dorsal fin about one third the height of the first, small eyes, and no

skin ridge between the two dorsal fins. It is grey above and pale below, sometimes with a pale stripe on the flank.

The bull shark is large, growing to a length of 3.4 m. Its omnivorous diet includes fish (including other sharks), dolphins, turtles, birds, molluscs, echinoderms and even terrestrial mammals. Bull sharks are considered to be an aggressive species and are considered dangerous to humans. Some authors consider the bull shark to be more dangerous than the great white shark and the tiger shark. This is because of the bull shark's omnivorous diet and habitat preferences, which mean it may be found in murky water, where a swimmer splashing about could be mistaken for a struggling fish. It has been responsible for a number of attacks on humans within its range.

19.2.2 The Fishery

Utilisation

Bull sharks are caught by inland communities for subsistence purposes, as a prime source of protein. The sharks are not commercially harvested because there are demands for the flesh at the local domestic markets.

19.2.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of bull sharks.

19.2.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of bull sharks.

Recommended legislation/policy regarding exploitation

The Department of Fisheries, in collaboration with the Environment Unit, should carry out an in-depth stock assessment survey to determine the status of freshwater shark stocks in the Pankumo River.

19.3 Megalopidae (tarpons)

19.3.1 Order

Elopiformes (tarpons and tenpounders)

Class

Actinopterygii (ray-finned fish)

Species present

Megalops cyprinoids (ox-eye herring)

Distribution

Ox-eye herring are found in the Indo-Pacific, from the Red Sea and Natal, South Africa (Smith 1986) to the Society Islands, north to southern Korea, south to the Arafura Sea (Russell and Houston 1989) and New South Wales. It is restricted to high islands in Micronesia (e.g. Palau, Caroline and the Mariana Islands). It has been reported as far inland as the lower Shire in Malawi and the Save-Runde junction in Zimbabwe (Skelton 1993). It is widespread in the lower Zambezi River channels up to Marromeu and in the Micelo River up to Malingapanzi

(Bills 1999). In Vanuatu, this fish is reported only in Malekula and Epi islands.

Ox-eye herring inhabit the lower reaches of streams, coastal rivers, estuaries and often the upper streams and inland lakes. It is distributed through out the tropical Indo-West Pacific.

Biology and ecology

Ox-eye herring favour fresh water, brackish water, and marine waters at depths up to 50 m. Adults are generally found at sea, but juveniles inhabit river mouths, inner bays, and mangroves. In fresh water, it occurs in rivers, lagoons, lakes, and swampy backwaters (Allen 1991). It tolerates salinities from 0–100. It is mainly diurnal (Coates 1987), and it feeds mainly on fish and crustaceans (Fischer et al. 1990).

Ox-eye herring breed offshore, possibly throughout the year. Larvae are transparent and resemble larval eels (Bell-Cross and Minshull 1988). Juveniles commonly enter fresh water (Kuiter and Tonozuka 2001). Ox-eye herring can be cultured in ponds, with the fry being sourced from coasts (Kottelat et al. 1993). It can tolerate oxygen-poor water by "breathing" air into a lung-like air bladder. In Vanuatu, it normally grows to a fork length of 36 cm. It has a minimum population doubling time of 1.4–4.4 years.

Dorsal spines (total): 0; Dorsal soft rays (total): 16-21; Anal spines: 0; Anal soft rays: 23-31. Lower jaw projects beyond snout; a bony gular plate present between the jaw bones. Last fin ray of dorsal long and filamentous; ventrally located pectoral fins; abdominal pelvic fins with 9 or more rays. Branchiostegals more than 23. Scales large. Color blue-green dorsally; silvery on sides

19.3.2 The Fishery

Utilisation

Ox-eye herring is a good angling fish. The flesh is considered poor quality for eating, although it has been recommended for aquaculture. In Vanuatu, for inland communities in Malekula and Epi, it is a source of protein.

19.3.3 Stock status

There has been no stock assessment survey carried out to determine the population dynamics and status of ox-eye herring in Vanuatu.

19.3.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation that manages the exploitation of ox-eye herring.

Recommended legislation/policy regarding exploitation

Because ox-eye herring does not play a significant role with regards to subsistence, and because it has no commercial value, there is no need to carry out assessment surveys, and thus, no need for management measures.

19.4 Hemiramphidae

19.4.1 Species present

Zenarchopterus sp. (Garfish)

Distribution

Garfish are found in coastal streams, inhabiting aquatic vegetation that lines the banks of large streams and mangrove swamps. The species is widely distributed from East Africa across the Pacific. In Vanuatu, it is found only on Santo Island.

Biology and ecology

A biological and ecological study of garfish has never been carried out in Vanuatu. The fish has a silver-coloured, narrow elongated body. It is easily distinguished by its very short upper jaw; the lower jaw forms a long beak. The body ranges from 115–170 mm in length.

19.4.2 The Fishery

Utilisation

Garfish are consumed by other marine animals.

19.4.3 Stock status

There has been no stock assessment survey carried out to determine the population dynamics and status of the garfish species in Vanuatu.

19.4.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation that manages the exploitation of garfish.

Recommended legislation/policy regarding exploitation

Because garfish do not play a significant role with regards subsistence, and because it has no commercial value, there is no need at this stage to carry out assessment surveys, and thus no need for any management measures.

19.5 Chandidae (perchiets)

19.5.1 Species present

Ambassis urotaenia. (Bleeker's glass perchiets**)**

Distribution

This species is widely distributed from India to the western Pacific. In Vanuatu, it is only found on Malekula Island. It frequently enters estuaries and lower parts of freshwater streams.

Biology and ecology

A biological and ecological study of Bleeker's glass perchiets has never been carried out in Vanuatu. The fish has a semi-transparent body with silvery sheen on its head and sides, and a row of single transverse scales on its cheek. It has two dorsal fins and a forked caudal fin. The body is covered with dark scales that form a network pattern. Its maximum body length is 75 mm.

19.5.2 The Fishery

Utilisation

Bleeker's glass perchiets are consumed by other marine animals.

19.5.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this freshwater fish species in Vanuatu.

19.5.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this resource.

Recommended legislation/policy regarding exploitation

Because Bleeker's glass perchiets do not play a significant role with regards to subsistence, and because they have no commercial value, there is no need at this stage to carry out an assessment survey, and thus, no need for any management measures.

19.6 Terapontidae (grunters or tigerperches)

19.6.1 Order

Perciformes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Hephaestus fuliginous (sooty grunter) and *Mesopristes argenteus* (silver grunter)

Distribution

In the western Pacific they are found from the Yaeyama Islands in Japan, south to Queensland, Australia and east to New Caledonia. Large populations have been reported to occur in brackish and fresh waters in Papua New Guinea.

The two grunter species do not share the same habitats. In Vanuatu, sooty grunters are found in the lower reaches of the Jordan River on Santo Island. It occupies large rivers and sometimes can be found inhabiting deep rocky pools near waterfalls.

Silver grunters inhabit lower sections of streams, often penetrating into inland deep stream pools.

Biology and ecology

Biological and ecological studies of the sooty grunter have never been carried out in Vanuatu. The body of the sooty grunter is dark grayish and often greenish; the lower areas of the head, breast and belly are whitish. The dorsal and anal fins are short. Juveniles have a large dark blotch on the anal fin and smaller black spot at the base of the last dorsal ray. Maximum body length is 45 cm.

Silver grunters are silvery and have long rigid dorsal and anal spines. Dorsal spines (total): 12; Dorsal soft rays (total): 10–11; Anal spines: 3; Anal soft rays: 8–9. The dorsal caudal and anal fins are yellowish. Its profile is ventrally flattened. Maximum body length is 28 cm. Juvenile silver grunters have four distinct black lines on their bodies. The fish inhabits inshore areas near mangroves. It is found in lentic and lotic freshwater (Paxton et al. 1989). Juveniles are commonly found in the lower sections of creeks and may penetrate several kilometres into fresh water (Allen1991). Maximum average body length is 28 cm.

Silver grunters favour fresh water, brackish water, and marine waters. They have a medium, minimum population doubling time of 1.4–4.4 years.

19.6.2 The Fishery

Utilisation

The two grunter species are a significant source of protein for local communities. They are locally known as "toktok" fish because of the grunty sound it makes when fished using hand lines.

19.6.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fresh water fish species in Vanuatu.

19.6.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this resource.

Recommended legislation/policy regarding exploitation

Because grunters play a significant role in the subsistence livelihood of local communities located close to the Jordan River, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.7 Terapontidae

19.7.1 Order

Perciformes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Terapon jarbua

Distribution

These fish are found in the Indo-Pacific from the Red Sea and East Africa to Samoa, north to southern Japan, south to the Arafura Sea (Russell and Houston 1989), Australia, and Lord Howe Island. They are also found in India (Jeyaseelan 1998). In Vanuatu, this fish has been recorded only from Epi Island.

Biology and ecology

Terapon jarbua prefers freshwater, brackish, and marine waters, and can occupy depths ranging from 20– 290 m. In the vicinity of river mouths, it is found over shallow sandy bottoms. It is also know to enter estuaries and rivers (Rahman 1989; Yamada et al. 1995; Kuiter and Tonozuka 2001). Adults form loose aggregations (Ref. 48635). Juveniles are

common in sandy intertidal areas, often in tidal pools. These fish are omnivorous (Paxton et al. 1989), feeding on fish, insects, algae, and sand-dwelling invertebrates (Lieske and Myers 1994). Adults spawn in the sea, and juveniles migrate to fresh water (Allen 1991).

Dorsal spines (total): 11–12; Dorsal soft rays (total): 9–11; Anal spines: 3; Anal soft rays: 7–10. Lower opercular spine extending well beyond the opercular flap. Post temporal bone exposed posteriorly and serrate. Body color is fawn above, cream below, nape dark; head, body and fins with and iridescent sheen. Three or four curved dark brown bands run from the nape to the hind part of the body, the lowermost continuing across the middle of the caudal fin. Adults have a large dark blotch on their spinous dorsal fins and stripes on their dorsal fin. Maximum body length is 157 mm.

19.7.2 The Fishery

Utilisation

Terapon jarbua are marketed fresh, dried or salted (Rainboth 1996). Although it has minor commercial value, it can be cultured on a commercial basis. In Vanuatu, this fish is a good source of protein for local communities.

19.7.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this freshwater fish species in Vanuatu. However, the fish has a low, minimum population doubling time of 4.5– 14 years (Preliminary K and tmax)

19.7.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities located in close proximity to the coast and estuaries, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented. Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fresh water fish.

19.8 Kuhliidae

19.8.1 Order

Perciformes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Khulia rupestris (jungle perch)

Distribution

This fish is found from Africa to Asia and Oceania, from East Africa to Samoa, north to the Ryukyu Islands (Japan), south to Queensland, Australia and east to New Caledonia. In Vanuatu, this species is found around most islands that have streams and rivers.

Biology and ecology

The fish prefers such habitats as reef-associated; catadromous; freshwater; brackish; and marine. It is primarily a freshwater inhabitant but may penetrate adjacent marine habitats (Randall and Randall 2001). It occurs in estuaries and the middle reaches of rivers, usually in relatively fast-flowing, clear streams (Allen 1991), but is not found above water falls.

Dorsal spines (total): 10; Dorsal soft rays (total): 10–12; Anal spines: 3; Anal soft rays: 9–11. Preorbital serrae 10–15 (obsolete in large specimens); body depth 2.6–3.0 in SL; mouth large for genus, maxilla reaching to below posterior half of eye; caudal fin emarginated and has a dark blotch at the lobes of the fins, lobes somewhat rounded, caudal concavity 5.3–8.7 in head length. Silvery, the scales dorsally on body with black edges, those on side with a black bar or spot; juveniles with a broad black zone, edged above and below in white, in soft portion of dorsal fin, and each lobe of caudal fin with a large, white-edged black spot; black areas in these fins enlarge with growth until in adults most of these fins black (caudal with upper and lower edges and corners whitish) (Randall and Randall 2001). Maximum body length is 450 mm with maximum published weight of 2,700 g (Smith 1986).

19.8.2 The Fishery

Utilisation

Khulia rupestris is considered to be a good food fish (Smith 1986). It also has commercial value as a game fish. It is a significant source of protein for local communities.

19.8.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this freshwater fish species in Vanuatu.

19.8.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this resource.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities located in close proximity to streams and rivers, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.9 Kuhlidae

19.9.1 Order

Perciformes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Khulia munda

Distribution

Khulia munda is found in Oceania in Fiji, Vanuatu, New Caledonia and Queensland, Australia. In Vanuatu, this fish is found on most islands that have streams and rivers.

Biology and ecology

This fish inhabits such environments as benthopelagic, fresh water, and brackish water. In Vanuatu, it inhabits the coastal reaches of streams and estuaries

Dorsal spines (total): 10; Dorsal soft rays (total): 10–11; Anal spines: 3; Anal soft rays: 11. Preorbital serrae 14–21; body depth 2.55–2.85 in SL; orbit diameter 2.55–2.8 in head length; maxilla usually reaching to below anterior margin of pupil; caudal concavity 2.5–3.0 in head length. Silvery, front of lips and upper half of snout blackish; caudal fin yellow with a very broad black posterior margin, the upper and lower margins narrowly black, but broadening towards base, often connecting across base of fin (Randall and Randall 2001). Average body length is 110 mm.

19.9.2 The Fishery

Utilisation

This freshwater fish is a significant source of protein for local communities.

19.9.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this freshwater fish species in Vanuatu.

19.9.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Khulia munda*.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities located in close proximity to the coastal reaches of streams and estuaries, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.10 Carangidae (jacks and pompanos)

19.10.1 Order

Percifomes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Caranx sexfasciatus (bigeye trevally)

Distribution

Caranx sexfasciatus is found in the Indo-Pacific, from the Red Sea and East Africa to Hawaii, north to southern Japan and the Ogasawara Islands, south to Australia and New Caledonia. It is also found in the eastern Pacific, from the southwestern coast of Baja California Sur, Mexico and the Gulf of California to Ecuador and the Galapagos Islands (Smith-Vaniz 1995). In Vanuatu, *Caranx sexfasciatus* is found only on Santo and Malekula islands.

Biology and ecology

Caranx sexfasciatus prefers such environments as reef-associated, amphidromous, fresh water, brackish water, and marine waters; and can occupy depths range up to 96 m. It inhabits coastal and oceanic waters associated with reefs (Smith-Vaniz 1995), and occasionally enters rivers. Juveniles may venture into estuaries, occasionally entering rivers and penetrating well inland (Allen 1991). *Caranx sexfasciatus* forms slow-moving schools in passes or outside the reef during the day, dispersing at night to feed (Bagnis et al. 1984). *Caranx sexfasciatus* feeds mainly on fish and crustaceans (Smith-Vaniz 1995).

Dorsal spines (total): 9; Dorsal soft rays (total): 19–22; Anal spines: 3; Anal soft rays: 14–17. Body color iridescent blue-green dorsally, silvery white below; soft dorsal lobe and anal fin with white-tipped lobes; caudal yellowish to black. Pectoral fins falcate; anal fin with 2 detached spines. Upper edge of opercle with a small blackish spot. 27–36 strong, dark scutes. Breast fully scaled.

Average body length is 250 mm, however this fish is able to grow up to 750 mm in body length with a maximum published weight of 18 kg (Frimodt 1995).

19.10.2 The Fishery

Utilisation

Caranx sexfasciatus is marketed fresh, dried or salted (Smith-Vaniz 1995), and frozen (Frimodt 1995). It is consumed broiled and baked (Frimodt 1995). It has commercial value and is a good gamefish. In Vanuatu, this fish is a good source of protein for local communities.

Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fish species in Vanuatu. However, the fish has a low, minimum population doubling time 4.5–14 years (Preliminary K and tmax).

19.10.3 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Caranx sexfasciatus*.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.11 Lutjanidae (snappers)

19.11.1 Order

Percifomes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Lutjanus argentimaculatus (mangrove red snapper)

Distribution

Lutjanus argentimaculatus is subtropical and is widely distributed throughout the Indo-West Pacific and East Africa to Samoa and the Line Islands (Kiribati), north to the Ryukyu Islands (Japan), south to Australia, and has dispersed into the eastern Mediterranean (off Lebanon) via the Suez Canal, although it is not well established there. In Vanuatu, *Lutjanus argentimaculatus* is found on Santo, Efate, Erromango and Malekula islands.

Biology and ecology

This fish is reef-associated, oceanodromous, and found in fresh water, brackish water, and marine waters; depth range 10–120 m. Juveniles and subadults favour estuaries or lower sections of fresh water streams.

Dorsal spines (total): 10; Dorsal soft rays (total): 13–14; Anal spines: 3; Anal soft rays: 7–8. Preopercular notch and knob poorly developed. Scale rows on back more or less parallel to lateral line, or parallel below spinous part of dorsal fin and sometimes rising obliquely posteriorly, or rarely with entirely oblique rows. Generally greenish brown on back, grading to reddish on sides and ventral parts. Trawl specimens from deep water frequently are reddish with dark scale centers and white scale margins, giving a reticulated appearance. Juveniles have a series of about eight whitish bars crossing their sides, and 1 or 2 blue lines across their cheek. *L. argentimaculatus* distinguished from the *L. bohar* by its longer snout and truncate tail and more bronze to greenish coloration (Myers 1999).

Lutjanus argentimaculatus is a euryhaline species (Lewis and Pring 1986). Juveniles and young adults occur in mangrove estuaries and in the lower reaches of freshwater streams (Sommer et al. 1996; Kuiter and Tonozuka 2001). Adults are often found in groups around coral reefs (Lieske and Myers 1994), eventually they migrate offshore to deeper reef areas, sometimes venturing to depths in excess of 100 m. They are mainly nocturnal, and feed mainly on fish and crustaceans. *Lutjanus argentimaculatus* is an excellent food fish (Anderson 1986), and an important market species throughout the Indo-Pacific region, although it is never found in large quantities. In Hong Kong, it is found in live fish markets (Lee and Sadovy 1998). *Lutjanus argentimaculatus* is a good aquaculture species because it does not go rancid easily when frozen (Lessa et al. 1999). It commands a good export market price with no limit on body size (Lessa et al. 1999). There are no reported damaging diseases (Lessa et al. 1999). Average body length is 340 mm with maximum published weight of 8,700 g and maximum reported age of 18 years.

19.11.2 The Fishery

Utilisation

Lutjanus argentimaculatus has commercial value and can be easily cultured. It is also a preferred fish for gamefishing. In Vanuatu, this fish is a significant source of protein for local communities.

19.11.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this sub-freshwater fish in Vanuatu.

19.11.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Lutjanus argentimaculatus*.

Recommended legislation/policy regarding exploitation

Because *Lutjanus argentimaculatus* plays a significant role in the subsistence livelihood of local communities located in close proximity to the estuaries or lower section of freshwater streams, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be implemented.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.12 Lutjanidae

19.12.1 Species present

Lutjanus fuscescens (spotted bass)

Distribution

This species occurs in China, the Philippines, Papua New Guinea, Solomon Islands and Australia. In Vanuatu *Lutjanus fuscescens* is found on Santo Island.

Biology and ecology

Biological and ecological studies of *Lutjanus fuscescens* have never been carried out in Vanuatu.

Lutjanus fuscescens has a single dorsal fin and is greenish-brown on its back and white on its ventral parts. Average body length is 400 mm, although overall fork length may be more.

Lutjanus fuscescens is partly a marine species, with adults found in coastal reefs or in deeper offshore areas. Juveniles and subadults favour estuaries or lower sections of freshwater streams.

19.12.2 The Fishery

Utilisation

Lutjanus fuscescens js a significant source of protein for local communities.

19.12.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this sub-freshwater fish species in Vanuatu.

19.12.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Lutjanus fuscescens.*

Recommended legislation/policy regarding exploitation

Because *Lutjanus fuscescens* plays a significant role in the subsistence livelihood of local communities located in close proximity to the estuaries or lower sections of freshwater

streams, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be put into place.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.13 Lutjanidae

19.13.1 Species present

Lutjanus russelii

Distribution

Lutjanus russelii occurs throughout the Indo-Pacific, including New Caledonia. In Vanuatu it is only found on Gaua.

Biology and ecology

Biological and ecological studies of *Lutjanus russelii* have never been carried out in Vanuatu.

This fish has a single dorsal fin with four distinct longitudinal stripes across its golden-yellow body. Average body length is 110 mm. *Lutjanus russelii* inhabits lower reaches of streams near coastal areas.

19.13.2 The Fishery

Utilisation

This freshwater fish is consumed by other marine animals. It does not provide a significant source of protein for local communities.

19.13.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this sub-freshwater fish species in Vanuatu.

19.13.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Lutjanus russelii*.

Recommended legislation/policy regarding exploitation

Because *Lutjanus russelii* does not play a significant role with regards to subsistence, and because it has no commercial value, there is no need at this stage to carry out assessment surveys, and thus, no need for any management measures.

19.14 Gerriidae (silver biddies)

19.14.1 Order

Percifomes (perch-like)

Class

Actinopterygii (ray-finned fish)

Species present

Gerres filamentosus (thread silver biddy)

Distribution

Gerres filamentosus is found in the Indo-Pacific, from East Africa and Madagascar to Japan and Australia, and has been reported from New Caledonia. It enters rivers and lakes in Madagascar and on the east coast of Africa. In Vanuatu, it is found only on Efate, Malekula and Maewo.

This species occurs throughout East Africa, the tropical Indo-Pacific, Australia and the eastern Pacific islands.

Biology and ecology

Dorsal spines (total): 9; Dorsal soft rays (total): 10–11; Anal spines: 2–3; Anal soft rays: 7–8. It is generally silvery. The second dorsal-fin spine is very long. There is a vertical series of spots along the side. Average body length is 220 mm.

This is marine species enters lakes and the lower reaches of freshwater rivers, and juveniles are found in brackish mangrove estuaries. *Gerres filamentosus* inhabits shallow waters over sandy substrates along the coasts and in estuaries. It feeds on small crustaceans, polychaetes and forams on sand or muddy-sand bottoms, as well as worms and insect larvae.

The fish prefers such environments as demersal, amphidromous, fresh water, brackish water, and marine waters. It can occupy depths ranging from 10–50 m. Normally this fish lives in mangrove areas, estuaries and shallow marine areas.

19.14.2 The Fishery

Utilisation

Gerres filamentosus has commercial value. It is normally salted or made into fish sauce. In Vanuatu this fish is a significant source of protein for local communities.

19.14.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this sub-fresh water fish species in Vanuatu. However, it has a high, minimum population doubling time less than 15 months (Preliminary K and tmax).

19.14.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Gerres filamentosus*.

Recommended legislation/policy regarding exploitation

Because *Gerres filamentosus* plays a significant role in the subsistence livelihood of local communities located in close proximity to mangrove areas, estuaries and shallow marine areas, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be put into place.

Research should also be carried out by the Department of Fisheries to determine the prospects of farming this fish.

19.15 Monodactylidae

19.15.1 Species present

Monodactylus argenteus (silver-moon fish)

Distribution

This species is found in the Indo-West Pacific, from the Red Sea and East Africa to Samoa, north to the Yaeyamas, and south to New Caledonia and Australia.

It is found in the freshwater tidal zone of the Mekong delta, and is widespread from India to Papua New Guinea. In Vanuatu, it is found only on Santo.

Biology and ecology

Also called a butterfly fish, *Monodactylus argenteus* is commonly found in mangrove estuaries, often entering creeks. It is sometimes found in silty coastal reefs. Small juveniles are solitary but can also live in small aggregations. *Monodactylus argenteus* feeds on plankton and detritus. It is highly territorial and be caught with throw nets. The fish has a diamond body shape; juveniles tend to have pelvic fins that are absent in adults. Average body length is 250 mm.

Dorsal spines (total): 7–8; Dorsal soft rays (total): 27–31; Anal spines: 3; Anal soft rays: 27–32. Adults are bright silver with yellow and dusky dorsal fin tip. Small juveniles are more colorful with yellow over most of the dorsal fin and two vertical black bands over the head.

19.15.2 The Fishery

Utilisation

The fish has minor commercial value, although it is highly sought after for the aquarium trade industry. In Vanuatu, this fish is a significant source of protein for local communities.

19.15.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fish species in Vanuatu.

19.15.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Monodactylus argenteus*.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities located in close proximity to large streams close to the coast, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures that should be put into place to ensure the long-term sustainable utilisation of this resource.

19.16 Scatophagidae

19.16.1 Species present

Scatophagus argus (spotted scat)

Distribution

This fish species is found in the Indo-Pacific, from Kuwait to Vanuatu and New Caledonia, north to southern Japan; and from Palau to Pohnpei in Micronesia. It has been reported from

Samoa and the Society Islands, and is found throughout India, Sri Lanka, Malaysia, Singapore, and the northern part Australia. In Vanuatu the fish is found only on Malekula.

Biology and ecology

Scatophagus argus inhabits harbors, natural embayments, brackish estuaries, and the lower reaches of freshwater streams, frequently occurring in mangroves. It feeds on worms, crustaceans, insects and plant matter. The dorsal, anal and pelvic spines are believed by Filippino fishers to be venomous and capable of inflicting wounds. It is used in Chinese medicine, and in Hong Kong it is found in live fish markets. It is marketed as fresh fish.

It is also called a butterfly fish and is brown with reddish-brown round spots on its body. The head profile ascends steeply with a deep concavity above the eyes. Dorsal spines (total): 10–11; Dorsal soft rays (total): 16–18; Anal spines: 4; Anal soft rays: 13–15. Average maximum body length is 380 mm.

Scatophagus argus is very resilient and has a high, minimum population doubling time of less than 15 months.

19.16.2 The Fishery

Utilization

In some countries, *Scatophagus argus* is one of the preferred species for aquaculture, because of its commercial value. In Vanuatu, it is a significant source of protein for local communities.

19.16.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fish species in Vanuatu.

19.16.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Scatophagus argus*.

Recommended legislation/policy regarding exploitation

Because it plays a significant role in the subsistence livelihood of local communities located in close proximity to large streams close to the coast, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be put in place to sustainably conserve this resource.

19.17 Mugilidae (mullets)

19.17.1 Species present

Four species of fresh water mullets are found in Vanuatu:

Cestraceus guamensis (white mullet)

Cestraceus plicatilis (black mullet)

Mugil cephalus

Crenimugil crenilabis

Distribution

These species are commonly widespread throughout the tropical Indo-West and central Pacific.

In Vanuatu, *Cestraceus guamensis* is found on only three islands, Santo, Maewo and Pentecost; *Cestraceus plicatilis* is found on almost all islands with large streams; *Mugil cephalus* is recorded only on Erromango and Aneityum islands; and *Crenimugil crenilabis* on Pentecost only.

Biology and ecology

Biology and ecological studies of these mullets have never been carried out in Vanuatu.

Mullets generally have silvery elongated bodies with a small mouth and fine or no teeth. They possess two well separated dorsal fins with the first dorsal fin having 4 spines. The eyes are generally partly surrounded by adipose tissue. Mullets are common throughout the large streams in Vanuatu. In 1992, Ryan reported two other mullet species *Lisa subviridis* and *Lisa crenilabis* in Vanuatu, which are now thought to be extinct in Vanuatu.

Cestraceus guamensis

This species is identified by its silvery white elongated body, and is often referred to as white mullet. It has an adipose eyelid and an elongated jaw that extends below the eye. This mullet has large scales and an indistinct lateral line. It inhabits the lower reaches of streams near the coast. Adults may move inland via large steams. Average fork length is 180 mm.

Cestraceus plicatilis (black mullet)

This species has a long jaw that extends to below the eye. Its eyes are partly surrounded by adipose eyelid. It possesses an indistinct lateral line. The posterior end of the lower jaw has 2 to 4 rounded fleshy lobes. The upper body is greyish, and the sides and belly are silvery white. It inhabits the lower reaches of streams near the coast. Adults may be found well inland up to elevations of 300 m in large and fast flowing streams.

Mugil cephalus

This species is olive green on its back, while its sides are silvery, and its belly is a silvery-white. It has a dark blotch at the base of its pectoral fin and has longitudinal faint brown stripes on its body and a white face on its ventral side. This mullet species inhabits shallow coastal seas and often enters estuaries or the lower parts of streams. Average fork length is 600 mm.

Crenimugil crenilabis

This species has a clearly marginate caudal fin and a small mouth. It does not possess adipose eyelids, or, if present, are poorly developed. The body is greenish to grey on the back, with silver on the sides and belly. The average fork length is 180 mm but it can grow bigger.

19.17.2 The Fishery

Utilisation

All four species of mullet are a significant source of protein for local communities. Surplus is sold locally to to earn cash.

19.17.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fish species in Vanuatu.

19.17.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of these mullet species.

Recommended legislation/policy regarding exploitation

Because mullets play a significant role in the subsistence livelihood of local communities located close to large streams near the coast, it is recommended that an assessment survey be carried out to determine the status of stocks and the type of conservation and management measures to be put into place.

Research studies should also be carried out by the Department of Fisheries on all four mullet species, to determine the prospects for commercial farming.

19.18 Blennidae

19.18.1 Species present

Meiacanthus anema

Distribution

This fish species is found in Asia and Oceania, from Indonesia and the Philippines, to New Guinea, Solomon Islands and Vanuatu. It is also reported from New Caledonia. In Vanuatu, this fish is found only on Efate Island.

Biology and ecology

Meiacanthus anema occurs in estuaries and freshwater habitats, particularly the lower reaches of shallow fresh water pools of rivers and streams, and frequently where mangroves are abundant. It has toxic buccal glands associated with its grooved canines. It is avoided by predators, which even reject it unharmed if they try to ingest it.

Blennies are small colourful fish with three distinct longitudinal dark or black stripes on their bodies. They have elongated bodies (and no scales) and a long-based dorsal fin. Average maximum body length is 7.2 cm.

The fish is very resilient and has an ability for medium, minimum population doubling time 1.4–4.4 years

19.18.2 The Fishery

Utilisation

This fish has aquarium trade value. In Vanuatu it does not play a significant role in the livelihood of the local communities. It is mainly preyed upon by carnivorous birds and by other fish living in rivers.

19.18.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this freshwater fish species in Vanuatu.

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Meiacanthus anema*.

Recommended legislation/policy regarding exploitation

Because it does not play a significant role with regards to subsistence, and because it has no commercial value, there is no need at this stage to carry out assessment surveys, and thus, no need for any management measures.

19.19 Eleotridae (gudgeons)

19.19.1 Species present

There are eight species of gudgeons found in Vanuatu:

Belobranchus belobranchus (throatspine gudgeon), *Eleotris fusca* (brown gudgeon), *Hypseleotris guentheri* (rainbow prigi), *Ophieleotris aporos* var. *aporos* (snakehead gudgeon), *Ophieleotris aporos* new var., *Ophieleotris aporos* var. *geuntheri, Ophieleotris porocephala* (spangled gudgeon), and *Oxyeleotris* sp. (sleeper goby).

Distribution

*Belobranchus belobranchu*s: This species is found in Indonesia, the Philippines, Papua New Guinea and Vanuatu. In Vanuatu, it is found only on Maewo, Pentecost and Efate islands.

Eleotris fusca: This species is found in Papua New Guinea and is widely distributed throughout the Pacific Island countries. In Vanuatu, it is found on almost all islands with river systems and streams.

Hypseleotris guentheri: This species is found in Indonesia, Papua New Guinea, New Caledonia, Fiji, Samoa and Vanuatu. In Vanuatu it is found only on Pentecost, Malekula, Epi, Efate and Erromango islands.

Ophieleotris aporos var. *aporos*: This species is widespread within the Indo-West Pacific. In Vanuatu, it is only found on Santo, Maewo, Pentecost, Malekula islands.

Ophieleotris aporos new var: This species is reported to be found only in New Caledonia and Vanuatu. In Vanuatu it is found on Pentecost, Santo and Efate islands.

Ophieleotris aporos var. *geuntheri:* This fish is found in New Caledonia, and in Vanuatu. In Vanuatu it is found on Santo and Malekula.

Ophieleotris porocephala: This species is widespread throughout the high volcanic islands of Oceania. In Vanuatu it is found on Santo, Malekula, Vanua Lava and Efate.

Oxyeleotris sp.: This fish is found only on Vanua Lava, Maewo and Pentecost islands

Biology and ecology

Gudgeons have elongated bodies, fairly flattened heads, and two separate pelvic fins. They are normally stream bottom dwellers.

Belobranchus belobranchus: This fish is dark brown with five broad light-coloured bars across its body. The body also has numerous dark horizontal lines on sides with light spots forming lines radiating from eye across the cheeks. Fins may have spots. This fish occupies the lower reaches of streams that have rocky or gravel bottoms. Average body length is 103 mm.

Eleotris fusca: There is a downward projecting spine at the lower corner of the preopercle margin and numerous dark horizontal lines on this fish's body. It is common throughout all parts of streams below waterfalls. Average body length is 150 mm.

Hypseleotris guentheri: The dorsal fins of males have white spots, and the dorsal fins of females have faint spots. This species inhabits shallow pools within the lower and middle reaches of clear, fast flowing streams. Average body length is 50 mm.

Ophieleotris aporos var. *aporos:* This fish has two to four brown stripes radiating from the lower part of the eye across the cheek. It has a number of transverse scales. Fin margins are yellow. This species occupies the lower reaches of estuaries of large rivers, swamps and lakes. Average body length is 201 mm.

Ophieleotris aporos new var.: The fish has a broad compressed head and a number of

transverse scales. It is yellow with dark red blotches arranged longitudinally on its body. It has dark-reddish fins with yellow margins and three dark stripes radiating from the lower part of the eyes across the cheeks. At the base of the pectoral fins there is a dark blotch. This species inhabits pools in the lower reaches of clear, fast flowing streams. Average body length is 230 mm.

Ophieleotris aporos var. *guentheri:* The body is spotted with longitudinal spotted lines along the body and white spotted fins. The female does not have spots on its body. This species inhabits the lower and middle reaches of large streams. Average body length is 129 mm

Ophieleotris porocephala: The body is dark brown with scattered white spots on the sides. The scales form longitudinal body lines. Fins have yellow margins. This fish inhabits the lower reaches of streams, estuaries and freshwater creek pools. Average body length is 180 mm.

Another species, *Ophieleotris macrolepidota*, was reported in Vanuatu in 1992 by Ryan. However, it appears that this species is now extinct.

Oxyeleotris sp.: The head of this fish is fairly compressed. The body is tan-brown and has narrow dark lines. It also has tan- brown blotches on the sides of its head and lips. The pectoral fins have white spots. It inhabits the muddy bottom of streams near coasts, and is considered an important source of food for local communities. Average body length is 350 mm.

19.19.2 The Fishery

Utilisation

Apart from the sleeper goby, gudgeons do not appear to play a significant role in the livelihood of local communities.

19.19.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of gudgeons in Vanuatu.

19.19.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of gudgeons.

Recommended legislation/policy regarding exploitation

It may be relevant for the Department of Fisheries, in collaboration with the Environment Unit, to carry out an extensive assessment of the status of gudgeon fish. Given the fact that three of the species may be extinct in Vanuatu, it may be essential to consider implementing some strict management measures.

19.20 Gobiddae (gobies)

19.20.1 Species present

The following 11 species of gobies are found in Vanuatu: *Awaous guamensis; Awaous ocellaris; Glossogobius celebius* (Celebes goby); *Mugilogobius fusculus* (obscure goby); *Periophthalmus argentilineatus* (silverstripe mudskipper); *Periophthalmus weberi* (Weber's mudskipper); *Redigobius bikolanus* (speckled goby); *Sicyopterus laceocephalus* (Micrurus); *Sicyopterus cyanocephalus; Sicyopterus* sp.*;* and *Vevineala pyrrhotigris*

Distribution

Awaous guamensis: Found in algal mats at the bottom of streams. Occurs only within some Pacific island groups, such as the Solomon Islands, New Caledonia, Vanuatu, the Marianas, and the Hawaiian Islands. In Vanuatu, it is found only on Aneityum Island.

Awaous ocellaris: Inhabits the middle reaches of streams with sandy bottom substrates. Found in southern Papua New Guinea and northern Australia. In Vanuatu, it is found on Maewo and Malekula islands.

Glossogobius celebius: Inhabits the lower reaches of wide streams. Commonly found in the western tropical Pacific. In Vanuatu, it is found only on Pentecost, Malekula, Epi, Efate and Maewo islands.

Mugilogobius fusculus: Occupies the lower reaches of streams, particularly within estuaries. It is found throughout the Indo-Pacific. In Vanuatu, it is only found on Maewo Island.

Periophthalmus argentilineatus: This species is reported to occupy the lower reaches of streams, particularly within extensive brackish mangrove areas. It occurs throughout the Indo-West Pacific, including Vanuatu, where it is found only on Malekula Island.

Periophthalmus weberi: Inhabits tidal fresh water areas within mangroves. Found in southern Papua New Guinea, northern Australia, and in Vanuatu where it is recorded only from Malekula Island.

Redigobius bikolanus: Inhabits the lower parts of streams. Found in Japan, the Philippines, Indonesia, Papua New Guinea, northern Australia, and Vanuatu, where it is found only on Efate Island.

Sicyopterus laceocephalus: This fish possesses well developed suckers, which enables it to climb rocks and move farther into inland waters. It is therefore found throughout all parts of streams, from the lower to upper reaches. Widespread throughout the western and central Pacific island. In Vanuatu, this fish is a common resident in all fast flowing streams.

Sicyopterus cyanocephalus: Inhabits fast flowing streams where bottom substrates are composed mainly of stones and boulders. Found in the Philippines, Indonesia, Papua New Guinea and Vanuatu, where it is found only on Pentecost Island.

Sicyopterus sp.: Found within the lower parts of streams that are fairly undisturbed. It is found on Efate, Pentecost and Maewo islands.

Vevineala pyrrhotigris: An endemic genus with only one species found on Ambae and Maewo islands.

Biology and ecology

This family of goby species is generally stream bottom dwelling. Bodies include a flattened head and pelvic fins that are fused to form a sucker, which enables the fish to attach itself to rocks while feeding.

Awaous guamensis: Has a duck beak-like mouth shape. Lacks cheek scales. Has two separate dorsal fins and a rounded caudal fin. Has broad jaws that extend back to below the eyes. Body is brownish with longitudinal rows of dark spots. As a defensive behaviour, this fish often takes cover by diving into the algal substrate when threatened. Average body length is 106 mm.

Awaous ocellaris: Lacks cheek scales. Body is brown with mid-lateral rows of 6–7 irregular dark brown blotches and numerous small brown blotches. Has a triangular dark brown mark on the upper pectoral fin. Average maximum length is 100 mm.

Glossogobius celebius: Has a flattened head and a more rounded snout than Awaous. Has broad cheeks that lack scales. The body is brown with five dark brown blotches on the middle

of sides. It has an orange and dark blotch at the base of the rear end of the dorsal fin. Average maximum body length is 120 mm.

Mugilogobius fusculus: Has broad cheeks with no scales. The scale is only present on the opercule. Has a rounded caudal fin and the first dorsal fin spine forms an elongated filament. Average maximum body length is 31 mm.

Periophthalmus argentilineatus: Lacks cheek scales. Has protruded eyes over its head. Has broad black stripe with a narrow white margin on the first and second dorsal fins. Outer edge of the second dorsal fin is broadly reddish. Pelvic fins are partly fused. Average maximum body length is 27 mm.

Periophthalmus weberi: Has a fairly flattened head, and lacks cheek scales. Has protruded eyes and pelvic fins that are partly fused.

Redigobius bikolanus: The head is fairly flat and lacks cheek scales. Has three faint brown bars on the head, and a brown body with dark spots and blotches. There are 26–28 mid-lateral scales and 7 transverse scales. Average maximum body length is 35 mm.

Sicyopterus laceocephalus: Lacks cheek scales. Has tear marks that extend vertically onto mouth ends. Has orange caudal fins with a black margin, which is prominent in adults. Has 17 transverse scales and an average maximum body length of 70 mm.

Sicyopterus cyanocephalus: Lacks scales and has tear marks that extend vertically onto mouth ends. Has two separate dorsal fins. The second dorsal fin may have a dark spot. The body has 7–8 black bars spreading across the body. It also has longitudinal lines of blotches along the body. Scales in the interior part of the body are smaller than those within the mid body. Has 17 transverse scales. Average maximum body length is 110 mm.

Sicyopterus sp.: Cheeks lack scales. Has tear marks extending vertically onto its mouth end. Has orange caudal fins and two separate dorsal fins. Has a light brown body with a dark orange line extending along the side from the body center to the base of the caudal fin. Body scales are smaller than those of *S. lacocephalus*. Average body length is 50 mm.

Vevineala pyrrhotigris: Generally a narrow elongated, and small-bodied fish. Has strong circular fused pelvic fins with a strong freanum with a reddish blood appearance when alive which fades into a brown colour when dead and preserved. The scales have black margins which form a rigid black transverse marks on the body from anal fin to base of the caudal fin. Average known body length is 21 mm.

19.20.2 The Fishery

Utilisation

None of the goby species play a significant role in the livelihood of the local communities.

19.20.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of goby species in Vanuatu.

19.20.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of gobies.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Fisheries Department to carry out

assessment studies on habitat damage that may have resulted in significant depletions of a number of goby species in Vanuatu.

19.21 Gobiddae

19.21.1 Species present

Sicyopus zosterophorum

Distribution

Sicyopus zosterophorum occurs within the upper reaches of streams within pools of creeks. The genus is found mainly in the western Indo-Pacific. In Vanuatu, *Sicyopus zosterophorum* is found only on Ambae and Pentecost.

Biology and ecology

This fish has an elongated and fairly compressed narrow body. Average body size is 25 mm. It has a scaleless head and has two separate dorsal fins. The eyes are positioned above the end of the mouth. There are dark stripes across the body, which are more distinct in males than in females.

19.21.2 The Fishery

Utilisation

This fish does not play a significant role in the livelihood of local communities.

19.21.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of *Sicyopus zosterophorum* in Vanuatu

19.21.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of *Sicyopus zosterophorum*.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Fisheries Department to carry out assessment studies on habitat damage, which may have resulted in population reductions of this genus.

19.22 Gobiddae (miniature gobies)

19.22.1 Genus present

Stenogobius

Distribution

This genus occurs within all parts of streams. It is widely distributed across the Pacific. In Vanuatu it is recorded from Efate, Erromango and Maewo.

Biology and ecology

There are two species of this genus, which are new species and have not yet been named.

Stenogobius species has a conspicuous black tear mark stripe below the eye, extending behind the end of the mouth. It has 10–12 black bars across its body. Average body length is 71 mm.

Stenogobius species lacks conspicuous dark bars across its body and has an orange caudal fin with a dark margin. Average body length is 87 mm.

19.22.2 The Fishery

Utilisation

This fish does not play a significant role in the livelihood of local communities.

19.22.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of miniature gobies in Vanuatu.

19.22.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of miniature gobies.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Fisheries Department to carry out assessment studies on habitat damage, which may have resulted in population reductions of this genus. A third species, *Stenogobius genivittatus*, was reported in Vanuatu by Ryan in 1992. This species may now be extinct in Vanuatu.

19.23 Gobiddae

19.23.1 Species present

Stiphodon rutilaureus

Distribution

This species occupies stream bottoms, and is common within shallow clear pools in the lower parts of streams near the coasts. It occurs throughout Malaysia, Indonesia, Papua New Guinea and many Pacific Island groups. In Vanuatu it is recorded on Efate, Erromango, Maewo, Santo and Vanua Lava.

Biology and ecology

This species has strong circular fused pelvic fins with a freanum edge that, when alive, is red; when dead it is brown. This fish has a flattened head and two separate dorsal fins. Males have colourful fins with a filamentous ray at the first dorsal fin. Females have a brown body with longitudinal line of dark blotches along the body side. In streams, males have been observed to swim in groups of two or three, with one female.

The genus has several species which have been reported in Vanuatu. *Stiphodon elegans* and *S. astilbos* were recorded in Santo by Ryan (1992). These species are thought to now be extinct in Vanuatu.

19.22.2 The Fishery

Utilisation

This fish does not play a significant role in the livelihood of local communities.

19.22.3 Stock status

No stock assessment surveys have been carried out to determine the population dynamics and status of this fish species in Vanuatu.

19.22.4 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this resource.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Fisheries Department to carry out assessment studies on habitat damage, which may have resulted in population reductions of this species.

20 Introduced freshwater fish

A number of exotic freshwater fish have been introduced into Vanuatu, either by health authorities to assist in the control of mosquito larvae, or to improve nutrients as food fish. While the introductions of exotic fish species were done in the past with good intentions, for example to increase food production and as biological controls, the environmental impact may be negative. Introduced species are more resilient and thus compete rigorously for limited space and food, often feeding on native fish and prawn species, including their larvae.

20.1 Poeciliidae (liver bearers)

20.1.1 Species present

Peocillia reticulate (guppies)

20.1.2 Distribution

This species is a native to northeastern South America and the West Indies. It was brought to Vanuatu to feed on the larvae of mosquitoes that carry malaria. There are large populations in Lake Wailenitaka on Ambae Island.

20.1.3 Biology and ecology

This species is considered a pest to native freshwater fauna due to its rapid breeding habits and ability to dominate and crowd out local native fish species.

Females can reach a maximum size of 50 mm and males 25 mm. The fish has 7–8 dorsal fin rays. Females have prominent rounded bellies, while males are more slender. These fish possess 26–28 mid lateral scales. The caudal fin often has a rounded black spot at its base.

20.1.4 The Fishery

Utilisation

This fish does not play a significant role in the livelihood of the local communities. However, it helps control the propagation of mosquito larvae in lakes and stagnant streams or water

holes.

20.1.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and status of stocks of this freshwater fish species.

20.1.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Department of Fisheries to carry out assessment studies to determine mechanisms to control the propagation of this fish species.

20.2 Poeciliidae (liver bearers)

20.2.1 Species present

Gambusia affinis (mosquito fish)

20.2.2 Distribution

This fish species is native to the Gulf of Mexico and North America. It is well established throughout the western tropical Indo-Pacific, except for Australia where its possession is strictly prohibited.

It was introduced into Vanuatu to feed on mosquito larvae. It has been widely distributed by health authorities to almost every island in Vanuatu, particularly densely populated areas where the incidence of malaria is high. This fish has established itself very well, and it is abundant in volcanic lakes — including Lake Siwi on Tanna and Lake Waimemea on Ambae Island — and in swamps, ponds, and small slow-flowing streams.

20.2.3 Biology and ecology

This species preys on native fish and prawn larvae. It often attacks larger fish, nipping off their fins and causing paralysis and eventually death.

20.2.4 The Fishery

Utilisation

This fish does not play a significant role in the livelihood of the local communities. However, it helps control the propagation of mosquito larvae in lakes and stagnant streams or water holes.

20.2.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish species.

20.2.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish species.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Department of Fisheries to carry out assessment studies to determine mechanisms to control the propagation of this fish.

20.3 Cichlidae

20.3.1 Species present

Oreochromis mossambica (tilapia)

20.3.2 Distribution

This species is native to eastern Africa. It was brought into Vanuatu to help control the larvae of mosquitoes that carry malaria. It has slowly become an important food fish for rural communities. This fish is abundant in volcanic lakes such as Waimemea on Ambae, Siwi on Tanna. It is also abundant in large rivers and streams on Santo.

20.3.3 Biology and ecology

This species is greenish on the back of its body, and silvery to grayish on its sides. Its belly is silvery white. It has an elongated dorsal fin with 10–13 rays. Maximum average length is about 300 mm. Females practice mouth brooding.

20.3.4 The Fishery

Utilisation

This fish plays a significant role in the livelihood of local communities, particularly as food. It can easily become a pest though due to its ability to rapidly breed and its ability to withstand water temperatures up to 40^0 C.

20.3.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish species.

20.3.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Department of Fisheries to carry out assessment studies to determine mechanisms for controlling the propagation of this fish species.

20.4 Cichlidae

20.4.1 Species present

Sarotherodon occidentalis (tilapia)

20.4.2 Distribution

This species is native to Senegal. It was brought into Vanuatu as an important food fish for rural communities. It is abundant in volcanic lakes such as Waimemea on Ambae, Siwi on

Tanna. It is also abundant in large rivers and streams on Santo.

20.4.3 Biology and ecology

This species has 12–23 dorsal fin rays, and has a distinct lateral line with 30–32 scales on the lateral line. Average body size is about 100 mm, however some individuals may grow even bigger. Females and males practice mouth brooding.

20.4.4 The Fishery

Utilisation

This fish plays significant role in the livelihood of the local communities, particularly as food. It can easily become a pest due to its ability to rapidly breed and its ability to withstand rigorous environmental conditions.

20.4.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish species.

20.4.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish species.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Department of Fisheries to carry out assessment studies to determine mechanisms for controlling the propagation of this fish.

20.5 Cyprinidae

20.5.1 Species present

Cyprinus spp. (carps)

20.5.2 Distribution

This fish is native to eastern Asia. It was brought into Vanuatu as an important food fish for rural communities. It is abundant in Lake Maniuro on Efate Island.

20.5.3 Biology and ecology

This species has an adverse influence on the environment because of its ability to rapidly breed and its sucking mode of feeding, which greatly disturbs the substratum causing turbidity in the water. They compete with native species for food, the main source being aquatic invertebrates.

The body colour is olive, bronze to gold, and may have black blotches. The belly is silvery yellow. It has 26–31 lateral line scales. Its head is fairly triangular and lack scales. It has a distinct forked tail. Average body length is 160 mm, however, it can grow even bigger.

20.5.4 The Fishery

Utilization

This fish plays a significant role in the livelihood of local communities, particularly as food. It can easily become a pest though due to its rapid breeding behaviour and its ability to withstand

rigorous environmental conditions.

20.5.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish.

20.5.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this fish.

Recommended legislation/policy regarding exploitation

It may be relevant for the Environment Unit and the Department of Fisheries to carry out assessment studies to determine mechanisms for controlling the propagation of this fish.

21 Common freshwater crustaceans

Freshwater crustaceans in Vanuatu comprise 18 species, eight of which are prawns belonging to the family Palaemonidae and the genus *Macrobrachium*. There are nine species of freshwater shrimps and one crab species belong to the family Grapsidae.

Freshwater prawns are found throughout the islands and the larger species provide an important source of protein for rural communities.

21.1 Palaemonidae

21.1.1 Species present

Macrobrachium gracilirostre

21.1.2 Distribution

This species occurs in Taiwan, Indonesia, Papua New Guinea, Fiji and Samoa. It is widespread in Vanuatu, and is in all streams throughout the islands.

21.1.3 Biology and ecology

The species rostrum is slightly convex, with 6–7 teeth behind its eyes. Teeth are more widely spaced in front of the eye. It has numerous dark green stripes along the body. The second pereopodes are fairly equal in length and similar in form. The carpus is longer than the merus. Maximum carapace length is about 25 mm.

21.1.4 The Fishery

Utilisation

This species plays a significant role in the livelihood of local communities, particularly as food.

21.1.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.1.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this prawn species.

Recommended legislation/policy regarding exploitation

It may be not relevant at this stage to impose legislation for its management.

21.2 Palaemonidae

21.2.1 Species present

Macrobrachium latimanus

21.2.2 Distribution

This species is widespread throughout India, Sri Lanka, the Philippines, Indonesia and eastward to the Marquesas Islands. It is widespread in Vanuatu and found in all streams throughout the islands.

21.2.3 Biology and ecology

This species is common in stream pools, particularly the upper reaches and sometimes above waterfalls.

Males have well developed rostrum, which are slightly bent downwards. It has 2–3 teeth behind its eyes. Those in front of its eyes are more crowded. The second pereopodes are more or less equal in length with the palm compressed to mass. The carpus is shorter than the merus. It has a blue or dark spot on its tail. Maximum carapace length is about 30 mm.

21.2.4 The Fishery

Utilisation

This species plays significant role in the livelihood of local communities, particularly as food. It is often harvested on a commercial basis for domestic consumption.

21.2.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.2.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this freshwater prawn species.

Recommended legislation/policy regarding exploitation

It may be relevant at this stage to carry out assessment surveys to determine the status of stocks.

21.3 Palaemonidae

21.3.1 Species present

Macrobrachium australe

21.3.2 Distribution

This species is widespread throughout the Indian and Pacific Oceans. It is found in all streams throughout the islands of Vanuatu.

21.3.3 Biology and ecology

This species is common in stream pools, and is particularly found in the lower reaches of streams.

Its rostrum is curved upwards at the tip with 2–3 teeth behind its eyes. The upper edge has 9–13 teeth. The second pereopodes are of different sizes. The carpus is longer than the merus. It has three distinct stripes (black or red) on its cephalothorax. Total body length is about 70–80 mm for females and 100–120 mm for males.

21.3.4 The Fishery

Utilisation

This species plays a significant role in the livelihood of local communities, particularly as food. It is often harvested on a commercial basis for domestic consumption.

21.3.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.3.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this freshwater prawn

Recommended legislation/policy regarding exploitation

It may be relevant at this stage to carry out assessment surveys to determine the status of stocks.

21.4 Palaemonidae

21.4.1 Species present

Macrobrachium lepidactyloides

21.4.2 Distribution

This species occurs in the Philippines, Indonesia and Fiji. In Vanuatu it is only found on Santo and Malekula islands.

21.4.3 Biology and ecology

This species is rare. It is common in large streams near the coast.

Its rostrum dorsal margin is slightly bent with 11 teeth unequally spaced. It has seven teeth behind its eyes and four teeth in front of its eyes. The second pereopodes have different lengths and sizes with palm compressed to mass. The carpus and merus lengths are more or less equal. Maximum carapace length is about 25 mm.

21.4.4 The Fishery

Utilisation

This species plays a significant role in the livelihood of local communities, particularly as food.

21.4.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.4.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of the resource.

Recommended legislation/policy regarding exploitation

It may be relevant at this stage to carry out assessment surveys to determine the status of stocks.

21.5 Palaemonidae

21.5.1 Species present

Macrobrachium placidulum

21.5.2 Distribution

This species is common in the Philippines, Indonesia, Papua New Guinea (Bismarck Archipelago), Palau and Fiji. In Vanuatu it is only found on Efate and Malekula islands.

21.5.3 Biology and ecology

This species occupies the lower parts of clear streams.

Its rostrum margin is slightly bent downward. The teeth are more widely spaced anteriorly than posteriorly. The second pereopodes are unequal lengths. The carpus is shorter than the merus. This species may have a black stripe at the tail base. Maximum carapace length is about 20 mm.

21.5.4 The Fishery

Utilisation

This species plays a significant role in the livelihood of local communities, particularly as food.

21.5.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.5.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this freshwater prawn.

Recommended legislation/policy regarding exploitation

It may be relevant at this stage to carry out assessment surveys to determine the status of

stocks.

21.6 Palaemonidae

21.6.1 Species present

Macrobrachium latidactylus

21.6.2 Distribution

This species is common in the Philippines, Indonesia, Malaysia and Taiwan. In Vanuatu it is only found on Santo and Malekula islands.

21.6.3 Biology and ecology

This species occupies the lower parts of large streams with bottom substrates comprising mainly sand and gravel.

Its rostrum margin is slightly bent downward with 3–5 teeth behind its eyes. The second pereopodes are unequal in length and are of different forms. The carpus is longer than the merus. This species may have a black stripe at the base of the tail. Maximum carapace length is about 25 mm.

21.6.4 The Fishery

Utilisation

This species plays a significant role in the livelihood of local communities, particularly as food.

21.6.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater prawn species.

21.6.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this freshwater prawn

Recommended legislation/policy regarding exploitation

It may be relevant at this stage to carry out assessment surveys to determine the status of stocks.

21.7 Grapsidae

21.7.1 Species present

Varuna litterata

21.7.2 Distribution

This species is common to East Africa, Japan and throughout the western Indo-Pacific. In Vanuatu it is only found on Erromango, Pentecost and Efate islands.

21.7.3 Biology and ecology

This species occupies the lower parts of large streams with bottom substrates that comprise

mainly sand and gravel.

Its carapace is slightly rectangular, with an "H" mark on the back. The body is reddish brown. Maximum carapace width is about 55 mm. Its legs have fine hairs.

21.7.4 The Fishery

Utilisation

This crab does not play a significant role in the livelihood of local communities.

21.7.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater crab species.

21.7.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this crab.

Recommended legislation/policy regarding exploitation

It may not be relevant at this stage to carry out assessment surveys to determine the status of stocks.

22 Freshwater eels

Freshwater eels belong to the order Anguilliformes. There are more than 500 fish species in the order Anguilliformes, and they are characteristically slender, elongated and usually scaleless, with long dorsal and anal fins that are continuous around the tail tip. They do not have pelvic fins but have a single fin that extends around much of the body posterior.

Eels are found in all seas, from coastal regions to midwater depths. Freshwater eels are active, predaceous fish with small embedded scales. They may take 10–20 years to reach sexual maturity before they migrate downstream to the sea to spawn and die. The transparent young drift to the coast and make their way upstream. The life cycle of eels consists of development and early growth in the open ocean: the planktonic (free-floating) dispersal of eggs and larvae, metamorphosis, juvenile and adult growth, and the migration of maturing adults to an oceanic spawning area.

Freshwater eels use their muscular bodies to slither up rapids and waterfalls towards the upper reaches of streams from which they enter inland lakes, such as Lake Letas on Gaua Island, in the Banks Torres group. In many islands of Vanuatu, eels are a culturally significant species, associated with streams and rivers. Freshwater eels are considered valuable food fish for local communities, including species ranging in length from 10 cm to about 3.5 m.

22.1 Anguillidae

22.1.1 Species present

Anguilla marmorata (giant long-finned eel)

22.1.2 Distribution

This eel is found throughout the Indo-Pacific, from East Africa to French Polynesia, north to

southern Japan. In Africa it is common in inland waters in Mozambique and lower Zambezi River. It is also common throughout the Pacific Islands.

This eel is demersal and can occupy freshwater, brackish and marine environments in depths ranging from 1– 400 m. In Vanuatu it is found in all stream courses and lakes throughout the islands.

22.1.3 Biology and ecology

Adults have a brownish to black marbling on their back on a grayish-yellow background. This coloration can fade away. Younger specimens are grey or orange and the marbling is less visible. The body has brown speckles scattered on the back, sides and fins; yellow between speckles and edge of pectoral fin; the belly is white or pale blue. Its head is rounded, the snout is depressed, the lower jaw is protruded, and the gill openings are small. The scales are matted-like under the skin, the pectoral fin is rounded, and the pelvic fin absent. This eels is distinguished from all other species by the mottled color and the long dorsal fin, which begins closer to the gill opening than to the anus.

This eel species is long-finned. The maxillary tooth band is relatively narrow, consisting of three longitudinal rows of teeth with toothless grooves between each row. The maximum recorded body length is 100 cm. However, there are reports of this species growing to over 100 cm in length.

This eel lives in freshwater areas as an adult, and in estuaries and seas as a juvenile. It is found in lowland rivers as well as upland tributaries. While in rivers, the sex gland of the fish does not develop and in winter it follows streams to river mouths where the sex gland begins to develop and afterwards it goes to the deep sea to breed. Its spawning grounds are deepsea gullies in the south of the Philippines, east of Indonesia and in Papua New Guinea. It inhabits deep rocky pools and is active at night, feeding on a wide range of prey, especially crabs, frogs and fish. It is thought to breed east of Madagascar where juveniles are carried to the East Coast by ocean currents.

This eel species has a very low, minimum population doubling time of more than 14 years. It can reach a maximum weight of 20.5 kg and has been reported to live up to 40 years.

22.1.4 The Fishery

Utilisation

This eel species has a commercial value and is commercially farmed. In Vanuatu, it plays a significant role in the livelihood of local communities. It is harvested by local communities and consumed locally as a source of protein.

22.1.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater eel. It is harmless and therefore there are fears that local populations could be in danger of being overfished.

22.1.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel species.

Recommended legislation/policy regarding exploitation

Given its significant role as a food source, it is recommended that assessment surveys are carried out to determine the status of stocks and to formulate management measures.

22.2 Anguillidae

22.2.1 Species present

Anguilla megostoma (Pacific long-finned eel)

22.2.2 Distribution

This eel species if found in the Indo-Pacific, from Sulawesi, Indonesia to the Society Islands in French Polynesia. It is also recorded from Pitcairn Island. In general, this species is common throughout the western and central Pacific region. In Vanuatu it is only found on Santo, Malekula, Gaua and Aneityum islands.

22.2.3 Biology and ecology

It is the only species that can be either variegated or plain-colored. Mottled individuals most closely resemble *Anguilla celebensis* and *A. interioris* in having broad, undivided tooth bands, but their ranges do not overlap. Plain-colored individuals most closely resemble *A. japonica* and *A. borneensis*, but those species are both geographically distant. *A. obscura* is also plain-colored but has a shorter dorsal fin. The skin is grey to yellowish and more or less spotted with brown or black. It can be sometimes uniformly brownish-red on the flanks and the back. The belly is white. Young specimens are grey and do not have spots. This eel species is also long-finned. It is generally brownish-yellow and has a large mouth. Average body length is recorded to be 430 mm, however, it may grow to a maximum size of 100 cm, weighing up to 9 kg.

This eel species is found in all parts of streams above waterfalls, in rocky pools, springs and lakes.

22.2.4 The Fishery

Utilisation

This eel species plays a significant role in the livelihood of local communities. It is harvested by local communities and consumed as a source of protein.

22.2.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish species.

22.2.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel species.

Recommended legislation/policy regarding exploitation

Given its significant role as a food source it is recommended that assessment surveys are carried out to determine the status of stocks and to formulate management measures.

22.3 Anguillidae

22.3.1 Species present

Anguilla obscura (Pacific short-finned eel)

22.3.2 Distribution

This eel is found in the Pacific Ocean, from western New Guinea and Queensland, Australia to the Society Islands in French Polynesia. A single specimen was recorded from a tributary of the Buffalo River, near King William's Town in South Africa, but this is questionable. This species is common throughout the western and central Pacific region. In Vanuatu it is only found on Santo and Gaua islands.

22.3.3 Biology and ecology

This eel is found in estuaries and inland lakes. It belongs to the group of anguillasthat have a short dorsal fin, that begins slightly before the anus. It most closely resembles *Anguilla australis* and *A. bicolor*, from which it can be distinguished with certainty only by the number of vertebrae. This eel species is short-finned, and has a uniform dark brown colour, which is lighter on the belly. Average body length is recorded to be 101 cm.

It is found in large turbid rivers and small creeks and occurs both in running and stagnant waters. It feeds mainly on fish, crustaceans and molluscs. It has a very low, minimum population doubling time of more than 14 years.

22.3.4 The Fishery

Utilisation

This eel species plays a significant role in the livelihood of local communities. It is harvested by local communities and consumed as a source of protein.

22.3.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater eel.

22.3.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel species.

Recommended legislation/policy regarding exploitation

Given its significant role as a food source, it is recommended that assessment surveys are carried out to determine the status of stocks and to formulate management measures.

22.4 Anguillidae

22.4.1 Species present

Anguilla reinhardti (marbled eel)

22.4.2 Distribution

This species is found in Papua New Guinea; eastern Australia, including Tasmania, Lord Howe Island; New Caledonia and New Zealand. In Vanuatu it is only found on Vanua Lava and Gaua islands.

22.4.3 Biology and ecology

This eel species is relatively rare in Vanuatu. It occurs in coastal lagoons, rivers, streams, lakes, swamps and farm dams, but prefers riverine habitats. It is mainly a nocturnal feeder, feeding on crustaceans, molluscs, aquatic and terrestrial insects, and fish including elvers and native trout.

It has a mottled color and tooth bands with a separated inner series. The only other species within its range with these characteristics is *Anguilla marmorata*, but that species has a longer dorsal fin. This eel species is long-finned. It is olive green to brownish with distinct darker blotching on its back, and a longitudinal row of dots on the sides. The belly is pale grey or white. The median fins are dark brown, and the pectoral fins are yellowish. The average body length is around 200 cm. Its maximum recorded weight is 16.3 kg and it can live up to 41 years and can release up to 5 million offspring per season. It has a very low, minimum population doubling time of more than 14 years.

22.4.4 The Fishery

Utilisation

This eel species play a significant role in the livelihood of local communities. It is harvested by local communities and consumed as a source of protein.

22.4.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater fish species.

22.4.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel.

Recommended legislation/policy regarding exploitation

Given its significant role as a food source, it is recommended that assessment surveys are carried out to determine the status of stocks and to formulate management measures.

22.5 Muraenidae (moray eels)

22.5.1 Species present

Gymnothorax polyuranodon (freshwater moray eel)

22.5.2 Distribution

This species is found in Indonesia, Fiji and northern Australia. In Vanuatu it is only found on Malekula, Epi and Erromango islands.

22.5.3 Biology and ecology

This eel species inhabits river mouths close to the sea. It has a snake-like body shape. Its dorsal fin is located above or in front of its gill opening. Its body is yellowish-brown and has large irregular round black blotches, which are joined to form longitudinal dark bands on the head. The average body length is about 80 cm.

22.5.4 The Fishery

Utilisation

This eel species does not play a significant role in the livelihood of local communities.

22.5.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population

dynamics and stock status of this freshwater fish species.

22.5.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel.

Recommended legislation/policy regarding exploitation

Given its lack of importance as a food source, it is not necessary at this stage to carry out assessment surveys to determine the status of stocks.

22.6 Ophichthidae

22.6.1 Species present

Achirophichthys kampeni (freshwater snake-eel)

22.6.2 Distribution

This is a rare eel species found only in Papua New Guinea and Vanuatu, where it is found only on Malekula, Maewo and Santo islands.

22.6.3 Biology and ecology

This eel species inhabits coastal streams with sandy substrates. It burrows into the sandy substrates for shelter. It has a long slender body and pointed snout. Its dorsal fin begins slightly behind its gill openings. It lacks scales, but has white pores forming a lateral line on the body. It is grayish on its dorsal side and whitish on its ventral. Average body length is 310 mm.

22.6.4 The Fishery

Utilisation

This eel species does not play a significant role in the livelihood of local communities.

22.6.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater eel species.

22.6.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel.

Recommended legislation/policy regarding exploitation

Given its lack of importance as a food source, it is not necessary at this stage to carry out assessment surveys to determine the status of stocks.

22.7 Ophichthidae

22.7.1 Species present

Lamnostona polythalmus

22.7.2 Distribution

This eel species is rare and found only Epi and Efate islands.

22.7.3 Biology and ecology

It inhabits river mouths and burrows into sandy bottom substrates.

This eel has a long, slender worm-like body and has a pointed snout. Its dorsal fin begins slightly behind its gill openings. It lacks scales. Average body length is 290 mm.

22.7.4 The Fishery

Utilisation

This eel species does not play a significant role in the livelihood of local communities.

22.7.5 Stock status

No stock assessment surveys have been carried out in Vanuatu to determine the population dynamics and stock status of this freshwater eel.

22.7.6 Management

Current legislation/policy regarding exploitation

There is currently no legislation to manage the exploitation of this eel species.

Recommended legislation/policy regarding exploitation

Given its lack of importance as a food source, it is not necessary at this stage to carry out assessment surveys to determine the status of stocks.

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Appendix 1: Reports of leatherback turtles in Vanuatu

Source: Leatherback turtles in Vanuatu (Petro et al 2005).

Island	Location	Beach or Area	Date	No. Turtles				Notes
				Crawls	Nests	Tagged	Eaten	
Ambae	West Ambae East Ambae	Devils Rock Lolowai area						Limited habit on Ambae but some black beaches & nesting reported in past, some consumed 20–30 years ago
Ambrym	Port Vato		1 Jan-2003			1(~3m)		All island beaches are black sand. Tagged turtle later seen swimming
			2004	None				
Efate	Mele Bay	Black-sands	1999/ 00 2003		1	1		Caught coming ashore, tagged and released but in injured state. Main nest could not be found but one small egg was found
		Melemaat	1997/98	2	1			Photographed & on postcard
	Teouma Bay		99/ 00				1	Black sand beach with river, turtle was consumed. Fisheries Department laid charge
	No location given		30 July 1997			1 (127cm)		
Epi	SW Epi	Votlo	12 Nov 2002 – 15 Feb 2003	36	31	9		See nesting survey report for additional information Storm surge destroyed some nests, some hatchlings seen Jan-03
	SW Epi	Votlo	Late Jan-04		5			
		Port Quimie	Jan-04		3	1		4–5 km suitable beach, north end towards Votlo one nest destroyed by storm
	East Coast	Big Bay	Jan-04		1			4–5 km black sand beach, limited surveys

Island	Location	Beach or Area	Date	No. Turtles				Notes
				Crawls	Nests	Tagged	Eaten	
Malekula	SW Bay	Dixon Reef to Bamboo Bay	Jan-04	2				3 km beach no regular monitoring
	SW tip	Malfakal	2000	Some				Suitable beaches between Caroline Bay & Malfakal
	SE Malekula	Maskelyne Islands	Few years ago				1	Killed but covered in sores so would not eat it.
	East Coast	Unua	Jan-02				1	Large area of suitable habitat—river estuary & 3 long black sand beaches
		Blacksand (N of Port Sandwich)	Feb-04				1	Nesting female eaten
	NW Malakula	Wilak	1997				1	4 km long black sand beach
Pentecost	Bay Martelli	Poinkros	2000				1	Nesting female eaten