National coral reef status report Tonga

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Introduction

The Kingdom of Tonga is located in the central South Pacific (Figure 1) and consists of 174 scattered islands of which 37 are inhabited (Figure 2). The present population is spread over the four main island groups of Tongatapu, Ha'apai, Vava'u and Niuas. Almost three quarters of the population live on Tongatapu (~66 979) with the total population 97 784 (Statistic Dept., 1996). Owing to limited natural resources, the population are largely subsistence farmers and fishermen. Overseas earnings come from agricultural products, tourism and remittances from Tongans working abroad (Zann, 1994).

The Kingdom's north/south axis spans 950 km including the Minerva Reefs. The Royal Proclamation of August 24 1887 established the Kingdom of Tonga as all islands, reefs, foreshores and waters lying between 15° and 23°30' South and 173° and 177° West (Campell and Lodge, 1993). This proclamation covers an area (land and sea) of about 395 000 km^2. The shallow water reef flat covers about 550 km^2 with an additional 3 045 km^2 of sea floor within the 200 m deep shelf. The Royal Proclamation of June 15 1972 confirmed the rights of the Kingdom of Tonga to the islands of Teleki Tokelau and Teleki Tonga (the Minerva Reefs) and all islands, rocks, reefs, foreshores and water lying within a radius of 12 miles thereof, extending to 179° W, the westerly extent of the Kingdom. Considering this claim, the territorial waters of Tonga encompass an area of 700 000 km^2 (Zann, 1994). The ownership of the Minerva Reefs is currently in dispute with Fiji.

The Tongan archipelago is situated along the boundary of the Pacific and Australian tectonic plates. It comprises both volcanic and uplifted coral islands and reefs, which cap the peaks of two parallel submarine ridges stretching south of Fiji. Volcanic islands include 'Ata island (southwest of Tongatapu, Lat. 22º 30 S and Long. 176º W), Hunga Ha'apai, Hunga Tonga, Kao and Tofua islands at Ha'apai, Late and Fonualei in Vava'u, and the two Niuas. These volcanic islands were formed on the volcanic arc running from the south ('Ata) to southeast and to the north to northwest (the two Niuas). The two Niuas are near the arc and explanation is still vague with regards to their formation. A few new islands were formed (volcanic eruption) on this arc in the last few years and only one still exists, while the rest sank again. Niuafo'ou's last erupted in 1942. Kao and Tofua are still active.

The archipelago has fringing, barrier and submerged reef types. The Niua group are high volcanic islands surrounded by fringing and barrier reefs. The Vava'u group, to the south, is generally composed of high volcanic and elevated limestone islands with reef communities or fringing reefs. High volcanic and low limestone islands characterize the Ha'apai. The reef types comprise reef communities, fringing, barrier and lagoon reefs. Tongatapu, the largest island, and 'Eua are limestone-capped islands which with low islands form the Tongatapu Group (Maragos and Holthus, 1999). The reef

areas are fringing and lagoon reefs with coralline algal reefs. These form a unique fringing reef along the south coasts of Tongatapu and ‘Eua Islands. (Nunn 1993).

The prevailing winds are southeasterly and occur generally from March to October. The cyclone season (November to March) is still predominated by the trade winds but is subject to higher rainfall and the occasional tropical cyclone. The average rainfall in the capital Nuku’alofa is 1733 mm. (UNEP/IUCN, 1988) with the temperature range from 110 C to 320 C. The Niuas have a warmer climate as the result of the lower latitude.

Although the coral reefs extend along the fringes of all the islands, a comprehensive overview has only been conducted for selected areas (Zann, 1982; MPCJ 1997; Holthus, 1996). There is a lack of scientific observation and analysis for most reef areas (Table 1).

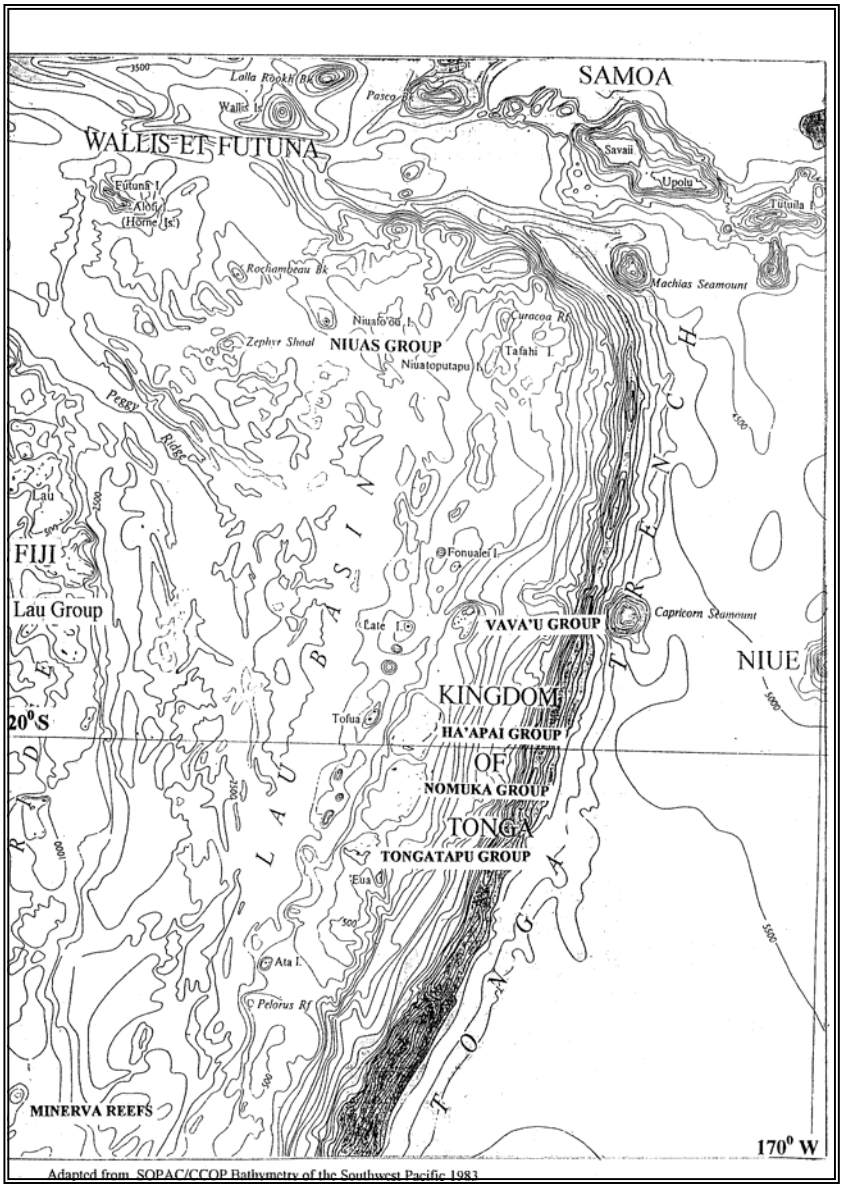


Figure 1
Bathymetric Map of Tonga.

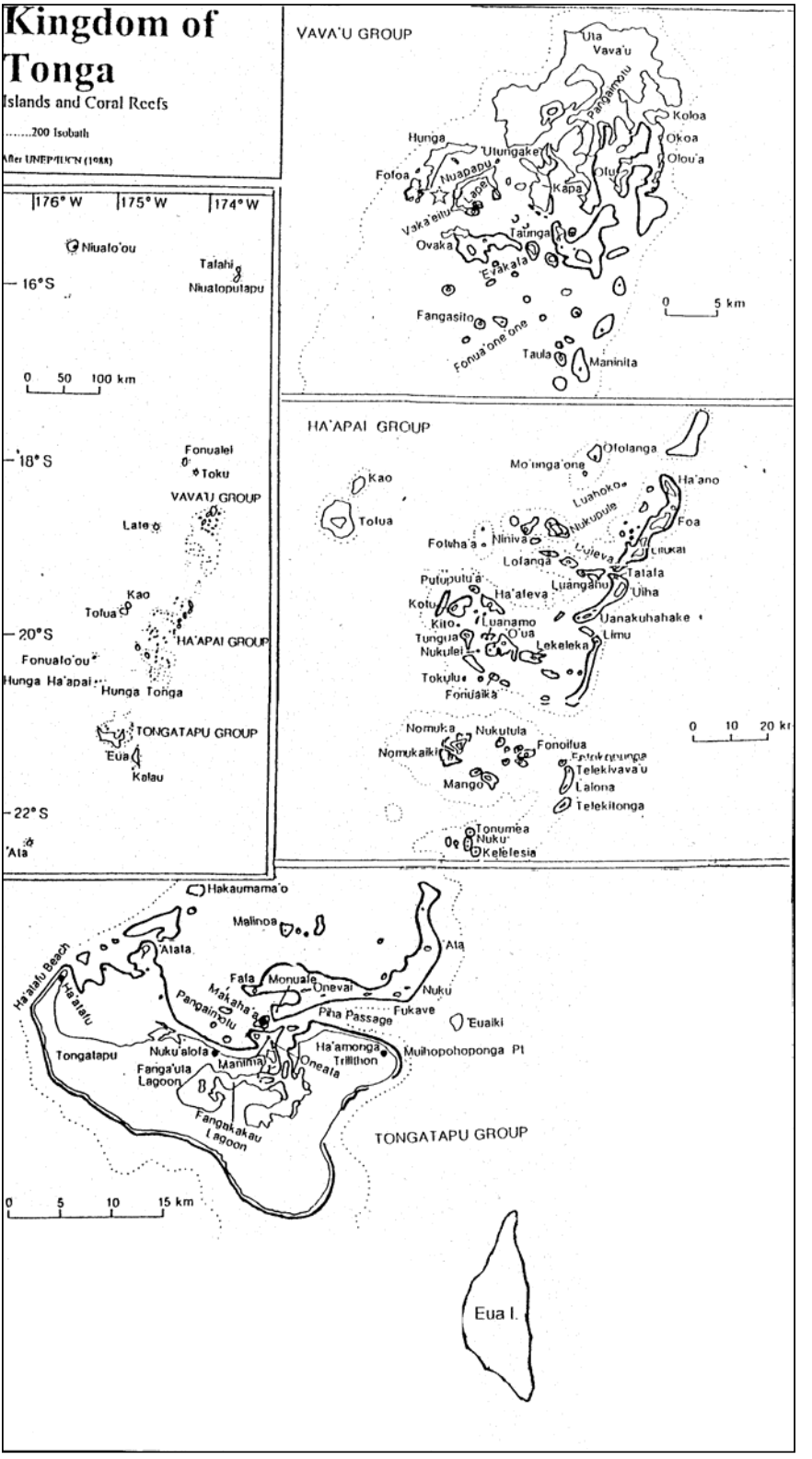


Figure 2
Kingdom of Tonga: Islands and Coral Reefs.

Status of coral reefs

Few assessments of Tongan coral reefs have been conducted. Description has been made by Dawson (1971) of Tofua, Kao, Late and Vava'u. Chesher (1984a,b; 1985) described areas around Tongatapu, Nomuka, Ha'apai and Vava'u groups. Zann *et al*. (1984) studied Fanga'uta Lagoon and adjacent coral reefs. Nunn (1993) described the unique algal-ridge forming a fringing reef along the southern coasts of Tongatapu. The Marine Parks Center of Japan (1997) conducted an inventory of the corals, molluscs and fish of Tonga's marine reserves around Tongatapu. Holthus (1996) described the coral reefs of Vava'u.

Marine Area (km2)	Total No Island Systems	Total Land Area	Total Population (1987)	No. of Recognizable Reef Systems				Tot.Lagoon And Reef Area (Km2)	Tot. Reef Perim (km)
				Reef Communities or submerged Reefs	Fringing	Barrier Or Lagoon	Atoll		
700,000	174	699	98,689	7	37	6	0	?	?

Adapted from Maragos and Holthus (1999)

Table 1
Geographic Statistics

Island and Reef Types

Details of the islands shows the types of landforms and reef types that exist (Table 2). Much information is lacking, representing gaps in our understanding of the coral reefs of Tonga. Some island types are basically volcanic some of which are active but most are composed of non-calcareous rock. The high limestone islands represent old coral reef accretion, which has been uplifted and aerially eroded. These are Pleistocene or Holocene in origin. Low coral islands are composed of deposits of coral rubble or sand.

From the larger islands of Tongatapu and 'Eua in the south, a series of reefs extend northward to Ha'apai and Vava'u. The reef types are fringing, which are represented as narrow reefs on the more recent volcanic islands to wide margins around the low islands and may contain lagoons. Platform reefs exist as detached shelf reefs. Other types are wave-cut raised reefs, lagoon and barrier reefs. Lagoon reefs are the patch reefs within the lagoon or the reef that surrounds it. The barrier reefs are those detached from the island. Reef communities are those reefs composed of coral assemblages but not being incorporated into a consolidated reef substrate. They may be referred to as submerged reefs or exist on soft bottom sediments. The long Ha'apai reef is unique as it lies on the upthrust edge of the Indian-Australian plate. The Ha'apai Group contains the largest area of coral reefs in Tonga, and amongst the largest in the South Pacific (Zann, 1994).

Name	Island Type & Number	Island Area	Reef Type	Reef Perimeter	Lagoon Area (km2)	Number of Passes and Channels	Number Lagoon Reefs
NIUA GROUP							
Fonualei	1 high volcanic	3.12	Fringing	?	0	0	0
Niua Fo'ou	1 high volcanic	52.3	?	26.8	0	?	0
Niuatoputapu	1 high volcanic	15.6	Barrier	18.8	?	?	?
Tafahi	1 high volcanic	3.4	?	7.3	?	?	?
Toku	1 high volcanic	0.4	Fringing	2.6	?	?	?
Vava'u Group							
Euakafa	?	0.52	?	?	0	?	0
Fangsito	?	0.067	Reef community & fringing	?	0	?	0
Fofoa	?	0.83	Fringing	?	?	?	?
Fonua'one'one	?	0.049	Fringing	?	0	?	0
Hunga	1 high limestone	5.6	Fringing	18.6	?	?	?
Kapa	1 high limestone	6.4	?	15.0	?	?	?
Koloa	?	1.8	?	?	?	?	?
Lape & Langitau	2 islands	0.04	?	?	?	?	?
Late	1 high volcanic	17.4	?	28.8	?	?	?
Maninita	?	0.028	Fringing	?	?	?	?
Nuapapu	?	3.2	Fringing	15.7	?	?	?
Ofu	?	1.25	Fringing	?	?	?	?
Okoa	?	0.44	?	?	?	?	?
Olou'a	?	0.49	?	?	?	?	?
Ovaka	?	1.3	Fringing	?	?	?	?
Pangimotu	1 high limestone	9.2	?	?	?	?	?
Taula	?	0.041	Fringing	?	?	?	?
Taunga	?	0.36	Fringing	?	?	?	?
'Uta Vaba'u	Many high limestone	86	Fringing	?	?	?	?
'Utungake	1 high limestone	0.93	?	?	?	?	?
Vaka'eitu	1 high limestone	6.90	Fringing	99.0	?	?	?
Vava'u	1 high limestone	103.6	?	?	?	?	?
55 Other Islands in the Vava'u Group Totaling 4,456km2							
Ha'apai Group							
Fetoa	?	0.16	?	?	?	?	?
Fetokopunga	?	0.008	?	?	?	?	?
Foa	1 high coral	13.4	?	18.1	?	?	?
Fonoifua	1 low coral	0.16	?	?	?	?	?
Fonuaika	1 low coral	0.02	Fringing	?	?	?	?
Fonuafo'ou	Submarine volcanic & intermittent island	0	Reef community	0	0	0	?
Fonualei	1 high volcanic	4.3	?	?	?	?	?
Fotuha'a	1 high	1.13	Reef community	11.0	0	0	?
Ha'afeva	1 high limestone	2.02	Barrier	14.8	?	?	?
Ha'ano	?	6.58	?	?	?	?	?
Hakauata	?	0.02	?	?	?	?	?
Home	1 submarine volcano	0.0	Reef community	?	0	?	?
Hunga Ha'apai	1 high volcanic	0.4	?	?	0	?	?
Kao	1 high volcanic	11.6	Reef community	14.2	?	?	?
Kelefesia	1 high volcanic	0.12	?	?	?	?	?
Kito	1 high	0.012	Fringing	?	?	?	?
*Kotu	1 high	0.16	?	?	?	?	?
Lalona	1 low	0.28	?	?	?	?	?
Lekeleka	1 low	0.12	?	?	?	?	?
Lifuka	1 high limestone	11.0	?	21.8	?	?	?

Limu	?	0.04	?	?	?	?	?
Lofanga	1 high	1.46	Fringing and lagoon	?	?	2	?
Luahoko	1 low	0.001	Fringing	?	?	?	?
Luanamo	?	0.024	Fringing	?	?	?	?
Luangahu	?	0.61	Fringing	?	?	?	?
Mango	1 high volcanic and limestone	0.64	Fringing and lagoon	?	?	?	?
Manoiki	?	0.16	?	?	?	?	?
Matuku	?	0.34	?	?	?	?	?
Meama	?	0.002	?	?	?	?	?
Mo'unga'one	1 high limestone	1.15	?	?	?	?	?
Niniva	?	0.49	Reef community	?	?	?	?
Nomuka	1 high limestone	5.34	?	?	?	?	?
Nomukaikai	1 high volcanic and limestone	0.66	Fringing	?	?	?	?
Nuku	2	0.016	Fringing	?	?	?	?
Nuku Falau	?	0.012	Fringing	?	?	?	?
Nukulei	?	0.012	Fringing	?	?	?	?
Nukupule	?	0.032	Fringing	?	?	?	?
Nukutula	?	0.08	Fringing	?	?	?	?
Ofolanga	?	0.89	Barrier	?	?	?	?
O'ua	?	0.97	?	?	?	?	?
Putuputu'u	?	0.001	?	?	?	?	?
Tatafa	?	0.23	?	?	?	?	?
Teaupa	?	0.02	?	?	?	?	?
Tanoa	?	0.012	Fringing	?	?	?	?
Telekitonga	1 low	0.45	?	?	?	?	?
Telekivava'u	1 low	0.02	?	?	?	?	?
Tofua	1 high volcanic	49.9	Reef community	26.7	?	?	?
Tolulu	1 low	0.012	?	?	?	?	?
Tonumea	1 high limestone	0.12	?	?	?	?	?
Tungua	?	1.52	?	?	?	?	?
Uanakuhihifo	?	0.1	Fringing	?	?	?	?
Uanakuhahake	?	0.49	Fringing	?	?	?	?
'Uiha	1 high	5.37	?	?	?	?	?
Uoleva	1 limestone	3.0	?	?	?	?	?
10 Other island in the Ha'apai Group Totaling 0.594 km2							
Tongatapu Group							
'Ata	1 high volcanic	2.27	?	?	?	?	?
'Eua	1 high volcanic	87.43	Fringing	45.2	?	?	?
Kalau	1 island	0.2	?	?	?	?	?
Minerva	1 low coral	?	?	?	?	?	?
Tongatapu	1 high limestone & 7 low coral islets	259.3	Fringing and lagoon	135.0	?	?	?
'Euaike	1 high limestone	1.05	?	?	?	?	?
Mahaha'a	1 low coral	0.039	Fringing	?	?	?	?
Malinoa	1 low coral	0.73	Fringing	?	?	?	?
Manima	1 low coral	0.03	?	?	?	?	?
Monuafe	1 low coral	0.02	Lagoon	?	?	?	?
Nuku	?	0.04	?	?	?	?	?
'Oneata	1 low coral	0.078	?	?	?	?	?
Pangaimotu	1 low coral	0.223	Fringing and lagoon	?	?	?	?
14 Other Islands in the Tongatapu Group Totaling 1.427 km2							

Adapted from Maragos and Holthus (1999): after Dahl (1991); ENEP/IUCN (1988)

Table 2
Islands and Coral Reefs of Tonga.

It is evident from the Table 2 that much needs to be documented with respect to the details of the coral reefs of Tonga. This lack of assembling knowledge prevents an accurate assessment of the country's natural wealth. Its value to tourism or fisheries relies on an understanding of the nature of the reef resource. One of the goals of the management of this resource is to quantify the nature of the reefs (i.e. replace the question marks). This is fundamental to development of coral reef management plan.

Biodiversity

There were 192 species of scleractinian corals described from the reefs around Tongatapu (11 reefs were sampled including the marine reserves). The coral coverage range from 2% Mounuafe reef to 50% at Hakaumama'o reef reserve (MPCJ, 1997). Holthus (1996) found that there was a mix of healthy, degraded and recovering coral communities (36 reef sites sampled in Vava'u). The reefs are described with respect to corals (73), echinoderms (6), some shellfish, algae and seagrass, and an overview of the reef types. The presence of the crown-of-thorns starfish was recorded through noting feeding scars.

Threatened and depleted species

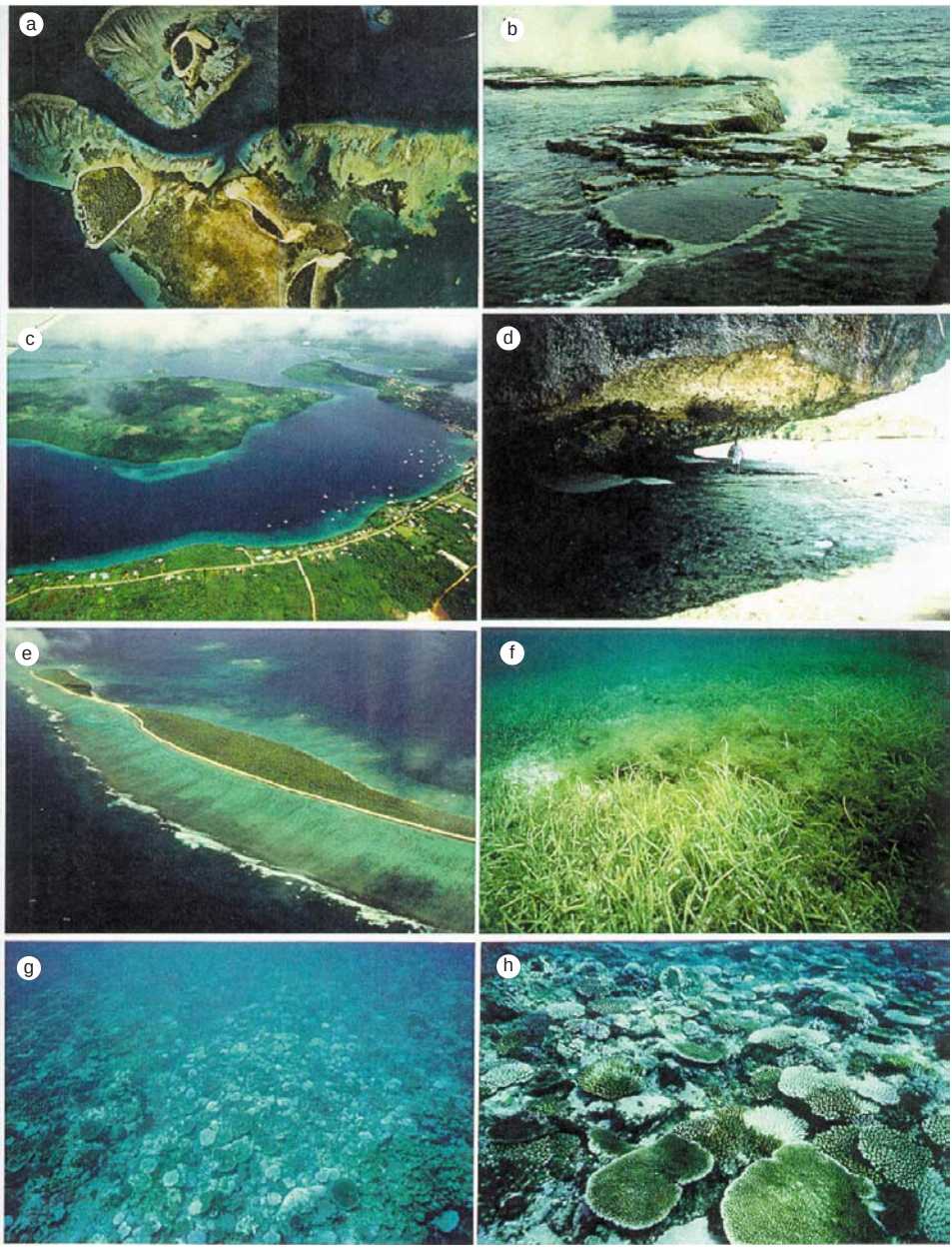
Black coral (*Antipathes*) and some molluscs were considered depleted in some areas of Tonga (ESCAP, 1990). There are six species of giant clam known to Tonga. *Hippopus hippopus*, the horse foot *Tridacna* clam has become extinct in Tonga in recent times (McKoy, 1980). This is also the case in Fiji and human collection is implicated but the fate of the species remains a mystery. The giant clam Tridacna derasa is considered severely over fished and has given rise to a mariculture program to re-establish the populations (Chesher 1986, 1987, 1991, 1993; Chesher and U. Fa'anunu, 1991). The species *Tridacna tevoroa*, endemic to the Lau and Tongan waters, has been overfished in the Ha'apai Group (Zann, 1994).

The survival of the green and hawksbill turtles may be threatened (Braley 1973 a,b; 1974). They are protected by law during the nesting season, though this is largely ineffectual (ESCAP, 1990).

Status of fishes

Biodiversity

General surveys have concentrated on the marine park areas. 229 species of fish were found in 39 families in the reefs around Tongatapu. Hakaumama'o Reef Reserve showed the greatest diversity with 127 species in 28 families. The most common families are the Labridae and Pomacentridae. Reef Fish of Tonga (Smithsonian Institute, 1993) provide information on the fishes of the Kingdom. 55 species of bivalves and 83 species of gastropods from 3 different habitats: seagrass bed, coral reef, sand were described (MPCJ, 1997). There are 13 species of holothurians, three, of which, are important commercial species.



The Coral Reef Environment: Kingdom of Tonga

a) The islands (left to right) of Pangimotu, Makaha'a, Manima and 'Oneata north of Tongatapu. The coral reefs radiate around Pangaimotu and Makaha'a with seagrass beds appearing as darker, blotchy areas inshore and, extensively, between the islands of Makaha'a, Manima and 'Oneata.

b) The coralline (*Porolithon*) algal ridge/fringing reef growth off the southwest coast of Tongatapu.

c) Narrow fringing reefs line the deep channel (~20m) between Vava'u and Pangai Motu with Neiafu middle right.

d) Wave cut notch on Koloa, a raised limestone island in the Vava'u Group.

e) A fringing reef Uonukuhahaki I. and Uonukuhihifo I. (left) and their fringing reefs in the southern portion of the Ha'apai Group.

f) Seagrass meadows north of Tongatapu with the green algae, *Cladosiphon sp.*, fouling the beds.

g) The seaward slope (5-6m depth) adjacent to Ha'atafu Beach Reserve, Tongatapu. Evidence of the coral bleaching event can be seen.

h) Close up of the coral assemblage (from g) shows coral bleaching resulting from the recent South Pacific warm water event. Bleaching in this *Acropora* dominated assemblage was largely confined to the corymbose colonies.

Fisheries

The average reef fish production is indicated in Table 3. The catch for the various localities are given in Table 4.

Subsistence fisheries	Nominal Value production (mt)	Commercial (US$) production (mt)	Value (US$) fisheries	Total fisheries production (mt)	Nominal Value (US$)
933	1,901,208	1,429	2,806,641	2,362	4,707,849

After Adams and Dalzell (1999) in Eldridge *et al.* (1999)

Table 3
Subsistence and Commercial Fisheries: Annual mean production - 1989 to 1992.

	Commercial	Subsistence	Total
Nuku'alofa	1,000	375	1,375
Vava'u	250	280	530
Ha'apai	100	180	280
Other	79	98	177
TOTAL	1,429	933	2,362

FAO Digital Atlas, 1998

Table 4
Catch landings (tonnes).

The finfish resource from the shallow-water reefs has been a major source of protein both in the subsistence and the artisanal fisheries in Tonga. 1993 estimates of fish landings at two landing sites, Vuna and Faua in Nuku'alofa, indicate that fish species classified as shallow-water reef fishes make up almost 70 per cent (200 mt) of the total artisanal finfish landings there. The main fish family recorded was parrotfishes. In 1987, the shallow-water reef fish landing in the Tongatapu artisanal fishery was estimated to be 333 mt of which emperors were the main family. 140 tonnes of mullet were landed. Apart from the reef and lagoon fish, other coral reef fisheries are beche-de-mer, the molluscs (trochus, triton, shell collecting, *Tridacna spp.*), aquarium coral and fish, and precious coral.

Though many of the mollusc resources are not harvested on a sustainable level, these resources have been an important seafood component in both the subsistence and artisanal levels of utilization. Giant clams have been subjected to heavy exploitation leading to very low populations in certain areas. The estimated shellfish (including giant clams) landing at Vuna and Faua in 1993 is 118 mt with *Anadara* making up 34 per cent and giant clams 33 per cent.

The development of the aquarium fish trade in Tonga has led to the utilization, not only of the small colourful reef fishes, but also juvenile giant clams, other shellfish species, corals and sea anemones (Matoto, 1997; Oliver and Smith 1994; Matoto et al. 1996). Export data submitted by the main aquarium fish exporter indicate that, in terms of the number of pieces exported during 1993, corals made up about 60 per cent of the total exports during the year. Between 1995 and 1996, aquarium exports by composition were fish 27 %, live coral and rock 29 %, soft coral 27 %, invertebrates 15 %, giant clams 2 %. Of the fish, 54 % were damselfish, 17 % angelfish, 11 % wrasses, 8 % clownfish, 6 % hawkfish, 2 %, butterfly fish and 2 % tangs (Matoto, 1997).

Harvesting of sea-cucumber for consumption on the subsistence level has never been high. This resource forms only a small portion of the local fishery. However, the commercial production of

bêche-de-mer for export has been a major development within the last few years. Some limited processing was reported in the 1980's but the industry boomed starting in 1990 when markets were established for a species currently known in Tonga as the sandfish, *Holothuria scabra*. This sea-cucumber species is abundant in shallow lagoons and fetches higher prices than the teatfish.

Two giant clam species, *Tridacna* gigas and *Hippopus hippopus*, were re-introduced into Tonga in 1990 and 1991. Both species are believed to have become locally extinct. The giant clam project started in Tonga with the creation of clam circles in 1986. Clam circles were created by the Ministry of Lands, Survey and Natural Resources in an attempt to revitalize the stocks of these animals. Several community giant clam sanctuaries were initiated. The first community-based clam circle was set up in Vava'u (Falevai community circle) and the Fisheries Division has continued with the program. Due to faster growth rates, the current giant clam project is concentrating on the production of *T. derasa* and *T. tevoroa* and the establishment of community-owned ocean nurseries. Recent inspection has revealed the clam circles at Falevai to be depleted of clams due to stealing and lack of attention. Signs have been erected to warn yachts from anchoring there (World Bank Report, 1999c).

Four hundred live *Trochus niloticus* were introduced from Fiji in 1992 and released on a reef west of Tapana Island, Vava'u (donor FAO). In 1994, 1100 were released in Tongatapu (donor JICA). In 1995, 500 were released in Ha'apai (FAO/JICA donors). In 1994, there was the first spawning induction and 2000 were released in Vava'u, Ha'apai, Tongatapu, and Niue. The second spawning in 1997 produced 10 000. About 2000 were released in Ha'apai and Vava'u. Evidence of new recruitment were reported from Vava'u, Ha'apai and Tongatapu.

Fifty mature green snails, *Turbo marmoratus*, were introduced from the Republic of Vanuatu in 1995. Twenty of these green snails were released in the wild at Hufangalupe but 23 were kept in baskets at the Ministry of Fisheries' giant clam ocean nursery in Sopu (FAA 1994). In 1996, 320 were introduced from Okinawa, Japan and 30 introduced from Vanuatu. 2719 were released in Tongatapu, 2500 in Vava'u, 500 in Ha'apai. In a seed production and release program in 1997, 40 were released. The program continues with 1900 (1997), 3800 (1998) and 10 000 (1999) released in cages and raceways. JICA researched an environmental impact assessment, though there has been no attempt to conduct an EIA for other species.

Four *Panulirus* species of spiny lobsters are found in Tonga. The main species harvested are the double-spine lobster (*P. penicillatus*) and the slipper lobster (*Parribacus caledonicas*). Information on the stock size, ecology and biology of this animal is incomplete. The stock is declining from overfishing.

There are seven species of mullet in Tonga. Four, of which, are currently fished and declining due to being overfished. In 1992, MOF/JICA set up a project to culture mullet in Tonga. Fish fry of the species *L. macrolepis, V. seheli, M. cephalus* from the wild and were reared for re-stocking in pens constructed near Tofoa in Fanga'uta lagoon but was later destroyed by hurricane.

Fisheries policies

Tonga's overall fishery policy is to increase fish production for export and as a source of high-quality protein for Tongans. Along with long lining and mariculture, future management objectives are to improve the subsistence and small-scale commercial fisheries. This involves development of fishery co-management arrangements to promote greater involvement by fishers and communities in inshore resource management.

Tonga has a limited natural resource base except for the potential of the EEZ. Fish is one of Tonga's highest export commodities, and marine fish offer considerable potential for sustainable resource

development. Although increasing amounts of imported fish and meat are consumed, especially in the urban centers, fish remains important particularly in the outer islands. Lack of land means an increasing reliance on the subsistence marine products. Subsistence activity from shallow-water reef and lagoons surrounding the islands provides a vital source of protein. The Government of Tonga is concerned with developing methods of increasing commercial production of fisheries without overexploiting. Fisheries are important but Tonga is a net importer of fish products. Much of the fishing is semi-commercial. 70% of the total annual catch are reef-lagoon fish. Octopus is popular and often abundant. Clam fishing used for local consumption, decoration and a small amount of export. Black coral is collected and fashioned into jewelry. Turtles are eaten for eggs and meat with the carapace used for decoration and jewelry.

Natural and anthropogenic threats to biodiversity

Anthropogenic Threats

75 % of the islands are uninhabited. The population is principally located on Tongatapu and around the provincial centers on ‘Eua, Lifuka in the Ha’apai and Neiafu in Vava’u. The population is growing at 0.5 % annually and there is an urban growth of 2.5 %. As a result, fishing has reduced stocks around Tongatapu and other populated areas.

Anthropogenic threats may involve construction, quarrying, pollution, overfishing, recreational activities or tourism. Fishing activities such as gleaning, dynamite or poisoning can have persistent impacts. Siltation from construction and quarrying sites have degraded the reefs adjacent to Nuku’alofa and Neiafu, Vava’u, though this is a localised problem in all of the groups. Causeway construction in the Ha’apai and Vava’u has caused degradation. Mangrove cutting has been banned but still occurs. Sand mining from beaches and dunes is a major problem.

The World Bank Report (1999b) identified threats at the community level as waste or rubbish pollution, pressure on resources from outside users, the cutting of mangroves and damaging of corals. Pollution and damage may result from discarded fish-fence wire and batteries. Removal of shell, gravel and muddy sands has destroyed mussel habitat. Causeway construction has blocked the water interchange and caused a build up of mud, which affected *Gafrarium* stocks. Anchoring in the clam circles was perceived as a problem. Net fishing and sophisticated gear use contributed to overfishing.

Eutrophication

Tonga does not have a sewerage system. Eutrophication by sewage (septic systems) occurs particularly at Nuku’alofa. An estimated 250 t of fertilizer is used on Tongatapu and Vava’u each year as of 1990 (ESCAP, 1990; Zann, 1994).

In Fanga’uta Lagoon, Tongatapu, an increase in seagrasses and mangroves and a decline in stony corals were to some extent attributed to eutrophication from urban nutrient run-off (Zann *et al.*, 1984; Zann and Muldoon, 1993). Landfill and the cutting of mangroves were considered problems.

The monitoring program currently running as part of TEMPP project (Tonga Environmental Management and Planning Project) is assessing the physical and environmental parameters such as nutrients, trace metals, pesticides, and general biology of the lagoon (Morrison J. 1999). The monito-

ring is budgeted to the Environmental Planning and Conservation Section, Ministry of Lands, Survey and Natural Resources to continue to the project.

Initial assessment of the physical and environment parameters, seem normal (e.g. pH, salinity, temperature, dissolved oxygen, and turbidity. The results were similar to other non-polluted lagoons being relatively free of contamination.

Summary research results found that nitrate and phosphate are limiting with respect to seasonal patterns. Four general surveys per year and a monthly program for nutrients are underway. Nitrates and phosphates are below the EPA guidelines. Ammonia was slightly elevated in some areas but below the EPA guidelines. The possible sources are septic system contamination.

Tests for E. coli in water, sediment and shellfish found levels below the EPA and WHO guidelines. The lagoon is considered safe for recreation and gleaning. Pesticides residues were sampled in sediment and soil. Two pesticides were present but in very low (ppb) concentrations (Chen, 1999).

Trace metals, though present in shellfish and sediments were unlikely to cause any major health problems. For many elements, the concentrations were below the detection levels, confirming no major problems with metal contamination (Brown and Morrison, 1999).

Tourism

Tourism is increasing with fishing pressure on delicacy items like lobster. SCUBA diving is available in Nuku'alofa and Vava'u increasing tourist appeal and making more of the coral reef available. Tongan tourism increased from 17 000 annually in 1982 to 25 500 in 1992. In some areas, the continuous fossicking by tourists is responsible for the breakage of corals though that caused through gleaning by Tongans is widespread and far exceeds this. Habitat loss has impacted other marine life. Anchorage of boats whether due to local fishing or tourism (diving boats etc) can be a problem.

Overfishing

For inshore fisheries, increased fishing pressure driven by improved access to markets, rising prices, and population growth is resulting in remarkable declines of important inshore marine resources (World Bank, 1999 a,b,c). There are numerous indications that both the condition of the resource is deteriorating and conflicts between user groups are increasing. Unlike the situation in other Pacific Island countries, coastal communities in Tonga have no preferential access to adjacent resources. This open-access situation may have worked reasonably well in the era of subsistence fisheries, but it has fairly recently collided with commercial realities and the carrying capacity of inshore resources. There is heightened concern by residents of outer islands that Tongans from anywhere, especially commercial operators from Tongatapu, could harvest the food resources adjacent to their villages in outer islands thereby affecting the food security situation. The Ministry's management interventions in inshore fisheries appear to fall into two categories: (1) implementation of the provisions of the Fisheries (Conservation and Management) Regulations 1993, and (2) bold action in support of fisheries which have collapsed (e.g. banning the export of giant clams in 1994 & beche-de-mer in 1997).

In many areas, overfishing of inshore resources is now severe and the deficiencies of a centrally implemented, regulation-based management system are becoming apparent. Fishery regulations are generally poorly understood or observed, and enforcement through Tonga's many scattered islands and reefs are difficult or impossible. The government is thus now investigating the possibility of co-management arrangements, under which responsibilities would be shared between government and fishing communities. Many local fishers and communities are in favour of such arrangements, and a pilot project is likely to be soon underway in Ha'apai (Petelo *et al.*, 1995; Gillett, 1997).

A ban on beche-de-mer exporting has been imposed in response to serious overfishing during the past five years. The ban is for ten years, although there is provision for a review after five years. Overfishing is a problem with other species, particularly clams. Black coral has also been over-exploited. The method of dragging an anchor line along the seabed to collect black coral is damaging to general benthos.

Destructive fishing techniques can be a major contributor to reef degradation. These involve smashing reefs to chase fish into nets, and the turning and breaking of rocks and coral to take invertebrates. Trampling of coral during food gathering on reef flats is a problem. Poisons such as bleach and pesticides are used.

Impacts on Vava'u Reefs

Holthus (1996) found human destruction and degradation of the coral reefs of Vava'u resulted directly form the breakage of coral during fishing activities, and indirectly from the input of increased silt and possibly chemicals (e.g. pesticides) and nutrients. Indicators of disturbance, *Acanthaster, Diadema spp.* and dead standing coral, were concentrated near land and in the eastern reef areas where coral diversity and live coral cover were found to be lower. Chesher (1985) found that 65% of the 100 reefs surveyed showed evidence of coral destruction from both natural and anthropogenic sources. Coral breakage through destructive fishing techniques during gleaning activities has heavily damaged some areas. The use of poisons may be widely destructive to fish and invertebrates and have long term impact. He detailed pollution sources (Chesher, 1984a).

Areas of Impact

Areas of disturbance are Fanga'uta lagoon in Tongatapu (eutrophic, major coral mortality and collapse of fisheries); Nuku'alofa and adjacent northern Tongatapu (physical disturbance, loss of habitat, eutrophic, overfishing, coral mortality). The inner reef areas along Ha'atafu Beach have experienced a proliferation of algal growth (*Turbinaria and Sargassum spp.*) in recent years due to eutrophication of lagoon waters. Inner Neiafu Harbour in Vava'u has been affected by sedimentation, crown of thorns, overfishing, and coral mortality (Zann, 1994).

Natural Impacts

Natural threats are volcanic activity, tropical cyclones, *Acanthaster* outbreaks, coral bleaching, coincidence of low spring tide, high temperature and rainfall. Coral mortality and the colonization by blue green algae may result from a variety of natural circumstances but may be attributed to stresses caused by storm damage, pollution, causeway construction and destructive fishing techniques (Chesher 1985). As most islands are low and lack rivers, soil loss and flooding is minimal. Flooding can be a major problem with cyclonic rain on Tongatapu.

Destructive cyclones occurred in the years of 1982, 1995, 1997, 1999 and 2000. In 1998, an El Niño year, high temperature during a daytime (noon) spring low tide affected benthic marine organisms. La Nina periods following El Niño are characterized by a period of heavy rain, decreased salinity and may affect marine organisms, especially during spring low tide.

The crown- of- thorns starfish, *Acanthaster planci*, have been reported throughout the archipelago. Outbreaks of the starfish have not been noted but chronic elevation of numbers has been recorded in Vava'u harbour in the early 1970 and 1980's. Moderate numbers were recorded at Ha'atafu and Pangaimotu Island off Tongatapu in 1992 (Zann and Muldoon, 1992).

Current and potential climate change impacts

Global warming

In recent years, concern has grown that the Earth's atmosphere is changing due to human causes burning of fossil fuels and deforestation among them. It is feared that this effect may cause global warming with an increase in sea temperatures. Studies suggest that global change of this magnitude could cause significant problems, including melting of the icecaps resulting in a sea level rise.

Global warming and sea-level rise are of concern in the low islands in terms of an alteration of coastal processes, submergence, pollution of groundwater and coral bleaching. Climate change may mean increased cyclonic activity, alteration in the rainfall pattern and periodic elevation in sea temperature.

Coral bleaching

Coral reef bleaching is a response to stress. The bleaching refers to the colouration of the organism resulting from the breakdown in the mutualistic dependency between the coral and the zooxanthellae. The corals lose some or all of the symbiotic microalgae (zooxanthellae), living in its endodermal cells. The effect occurs in diverse invertebrate taxa. It frequently results in a white colouration due to the whiteness of the coral skeleton or the soft coral tissue. A bleached organism may be particularly brightly coloured due to the appearance of its natural animal coloration in the absence of the darker, green/brown, zooxanthellae. Though bleaching may be caused by a variety of stresses (freshwater, ultra-violet light). The recent widespread bleaching observed globally is the result of prolonged periods (few weeks or more) of elevated temperature 1-20C above average sea temperatures.

Historically, published records of coral reef bleaching incidents from 1870 to present suggest that the frequency, scale and severity of recent bleaching events are unprecedented. There have been 60 major events from 1979 to 1990 globally (Glynn, 1993) with four of the most severe occurring in French Polynesia in 1994; Maldives and Indian Ocean in 1997/98; the Great Barrier Reef in 1998; Palau in 1998 and Fiji, Tonga and Cook Islands in 2000. There has been a co-occurrence in many coral reef regions and often over the bathymetric depth range of corals with > 95% mortality in some areas.

Causes of small scale bleaching events can often be attributed to particular stresses but the widespread effect is certainly from elevated temperatures caused by maximum seasonal solar heating and calm clear weather allowing the sea surface to heat up. Global temperature satellite surveillance by the National Oceanic and Atmospheric Agency (NOAA) has revealed areas of elevated sea surface temperatures, which exceed the average sea temperatures for periods of time and are characterized by a bleaching event. A constant referred to as Degree Heat Weeks (DHW) is now being tested to determine the extent of bleaching as the result of both degree of elevation over the average, and length of warming period. In the Maldive Islands situation (Wilkinson *et al.*, 1999) and currently in Fiji, the satellite assessment of hotspots was very accurate in determining the areas and degree of bleaching that occurred.

Given the projected elevation of temperatures (1-20C) over the next 30 years (Manabe *et al.*, 1991), there is concern that the upper thermal tolerance limits of many reef-building corals could be exceeded. Many corals may be unable to adapt physiologically or genetically to such marked and rapid temperature increases. Coral bleaching around the world would increase in frequency and severity until it occurred annually by 2030, unless global warming is reversed. Depending on its severity or frequency of occurrence, a single bleaching event will take reefs from 30 to 100 years to recover. If there

is unrestrained warming, then the coral fauna will be progressively reduced and require a much longer recovery time. Genetic accommodation, replacement by heat resistant species and/or global cooling would ameliorate the effects of bleaching (Hoegh-Guldberg, 1999).

The South Pacific bleaching event currently underway was the result of the warming of a band of oceanic water extending from Fiji to Easter Island and included the Cook Islands and Tonga. Bleaching has occurred in all of those places.

In Fiji, bleaching is 90% in some areas. Only a few species remain unaffected. The effect is not uniform with less bleaching in the far northern part of the group. Other areas of the country for some unknown reason appear less affected. The bleaching is mainly confined to shallower than 30m and is not widespread at 40m.

Tongan Bleaching Event

Tonga has reported coral bleaching (February, 2000) around Tongatapu and the Ha'apai Group. Observations from the Ha'atafu Reserve on Tongatapu (May 5-10) revealed the phenomena to be widely evident on the reef slope and in the lagoon. The event was similar to Fiji with the corals exhibiting varying degrees of bleaching. The nearshore lagoon is dominated by Montipora hispida with M. incrassata subdominant. Though representing areas of substantial coral cover, these species showed only minor bleaching. By contrast, *Goniastrea retiformis, Platygyra sinensis* and *P. daedalea* were invariably 80-100 % bleached.

On the outer reef slope, the corymbose *Acroporas* were most notably affected with the tabulate colonies showing only minor bleaching and, in many cases, unaffected. Coral death was minimal with a visual estimate of 2-5 %. Those that had died and were covered in part or wholly by algal growth were the hydrozoan corals *Millepora exaesa* and *M. dichotoma*. Among the Acroporas, *A. humilis, A. monticulosa* and *A. robusta* were characterized by varying degrees of death. The first two showed a range of minor bleaching to total colony death. Some colonies of *A. robusta* were apparently entirely unaffected though other colonies were part or totally dead. Many colonies of this species were totally bleached though still living.

Future Bleaching Events

In 1997-98 the hottest average sea temperatures on record occurred in the Indian Ocean and this effect migrated throughout the Indian Ocean to varying degrees. The southeast Asian and western Pacific area was affected with particularly devastating effects on the coral reefs of Palau. In some places, the coral mortality was >95 %. Coral reefs became algal reefs.

In the worst case scenario, events as severe as 1998 are now projected to become commonplace by 2020. Globally, coral reefs are expected to face bleaching every year by 2030. During the past 100 years the gradually increasing sea temperatures have been pushing the reefs closer to their tolerance levels, so now even the slightest increase in temperature can cause coral bleaching, This was witnessed in the Solomon Islands this year.

The question remains as to how well the corals will adapt to the hotter conditions. Corals are not showing any sign they can adapt fast enough to keep pace with changes in ocean temperature. Most of the evidence indicates bleaching events are signs that the genetic ability of corals to acclimatize is currently being exceeded (Hoegh-Guldberg, 1999). Natural selection may prevail with the alteration in the species composition of the affected reefs.

Rising Sea-level

Sea levels have fluctuated widely in the geologic past. Since the last ice age, sea level has been relatively stable. However, during the past 20 years, concern has been expressed in the scientific community that the atmosphere may be warming, and causing sea levels to rise catastrophically, with the melting of polar ice.

If sea level change is a reality, it will have dramatic effects on coastal communities throughout the world. Although, coral reefs may be able to continue their upward growth with little real change in reef communities. However, there are limits to the rate of effective upward growth. Coral reefs represent a variety of locations and their growth rates also vary. Reefs which occur at depth grow more slowly and may be approaching the Darwin Point (Grigg, 1982) where they may 'drown' due to tectonic submergence. Some coral reefs that cannot continue their upward growth may have growth retarded due to factors such as chronic turbidity.

El Niño conditions are accompanied by lower than normal sea level in the Western Pacific, which may lead to widespread death of corals due to exposure to air. Corals and coralline algae, and certain other reef organisms are distributed in well-defined zones. Organisms are distributed as they are in relation to tidal levels in the intertidal zone partly in response the rates of exposure. If for any reason such organisms are subject to different levels of exposure, they may die. Some are found only in wave washed areas or very shallow water, and very far from the intertidal zones.

Increase in cyclonic storm intensity, rainfall extremes, frequency of El Niño events

Anecdotal observations include:

- a greater frequency of cyclones in the last few years;
- increased rainfall;
- higher average water temperature;
- sea level trend positive (19mm/yr.) during the last few years;
- seasonal variation shift by few weeks;
- coral bleaching event in Tonga;
- potential changes of the marine ecosystem and habitat due to changes in salinity etc.

Potential climate change impacts:

- erosion of coastal environment;
- low lying areas in Tonga will be affected by the ingress of sea water;
- changes in marine habitats.

Marine protected ateas

The concept of parks and reserves is not new to Tonga. In 1946, 'Ata, the then Minister of Lands, gazetted a park reserve at Haveluloto along the shore of Fanga'uta Lagoon. This set the legal prece-

dent of parks and reserves coming under the Ministry of Lands and demonstrate the foresight on the part of the Tongan government. Then in 1972, King Taufa'ahau Tupou 1V declared 2 reserves at Muihopohoponga and at Ha'amonga Trilithon. Muihopohoponga is a 2 km stretch of beach on the extreme eastern end of Tongatapu. The Ha'amonga Trilithon, the Stone Henge of the South Pacific, is a 23 hectare reserve. Under the Parks and Reserves Act of 1976, Tonga has gazetted two national parks, which comprise the entire islands of Mounuafe and Malinoa and five marine reserves. In 1979, two reserves were established around the island of Malinoa and Mounuafe and three reefs at Pangaimotu, Hakaumama'o and Ha'atafu. The Ministry of Lands, Survey and Natural Resources administers parks and reserves.

The Minister for Lands is the chairman of the Parks and Reserve Authority with the members including the Secretary for Lands, Survey and Natural Resources, Secretary for Fisheries, Director of Agriculture and Forestry, Director of Tourism, Head of Environmental Planning and Conservation Section of the Ministry of Lands, Survey and Natural Resources.

The whole Ha'apai group was declared as the Ha'apai Conservation Area by Cabinet following the recommendations by SPREP, Ministry of Lands, Survey and Natural Resources and the Ha'apai Committee. Proposed reserves for Vava'u are the Coral Garden at Nuapapu, Maninita and Mounu Island. Biological surveys or inventories of the reserves were carried out by Marine Parks Center of Japan (MPCJ) and the Ministry of Lands, Survey and Natural Resources in 1997.

The Ministry of Lands, Survey and Natural Resources coordinates policymaking, natural resources and enforcement, as well as parks and reserves. Under the Parks and Reserves Act (1972), there were five marine reserves on Tongatapu (see below). Some areas have been protected through Royal Proclamation. Fanga'uta and Fangakakau Lagoons are protected under the Birds and Fish Preservation Act of 1915 against commercial fishing, traditional fish traps, effluent discharge, dredging, the construction of any building works, harbours, wharves, piers or jetties, or the cutting of mangrove trees.

The Parks and Reserves Act 1988 protects, manages and develops natural areas. The following five parks and reserves have been established under this Act (WCMC 1991):

- Fanga'uta and Fangakakau Lagoons Marine Reserve - Tongatapu
- Hakaumama'o Reef Reserve
- Pangaimotu Reef Reserve
- Monuafe Island Park and Reef Reserve
- Ha'atafu Beach Reserve
- Malinoa Island Park and Reef Reserve.
- 'Eua Island National Park*

(* not marine)

Areas of black coral have been set aside by Government and a program of fragmenting and planting are management measures. Protected clams, arranged in circles, were also established to promote re-establishment of clam stocks. Turtles are theoretically protected through the Bird and Fish Preservation Act.

Enforcement of park boundaries and regulations is poor. From the Fisheries Sector Study (Gillett 1997), Adams and Ledua (1997) reviewed the regional experience with reserves and stated some of the problems:

- Marine protected areas do not have a good record in the Pacific. It is usually difficult to get community agreement to set them up, and in areas where they do exist they are rarely respected or effec-

tively enforced. The lack of respect for the legislation sometimes results from its new and novel nature. Community-based management or involvement in decision making is a new concept to Tonga as well as the other Pacific countries. Generally legislation in Tonga uses a top down approach. Progress is being made with the community and NGO involvement is now in place.

- A particular community could be required to give up effective ownership of an area (even if legal ownership is vested in the State) for the long-term benefit of other communities.

- The efficacy of reserves for rehabilitating or sustaining surrounding fisheries has not yet been unequivocally proven whilst their capacity to divert resources from other, perhaps more effective management and conservation methods, is well known. Despite this there is widely held belief and evidence that reserves are effective for rehabilitating and sustaining marine resources. Reserves are established for different purposes (IUCN categories) and each reserve serves its duty well enough even though there may be abuse through fishing.

- With marine reserves in place, fisheries managers may be lulled into tranquillity and feel that nothing further need be done. Generally, however, diverse activities have been carried out in the reserves. A management plan is in place with a program of development. Funding and manpower can be a problem for some aspects of development and monitoring.

In view of the above concerns, Gillett (1997) recommended only carefully considered and judicious use should be made of marine protected areas for inshore fisheries management in Tonga. Attention should be given to:

- Establishing reserves only where there is full consultation and agreement from adjacent communities;

- Realistically appraising the amount of surveillance/enforcement required for each reserve;

- Assessing the total amount of Ministry surveillance/enforcement resources available for all inshore resource management and assuring that those resources channeled to reserves are in proportion to the benefits from reserves (i.e. not a dominant portion of all surveillance/enforcement resources)

Clam Circles and other protection

The first clam circle was at Mounu Reef and was established by the Ministry of Lands, Survey and Natural Resources with Dr. Richard Chesher and in the Pangaimotu Island Reserve. The first community-based sanctuary was established at Falevai by the Ministry of Lands and the Falevai community. Through awareness of the project's objectives, respect was gained for the clam sanctuary concept. The success was the result of developing local understanding, providing legal protection and local involvement. A video was made and proved effective. In 1990, the King gave a prize for the best Giant Clam Sanctuary, which exists today. Sadly poaching occurred by a Fisheries officer in Vava'u. The Ministry of Fishery later established many clam circles in Vava'u.

Policing of reserves, generally, is not difficult but funding is the main problem. There are two boats for patrol and scientific survey. Equipment was provided by JICA. Policing in Tongatapu of several marine reserves has been a problem. Unlike the clam projects, the locals were not involved in the creation of and the gaining of respect for the reserves. Protection has proved to be extremely difficult.

Game fishermen tag and release billfish and international billfish tournaments encourages tag and release. Sailing charter companies encourage protection of the marine environment by providing details of suitable anchorages. 1997 Guidelines were created and piloted by collaborative efforts between government officials and operators in an attempt to further protect the maritime environment (Ruffle-Klugkist, 1998).

Flint (1999) notes seabird breeding sites of world importance. They are the islands of Fonualei, Hunga Tonga, Hunga Ha'apai, 'Ata, Late, and Tofua. There are 16 breeding species and only one sea bird reserve. The vulnerable species that nest here are Herald's Petrel, Audubon's Shearwater, and possibly Phoenix Petrel. The threats are mammalian predators and human use. Actions required are the survey of the nesting populations, protection, management, and predator control. There is moderate intern legislation for the protection of seabirds.

A detailed environmental management plan has been prepared but not implemented (ESCAP, 1990). Tonga is signatory to the Convention on Biological Diversity and the U.N. Convention on the Law of the Sea. It is not signatory to the Convention on International Trade in Endangered species.

Conservation needs to be preached from the pulpit. There must be a responsibility for the clergy to preach conservation. It could be used in Tonga with effective results.

Current monitoring and management capacity

Monitoring

There is currently a monitoring program on marine parks and reserves in Tonga, which includes six-monthly surveys of all the reserves, surveillance fortnightly, and an awareness program. A management plan for the Parks and Reserves is now in place. TEMPP (Tonga Environment Management and Planning Project) is a project of environmental capacity building by the Ministry of Lands. Its activities including a monitoring program for the Fanga'uta Lagoon which is conducted by EPACS.

Control, development and management of the fisheries resources are the responsibility of the Ministry of Fisheries. Problems exist with the regulation and management of coral reef fisheries. Active management intervention, as envisaged by the Fisheries Act, is largely absent (Gillett, 1997). In the eight years since the Fisheries Act became law, no fishery plans have been prepared. No licensing of fishing vessels presently occurs, and there appears to have been a lapse in the licensing system for fish fences. With a few notable exceptions, enforcement of the existing laws and regulations has been weak. The Sector Study's Legal Specialist noted that since the Fisheries Act came into operation, only a few fisheries cases have been prosecuted and there is currently no set enforcement or regular inspection programme.

Although the lack of information is sometimes cited as the reason for lack of management action, in many important and declining inshore fisheries there has been significant research. There seem to be numerous cases of substantial research leading to management suggestions upon which little action has been taken. For example, Preston and Lokani (1990) recommended several simple, easy-to-implement management measures for beche-de-mer, none of which were implemented until the fishery was doomed. Kailola (1995) gives detailed information and proposes management action for beche-de-mer, lobster, mullet, *Tridacna*, aquarium fish, coral, and octopus as well as seven other inshore resources, but there appears to have been no follow up action. Udagawa *et al.* (1996) give a history of advice on lobster management in Tonga and show "10 years of delay and negligence" in its implementation. This inactivity in fisheries management is thought to be related to the lack of accountability of the Ministry.

Management measures

Current programmes

Following are some recent or current programs:

- The JICA inventory surveys of the reserves, which includes corals, fishes and other coral reef organisms. There is a local training component in survey techniques.

- The Smithsonian Institute Washington D.C, conducted reef fish surveys

- The GEF/UNEP sponsored the development of the Biodiversity Strategy and Action Plan

- The National Tidal Facility (Aust.) program is monitoring sea level. This involves a tide gauge installation, data available for tide, sea level and temperature and other physical parameters.

- The International Maritime Organization (IMO) has a program concerned with marine pollution control.

- SPREP has a Biodiversity Conservation Area

Marine Tenure: a conservation strategy

Although practiced in the past, customary marine tenure has not been active in Tonga since 1887, and access to fishery resources is now open. Tongans may fish anywhere (apart from in marine reserves and other formally-declared closed spaces), and management is through legislation and regulation rather than a community-based system. Various fishery regulations have been promulgated, relating to size limits, licensing of fish fences, use of fish aggregation devices and the control of fish exports and processing facilities.

Surveys

The Australian Institute of Marine Science (AIMS) has conducted training in the Global Coral Reef Monitoring Network (GCRMN) techniques of coral reef survey using the AIMS Reef Monitoring and Data Entry System (ARMDES) method. Interest in the wild harvest of the edible seaweed *Cladosiphon sp.* for the Japanese market has led to the survey and assessment of resources throughout the Kingdom.

International and Regional Assistance

The South Pacific Regional Environmental Programme (SPREP) has actively supported studies in Tonga for reef description such as Holthus (1999) which involved fisheries recommendations for coral harvesting. Also SPREP supported an assessment made by Oliver and Smith (1994). SPC conducted an environmental impact assessment on the aquarium fish and coral trade (Moat et al. 1996). Matoto's (1997) description of the aquarium trade was supported by the University of Rhode Island. The Forum Fisheries Agency (FFA) compiled the Fisheries Resources Profiles: Kingdom of Tonga (Bell et al., 1994). The Food and Agriculture Organization (FAO) of the United Nations Development Programme (UNDP) produced the Fisheries Sector Study (1997). FFA and FAO provided a regional compendium of fisheries legislation (1993). Japan International Cooperation Agency (JICA) has developed an aquaculture project involving in research and facility.

Government policy laws and legislation

The overall theme during the Kingdom's Fifth Development Plan period (1985-1990) was geared towards identifying options to enhance the basic subsistence living. Thus emphasis was placed on the development of the commercial private sector which included fisheries. The Sixth Development Plan (1991-1995) aims at achieving sustainable economic growth conducive to a higher per capita income with special emphasis placed on export and tourism sectors. Fisheries have been identified as one of the sectors demonstrating the highest growth potential. It also encourages alternative fishing habits to prevent over-exploiting of tradition fishing grounds.

Below are acts that relate to coral reefs and several have been reviewed by Pulea (1992):

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

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

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

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

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

- Part II of the Act deals with Fisheries Conservation, Management and Development. Section 3 requires the Director (now Secretary) of Fisheries to progressively prepare and keep under review plans for the conservation, management and development of the fisheries in the fisheries waters of Tonga. The Director is required to consult with local government authority and local fishermen concerned in the preparation and review of each fishery plan. The Minister approves these plans. The general provisions of the act include prohibited fishing methods, reserved fishing areas, import and export of live fish, controls over the export of fish and fish products, statistics (Gillette, 1997).

- Bird and Fish Preservation Act provides protection for certain species of fish, birds and turtles, mangroves and the use of certain traps, drilling dredging or polluting of lagoons.

- Fisheries Regulation Act 1989 provides for the protection of whales, use of poisons and explosives and require licenses. Prohibit fishing for coral, marine mammals or leatherback turtles or not remove eggs. The remaining species of turtles are restricted to a season of 5 months. *Tridacna sp.* had size limits as have pearl oyster and triton shells. Collection of lobsters and slipper lobsters are restricted to size and banned if carrying eggs.

- Park and Reserve Act 1976 provides for the establishment of protected areas.

- Water Board Act, Acts 18 of 1966 and 19 of 1974. Enacted to minimize water pollution and water waste.

- Petroleum Mining Regulation. Ministry of Lands legislation to prevent pollution of high seas or coastal waters by oil, mud, or other fluids.

- Petroleum Exploration Act 1979, 1985. Ministry of Lands legislation to prevent to pollution of natural resources.

Several new items of legislation are:

- The Prevention of Marine Pollution Bill is drafted and waiting minor amendments before going to Parliament. This contains provisions for the prevention of the release or threat of hazardous substances such as oil and other pollutants to the marine environment

- Environmental Impact Assessment (EIA) Bill (Ministry of Lands, Survey and Natural Resources) contains provisions to formalize the requirement for environmental impact assessment before development approvals can be granted.

Marine conservation issues have been incorporated into the primary and secondary school curricula like geography and biology but hampered by shortages of funds. Main conservation topics for student research in the secondary school include marine parks, mangroves and coral reefs. Public awareness is through the environment section of the Ministry of Lands and Survey and Natural Resources and JICA at the Division of Fisheries. A National Environmental Awareness Week (Ministry of Lands) involves various activities including coral reef related topics and issues.

Gaps in capacity and requirements for legislation

There is a lack of governmental resources for the management of marine protected areas including monitoring, enforcement, and educational programs. Conservation and environmental regulations are inadequate, poorly implemented and enforced. Traditional forms of management and conservation are non-existent, being lost to an open access system. Open access fishing areas create a disincentive to conserve: “If I don’t get it today, somebody may get it tomorrow”. Fishermen equipped with modern fishing and boating gear and stimulated by commercial interests exacerbate the problem (Eldredge *et al.,* 1999).

Areas that require a pro-active approach are (after Maragos and Holthus, 1999):

- Education: There is a lack of educational materials, inadequate opportunities for formal education or public lectures. Conservation practices need to be promoted.

- Capacity-building: There are inadequate training programs that develop expertise in the management of coral reef areas. Information gained from fisheries data or otherwise needs to be better utilized in the decision making. There is often a lack of adequate capacity to survey and monitor coral reefs, particularly in a manner whereby the information can be effectively used.

- Village Orientation of Extension Services: The MoF extension services appear to be related to the more basic issue of enhancement of the stakeholder orientation of the Ministry. A review of another government department in Tonga similarly concluded that "responsiveness to clients and improved performance requires a fundamental shift in institutional culture to embrace a service and output achievement orientation". The challenge will be to devise strategies to re-orient the Ministry to the

stakeholders, rather than focussing on itself. Even with the best of intentions, the Ministry would not be able to fully cater to the needs of the fisheries stakeholders without input by those stakeholders. To develop a service and output achievement orientation which would encourage and enhance extension and other activities, there should be some form of permanent structured input by stakeholders into the Ministry's policies and workplans (Gillett, 1997).

- Accountability for the Ministries: Communication and feedback on projects are often lacking. There are no repercussions for inaction.

- Marine Protected Areas (MPA's): The success and desirability of the existing marine protected areas needs to be assessed. Other areas need to be designated throughout the Kingdom.

- Coastal Zone Management (CMZ): There is a lack of CMZ management and enforcement. Legislation needs to directly address the coastal zone. The laws need to be cohesive and may involve the development of a coral reef management plan. Ministries have a poor record of enforcing CZM regulations. With this realization, initiatives need to be pursued that promote community-based monitoring and enforcement.

Conclusion and recommendations for reef conservation

a) Develop a program of coral reef survey and long-term monitoring. This is particularly important around the urban centers as well as areas where little information exists.

b) Need to establish a database of coral reefs and marine organisms.

c) Establish a cogent policy for integrated coastal zone management and environmental impact assessment to control land-based influences such as construction, agriculture and pollution.

d) Conserve subsistence fisheries resources. Develop attitudes and measures to regulate fishing both in terms of overfishing and the use of destructive methods. Regulate commercial fishing on coral reefs.

e) Develop policy to establish coral reef-protected areas.

f) Education, particularly at the school level, of environmental and conservation issues. Traditional values should be incorporated into any program.

g) Encourage active public participation in coral reef issues. Education needs to be expanded into the community. Media should participate more. Village and church groups, and NGO's are important in education and management. Participation of fishermen is important.

h) Develop capacity building and training of government and non-government personnel in activities that lead to the protection of coral reefs (monitoring, EIA, education, enforcement).

i) Ministries working independently of each other need closer communication and cooperation.

j) Improve communication to facilitate regional cooperation and assistance.

k) Improve co-operation between government authorities concerned with coral reef stewardship.

l) Re-establish some marine tenure to reinforce the concept of community-based management of the coastal resources.

m) Provide support for the Ministry of Fisheries resource management based on effective extension work where the lack of funds and insufficient staff impeded success.

Table of Acronyms

AIMS	Australian Institute of Marine Science
ARMDES	AIMS Reef Monitoring and Data Entry System
DHW	Degree Heat Weeks
EPACS	Environmental Planning and Conservation Section
FAO	Food and Agriculture Organization of the United Nations
GCRMN	Global Coral Reef Monitoring Network
IMO	The International Maritime Organization
JICA	Japan International Cooperation Agency
MPCJ	Marine Parks Center of Japan
MoF	Ministry of Fisheries
NOAA	National Oceanic and Atmospheric Agency
SPREP	South Pacific Regional Environment Program
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
TEMPP	Tonga Environment Management and Planning Project

Bibliography

ADAMS T., DALZELL P., 1999 —
In Eldredge L.G., J.E. Maragos, P.F. Holthus and H. Takeuchi 1999. Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Vol 2 Population, Development, and Conservation Priorities East West Center/Pacific Science Association ISBN 0-86638-184-8.

ADAMS T., LEDUA E., 1997
Inshore Resources Management and Conservation: Current Trends and Alternate Strategies. Paper prepared for the Pacific Science Association Inter-Congress meeting, Suva, Fiji, July 1997.

BELL L., FA'ANUNU U., KOLOA T,. 1994 —
Fisheries Resource Profiles: Kingdom of Tonga. Report 94/5, Forum Fisheries Agency, Honiara, 170 p.

BRALEY R., 1973 —
The marine turtle situation. Fisheries Lib. 6 p.

BRALEY R., 1973 —
Tonga turtle survey nesting season, 1973. Fisheries Lib 4 p.

BRALEY R., 197 —
The present marine turtle situation in Tonga. Fisheries Lib 9 p.

BROWN L. P., MORRISON J. R., 1999 —
"Trace metals in shellfish from the Fanga'uta Lagoon system and nearby waters, Tongatapu, Kingdom of Tonga". Australian Nuclear Science and Technology Organization, PMB No. 1, Menai NSW2234

CAMPELL B., LODGE M., (eds.) (1993) —
Regional Compendium of Fisheries Legislation (Western Pacific Region). Report to the Governments of the South Pacific Forum Fisheries Agency. Volume III. Fisheries Management and Law Advisory Programme. Forum Fisheries Agency/Food and Agriculture Organization of the United Nations, Rome.

CHEN Z., 1999 —
"Pesticides residues in sediment and soil samples from the Kingdom of Tonga" CSIRO Land and Water, Private Mail Bag no. 2, Glen Osmond, Adelaide, SA 5064.

CHESHER R. H., 1984a —
Pollution sources survey of the Kingdom of Tonga. SPREP/ Topic Review 19, South Pacific Commission, Noumea, New Caledonia, 110 p.

CHESHER R. H., 1984b —
Resource Assessment Report: Black Coral of Tonga, South Pacific Commission, Noumea, New Caledonia.

CHESHER R. H., 1985 —
Practical problems in coral reef utilization and management: a Tongan case study. Proceedings of the 5th International Coral Reef Congress, Tahiti 4: 213-17.

ELDREDGE L. G., MARAGOS J. E., HOLTHUS P. F., TAKEUCHI H., 1999 —
Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Vol 2 Population, Development, and Conservation Priorities East West Center/Pacific Science Association ISBN 0-86638-184-8.

ESCAP, 1990 —
Environmental management plan for the kingdom of Tonga. A report to the Government of Tonga on Environmental Management, ESCAP, Bangkok.

FFA, 1994 —
Fisheries Resources Profiles: Kingdom of Tonga. Lui A.J. Bell, 'Ulunga Fa'anunu and Taniela Koloa. FFA Report 94/5.

FLINT E., 1999 —
Seabird Populations and Conservation. In Eldredge L. G., J. E. Maragos, P.F. Holthus and H. Takeuchi 1999. Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Vol 2 Population, Development, and Conservation Priorities East West Center/Pacific Science Association ISBN 0-86638-184-8.

GILLETT R., 1994 —
Management of National Fisheries Resources, Kingdom of Tonga. Food and Agriculture Organization of the United Nations, Rome.

GILLETT R., 1997 —
Tonga Fisheries Sector Study. Report of the Fisheries Specialist. FAO TECHNICAL COOPERATION PROGRAMME FI: TCP/TON/6711, Version 9/3, file report-1.doc

GLYNN P. W., 1993 —
Coral reef bleaching ecological perspectives. Coral Reefs 12:1-17.

GRIGG R. W., 1982 —
Darwin Point, a threshold for atoll formation. Coral Reefs 1: 29-34.

HOEGH-GULDBERG O., 1999 —
Climate Change Coral Bleaching and the Future of he World's Coral Reefs. Greenpeace, Sydney. 27 p.

HOLTHUS P., 1999 —
The coral reef of the Vava'u Group, Tonga. SPREP publ.

KAILOLA P., 1995 —
Improved Fisheries Management for Food

Security. Technical Report 2, TP/TON/4453, FAO, Rome, 106 p.

Manabe S., Touffer R. J., Spelman J. M. J., Bryan K., 1991 — Transient responses of a coupled ocean-atmosphere model to gradual changes of atmospheric CO2 Part I: Annual mean response. J Climate 4: 785-818.

Maragos J. E., Holthus P. F., 1999 — Status of the Insular Tropical Pacific Coral Reefs. Eldredge L. G., J. E. Maragos, P. F. Holthus and H. Takeuchi 1999. Marine and Coastal Biodiversity in the Tropical Island Pacific Region. Vol 2 Population, Development, and Conservation Priorities East West Center/Pacific Science Association ISBN 0-86638-184-8.

Matoto A. L. T., 1997 — International Trade in Aquarium (Ornamental) Fishes in the Kingdom of Tonga. MSc. rpt. Resource Economic, Uni. of Rhode Island.

Matoto S., Ledua E., Mou-tham G., Kulbicki M., Dalzell P., 1996 — The Aquarium-fish fishery in Tongatapu, Tonga. Status and Recommendations for Management, SPC, Noumea, New Caledonia.

McKoy J. L., 1980 — Biology, exploitation and management of giant clams (Tridacnidae) in the Kingdom of Tonga. Fisheries Bulletin 1, Fisheries Division, Tonga.

Ministry of Lands, Survey and Natural Resources, 1995 — Ha'apai Conservation Area Project Preparation Document, South Pacific Biodiversity Conservation Programme, SPREP, Apia, Samoa.

Morrison J., 1999 — " Working Paper 20 & 15". Tonga Environmental Management and Planning Project, Environmental Planning and Conservation Section, Ministry of Lands, Survey and Natural Resources, Tonga.

MPJC (Marine Parks Center of Japan), 1997 — The Report of the project for Resources Survey and Conservation of Tongan Marine Reserves. Marine Parks Center of Japan and Min. of Lands, Survey and Natural Resources, Tonga.

Oliver J., Smith A., 1994 — Report to the Prime Minister's Office concerning the collection of corals and aquarium fish for export from the Kingdom of Tonga. South Pacific Regional Environment Programme, Apia, 21 p.

Nunn P. D., 1993 — Role of Porolithon Algal-ridge growth in the development of the windward coast of Tongatapu Island, Tonga, South Pacific. Earth Surface Processes and Landforms, Vol. 18, 427-439 (1993).

Nunn P. D., Waddell, 1992 — Implications of Climate Change and Sea Level Rise for the Kingdom of Tonga. SPREP, Apia, Samoa.

Petelo A., Matoto S., Gillett R., 1995 — The case for community-based fisheries management in Tonga, Workshop on Inshore Resource Management, Background Paper 61, Workshop on the Management of Pacific Island Inshore Fisheries, SPC, Noumea, New Caledonia.

Preston G., Lokani P., 1990 — Report of a survey of the sea cucumber resources of Ha'apai, Tonga. South Pacific Commission, Noumea.

Pulea M., 1992 — SPREP Review of Environmental Law in the Kingdom of Tonga. Strengthening Environment Management Capabilities in Pacific Island Developing Countries, RETA 5403. Australian Centre for International Law, Faculty of Law, University of Sydney, Australia

Ruffle-Klugkist K., 1997 — Country Report Tonga. Regional Marine Workshop Report. Ed Tuqiri S. and South G.R.

Statistic Dept., Tonga, 1996 — Administrative Report and General Table, Statistic Dept. 1996 Population Census.

Thistlewaite R., Sheppard D., Prescott N., 1993 — Kingdom of Tonga: Action Strategy for Managing the Environment, SPREP, Apia, Samoa.

Udagawa K., Kikutani K., Fa'anunu U., Kava V., Tu'avao T., 1996 — Lobster management manual. Ministry of Fisheries, Tonga, 14 p.

UNEP/IUCN 1988 — Coral reefs of the World Vol. 3: Central and Western Pacific. Compiled by Wells SM and Jenkins MD. UNEP Regional Seas Directories and Bibliographies. IUCN and UNEP p. 329 ISBN 2-88032-945-0.

Wilkinson C., Linden O., Cesar H., Hodgson G., Rubens J., Strong A., 1999 — Ecological and socioeconomic impacts of 1998 coral mortality in the Indian Ocean: An ENSO impact and a warning of future change? Ambio Vol 28 No.2 March 1999.

World Bank Report, 1999a — Voices from the Village. A comparative study of Coastal Resource Management in the Pacific

Islands. Pacific Islands Discussion Paper Series. No. 9, East Asian and Pacific region. Papua New Guinea and Pacific Islands Country Management Unit.

WORLD BANK REPORT, 1999a —
Summary Report. Voices from the Village. A comparative study of Coastal Resource Management in the Pacific Islands. Pacific Islands Discussion Paper Series. No. 9a, East Asian and Pacific region. Papua New Guinea and Pacific Islands Country Management Unit.

WORLD BANK REPORT, 1999c —
Voices from the Village: A comparative study of Coastal Resource Management in the Pacific Islands. Site Visits and National Summaries Appendix. Pacific Islands Discussion Paper Series. East Asian and Pacific region. 72 p.

WCMC-WORLD CONSERVATION MONITORING CENTRE, 1991 —
IUCN directory of protected areas in Oceania. IUCN, Gland, Switzerland, and Cambridge, UK.

ZANN L. P., 1982 —
Tonga's artisanal fisheries. Institute of Marine Resources, University of the South Pacific, Suva, Fiji.

ZANN L. P., 1994 —
The Status of Coral Reefs in South Western Pacific Islands. Marine Pollution Bulletin, vol. 29, Nos. 1-3, 52-61.

ZANN L. P., KIMMERER W. J., BROCK R. E., 1984 —
The ecology of Fanga'uta Lagoon, Tongatapu, Tonga Institute of Marine Resources, University of the South Pacific and International Sea Grant Program University of Hawaii. 100 p.

ZANN L., MULDOON J., 1993 —
Management of marine resources in the Kingdom of Tonga. Unpubl. Tech. Annex to Tonga Natl. Tourism Plan, Nicholas Clark and Assoc., Canberra, Australia

The status of the coral reefs of Tuvalu

Samasoni Sauni

Introduction

Tuvalu, formerly known as the Ellice Islands under the British Protectorate consists of nine coral islands and atolls (see Figure 1). It lies in the south central Pacific, north of Fiji, and geographically located between 5°31' and 10°45' South, 176° and 180° East. With a population of approximately 10 114 (Tesfagiorhis, 1991), Tuvalu's small land area of only 26 km^2 has 40% of the population residing In the capital, Funafuti. The overall population density was 395 persons km^2 with Funafuti scoring the highest (1372 persons km^2) (Tesfagiorhis, 1991). Tuvalu's population is 96% Polynesian and the local tongue is akin to Samoan, although English is widely spoken. The country places much hope for future economic growth on the fishery resources contained within its large EEZ area, which covers 900 000 km^2 (SPC est.) of the South Pacific Ocean. Tuvalu's EEZ has a higher ratio of sea to land area than any other nation. Open waters range to approximately 5000 m at their greatest depth. Scattered throughout the EEZ are many submarine seamounts whose summits may rise to within 30 m of the water's surface (Sauni, 1997).

Tuvalu's shallow marine environments are dominantly fringing and patch reefs. Five of the islands are true coral atolls, with a continuous eroded reef platform surrounding a central lagoon, three islands are comprised of a single islet made up of sand and coral materials (McLean & Hosking, 1991). One island though, has the character of both an atoll and reef island. These atolls and low coral islands are generally subject to constant change through continuing growth of living corals, erosion and accretion of wave action. All the atolls and islands are low-lying, with an average elevation of about 3 m above sea level. Patch reefs and relatively barren coralline sand flats within shallow (≤ 50 m) lagoon waters are surrounded by deep open ocean. There is no continental shelf to seaward of any of the islands, the only substantial areas of shoal water being found in the internal lagoons. Water depths increase very rapidly from the coast to over 1000 m within a few kilometers from the shore or outer reefs.

Status of coral reef benthos

Reefs prior to 1998

Unlike other islands in Tuvalu, Funafuti alone had had extensive research on its marine habitats and geomorphology (McLean & Hosking, 1991; Robert *et al.*, 1989; ADAB (Australian Development Assistance Bureau), 1985; Johnson, 1961). Nonetheless, the information gathered is relatively the same in all the atolls and islands. The coral atolls are characterised by a perimeter of coral islands and coral reefs and relatively extensive lagoons formed by the submergence of the volcanic origin centre. The first attempts at proving Darwin's theory of atoll formation were undertaken through core sampling on Funafuti and its adjoining reefs. The lagoons reach depths of 60 m and are comprised of

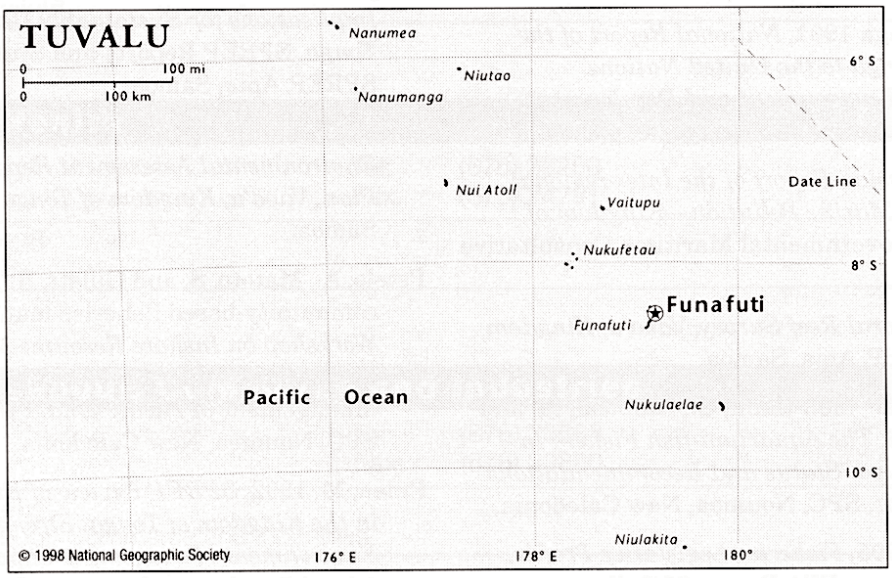


Figure 1
Map of Tuvalu.

coralline sand flats that are of low productivity due to the lack of any land based nutrient runoff and higher productivity reef flats.

Intermittent coral heads, protruding from the sand mantle cover large areas of the lagoon floor. At least, for the deep central part of Funafuti lagoon and many sloping margins, few coral heads ranged from 30–50 m (ADAB, 1985). Coral fauna on atolls and islands includes representatives of most major coral families; the majority of which consist almost entirely of acroporine skeletons (ADAB, 1985). On Funafuti, the deep lagoon bed is inferred to be underlain by algal sand for up to 20-25 m; this is then followed by an irregular coral surface whose base is an inferred unconformity at depths up to 70m below datum (McLean & Hosking, 1991).

In Tuvalu, the atoll islands are characterised by relatively narrow reef platforms and limited lagoonal area. Table 1 provides a summary of the geography of Tuvalu.

Atoll beaches are mainly formed and consist of foraminifera sand, with deposits of moderately well graded medium and coarse sand with fine content (< 75mm) of 0-5 % and gravel content 0–20 %. Gravel content is usually *Lithothamnion* or shell fragments (ADAB, 1985). Also, *Halimeda* sand

Reef Top	Nanumea	Nanumaga	Niutao	Nui	Vaitupu	Nukufetau	Funafuti	Nukuelaelae	Niulakita
Reef Type	atoll	patch	patch	atoll	Atoll/patch	atoll	atoll	atoll	patch
Reef Platform	1710	413	306	1601	906	2559	3696	1404	74
Islets	366	301	235	352	529	331	275	183	42
Beaches	21	71	2	22	17	65	27	33	8
Reef Flat	1323	98	69	1228	361	2163	3398	1188	24
Lagoon	325	-	-	337	109	9093	20521	2377	-

Table 1
Reef and Island Areas (ha) of Tuvalu (Source: McLean & Hosking, 1991).

occurs in all deep-water areas while foraminifera sand is only found in shallow areas. *Halimeda* sand, which is derived from the calcareous plant *Halimeda*, was found accumulated on the lagoon floor; the thickness of the deposits increases from the shallow water towards the lagoon centre but most large deposits are in excess of 20 m depth. The most extensive deposit of this material is less than 27 m of water and is estimated to contain up to 7 000 000 m^3 of *Halimeda* sand. An enormous quantity of this sand is available from the lagoon floor in water depths of 30–50 m (ADAB, 1985).

Lime sand, formed largely from the skeletal remains of calcareous algae, exists around the lagoon margin in water depths generally 15 - 25 m towards the shore of Funafuti island (ADAB, 1985), often mixed with foraminifera sand. The deposits are more extensive than those of the foraminifera sand but are fine and variable; deposits often form only a small film over the reef. The total available quantity of mixed foraminifera and lime sands is of the order of 320 000 m^3.

1998 coral bleaching

There are no current documented records or surveys on the 1998 coral bleaching, and no research on the impact of the bleaching phenomenon has been carried out. Nonetheless, there is anecdotal evidence on past coral bleaching observations among the islands of Tuvalu; mainly on Funafuti.

Coral reef biodiversity

Mangroves and seagrasses

Small stands of mangroves occur on three of the limestone islands and two of the atolls include two species (Woodroffe, 1987; Scott, 1993). The dominant species in the mangrove swamp and ponds is *Rhizophora mucronata*. Associated species on raised areas within the main swamp complex include trees and shrubs such as *Scaevola taccada*, *Calophyllum inophyllum*, *Guettarda speciosa*, *Cordia subcordata*, *Pemphis acidula*, etc. Of these only *Rhizophora* extends into the main tidally inundated areas, rooted in soft organic "mangrove mud". The swamps and ponds are fringed by much richer terrestrial vegetation, which extends down to high water mark. The aquatic flora of these enclosed tidal areas consists only of sparse filamentous algae such as *Chlorodesmis* and *Microcoleus*. The marginal mangrove areas are characterised by large populations of a small gastropod, a *Terebra* species.

Flora

The flora of the lagoon sands is relatively depauperate (ADAB, 1985). The main primary producers, and the dominant components of plant cover in most lagoon areas, are calcareous algae of the genus *Halimeda*. *Halimeda* species range from the intertidal zone to depths of 40 m and more. The main species identified in the ADAB (1985) report are *Halimeda macroloba*, *H. opuntia* & *H. cylindrica*. Additional species collected and identified by the 1896 – 1898 Expedition include: *H. tuna*, *H. laxa* (now *H. gracilis*), and *H. cuneata* var *elongata* (now *H. copiosa* f. *elongata*). *Halimeda gracilis* was also recorded by Chapman (1955) in dredging from 50 m depth, 2.4 km south of Fualifeke on Funafuti. Other relatively common genera include the brown algae *Padina* and *Dictyota*, notably *D. dichotoma*; the green *Caulerpa*; and the heavily branched red *Liagora* (ADAB, 1985). The main common species of *Caulerpa* is *C. racemosa*, while the "turtle-grass", *Syringodium isoetifolium* is also found in Funafuti lagoon.

The most significant plant components of the patch reefs and coral heads are crustose coralline algae of the family Corallinaceae, commonly known as *Lithothamnia* (ADAB, 1985). The dominant Corallinaceae recorded in recent and Pleistocene materials from the Funafuti borings are *Porolithon onkodes, P. craspedium, P. gardineri, Goniolithon frutescens, Lithothamnion philippii* and *Lithophyllum subtilis* (Johnson, 1961). The coral head epiflora is somewhat identical to that of the sand. The main differences are that the smaller *Halimeda* species, *H. opuntia* and *H. cylindrica*, are more common on coral, and the larger *H. macroloba* less so; *Dictyota, Padina* and *Liagora* are much more abundant; and *Caulerpa* species, notably *C. racemosa*, are common on the coral heads but not on sand. *Halimeda* species bear a foraminiferal epifauna, primarily *Sagenina* (ADAB, 1985). The flora of the reef flats is similar in species composition to that of the submerged coral heads, but differs in the relative abundance of the species concerned.

Three main growth forms of flora are branching, nodular and crustose. These were referred to by the Royal Society Expeditions of 1896-1897 as *Lithothamnion ramosus, L. nodosus,* and *L. philippi*, respectively. The crustose and nodular forms also colonise living corals, particularly on the shallow fringing reefs near the main entrance channels to the Funafuti lagoon (ADAB, 1985).

Fauna

Like other atolls in Tuvalu, the infauna of Funafuti lagoon bed sands consists largely of worms, molluscs and formaninifera. According to ADAB (1985), mature *Lambis truncata* can be found on the sediment surface. In a statement recorded by Chapman (1900-1903; cited in ADAB, 1985), the spurred forms of *Calcarina* and *Tinosporus*... are both common near the rim of Funafuti lagoon. Further, ADAB (1985) states that the number of genera of the foraminifera range from 21 to 28; this fluctuation of which could have been caused by the greater influence of marine conditions and food-supply from the seaward face. Nonetheless, in the middle of the lagoon only 3 genera are present, namely, *Sagaenina*, *Amphistegina*, and *Heterostegina*. Whilst, the greater number of generic forms gradually die out towards the centre of the lagoon, a few, with some special varieties, make their appearance and in tolerable abundance, in consequence of the more tranquil conditions prevailing there.

Worm tubes are primarily terebellid, cirratulid and phyllodicid polychaetes, including *Phyllodoce*; specimens of which are held at the Australian Museum. The infauna of coral heads is very diverse, and is comparable to that of the reef flats. It includes boring annelids, sipunculids such as *Aspidosiphon, Cloeosiphon, Lithacrosiphon, Parasiidosiphon, Phasocolosoma* and *Themiske*, boring sponges such as *Clione* species, molluscs such as *Arca, Lithophaga, Tridacna* and *Vermetus*; encrusting foraminifera such as *Polytrema* and various echinoderms and crustacea. Besides the corals themselves, the epifauna of the submerged coral heads includes encrusting foraminifera and sponges such as *Polytrema planum* and *Hippospongia dura*, sparse hydrocorallines and ascidians, various small echinoderms and crustacea and a wide range of molluscs (ADAB, 1985).

The epifauna of the lagoon floor sands of Funafuti which include hermit crabs, holothurians and sponges is relatively sparse but in abundance (ADAB, 1985). Two sponges are common in potential source areas and referred tentatively to as *Euspongia irregularis* and *Spinosella glomerata*. Below 25 m depth the sponges are replaced by species of *Clathria, Echinodictym* and *Acanthella* (Whitelege, 1897). Holothuria recorded in 1983 include *Microthele nobilis, M. axiologa, Thelenota ananas, T. anax* and *Halodeima atra* (ADAB, 1985). Of these, however, only *H. atra* is abundant, and this species is largely confined to the intertidal zone to about 4 m depth. According to Zann (1983), *Bohadschia marmorata* is reported from the *Bohadschia* (then "*Holothuria*") *argus*.

Echinoderms were also very sparse, with a single large *Culcita acutispina* species and several small *Linckia* spp. being the only representatives (ADAB, 1985; Whitelegge, 1897). Whitelegge (1897)

recorded the common blue, *Linckia laevigata* but this species was not found in recent surveys. Occasional large molluscs such as *Lambis truncata* were also recorded. Two species of pearl oysters, *Pinctada maxima* and *P. margaritifera* have been recorded (Belhadjali, 1998).

Corals

The lagoon has low benthic cover with staghorn and other corals dominating reef tops; however, it has a high cover by *Dictyota* and other macroalgae. The reef slope is dominated by *Acropora* including *A. nobilis* and *A. florida*, with lower cover of plating *A. hyacinthus* and several corymbose forms. The dominant algae in this habitat include *Halimeda* species and several types of corallines. The coral cover and species diversity on the reef slope is about the same as channels.

On the ocean side terrace habitats are rich in coral cover and diversity. The channels have good cover by staghorn and plating *Acroporas* in addition to species of *Montipora, Favia, Fungia, Hydnophora, Montastrea, Pocillopora verrucosa* and *P. edyouxi*. The dominant macroalga present is *Halimeda*, though corallines and turf algae are also common. On the ocean side however, terrace habitat is dominated by the presence of low ridges running perpendicular to the shoreline out to the break of slope at approximately 20 m depth. The area is dominated by a wide variety of corals, including large plates of *Acropora hyacinthus*, faviids, pocilloporids (*P. verrucosa, P. edyouxi*) and the macroalga *Halimeda*. The coral cover was approximately 40 % at the two southern passage controls, being lower (~12 %) at Papaelise. Species richness was, however, approximately the same on the ocean side of Funafuti lagoon.

Crown-of-thorns

Signs of crown-of-thorns outbreaks are frequently found on the lagoon and ocean terrace of Funafuti, ranging from 0 to 119 cotsha^{-1} (Anon., 1995; Funafuti Marine Conservation Area, 1997). Crown-of-thorns starfish were also observed at 37% of the sites surveyed on Funafuti (Belhadjali, 1998). Anecdotal evidence also suggests that *A. planci* densities are also high (>100 cotsha^{-1}) on some of the bommies on Funafuti lagoon.

To a lesser extent, the animals can also be found on Nukufetau (Belhadjali, 1997), and Nanumea (Belhadjali, 1998). According to Belhajdali (1998), one specimen of *Acanthaster planci* was found on Nanumea lagoon, feeding on table coral at 15 m water depth. The Tuvalu Fisheries Department has been monitoring the occurrences of *A. planci* in Tuvalu, to provide a database of crown-of-thorns occurrences.

Holothurians

Bêche-de-mer are not part of the traditional diet of Tuvaluans, thus, are of little interest. Seven species were recorded during fisheries surveys over the years with the white teatfish (*Holothuria fuscogilva*) and black teatfish (*H. nobilis*) being the more prominent ones (Belhadjali, 1998). The low commercial value species are also common, including the *H. fuscopuntata, Actinopyga mauritiana, Bohadschia argus, B. marmorata/vitiensis*, and *H. atra*.

The available stocks of bêche-de-mer appear to have declined dramatically having negative implications for the export market. For instance, the density of *Holothurus nobilis* was recorded on some lagoons to be 18.11 specimens ha^{-1}, and 7.57 specimens ha^{-1} in ocean sites. These densities are comparable to densities found in Tonga, 18.7 ha^{-1} (Preston & Lokani, 1990), or around Manus Island, PNG, 9.57 ha^{-1} (Lokani & Chapau, 1992, cited in Belhadjali, 1998). On Funafuti, the density of bêche-de-mer (*H. nobilis* and *Actinopyga miliaris*) ranged from 23.8-47.6 specimens ha^{-1}. These specimens were observed at 21% of the sites surveyed (Funafuti Marine Conservation Area, 1997).

Interest in exporting bêche-de-mer in Tuvalu dates back to the late 1970s and early 1980s. The Fisheries Department purchased bêche-de-mer from fishers and exported approximately 2.9 mt from 1979-1982 (Belhadjali, 1997). There has been no production and export in Tuvalu in subsequent years despite efforts to revive interest in the fishery. It is unlikely that with present low densities of bêche-de-mer, coupled with the small area of suitable habitat in the islands surveyed, any commercial venture would be viable.

Giant clams and other invertebrates

Two main species giant clams are found in Tuvalu: *Tridacna maxima* and *T. squamosa*; the former being heavily fished (Braley, 1988; Langi, 1990; Belhadjali, 1998). Poor stocks of giant clams are now available on islands with no lagoons and thus, rarely consumed. There is no commercial market for clams in Tuvalu except one atoll and the people rarely eat them now. Belhadjali (1998) found the abundance of giant clams in ocean sites to range from 14.02 clams ha^{-1} (*T. maxima* 6.9ha^{-1}, *T. squamosa* 7.12ha^{-1}) to 16.64ha^{-1} (*T. squamosa*) on some islands. There is a general trend in increasing abundance of giant clams from a South-North direction, however, *T. maxima* is not found in the northern islands. Giant clams in Tuvalu are especially susceptible to recruitment failure if the stock levels fall below sustainable limits (Belhadjali, 1998).

Only one specimen of *Trochus niloticus* was observed during the Funafuti Marine Conservation surveys. Belhadjali (1998) observed thorny oysters of the family Spondylidae in the atolls of Nukulaelae, Nui and Nanumea. The highest density of thorny oysters was in Nui lagoon, 555 ha^{-1} (Belhadjali, 1998).

Status of coral reef fishes

On Funafuti alone at least, 400 species of fishes have been documented (Jones *et al.*, 1991).

Trials to export valued demersal species predominantly of snappers to Hawaii were carried out in Tuvalu between 1992-1994. Artisanal fishermen on Funafuti sometimes sell their catch directly from handcarts. NAFICOT (The National Fishing Corporation of Tuvalu) operates a small fish retail outlet there, and during 1996 also made export shipments of deep bottom snapper, averaging 200-300 kg/fortnight. There were also attempts to export snappers to Marshall Islands and Fiji. Further, there have been numerous requests from overseas investors, particularly, from Asia, to establish an aquarium fisheries. Fishing trials and surveys conducted on Tuvalu's deep reef slopes between 1991 and 1994 indicated that stocks of deep-water snappers could sustain a catch of 100t yr^{-1}. Sauni (1997) reported a dominance of emperors, cods and groupers during his surveys, particularly, *Lethrinus gibbus*. Other species including spinefoot *Siganus vermiculatus*, *Lutjanus kasmira* and cardinal fish were also ranked high in numerical abundance (Sauni, 1997; see Table 5). Sauni (1997) highlighted that lagoon and reef species were prominent in terms of numbers and weight and, low catches by weight were, recorded for demersal and baitfish species.

In the past tilapia have been introduced into borrow pits in Funafuti and other locations, but this was not considered a success. The construction of Tuvalu's first purpose-built aquaculture pond, for milkfish, was completed on the island of Vaitupu in 1996. It is intended that operation of the Vaitupu pond will provide a model for subsistence aquaculture activity elsewhere in Tuvalu. Aquaculture research projects involving giant clams and introduced *Eucheuma* (*Kappaphycus*) seaweed have been carried

out, the former as a possible means of re-stocking wild populations, and the latter for commercial production. Neither has so far led to any kind of commercial development.

In attempts to create new resources and enhance available stocks, several undertakings were carried out, and are described below:-

- Tilapia and *Trochus* were introduced to Tuvalu in attempts to create new resources and small-scale fisheries based on them. The introduction of tilapia into borrow-pits on Funafuti resulted in long-term negative ecological impact and no local benefit, as tilapia is not favored as a food fish by Tuvaluans. *Trochus* were introduced to six islands (Funafuti, Nukufetau, Nukulaelae, Nanumea, Atafu and Nui) from Fiji and the Cook Islands in four separate introductions carried out between 1985 and 1989. Progress of the introductions is still being monitored. A survey of two of these islands in 1994 recorded few adult trochus.

- Fishing trials and surveys conducted on Tuvalu's deep reef slopes between 1991 and 1994 indicated that stocks of deep-water snappers could sustain a catch of 100t.yr^{-1}. Although government has promoted wider development of the export snapper fishery, there has been little private sector participation. This is due to a range of factors including the relatively high cost of entering the fishery, the local difficulty in raising capital, and the poor handling, distribution and export infrastructure that exists in Tuvalu.

- NAFICOT carries out commercial fishing using two of six fishing launches provided to Tuvalu in 1991 under Japanese grant-aid. The company sells its catch through a small fish retail outlet in Funafuti, and makes occasional exports of deep water bottom snappers.

NAFICOT also previously operated a pole-and-line vessel, Te Tautai, provided under Japanese aid. The vessel produced good catches during the 1980s, with a peak catch of 1091t in 1988. However, the operation suffered due to poor local supply of baitfish and Te Tautai was frequently obliged to fish in Fiji under a licensing agreement. The vessel was later chartered to the South Pacific Commission between 1991-1993 for regional tuna tagging work, subsequent to which it sank in Funafuti lagoon.

Tuvalu previously had no access agreements with foreign fishing interests, except via the US Multilateral Treaty, but since 1994 has made agreements with both Japan (10 vessels) and China (15 vessels). The conclusion of these agreements coincided with Tuvalu's deployment of a fishery patrol vessel provided by Australia under a defence cooperation agreement. Foreign fishing vessels took 3753 t of tuna and allied species in Tuvalu's EEZ in 1995. Of this 3267t (87%) was taken by US purse seiners.

Threats to coral reef biodiversity

Major issues affecting coral reefs and associated environments in Tuvalu are:

- Tropical cyclones, climate change and possible sea level rise;

- Reef channel blasting, channelling and dredging affecting corals, fish and water circulation;

- Over harvesting of marine resources;

- Pollution: sewage and waste disposal;

- Beach rock/ sand mining and sedimentation; and Ciguatera fish poisoning.

- Below are brief details of the above issues.

Climate change impacts

Tuvalu faces serious coastal problems particularly with certain areas being inundated. Frequency of cyclones and storms further exacerbates this problem with increased erosion of beaches and changing patterns of coastline. For instance, the 1972 hurricane Bebe left irreparable damages on coastal areas. ADAB (1985) stated that this particular cyclone created what is now called the 'hurricane Bebe Bank' on Funafuti. The bank consists of an accumulation of gravel and cobble sized, partly rounded coral fragments which were deposited on the ocean reef fringing the south east part of the Fogafale atoll on Funafuti (ADAB, 1985).

Since the hurricane, the Bebe Bank's materials have been washed out on the reef, southwards along the beach and towards to the ocean channels where it dissipates. The material forming the bank is the hardest, most compact type of coral that formed dense, hard limestone. This is the only source of durable limestone on the atoll and the only viable source of rock that can be crushed for concrete aggregate. It is considered that the Bebe Bank affords protection to the islands in easterly winds and that removal of it from the eastern side of the islands would be detrimental. The total available volume of the material is 615 000 m^3 of which 575 000 m^3 is protecting the islands (ADAB, 1985). The Bebe Bank spits also enclose sheltered tidal pools (moats) containing small colonies of *Porites, Acropora, Lithothamnion, Caulerpa* and *Halimeda,* occasional holothurians and echinoderms, and a range of small fish, notably *Canthiogaster*.

Reef blasting, channelling and dredging

Dredging of lagoonal materials on Funafuti for engineering and construction purposes were seen as a threat to low coastlines (Berdach & Maynard, 1994). Lagoon or channel dredging, causeway and seawall construction, and similar earthwork projects are suspected of being linked with outbreaks of ciguatera poisoning. ADAB (1985) recommended that dredging could be sustainable over a period of up to six years. This is to ensure minimum disturbance to offshore and onshore biological and sociological environments. In regard to deposits at Bebe Bank east of Funafuti Island, it was recommended that the probable maximum rate of utilisation of this material should be low (2000 m^3yr^{-1}, or 40 m^3wk^{-1}); projection of the effects of removing other parts of the Bebe Bank would be up to 20 years premature. In fact, the Bebe Bank has changed dramatically in the last 12 years, during which time the recoverable deposits have accumulated, and further accumulation may occur. Similarly, the existing deposits may be dissipated under certain sea conditions (ADAB, 1985).

Over the years, channels have been constructed as part of aid-funded development programs. Existing channels vary in age, size and method of construction, with some extending for several hundreds of metres to sand or rubble beaches. Some channels are very wide and deep, and are known to have caused large changes in the physical and biological environments in the immediate surroundings. Below are summaries of reef status as reported in recent surveys on Funafuti lagoon.

Over-fishing

Berdach & Maynard (1994) stated that intensified exploitation of food fish could result in the direct depletion of near shore species which much of the population presently rely upon. Sauni (1997) gave an annual estimate of catch of 282.9 kg $person^{-1}yr^{-1}$ which is about 14 % lower than the annual mean fish consumption of 327.6 $kgcapita^{-1}$ estimated from the consumption household survey. It is speculated that

the high current consumption rate could be driven by high catch rates (Sauni, 1997). Sauni (1997) further discovered the increasing fishing assets per household compared to past records from the 1980s and 1990s. Based on data from the creel survey, the estimate per capita annual catch on Funafuti was 1.3 $kghead^{-1}hr^{-1}$, which is approximately 64 % greater than the SPC estimate of 1993 & 1994.

King (1995) estimated 26 t yr^{-1} of sustainable yield around 37nmi fishable habitat and 50 t yr^{-1} on seamounts for all islands. The annual sustainable yield for Funafuti alone is likely to be 8t yr^{-1} on this basis. Given this, it appears that the reef and lagoon areas primarily involved are being subject to unsustainable fishing pressure. According to Sauni (1997), catch and consumption rates for at least Funafuti and Nukufetau, indicate a high level of fishing pressure on existing standing stocks. Further, Sauni (1997) found a high level of fishing assets for each household in Tuvalu; this probably encourages fishers to prosecute modern forms of fishing and, hence further exacerbate pressures on stocks. For instance, the high investment of fishermen in modern boats is evidently aimed at achieving higher catches for sale (Sauni, 1997).

Coastal lagoon and fin-fish catches in Tuvalu will continue to be the main source of subsistence protein for the foreseeable future. Problems are likely to occur on Funafuti where yields from coral reef fisheries may not keep pace with population or tourism growth and, where there are no major efforts to target offshore fisheries, or the development of mariculture as alternatives (Sauni, 1997).

Pollution

With the exception of ubiquitous solid domestic litter in Funafuti lagoon (which, while unsightly, is biochemically benign), Tuvalu's coastal environment is relatively pollution-free (Berdach & Maynard, 1994). However, with continued population increases, it would be expected that increasing environmental pressures might result in pollution, landform alteration, and over-exploitation of resources. Increased human and animal waste entering the lagoon environment could lead to elevated bacterial levels, with resultant disease outbreaks and public health risks. Increased organic nutrient loading could also result in algal blooms that choke the corals upon which reef fish and other organisms depend for food and habitat. Other land-based pollution (from petroleum products, batteries, etc) could produce discharges of toxic substances into lagoons or coastal areas (Berdach & Maynard, 1994).

Coastal resources mining and sedimentation

Coral excavation from coastal areas for construction purposes is one major problem facing the atolls and islands of Tuvalu. Having minimal opportunities for exploring alternative coral rubble, the majority of Tuvaluans including the government have pressured coastal areas a great deal. As a consequence, the rate of erosion and sediment movements along coastal areas has increased drastically. Even so, with the construction of seawalls, whether cemented or manually stacking bulky stones as means of protecting erosion has indeed affected coastal and beach areas (Robert *et al*., 1989).

ADAB (1985) referred to land reclamation material as medium to fine calcareous sand deposit varying in thickness to 25 mm. Virtually the whole lagoon beds in most atolls and islands have 2-4m thick, blankets of these sand deposits in water over 10 m deep. On Funafuti, cobbles from the hurricane Bebe Bank on the southern end of Funamanu and northern end of Falefatu Island are frequently used for engineering and building materials. The cobbles have a total quantity of up to 40 000 cubic metres (ADAB, 1985). It was cautiously advised not to over-exploit the deposits and so remove the erosion protection that they now provide to the island.

Whilst the coral fauna of the submerged heads is very depauperate, that of the lagoon rim and shallow shoals is relatively diverse, though not as diverse as that of the deep channels receiving ocean water. This suggests that whilst the turbidity, probably low nutrient status, and possibly the higher temperature of the lagoon waters all contribute to reducing coral diversity in the lagoon, the most significant factors are the low light penetration and high sedimentation rate (ADAB, 1985).

Ciguatera

Ciguatera fish poisoning is a serious problem in Tuvalu, particularly on Niutao, Funafuti and Nukufetau where outbreaks have been reported (Kaly & Jones, 1994a; Tebano, 1991). Fish species linked with ciguatera in Tuvalu vary from island to island. In Niutao alone, it was obvious that it has greatly suffered from the adverse impact of reef blasting which flared and spread ciguatera poisoning.

The trigger to the initial population explosion of the organism is not well understood. However, it is believed that disturbances such as storms, channel blasting and dredging or nutrient build up may be contributing factors. Kaly & Jones (1994a & 1994b) found no clear evidence for the view that physical disturbances, such as shipwrecks and boat passages, promote outbreaks of ciguatera fish poisoning. The boat channel on some of the islands and shipwrecks on others all exhibited *Gambierdiscus toxicus* densities and *Ctenochaetus strigosus* toxicity in the range observed at sites several distances from these disturbances (Kaly & Jones, 1994a & 1994b).

Moreover, in monitoring the Nanumea boat channels and trends at Niutao, it is suggested that disturbance may sometimes play a role. Kaly & Jones (1989) claim that the outbreak of ciguatera which occurred prior to the blasting of channels could not primarily be attributed to the cause; the blasting, however, initially exacerbated the problem by making already poisonous and highly prized reef fish available for consumption. Numerous studies show that the concentration of the presumed causative organism, *G. toxicus*, is not necessarily linked with an increase in toxin level or the outbreak of ciguatera (Tebano & McCarthy, 1984). The notable outbreak of ciguatera was in 1989 on the island of Niutao after a reef was blasted at the south-western part of the atoll (Tebano, 1991). Fish poisoning cases from other islands prior to 1982 could also be remembered by the old people of Tuvalu.

Current MPAS, monitoring and conservation management capacity

Fisheries management and conservation

In the pre-colonial times, there was a well-established system of traditional resource management, but this was broken down long ago. Traditional sea tenure in the past was important in limiting access to the fishery. Overfished species were protected and fishing activities were regulated by a strong mix of taboos, social restrictions and beliefs, to ensure a high yield from the waters adjacent to the atolls (Belhadjali, 1995b). Secrecy, clan specialization and other cultural features have aided management of fish resources (Zann, 1983). In Tuvalu, each clan has specific skills that are closely guarded. Kennedy (1931) described a lands court case in which a man in Tuvalu actually traded land for a fishing secret, because he did not convey this secret to his clan before his death, the clan requested, and was awarded, their traditional land back.

The invocation of a taboo (tapu), was an effective mechanism of enforcing a protective proclamation. Zann (1983) stated that the island king or community for breaches of fisheries legislation might impose a range of penalties from fines to removal of fishing rights. According to Sauni (1997), a person who continuously broke communal tapu was either beaten up or sent adrift (Lauti, T. & Vine, pers. comm., 1997). The tapus are rarely used today, but all tapu and various penalties were geared towards conserving fish stocks and settling disputes in the community. Sauni (1997) further stated that "sustainable development and conservation" are not new concepts. Rather, ancestors of Tuvalu have attempted to manage their marine resources, but, few of those practices involved have survived, although sea tenure was probably important in limiting access.

A conservation ethic remains very strong today and a wide range of conservation practices (e.g., prohibition of harvesting small clams on Nukufetau) are still in use (Sauni, 1997). Tuvalu has recently established its first marine park within the Funafuti lagoon, with the assistance of UNDP and the South Pacific Regional Environment Programme (SPREP). This marine reserve covers an area of 40 km^2 and includes six islets and adjoining reefs and waters. The goal of this initiative is the preservation of marine and terrestrial biodiversity. Responsibility of monitoring and policing of the reserve rests on the project personnel, Funafuti Town Council, the Environment Unit and the Fisheries Department. It provides a basis for fishery reserves being established elsewhere in Tuvalu. Furthermore, certain over-fished species such as giant clams and pearl oysters were protected and fishing effort regulated by various restrictions using social beliefs and tapu (Zann, 1983). The Fisheries Department has established a giant clam sanctuary on Funafuti in an attempt to restock giant clams. *Trochus* were also air dropped on a number of islands to restock the fishery.

Research and training

The Fisheries Department, often with the participation or support of external agencies, has undertaken fisheries research in Tuvalu. The research followed three main avenues:

- **Monitoring**, intended to allow ongoing assessment of the status of the main fisheries. A major activity has been the Ciguatera Monitoring Project, which was established in response to a severe outbreak on Nui island in 1988;

- **Surveys and resource assessments**, intended to provide snapshots or status reports on specific resources. Such surveys have been focussing on bottom fish, bait fish, pearl oysters, bêche-de-mer, trochus, tuna and giant clams; and

- **Development-oriented research**, aimed at identifying new grounds or techniques with commercial fishing or aquaculture potential. The major activity undertaken in this area has been research into deep-slope bottom fish resources that commenced in 1991, as well as the later development of a management plan for this fishery.

The Fisheries Department maintains an extension service that focuses on providing training for fishers in outboard motor maintenance, fishing techniques, fish processing and safety at sea. For instance, fish aggregation devices (FADs) were deployed around Funafuti during the early 1990s, and at all outer islands in 1993, to enhance subsistence and artisanal tuna fishing. Associated with the FAD programme was the development of mid-water fishing techniques suited to small fishing craft. Further, a marine training school on Funafuti provides courses for merchant seamen, most of whom subsequently serve on overseas cargo or fishing vessels. Higher-level training is usually sought overseas, often at the University of the South Pacific in Fiji.

A National Coordinating Center is under construction for the monitoring and management of foreign fishing vessel activities within Tuvalu's EEZ.

The Tuvalu Fisheries Department, through its extension section, began training fishers in Funafuti and Nukufetau, the only two islands identified as having any commercial beche-de-mer resources. The Fisheries Department also produced a leaflet in Tuvaluan.

Lagoon surveys

As part of a monitoring programme for coastal erosion of the inhabited islands within the atolls of Nukulaelae and Nukufetau, a series of beach profiles were established to help monitor the sediment movement and erosion rates of the more seriously affected parts of the coastlines. Robert *et al*. (1989) stated that problems of erosion and the construction of sea wall protection by using rocks obtained from the other uninhabited islands in the lagoon had caused erosion problems on Nukulaelae and Nukufetau islands.

Beach profiles were established around the main inhabited island of Nukulaelae and Nukufetau to monitor the erosion and sediment-transport trends of the coastline. Photographs of the beach profile locations were taken for re-surveying at periodic intervals; initially at six-monthly intervals for two years. Also, officials of the Lands Department continually monitor this work. Furthermore, a large black coral tree some 2 m high was seen in about 60m of water in Nukufetau lagoon; black corals were also sighted in Nukulaelae. It was reported that some additional black coral trees could be found at some deeper depths (Roberts *et al.*, 1989). There is some evidence of accumulation of phosphate at Nukufetau atoll.

Government policies, laws and legislation

The primary fisheries agencies are the Department of Fisheries (DOF) and NAFICOT. Both lie within the Ministry for Natural Resources. The DOF is responsible for the control, management and development of fisheries under the Fisheries Act, 1978. The NAFICOT is responsible for the commercial development of fisheries in Tuvalu through the National Fisheries Corporation of Tuvalu Act, 1980. The recent establishment of the Environment Unit within the same ministry shares some tasks with DOF in regard to related activities on conservation of marine resources.

The basic fisheries law in Tuvalu is the Fisheries Act of 1978, which was revised in 1990. The Act provides for the Minister responsible for fisheries to take such measures as he sees fit to promote the development of fisheries and to ensure that fishery resources are exploited to the full for the benefit of Tuvalu. Other relevant legislation includes the Marine Zones (Declaration) Act of 1993 and the National Fishing Corporation of Tuvalu Act of 1980, revised in 1982. The Marine Zones Act refers to sovereign rights to explore, exploit, conserve and manage living and non-living resources within the area of its jurisdiction. The Local Government Act gives local governments powers to improve and control fishing and related industries and prohibit, restrict or regulate the hunting, capture, killing or sale of fishes.

Several of the island councils have exercised the above powers and have enacted legislation to control fishing in their waters. Local government By-Laws in Tuvalu include several categories such as:

- Prohibition of certain fishing practices such as use of spears and nets with mesh size of < 1.5 inches; and the use of mechanically powered boats on one island;

- Prohibition of fishing practices in certain areas. For instance, the use of spears in waters enclosed by

the reef; fishing for rock cod using spear or net in specified areas of the lagoon; and, a ban on the use of fish traps and fish nets in a some designated areas;

- Prohibition of certain fishing practices in relation to certain species. For instance, prohibition on the use of nets < 1 inch mesh size to capture spinefoot;

- Prohibition of fishing practices in certain areas at certain times in relation to certain types of fish such as flowery cod between June and August using a spear or net in various areas;

- Licensing of commercial fishermen. Provision of licenses to allow commercial fishermen to sell their catch;

- Prohibition of the collection of shellfish for public health reasons. For instance, collection of shellfish, crabs, octopi, squids or crayfish within a hundred feet of a latrines.

In addition to the regulatory powers of the Minister for Natural Resources, the Councils of Chiefs (maneapa) exercises powers over fishing practices of the community. Enforcement of these maneapa laws is through the strong social conscience and responsibility that is characteristic of most Polynesian cultures (Belhadjali, 1995).

The Department of Fisheries maintains direct contact on technical issues with regional and international organizations dealing in fisheries. Policy and other matters are managed in the first instance through the Department of Foreign Affairs. Tuvalu is a member of the Secretariat of the Pacific Community, the South Pacific Forum Fisheries Agency (FFA) and the South Pacific Regional Environmental Programme (SPREP). Tuvalu is also party to a number of treaties and agreements relating to the management of regional fisheries, including:

- Treaty on Fisheries Between the Governments of Certain Pacific Island States and the Government of the United States of America;

- the Convention for the Prohibition of Fishing with Long Driftnets in the South Pacific;

- the Niue Treaty on Cooperation in Fisheries Surveillance and Law Enforcement in the South Pacific Region;

- the Nauru Agreement Concerning Cooperation in the Management of Fisheries of Common Concern; and

- the Palau Arrangement for the Management of the Western Pacific Purse Seine Fishery.

Tuvalu is a signatory to the United Nations Convention on the Law of the Sea (UNCLOS) and the Agreement for the Implementation of the Provisions of the United Nations Convention of the Law of the Sea of 10 December 1982 Relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks.

Gaps in current monitoring and concervation capacity

Tuvalu faces great difficulties in establishing periodic monitoring and conservation of marine resources. Although a limited number of research projects have dealt with baseline information on coral reefs and pollution problems, very little appears to have been done on enforcement and monitoring programmes. There appears to be no existing standard concerning coral reefs against which performance and compliance can be evaluated. For example, it is very difficult to evaluate the

extent of damage in marine communities caused by shipwreck, spills, hurricanes or crown-of-thorn infestation.

Efforts in relieving fishing pressures on existing stocks have been the introduction of giant clams, *Trochus* and *Eucheuma* seaweed to better utilize appropriate habitat to produce exportable species (Wilson, 1995). These projects are important alternatives for home consumption and earnings and, would help relieve fishing pressures by actively engaging fishermen. They have not been well monitored and managed, and a need exists to review the future of these programmes. Furthermore, there are still important information gaps that need addressing. A great deal of important work remains to be accomplished on coral reefs of Tuvalu. Rapid environmental changes and rate of resource use are stimulating new avenues of research as are new research techniques and rapidly developing new fields of scientific endeavour. It is important to acquire sound knowledge base against which to measure and assess obvious and growing environmental stresses that threaten coral reefs.

The data needs concerning coral reefs of Tuvalu fall into two major categories: environmental baseline conditions and monitoring and, fundamental oceanographic and biological processes that control sensitivity to and recovery from environmental changes. Research work in the former has already been started but lacks manpower and funding for periodic monitoring. Little work has been done on the latter; for instance, no research on coral bleaching.

Attempts to provide access to wider markets for outer islands fishers have been constrained through inadequate shipping services, and lack of cold storage and other processing facilities at the landing sites. Trials have been made in the production and export sale of dried fish and of tuna jerky produced by solar-drying at outer island centres but so far these have not led to commercial development.

Furthermore, development of commercial fishing activities cannot progress until several critical constraints are removed, which include:

- lack of managerial knowledge and expertise to undertake planning and implementation of commercial fisheries ventures;

- lack of adequate and consistent data gathering required for accurate monitoring of the state of local fisheries resources and activities;

- lack of incentives to attract local fishermen to participate in commercial fishing activities; and

- potential threat of deteriorating coastal resources as a result of over exploitation by the large population on Funafuti atoll. This has hindered development of commercial fisheries activities in the past.

According to Belhadjali (1995), there is great potential for conflicts in the regulation of fishing and fisheries in Tuvalu, particularly due to the number of ‘institutions’ involved in the control of fishing. There are reportedly several ‘hierarchy’ conflicts between the council of chiefs and the local governments (Island/Town Councils). This lack of centralized regulations could potentially delay or hinder the development of commercial fishing enterprises.

One major potential source of dissension regards ownership of marine resources in the islands, especially Funafuti. There are several communities living on the capital Funafuti, many employed by the government. The question of ownership and access to the marine resources of Funafuti is one that needs to be settled quickly before further commercialisation of the fisheries occurs. Thus, Belhadjali (1995) states that the Tuvalu Fisheries Department has identified regulations of fishing and fisheries in Tuvalu as a major area that needs looking into before additional management strategies are implemented.

Conclusions and recommendations

Subsistence activities dominate Tuvalu's fisheries sector while the commercial fisheries sector is practically non-existent. Most of the fishing is at the subsistence level to provide food for immediate families and relatives. Fisheries centres have been established on several outer islands with the intention of providing fishers there with income earning opportunities.

There is sufficient evidence of declining population of harvestable reef fishes and invertebrates and thus, a genuine need for conservation and sustainable harvesting. Also, there are enough powers vested on the Minister of Natural Resources and local maneapa administrations to devise appropriate policies and tapus to control the concerns raised above. On one hand, some people generally thought that laws restricting fishing would be gradually accepted and on the other hand, people in the northern islands thought that the laws would be accepted in theory, but not in practice. As a result, a major gap or ongoing conflict exists between utilising and management of marine resources by the same users. The foremost strategy to solve such conflict would be simply raising the level of awareness among resource users based on hard scientific data. While research has been carried out in the past, consistent and regular surveys are needed to detect new trends and patterns on the status of marine resources.

In Tuvalu, there is only a handful of trained marine science graduates to carry out research and monitoring work on marine resources. The Fisheries Department is still very much relying on outside funding and expatriates to do the work instead. Even with new graduates, it often takes time to get them recruited by the Fisheries Department because of funding constraints. It is therefore recommended that the government secure funding and put in place positions to absorb new marine science graduates. It would be a major loss to the country if these graduates leave because of the reasons highlighted above.

All past research on marine resources wase properly documented and reports are stored in the Fisheries Department and Ministry of Natural of Resources head office. However, no proper database has been set up to store all these data. The Fisheries Department is working in collaboration with ICLARM to incorporate relevant data into FishBase. Regardless, it is recommended that a database should be set up within the Fisheries Department or the Ministry of Natural Resources head office to store information on coral reefs obtained from periodic surveys.

Research should be oriented to the establishment of environmental baseline conditions and the monitoring of changes against the baseline to provide a basis for management. Environmental baseline studies should include water quality, sediment and inventories of marine biological resources. Data collection on associated fishing effort to include economic and social factors is also recommended. The use of a Geographical Information System (GIS) would be most valuable to study the extent of coral reefs, mangroves and seagrass beds. A Marine Reference Collection should be encouraged and specimens should be deposited at the Marine Studies Collection of the University of the South Pacific. Basic data about the abundance, distribution and life history of the diverse fish species are also needed to establish a fish database for Tuvalu. The designing of a monitoring programme is recommended to identify trends and detect changes in coral reefs and related ecosystems. The programme should also differentiate changes attributable to natural processes from those due human activities, discriminate among the anthropogenic, climatic and other components and determine the potential of reefs and reef organisms as early warning indicators.

Based on the survey, Belhadjali (1998) recommended that there should fishing restrictions which include:

- Ban the use of underwater breathing apparatus (SCUBA and hookah gear) in harvesting of marine species;

- Ban the commercial export of giant clam meat to overseas markets;

- Maintain the current fishing ban on the introduced species *Trochus niloticus*;

- Licence commercial bêche-de-mer fishers that export to overseas markets; and

- Further research be carried to assess the reef fish resources and, monitor the population levels of crown-of-thorns starfish Acanthaster planci in Funafuti lagoon.

Similary, SPREP (1994) recommended:

- The establishment of permanent marine protected areas, representing different ecosystems, to give sanctuary for rare species, to provide protected areas for fish breeding and from which restocking can take place;

- Undertake a fish stock assessment survey (of key indicator species and the foods on which they rely) and an assessment of the threat from ciguatera;

- Institute a system of resting areas from fishing for various periods to encourage the recovery of marine species. This system has traditionally been used on some islands where island councils close certain waters for specific periods for cultural or management reasons;

- Stop fishing for species acknowledged as being rare such as giant clams and turtles; and

- Stop the practice of net fishing in those lagoon areas subject to heaviest fishing pressure (e.g., offshore from village areas);

ADAB (1985) recommended immediate and effective regulation of the utilisation of the existing available deposits of granular materials, in gravel to cobble sizes. This is to ensure effective protection of the island and thus, reduce erosion rate as a result of oceanic waves. Berdach & Maynard (1994) recommended that as far as environmental protection and resource management is concerned, an effective system of resource management be instituted which entails:

- Estimation of MSYs for those marine resources which are to be harvested;

- Establishment of policy guidelines and licensing of activities which affect the marine environment either directly or indirectly;

- Reliable monitoring of effort and yield;

- Evaluation of data; and

- Refinement and adjustment of licensing requirements and government of Tuvalu policy guidelines, as necessary.

On the whole, some excellent policies, legislation and plans have already been formulated. What is left now is the co-ordinated effort in the implementation. Among others, is the paramount importance of monitoring and research of coral reefs so as to compliment management and decision making that leads to conservation and sustainability of marine resources. A good data series on the status of coral reefs from years of research should play an important role in validating management and control measures over the long term. It is thus, strongly recommended that scientists should participate actively in coastal-marine conservation so as to appreciate the physical and biological complexity of marine resource systems. Moreover, such management should be extended to address additional economic, social and environmental objectives such as fisher's welfare, economic efficiency, the allocation of resources and environmental protection. Whichever options and management measures are selected, a permanent, even if low level system of data collection should be established to monitor the 'health' of marine resources and, to determine the effectiveness of management strategies.

Appendix: summaries of coral reef benthos and fishes in Tuvalu

Lyngbya majuscula	*Caulerpa racemosa*
Boodlea siamensis	*Pocockiella variegata*
Dictyosphaeria cavernosa	*Padina commersonii*
Valonia ventricosa	*Dictyota bartayresiana*
Halimeda opuntia	*Herposiphonia tenella*
Halimeda tuna	*Ceramium personatum*
Halimeda incrassata	

Table 2
Algae from Funafuti lagoon (Sources: ADAB, 1985).

Miliolina seminulum	*Orbitolites complanata*
Miliolina reticulata	*Orbitolites marginalis*
Valvulina davidiana	*Cymbalopora poeyi*
Calcarina hispida	*Tinoporus baculatus*
Amphistegina lessonii	*Polytrema miniaceum*

Table 3
Foraminifera from Lagoon beaches of Funafuti (Sources: ADAB, 1985).

Psammocora contigua	*Pocillopora damicornis*
P. haimeana	*P. eydouxi*
P. superficialis	*P. verrucosa*
Stylophora pistillata	*Favia pallida*
Platygyra daedalea	*Hydnophora microconos*
Plesiastere versipora	*Leptastrea cf. Bottae*
Pavona cf explanulata	*L. transversa*
P. varians	*Coscinaraea columna*
Fungia fungites	*Lobophyllia hemprichii*
F. scutaria	*Porites lutea*
Acropora aculeus	*P. lobata*
A. conigera	*P. lichen*
A. cytherea	*A. rosaria*
A. hyacinthus	*A. tenuis*

Table 4
Reef corals recorded from Funafuti (Source: ADAB, 1985).

Pelagics	
Elagatis bipunnulatus	*Acanthocynbium solandri*
Grammatorcynus bilineatus	
Demersal	
Epinephelus microdon	*Aphareius furca*
Pristipomomoides zonatus	*A. rutilans*
Aprion virescens	*Cephalopholis urodelus*
Scombroides lysan	*Lutjanus fulvus*
Lagoon and reef	
Lutjanus gibbus	*Lethrinus miniatus*
L. kasmira	*L. harak*
Sphyraena forsteri	*L. mahsena*
Siganus vermiculatus	*Monotaxis grandoculis*
Myripristis vilaceus	*Variola alboomarginata*
Carangoides fulvoguttus	*Kyphosus cinerascens*
Mulloidichthys dussumieri	*Naso unicornis*
Archamia lineolata	*Selar crumenopthalmus*
Pterocaesio diagramma	

Table 5
Common harvested reef fishes by local fishers (Source: Sauni, 1997).

Bibliography

ADAB, 1985 —
Tuvalu Lagoon Bed Resources Survey. Report prepared for the Tuvalu Government, Vol. 1.

Anon, 1995 —
Funafuti Marine Conservation Project preparation document, Environment Unit, Ministry of Natural Resources, Government of Tuvalu, 143 p.

Belhadjali K., 1995 —
Tuvalu country statement: Joint FFA/SPC workshop on the management of South Pacific inshore fisheries, June 26-7, 1995, Integrated Coastal Fisheries Management Project, Technical Document No. 11, Noumea, New Caledonia.

Belhadjali K., 1997 —
Beche-de-mer production in Tuvalu. Beche-de-mer Information Bulletin, No. 9, SPC, New Caledonia.

Belhadjali K., 1998 —
A Survey of the Inshore Fisheries Resources of Tuvalu. Unpub. report prepared for the Fisheries Department, Ministry of Natural Resources & Environment, Tuvalu Government, 101 p.

Berdach J. T., Maynard J.A., 1994 —
A study of the fisheries sector of Tuvalu: with recommendations for commercial and institutional development. Technical report prepared for Asian Development Bank and the Government of Tuvalu, 1-19.

Braley R. D., 1988 —
The status of giant clam stocks and potential for clam mariculture in Tuvalu. A report prepared for the Fisheries Division, Funafuti, Tuvalu, and the South Pacific Aquaculture Development Project, Suva, Fiji.

Chapman F.,1903 —
J. Linn. Soc. (Zool.), 28: (1900-03): 381-2; 386-7.

Chapman V. J., 1955 —
Pacific Science, 9: 354-356.

Dahl A. L., 1986 —
Review of the Protected Areas System in Oceania. UNEP & IUCN Commission on National Parks and Protected Areas, Gland, Switzerland.

Funafuti Marine Conservation Area, 1997 —
Preliminary survey of the Funafuti Marine Conservation Area. Unpub. report, Funafuti, Tuvalu.

Johnson J. H., 1961 —
Fossil algae from Eniwetok, Funafuti and Kita-Daito-Jima. In: U.S. Geol. Surv. Prof. Pap., 260-Z.

JONES G. P., KALY U. L., CLEMENTS K., 1991 — Preliminary records of the coral reef fishes of Tuvalu. *South Pacific Journal of Natural Sciences*, 11: 40-57.

KALY U. L., JONES G., 1991 — Preliminary assessment of a severe outbreak of ciguatera at Niutao, Tuvalu. *South Pacific Journal of Natural Science*, 11: 62-81.

KALY U. L., JONES G., 1993 — Pilot dredging project – Funafuti, Tuvalu: Assessment of ecological impacts on lagoon communities.

KALY U. L., JONES G., 1994a — Test of the effect of disturbance on ciguatera in Tuvalu. *Memoirs of the Queensland Museum*, 34(3): 523-532.

KALY U. L., JONES G., 1995 — Tuvalu Reef Channels Project – Project 1: Project plans and environment risks. Unpub. Report prepared for New Zealand Ministry of Foreign Afairs and Trade. Development Cooperation Division, 31 p.

KALY U. L., JONES G. P., 1994b — Long term effects of blasted boat passages on intertidal organisms in Tuvalu: A meso-scale human disturbance. *Bull. Mar. Sci.,* 54: 164-179.

KENNEDY D.G., 1931 — Field notes on the culture of Vaitupu, Ellice Islands. Polynesia Society, New Plymouth, England.

KING M., 1995 — Management plan for the deep-water bottom-fish fishery in Tuvalu. Unpub. discussion paper, Government of Tuvalu, 18 p.

LANGI V., 1990 — Marine resource survey of Nanumea and Nui Islands, Northern Tuvalu (giant clams, trochus, beche-de-mer, pearl oysters). Report for the Fisheries Division, Ministry of Natural Resources & Home Affairs.

MCLEAN R. F., HOSKING P. L., 1991 — Geomorphology reef islands and atoll motu in Tuvalu. *South Pacific Journal of Natural Science*, 11: 167-189.

PRESTON H. L., LOKANI P., 1990 — Report of a survey of the sea cucumber resources of Haápai, Tonga. Country Assignment Report, South Pacific Commission, Noumea, New Caledonia.

ROBERT B., SMITH D. M., REAGRIE E. S., SENEKA F., 1989 — Survey of Nukulaelae and Nukufetau Lagoons. Unpub. Report prepared for SOPAC Technical Secretariat & Lands Department, Tuvalu Government, 60 p.

SAUNI S., 1997 — An Assessment of Fisheries Statistics in Tuvalu: with specific reference to Funafuti and Nukufetau Islands. Unpub. MSc thesis, University of Newcastle upon Tyne, England, 94 p.

SCOTT, D. A. (ed.), 1993 — A Directory of Wetlands in Oceania. IWRB, Slimbridge, UK & AWB, Kuala Lumpur, Malaysia.

SPREP, 1994 — State of the Environment Report, Government of Tuvalu, 16-18.

TEBANO T., MCCARTHY D., 1984 — Ciguatera fish poisoning and the causative organism in the Gilberts, Kiribati. Institute of Marine Resources, University of the South Pacific, Publication, 46 p.

TEBANO T., 1991 — A preliminary survey on ciguatera fish poisoning in Tuvalu. Technical Report 11, Marine Studies Programme, University of the South Pacific.

TESFAGIORHIS H., 1991 — Tuvalu: 1991 Population and Housing Census. Analytical Report, Government of Tuvalu, 2: 1-5.

WHITELEGGE T., 1897 — The Crustacea. *Aust. Mus. Mem*., 3: 127-154.

WILSON M. A., 1995 — Tuvalu: Fisheries Resources Profiles. Report prepared for the Forum Fisheries Agency, Solomon Islands, 98 p.

WOODROFFE C.D., 1985b. Vegetation and flora of Nui atoll, Tuvalu. *Atoll Res. Bull*., 283: 1-18.

WOODROFFE C. D., 1987 — Pacific Island Mangroves: Distribution and Environmental Settings. *Pacific Science*, 41(1-4): 166-185.

ZANN L. P., 1983 — Traditional Management and Conservation of Fisheries in Kiribati and Tuvalu atolls. Institute of Marine Resources, The University of the South Pacific, Fiji, 1-23.

Status of coral reef and reef fish resources of Vanuatu

William Naviti

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Introduction to Vanuatu

Vanuatu is an archipelago of over 80 islands stretching 1300 kilometres from north to south in the Western Pacific Ocean. The islands include both igneous formations and limestone derived from uplifted fringing coral reefs (Preston, 1996). The combined land area is 12 190 km^2. The maritime exclusive economic zone covers 680 000 km^2.

Vanuatu's population, 79% of which live along the coast, is experiencing rapid growth, at least 2.8 % annually, according to the 1989 Consensus (Statistics Office, 1994). Of the estimated 177 400 people, 44 300 live in the two urban areas of Port Vila and Luganville (Statistics Office, 1997:2). Almost 80% of the population live on 7 islands: Efate, Santo, Luganville, Tanna, Malekula, Pentecost, Ambae and Ambrym. Over 70% of the population live on their traditional lands, growing food crops and harvesting forest and marine resources for local cash needs, personal consumption, exchange and gifting (Government of the Republic of Vanuatu, 1999b). Over 110 languages were in use in 1989 (Statistics Office, 1997).

Status of coral reefs and other benthos and biodiversity

Coral Reefs

The coral reefs of Vanuatu contribute to rural incomes, nutrition, shoreline protection and, more importantly, self reliance for the people of Vanuatu, particularly coastal communities. However, there are relatively few extensive shallow water reefs surrounding the 80 high islands in the Vanuatu archipelago. Inner reef areas are limited to narrow fringing reefs and reef platforms surrounding islands and a few lagoons and barrier reefs, totalling an area of approximately 408 km^2 (Bell & Amos, 1993). Mangroves and estuarine habitat amount to a total area of only 25 km^2 (Bell & Amos, 1993). The distribution of all reefs in Vanuatu down to 400 metres is provided in table 1 (David & Cillaureen, 1989).

A nation-wide survey of the corals and associated ecosystems in Vanuatu was conducted in March and April, 1988 by scientists from the Australian Institute of Marine Science (AIMS) and the Great Barrier Reef Marine Park Authority (GBRMPA) (Done & Navin, 1990). The survey described the current condition, character and baseline information about coral reefs and seagrasses for 35 locations throughout Vanuatu.

Islands	Surface Area (ha)				
	Island	Shelf	10-100m	100-400m	Total Reef Area
Torres	12 000	1600	26 130	20 600	48 330
Ureparapara	3900	289	1650	5150	7080
Vanua Lava	33 000	1640	6500	16 390	24 530
Mota	1500	110	850	3170	4130
Mota Lava	3100	570	2450	4120	7140
Mere Lava	1500	30	550	1780	2 360
Gaua	33 000	1 510	3280	16 990	21 780
Rowa	10	2630	1700	4270	8600
Santo-Malo	424 800	4 500	60 000	142 970	207 470
Ambae	41 000	230	3850	11 480	15 920
Maewo	28 000	780	6030	33 470	40 280
Pentecost	49 000	1730	8950	25 000	35 680
Malakula	205 300	10 110	45 100	101 350	156 560
Ambrym	66 500	700	7250	26 650	34 600
Epi-Paama-Lopevi	47 800	2500	19 130	76 510	98 140
Tongoa-Tongariki	5 000	150	4720	16 530	21 400
Emae-Makura-Mataso	3 600	2020	4660	30 820	37 500
Efate	92 300	8070	28 450	95 330	131 850
Erromango	88 700	1340	4250	55 660	61 250
Tanna	56 100	13 10	7450	42 440	51 200
Aniwa	800	310	1150	5120	6580
Futuna	1100	100	1400	3700	5200
Aneityum	16 000	2580	18 450	14 820	35 850
Total	1 218 900	44 800	362 950	754 680	1 063 430

Table 1
Area Distributions of Vanuatu Reefs down to 400 m
(David & Cillaurren, 1989).

Vanuatu's coral reef exhibit a range of characteristics expected of an archipelago including exposed outer reefs, sheltered flats and lagoons, partially sheltered open embayments and sheltered embayments (Done & Davin, 1990). Exposed coral reef slopes and crests were dominated by coralline algae and robust plating and branching corals (*Acropora* and *Pocilloporidae*), changing to dominance of a mix of massive and branching corals 3 to 5 metres below the level of the reef flat (Done & Davin, 1990:17). Sheltered parts of the outer reef were characterised by various species of *Acropora* and *Montipora* (Done & Davin, 1990:17). Massive *Porites* were prevalent in open embayments while sheltered embayments were strongly dominated by soft corals (Done & Davin, 1990:22). It is postulated that the colonisation of coral reefs in Vanuatu is assisted by a dispersal pathway through the Solomon Islands to the Great Barrier Reef in Australia (Done & Navin, 1990).

The coral reefs surveyed included many areas of exceptional visual quality while others had various degrees of coral death and physical damage, probably as a result of cyclones and crown of thorns starfish (Done & Navin, 1990). The most aesthetically appealing reefs were at Inyeug, Aneityum, Cook Reef, Hog Harbour, Santo, Reef Islands, and Ureparapara (Done & Navin, 1990).

The AIMS survey team concluded that, overall, the reefs had deteriorated since an earlier survey carried out in 1985. At approximately half the sites surveyed, there was at least as much dead standing coral as live hard coral, and in approximately one fifth of the sites, there was more than four times the percent cover of dead standing coral as there was living coral (Done & Davin, 1990:26).

Status of fishes (commercial, subsistence and aquarium)

Shallow water reef fisheries

The survey by AIMS (Done & Navin, 1990) on shallow water (<30 metres) reef fishes identified a total of 469 species, of which 25 were easily distinguishable under 6 major groups. These include 10 species of Pomacentridae, 5 of Scaridae, 3 of Labridae, 3 of Acanthuridae, 2 Siganidae and 2 Chaetodontidae (Williams, 1990). Williams (1990) noted that the south eastern side of Cook Reef and the eastern side of Santo had a particularly high fish species diversity and that some species, especially scarids, were more abundant in these areas.

Vanuatu's largest coastal fishery is the artisanal and subsistence fishery where the bulk of the fish are sold locally and consumed in rural areas. The methods employed in the subsistence fishery range from collection by hand to gill netting on the reef, set or surround nets and diving using spear guns. In more remote areas, more traditional methods, generally limited to the shallower areas of the coastline, include spears, bows and arrows, fish fences and traps and poisoning using leaves (Bell & Amos, 1993).

The size of the subsistence harvest was recently estimated at approximately 2500 tonnes (Wright, in prep) making it 4 times larger than the commercial catch (Preston, 1996)[1]. However, the market is also affected by a high incidence of ciguatara poisoning. Table 2 shows the percentage breakdown for the village fisheries catch in 1983, at that time estimated to be 2402 tonnes.

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

Table 2
Percentage fish groups from Village Fisheries in 1989 (David, 1990).

Shallow water reef fish and coastal pelagics provide and estimated 40 tonnes to the local markets (Wright, In prep). Beche-de-mer, trochus, green snails, crustacean fisheries and aquarium fish provide coastal communities with immediate cash, possibly up to VT40 million annually (Wright, In prep).

Deep water reef fisheries

The Secretariat of the Pacific Community (SPC) and Institute for Research and Development (IRD) conducted studies of deep slope fish stocks between 1974 and 1988 as components of a range of fishery development projects (Dalzell & Preston, 1992). The initial aim of these studies was to establish whether deep dropline fishing was viable at a given location and to use this information to set up 25

[1] Despite an incentive scheme involving a subsidised fuel price program to those that submit data returns, and 50 Vatu for every form returned and correctly completed , there is under-reporting of subsistence fish catches (Bell & Amos, 1993) and accurate figures are not available for the actual size of the artisinal and subsistence fishery.

village based fishing enterprises. However, the rate of expansion exceeded expectations and by 1986, there were 80 such enterprises throughout Vanuatu (Dalzell & Preston, 1992). Since that time, numbers have declined dramatically, possibly because the equipment and ice making facilities are no longer serviceable.

Demersal or bottom fishing activities are usually carried out in shallow coral reefs and lagoon areas. Dominant species are the snappers (*Lutjanidae*), groupers (*Serranidae*) and emperors (*Lethrinidae*) (Dalzell & Preston, 1992). The percentage composition of the dropline catches by number and weight from dropline fishing on deep reef slopes (after 4 visits by SPC Master fisherman) for Vanuatu and the average of a range of Pacific Island countries (PICs) is shown in table 3 below:

Catch	Vanuatu		Mean for all other PICs	
	No.	Wt. (kgs)	No.	Wt. (kgs)
Etellinne/Apsillinae (Deep water snappers)	49.5	45.5	38.7	32.7
Lutjaninae (Shallow water snappers)	23.6	10.6	15.7	12.1
Lethrinidae (Emperors)	3.5	2.1	9.9	6.1
Serranidae (Groupers and Coral Trouts	13.0	19.1	4.3	12.0
Carangidae/Scombridae (Trevallies, jacks, tunas & mackerals)	2.1	3.9	9.2	11.7
Gempylidae (Oilfish and snake mackerels)	1.6	4.6	3.3	6.8
Sphyraenidae (Barracudas and seapikes)	0.1	0.2	1.5	1.7
Other teleosts	2.5	1.3	3.6	2.1
Sharks	4.0	12.9	3.8	15.1

Table 3
Percentage catch composition by number and weight from dropline fishing on deep reef slopes for Vanuatu and other Pacific Island countries.

Fishing in deeper waters outside the lagoon takes the form of trolling and mid water hand lining for pelagic species such as tuna and mackerels. Dalzell and Preston (1992) used the results of research by Brouard and Grandperrin (1985) and Carlot and Nguyen, (1989) to estimate the total standing stock of Vanuatu to be roughly 980 tonnes and the maximum sustainable yield (MSY) to be between 98 and 294 tonnes. However, these figures should be treated extremely cautiously due to poor data quality, inconsistent sampling methods, differences in experimental designs, observer bias etc. Brouard and Grandperrin (1985) concluded that 'the bottom fish resources of the outer slope are, as it turns out, rather limited, which means that the fishery must be managed with great care'.

The deep slope fishery was initially established to increase the supply of fish to Port Vila, for export and to supply the burgeoning tourist industry (Dalzell & Preston, 1992). In the early 1990s, landings of deep slope fishes amounted to between 30 and 40 tonnes/year from the village based fisheries (Dalzell and Preston, 1992). It is now estimated that deep-water snapper fisheries provide 80 tonnes annually to domestic markets with relatively minor amounts exported (Wright, in prep).

Consumption of deep slope fishes by Ni-Vanuatu has increased gradually to the point where fish originally sent from rural centres to Port Vila is now retained for local consumption (Dalzell & Preston, 1992). Other contributing factors to the decline in the amount of fish reaching the main urban centre include poor vessel design because vessels cannot operate profitably after they had fished the initial virgin biomass (Dalzell & Preston, 1992), absence of a reliable inter-island freight service, lack of ongoing support to the fledging businesses, infrastructure and ongoing training.

Small amounts of aquarium products and bech-de-mer are exported but revenue to the government has been limited (Wright, in prep). For example, the annual average value of shell during the last decade amounted to VT98 million, representing 90 percent of marine product exports (Wright, in prep).

Natural and man made threats to biodiversity

Man made threats

Man made threats to the marine resources of Vanuatu include coastal construction, land reclamation, waste disposal, livestock farming, logging, soil erosion and effluent from septic tanks (SPREP, 1999). Done and Navin (1990) further suggest that the two major threats to the coral reefs of Vanuatu appear to be siltation accompanying logging of steep watersheds and eutrophication caused by domestic sewage discharged into reef waters.

The main threats to coral reefs in Vanuatu appear to occur in and around Port Vila. A study of water quality in 2 areas of Port Vila by Yeun (1980) showed high levels of faecal contamination and BOD in some areas, attributed to a malfunctioning water tank at the hospital treatment facility, storm water effluent and effluent from hotels. More recently, there is anecdotal evidence that during periods of high rainfall, runoff from settlements located behind the airport has affected the water quality in the Mele Bay harbour E. Bani (2000, pers. comm., 2 May). One tour operator reported a bleaching event of corals in this Bay during 1997. Also in the Port Vila area, areas of coral reef flats have been denigrated through land reclamation as a result of construction of resorts and villa's.

Outside of the main urban areas, the Environment Unit have received reports that some coastal village communities are concerned about the level of harvesting of non motile reef biota L. Silas-Nimoho (2000, pers. comm., 2 May). Destructive fishing practises including dynamiting have largely ceased, although there has been reports of Clorox use in the river systems E. Bani (2000, pers. comm., 2 May). Indiscriminate use of nets of all sizes is also increasingly recognised as a key threat to marine biodiversity L. Silas-Nimoho (2000, pers. comm., 2 May).

Collection of corals for the local tourist trade and home decorations (Bell & Amos, 1993) is not a significant problem for Vanuatu at present as only one operator was licensed as of 1997 *D. Kalfatak* (2000, pers. comm., 2 May). However, approximately 3 operators have recently applied for permits to export live coral (including both coral rubble which are covered with turf algae and other small organisms) for the aquarium trade. These proposals involve the culture of corals and giant clams (*Tridacna*) for export. Landowners, unaware or not concerned with the regulations of the Environment unit, have also been know to use corals to build houses and sea-walls.

Natural threats

Vanuatu is regularly under the influence of cyclones, ranging in frequency from 1 every 3 years to 3 in a year (Anon, 1984). The most devastating cyclone in the last 20 years was Cyclone Uma which passed through Vanuatu in 1987, causing extensive damage to Efate and it's coral reefs. A number of less intense cyclones have passed over Vanuatu in recent years but the extent of damage to the coral reefs has not be assessed.

Large populations of the Crown-of-thorns-starfish *Acanthaster planci* were located at 10% of the sites visited by the AIMS survey team, namely Port Vila, Aneiyum, Epi and Malekula (Done & Navin, 1990). Nevertheless, coral regeneration was good across all sites (Done & Navin, 1990). Crown of thorns outbreak have been of concern to local tour operators over the years. One outbreak was also reported in 1996 on Efate E. Bani (2000, pers. comm., 2 May). However, the amount of damage to those areas from this predator has not been properly assessed.

In geologic time and even during the last 50 years, periodic tectonic uplift and subsidence of islands have been catastrophic to Vanuatu's coral reefs and seagrasses when they were left permanently exposed to air (Done & Navin, 1990).

Current and potential climate change impacts

The Pacific Islands Climate Change Assistance Programme (PICCAP) country team in Vanuatu has determined that the impacts of climate change will be spread inequitably throughout the islands of Vanuatu, and will particularly affect low lying islands and their fringing reefs. The main impacts include significant increases in the frequency of cyclones, a gradual decline in rainfall and an increase in temperature of between 1 and 2 degrees up to the year 2050 (Government of the Republic of Vanuatu, 1999b: 24).

Coral mortality as a result of raised sea surface temperatures is a serious concern for the Vanuatu Government. Apart from reduced opportunities for fishing, similar concerns are shared for the state of fisheries where rises in sea surface temperature and consequent reduction in the amount of available oxygen could result in increases in fish mortality (Government of the Republic of Vanuatu, 1999b: 30).

The impacts from sea level rise are expected to be negated by the rate of tectonic uplift of some islands (Government of the Republic of Vanuatu, 1999b). However, the impacts of sand extraction from the reef flats and mangrove removal may be compounded by the effects of sea level rise.

The first National Communication, prepared through PICCAP, cautions that there is insufficient data to properly quantify impacts, identify areas of high vulnerability and design appropriate adaptation policies (Government of the Republic of Vanuatu, 1999b). For example, only one weather station in the country has records exceeding 50 years. The Action Plan proposed as part of this first National Communication emphasises activities that will address this lack of data and strengthen national capacity, especially at a national and provincial level to meet this challenge (Government of the Republic of Vanuatu, 1999b).

The Vanuatu government is also considering integrating climate change considerations with multi sectoral activities and institutionalising integrated social, environmental and development planning (Government of the Republic of Vanuatu, 1999b). The current Prime Minister of Vanuatu, the Honourable Donald Masikevanua, has declared his commitment to participating in international efforts to combat global warming and sea level rise (Government of the Republic of Vanuatu, 1999b)

Marine protected areas and level of management

Each cultural group in Vanuatu has it's own traditional approaches to the management and conservation of marine biological resources D. Kalfatak (2000, pers. comm., 4 May) which include the establishment of managed or protected areas. Many coastal communities apply simple environmental indicators to manage their marine resources such as the physical size of the resource, abundance and catch per unit effort (Whyte *et al.,* 1999). Traditional approaches to coral reef conservation have been supplemented by a range of measures introduced by government and non government organisations and individuals in the private sector.

Taboos which apply to one managed area can be transferred to other areas. Some protected areas have management provisions that take into account religious practices. For example, within the Nagha and Pincia Protected Areas, turtles are protected during the nesting season but, since the community are Seven Day Adventists, fishing is allowed on Fridays J. Whyte (2000, pers. comm., 4 May). Unfortunately, however, not all management provisions and taboos are adhered to by neighbouring village communities and visitors.

Table 4 provides some examples of protected or managed marine areas which have been set up under customary tenure arrangements by coastal communities and by the Vanuatu government. Such measures have usually grown out of the need to protect and develop important economic industries such as fishing and tourism as well as conservation measures such as restocking of trochus and giant clams *Tridacna* D. Kalfatak (2000, pers. comm., 4 May).

Currently, there is only one formally declared marine protected area (MPAs) in Vanuatu (see table 4). The Colonial government designated small areas of land off Espiritu Santo which include foreshore areas (eg Aore Recreational Park, Bucaro Recreational Park, Naomebaravu-Malo Reserve), but in general, people are not aware that they are maintained as a reserve and the use restrictions placed upon them J. Whyte (2000, pers. comm., 3 May).

The Draft Environmental and Resource Management Bill (1999), currently being circulated for public comment, provides for the establishment of Community Conservany Areas. Under these arrangements, a land owner or group of land owners can approach the national government to register their interest in establishing a private conservation scheme. The proposal is then to be considered by the Biodiversity and Conservation Committee who are required to: consult with the land owners and other interested parties to review and evaluate the nature of the scheme; accurately identify the area; verify rights and interests in land proposed to be included in the scheme and; identify and evaluate any conservation, protection and management options that may be proposed (Government of the Republic of Vanuatu, 1999c).

In order to meet the requirements of the (draft) Bill, the Biodiversity and Conservation Committee may also provide technical assistance to the land owner or group of land owners to undertake any survey or inspection of the area. Once all requirements of the Bill have been met, the Community Conservancy Area may be registered, maintained for this purpose by the Environmental Registry maintained by the Department of Environment and Conservation.

Island	Place	Community	Purpose	Year	Term (years)
Ancityum	Anawonjei Reef	Onedec Community	Protect marine resources/custom tabu	1991	10
Ancityum	Anelgauhat Reef	Anelgauhat	Maintain marine resources – Fisheries Act	1991	10
Efate	Emua	Emua & Saama Village	Tabu on reef	1995	3
Efate	Erakor and Empten Lagoons	Erakor Village	Tabu on harvesting marine resources	1997	1
Efate	Hideaway Island	Mele Village	Trochus stocking/marine reserve	1996	3
Efate	Mangalilu	Mangaliliu Village	Protect marine resources	1995	5
Epi	Ponkovio	Ponkovio Village	Tabu protecting marine resources	1989	?
Malakula	Nagha and Pincia Protected Area	Wiawi Village	Marine and forest conservation	1994	10
Malakula	Narong Marine Reserve	Selanamboro Village	Protect marine nursery area	1992	10
Malakula	Nawo Marine Konsevesen Area	Uripiv Island	Conserve reef and marine life	1995	3
Malakula	Nevnal	Leviamp Village	Conserve marine and forest area	1995	10
Malakula	Ringi Te Suh	Pelongk Village	Conserve marine resources	1991	5
Pentecost	Lekavik	Lebwibwi Village	Tak tabu on marine area	1998	15
Santo	Loru Conservation Area	Khole Village	Protect forest and marine resources	1994	?
Santo	President Coolidge Marine Reserve	None	War grave and dive site		

Table 4
Examples of Marine Protected Areas in Vanuatu (adapted from Whyte *et al*., 1998).

Government policy, laws and legislation

The Constitution (Chapter 21, Article 71) ascribes "all land in the Republic as belonging to the indigenous custom owners and their descendants". The Land Reform Act (CAP 123) defines land as "extending from the seaside of any foreshore or reef but no further". However, this is at variance with common practice since customary ownership is often exercised over uninhabited offshore or detached reefs and islands (Preston, 1996: 17).

Traditional ownership of nearshore areas, particularly coral reefs, is hereditary (Amos, 1995). Customary law in Vanuatu dictates that most nearshore areas, especially coral reef flats owned by clans or larger communal groups, are not subjected to open access fisheries (Amos, 1995).Therefore, the marine resources of these areas are the property of landowners who may exploit or restrict access to them as they see fit (Preston, 1996).

The primary related responsibility for marine and coastal resource management in Vanuatu rests jointly between the Department of Fisheries within the Ministry of Agriculture, Quarantine, Forestry and Fisheries and the Environment Unit within the Ministry of Lands and Natural Resources. However, Vanuatu is party to, and abides by a range of regional and international agreements. Key legislation for the governance of Vanuatu's marine sector is shown in table 5.

Legislation	Purpose
Marine Zones Act, CAP 138 of 1982	Delimits archipelagic zones to define territorial sea and other maritime zones (Preston, 1996).
Fisheries Act, CAP 158 of 1982	Development and management of fisheries including provi sions to prohibit the use of explosives, poisons and noxious substances for fishing (Preston, 1996).
Fisheries Regulations Order No 49 of 1983	Conservation and regulation of fisheries including aqua rium fish and coral.
Foreshore Development Act CAP 90	Regulates foreshore works.
United Nations Convention on the Law of the Sea (UNCLOS)	Law of the sea issues
Convention on Biological Diversity (CBD)	Signed in 1992 and ratified by the Vanuatu Government in 1993. Framework to manage and conserve biological diversity.
Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES)	Regulates trade on 'red' listed species including giant clams.

Table 5
Key legislation of Vanuatu's Marine Sector.

The Fisheries Department, is responsible for the regulation, development and management of fisheries resources within Vanuatu. The objective of the Department is to have control over access to the fishery resources that ultimately limits, redistributes or otherwise modifies the type or amount of fish or seafood being caught.

The main piece of legislation dealing with the management of inshore fisheries is the Fisheries Act (CAP 158) 1982 and subsequent amendments. Under this Act, export of corals and coral products is only permitted with licences and permits. Fisheries Regulation number 19 prohibits the taking of more than 3 pieces of coral in any period of 24 hours except with the permission of the Director of the

Fisheries Department. Other restrictions considered in the past by the Vanuatu government include licensing collectors, imposition of quotas, prohibition of the use of SCUBA, restrictions on the collection of certain species, zonation of areas for collection and restrictions on the number of operators (Bell & Amos, 1993).

Although, it has tended to focus on the development of commercial fisheries, some observers (see Palfreman and Stride, 1996) feel that the Fisheries Department should place "greater priority… on the management of reef resources on which a far larger target group depends and which make a greater contribution to rural incomes, nutrition and self reliance in the rural areas than the commercial fishery". That said, it is expected that the traditional customs of people and customary marine tenure will have greater emphasis in the 2000 review of the Fisheries Act (CAP 158) 1982 (Jimmy, 1995).

Consideration of the impacts from developments on the environment is the responsibility of the Environment Unit, Ministry of Lands and Natural Resources. The Environment Unit is responsible for advising the Government on a wide range of environmental issues and for developing policies, programmes and projects concerned with environmental management. Policies and programs include surveys of flora and fauna, new legislation and environmental impact studies.

A set of general guidelines for the production of Environmental Impact Statements (EIS) was produced by the Environment Unit in 1987 (Government of Vanuatu, 1987). A requirement of these guidelines is to produce a report or statement with a description of the existing environment including the ecological resources, and design of a monitoring programme which will investigate adverse impacts for as long, or longer than, the project itself (Government of Vanuatu, 1987). The guidelines provide for community consultation and local knowledge to be taken into account in siting of development projects. However, ensuring compliance of these guidelines is particularly problematic in Vanuatu because the islands are so scattered and the cost of travel is high.

The EIS guidelines will continue to be used as a formal policy document for assessing environmental impacts on projects until the (Draft) Environmental and Resource Management Bill (Government of the Republic of Vanuatu, 1999c), submitted for public review in April 1999, is approved by Parliament E. Bani (2000, pers. comm., 4 May). Within three years of this Act coming into force, a Coastal Management Committee is required to initiate and develop a coastal resource inventory at the local, island, provincial and national level (Government of the Republic of Vanuatu, 1999c).

The Foreign Investment Review Board within the Vanuatu Government has right-of-veto over any foreign development project. In the outer islands, however, it is often the case that developers will approach the local villages and communities directly, thus bypassing the appropriate licensing and permitting authorities L. Silas-Nimoho (2000 pers. comm., 4 May).

Reclamation of lands in the Port Vila area is governed by the Foreshore Development Act and is the responsibility of the Ministry of Internal Affairs. However, in rural areas this responsibility falls to the Ministry of Lands and Natural Resources.

The Tourist Office administers permits to tour operators. Although no guidelines are provided to prospective operators, most operators appear to have adopted good codes of practice during their operations R.Dennis (2000, pers. comm., 3 May).

Current monitoring and management capacity

Monitoring Capacity

Survey and monitoring of coral reefs has only been conducted on an ad hoc basis since the AIMS survey in 1988, largely as part of the feasibility assessment of foreshore development projects (eg jetties) and as a result of the establishment of a Marine Protected Area in Hogg Harbour.[2] Due to tectonic uplift, poor siting and construction methods and lack of community acceptance, many of these development projects are no longer operational and follow up monitoring has not been carried out E. Bani, (2000, pers. comm., 2 May).

Both the Fisheries Department and the Environment Unit believe that monitoring of coral reefs is a priority but lack the resources to develop the programme. SPREP have tried to encourage monitoring through the conduct of training in coral reef monitoring to people from the government and non government sectors of Vanuatu in 1990 and again in 1998. Whilst equipment was provided to all participants, most lacked the resources to design and implement monitoring projects on their own.

Vanuatu also participates in the 'State of the Environment Reporting' initiative co-ordinated by the Statistics Office and the Environment Unit. This is a UNEP initiative implemented through SPREP to establish a database of relevant environmental criteria for ongoing assessment of the state of Vanuatu's environment. The last national report was prepared in 1995. However, although forms were circulated, they were not generally completed.

A small research unit was formed within IRD, formerly ORSTROM, in the early 1980s. Although no longer in Vanuatu, the unit conducted some exploratory surveys of sea-mounts and reef slopes and promoted the establishment of a coastal station for the study of the marine environment (Bell & Amos, 1993).

Despite the lack of government, non government and international organisations involved in coral survey monitoring programmes, many coastal village communities regularly undertake monitoring of marine resources through observations of simple environmental indicators (Whyte *et al.*, 1999). In this context, the key consideration for the communities is the capacity of marine ecosystems to provide adequate resources to meet village needs in the short term (Whyte *et al.*, 1999).

Management Capacity

In the past, because of a lack of resources, regulatory agencies typically have had difficulty maintaining their services and instead have tended to focus only on immediate pressing concerns (Government of the Republic of Vanuatu, 1999b). Despite concerted effort through the Comprehensive Reform Programme (CRP) during 1999, and a plethora of training and other capacity building initiatives, this situation is unlikely to change in the short to medium term.

The Environment Unit currently has 2 full time staff although other staff have been funded out of project costs. The Vanuatu Fisheries Department currently has a staff of 14, located throughout the country, representing a 44 percent decrease in the total staffing budget since 1999 (Wright, in prep).

[2] Funded by USAID through the Profitable Environment Protection Project K. Fry (2000, pers, comm., 3 May).

According to the 2000 – 2004 Corporate Plan for the Ministry of Agriculture, Quarantine, Forestry and Fisheries (Government of Vanuatu, 1989), emphasis for the Fisheries Department will be to strengthen its services to the rural population to enhance maximum benefits of their resources. The 2000 budget for the Vanuatu Fisheries Department is approximately USD300,000. Other than the salary component (approximately 70%), the budget will be used to fund 4 programmes:

Program A - Resource Assessment, Management, Computer and Information Section;

Program B - Rural Fisheries Development Programme;

Program C - Administration and Support Services and:

Program D - the Santo Boat building Project.

Of these programs, Program A and Program B are most likely to contribute to coral reef management. Program A is concerned with stock assessment of marine resources, although a stronger emphasis on stock and habitat monitoring is also planned. Program B is concerned with the sustainable development and management of coastal fisheries up to the six nautical mile limit.

The Decentralisation and Local Government Act of November 1994 , an indirect response of earlier government reform, gives more powers to Local government Councils in six newly defined provinces of Vanuatu (see Preston, 1996). As a consequence, Provincial Governments have become more active in the administration of fishing activity within six nautical miles offshore (Jimmy, 1995 and Wright, in prep). However, the majority of the Provincial Governments have few trained technical staff who have the capacity to assess and monitor any damage arising from the projects, none have dedicated fisheries/environmental officers or planners, and all have extremely limited resources (Government of the Republic of Vanuatu, 1999b: 42). In some cases, decisions have been made by the Provincial Governments which contradict national laws and legislation, resulting in a number of ‘conflicts of interests’ at different management scales and confusion as to roles and responsibilities of the respective agencies.

Decentralised village based management may work well in Vanuatu, especially in areas where customary tenure facilitates local control of fishing activities and villagers have access to biological information about the resource (Johannes, 1994). Coastal village communities have also used resource management tools such as bans on fishing individual species or entire sections of fishing grounds, but lack adequate technical advice to tell them how, where and when to maintain these restrictions (Johannes, 1994).

Requirements and recommendations for coral reef conservation

Coral reef conservation and associated resources in Vanuatu can only occur through good governance and stewardship. The main factors hampering good governance and stewardship include: a lack of understanding and awareness of the short and long term effects of various pressures on coral reefs and responses to them; ineffective management arrangements and frameworks to integrate the various management initiatives, policies and plans, including those developed at the community; limited capacity at the regional, government, community, and individual level to manage coral reefs and; inappropriate and intermittent technical and financial support to sustain reef conservation initiatives.

Understanding coral reef resources status, pressures and responses

The lack of reliable data and information about the use of coral reefs, fish stocks and condition of the habitat makes it difficult to get an accurate picture of levels of exploitation and levels of sustainability. In addition, some marine resources require more information to manage than others due to complex life histories, ecological characteristics and demand factors. Various innovative incentive schemes[3] have been trialed to address this problem with mixed success. Improvements are also needed in completing and sending fisheries and environmental data to the appropriate places for processing, analysis and storage.

Jimmy (1995) recognises the need to educate some coastal communities on basic biological information on inshore resources and fishery management tools such as taboos, closure areas and catch size limits. Fisheries or Environmental Extension officers may have a significant part to play in teaching coral reef monitoring methods to coastal communities and vice versa. These officers could help raise awareness of the importance of particular coral reefs, and at the same time, provide practical site specific response options. It may also be possible to incorporate coral reef educational material in the school curricula, although this has had limited success as environmental topics are often out-competed by other core curricula subjects.

Awareness of the importance of coral reefs in Efate is now fairly widespread as a result of initiatives such as the 1997 Pacific Year of the Coral Reef Campaign in Vanuatu. However, this awareness is yet to reach the broader community and particularly the outer islands. Most of the previous environment awareness raising activities have been broadcast over radio. However, although radio is one of the only media which is accessible throughout the islands, it is unable to provide visual and physical cues and suffers from language barriers (Government of the Republic of Vanuatu, 1999b). Alternative approaches, although far more expensive, are those that involve visual clues through questioning and discussion. Meetings, workshops and particularly drama are also of demonstrated value in Vanuatu. For example, the Wan Smol Bag theatre group has been very successful in raising awareness of the need for coral reef conservation and has been instrumental in establishing MPAs in some coastal communities.

Management arrangements

Vanuatu is currently undergoing reform in the traditional spheres of governance as well as the larger macro-economic environment such as infrastructure, communications and services. However, as mentioned previously, there are still some fundamental problems that need to be addressed to improve the effectiveness of those arrangements, once finalised.

[3] An incentive scheme to encourage fishers to provide information on their fishing operations in return for purchasing fuel at duty free prices has so far only provided data from 34 of the 88 artisinal fishing projects that were operational in 1988 (Wright, in prep).

Any initiatives to monitor and manage the reef need to be co-ordinated and integrated to ensure that the knowledge base is well documented and accessible by all stakeholders. Despite the extensive personal networks throughout the government sphere, inter-governmental and intra-governmental co-ordination is currently relatively weak but could be enhanced through team building and improvements in communication technology.

Donna Kalsatek and Leah Nimoho (2000, pers. comm., 3 May) argue that monitoring and management of coral reefs should be devolved to the communities, as the principle resource owners. Such measures legitimise the in-depth knowledge that Ni Vanuatu have of their local environments. Johannes (1994) also believes that such decentralised village based management work well in areas where customary tenure facilitates local control of fishing activities, providing coastal communities have an adequate biological information from which to make management decisions. Currently, however, coastal communities are applying controls (eg closures of individual species or entire sections of fishing grounds) without adequate technical advice.

Whyte *et al*. (1999) emphasise that traditional resource management and monitoring will not be effective unless: tradition remains strong; immigration has not led to sectors of the population not responding to local institutions; cosmopolitan influences are relatively weak; and local leaders are committed to resource management. Also, while Ni Vanuatu perceive that their marine resource base is resilient, they will not be easily motivated to make major changes to their existing resource management practices (Whyte *et al*., 1999). In any case, devolution of management to the coastal communities may be more efficient for many of the earlier stages of management (assessment, exploring values etc.) but may require more effort in compliance.

In order to achieve economies of scale and synergy at the various levels of community and government, possibilities exist to work through the stakeholder network (comprising representatives from national governments, provincial governments, non government groups and the private sector) set up under the National Biodiversity Strategic Action Programme (NBSAP) to conduct monitoring of marine protected areas.

Opportunities may also exist to involve the local dive industry in monitoring the sites of their operations. Members of dive associations such as Dive Adventures, PADI and ProDive in Australia and other neighbouring countries, could be provided training in these techniques prior to coming to Vanuatu and undertake the surveys during their holidays J. Denis (2000, pers. comm., 4 May). To be successful, information sessions would also need to be held in Vanuatu for local dive operators. However, the dive industry is seasonal where the only opportunity to conduct monitoring programmes occur through the second half of January, the whole of February and March.

Capacity building

Capacity building in coral reef conservation is a long term process that needs to focus on training in coral reef monitoring and management as well a whole range of business development skills including marketing and financial management. Capacity building measures in the past have included use of volunteers and expatriate advisers. Although expatriate advisers can cross boundaries that Ni Vanuatu may be reluctant to cross due to cultural and social reasons, they often have short tenures and can interrupt project continuity. On the other hand, expatriate advisers can provide a form of advice based on experience that the Vanuatu may not necessarily possess, also reducing the requirement for larger government.

Support is also needed to trial and extend the results of pilot coral reef conservation projects to other areas. Partnerships with others who are the beneficiaries (e.g. industry) or stakeholders of the resource should be developed to ensure efforts by any one promoter or broker are enhanced, encouraged and supported.

Community groups in general are aware that their coastal and marine resources are declining (Whyte *et al.*, 1999). Feedback to government regulatory agencies indicate that most communities are familiar with the nature of the threats to their resources. However, they cannot be expected to manage some of these threats, such as some of the land based sources of pollution, and may need external help (see also The World Bank, 1999) and training.

Financial support

The key to sustainability of coral reefs is to offer communities, government, NGOs, the private sector and donors financial support to develop a sound and well integrated monitoring and management system. Initially, this will require scoping of critical issues through a range of meetings and other consultative mechanisms. Donors should also be brought into this process to ensure that their funding programmes can be structured accordingly. To be successful in the medium to long term, such initiatives need to be supported by a modest but steady influx of resources over a sustained period and linked to a range of new and existing conservation and management initiatives.

People consulted

Ross Dennis, Nautilus Scuba Diving

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Bibliography

Amos M., 1995 —
Combination of fisheries management regulation, traditionally base management and wild stock enhancement using hatchery reared trochus juveniles as a precautionary management principle for *Trochus Niloticus* Resources in Vanuatu. In P. Dalzell and T.J Adams (eds.) *South Pacific Commission and Forum Fisheries Agency Workshop on the Management of South Pacific Inshore Fisheries*. Manuscript collection of country statements and background papers. Vol. II, BP 37. 1-10.

Anon, 1984 —
Pacific Islands Pilot, Volume 2. Tenth Edition. *Hydrographer of the Navy***,** 462 p.

Brouard F., Grandperrin R., 1985 —
Deep-bottom fishes of the outer slope in Vanuatu. South Pacific Commission 17th Regional Technical Meeting on Fisheries, Working Paper 12. 127 p.

Bell L. A. J., Amos M. J., 1993 —
Republic of Vanuatu Fisheries Resource Profiles. FFA Report 93/49. Forum Fisheries Agency, Honiara, Solomon Islands.

Carlot A.H., Nguyen F., 1989 —
Preliminary study on populations of Vanuatu deep bottom fish after seven years of exploitation. Paper presented at the United States Agency for International Development and National Fisheries Service Workshop on Tropical Fish Stock Assessment, 5-26 July 1989. Hawaii.

Dalzell P., Preston G. L., 1992 —
Deep Slope Fishery Resources of the South Pacific. A summary and analysis of the dropline fishing survey data generated by activities of the SPC Fisheries Programme between 1974 and 1988. Inshore Fisheries Research Project – Technical Document No 2. South Pacific Commission, Noumea, New Caledonia. 251-280.

David G., 1990 —
Strategies of reef resources exploitation in Pacific Islands. The case of Vanuatu. Proceedings of the ISRS Congress, 1990, 61-74.

David G., Cillaurren E., 1989 —
A Survey of Village Subsistence Fishing in Vanuatu. Notes and Documents on Oceanography, No 19, Orstom, Vanuatu.

Done T. J., Navin K. F., 1990 —
Vanuatu Marine Resources: Report of a biological survey. A project of the Australian International Development Assistance Bureau. Australian Institute of Marine Science, Townsville, Australia. 272 p.

Government of the Republic of Vanuatu, 1987 —
General Guidelines for the Production of Environmental Impact Statements. Technical Paper. 1. 1-6.

Government of the Republic of Vanuatu, 1999 —
Corporate Plan for the Ministry of Agriculture, Quarantine, Forestry and Fisheries 2000 – 2004, Port Vila, Vanuatu. 1-29.

Government of the Republic of Vanuatu, 1999b —
Vanuatu National Communication to the Conference of the Parties to the United Nations Framework Convention on Climate Change. 54 p.

Government of the Republic of Vanuatu, 1999c —
Draft Environmental and Resource Management Bill. Submitted for Public Review, 30th April, 1999. 96 p.

Jimmy R. A., 1995 —
Country Statement: Current Management Policies and Problems of the Inshore Fisheries Resources in Vanuatu. In P. Dalzell and T.J Adams (eds.) *South Pacific Commission and Forum Fisheries Agency Workshop on the Management of South Pacific Inshore Fisheries*. Manuscript collection of country statements and background papers. Vol. 1 CP 14, 1-12.

Johannes R. E., 1994 —
Government supported, village based management of marine resources in Vanuatu. FFA Report 94/2. Forum Fisheries Agency, Honiara, Solomon Islands.

Palfreman J., Stride R., 1996 —
Evaluation of Fisheries Extension Training Service and Training Centre Project in Vanuatu. Evaluation Project No, 6/ACP/VA/005. Mimeo.,pag.var.

Preston G. L., 1996 —
Strengthening of National Fisheries Policy – Vanuatu. Masterplan for the Sustainable Management and Development of Vanuatu's Inshore Fisheries Resources. FAO Technical Report No 3. Bangkok, Thailand.

SPREP, 1999 —
Coastal Management Profiles. A Directory of Pacific Island Governments and Non Government Agencies with coastal management related responsibilities. South Pacific Regional Environment Programme, Apia, Samoa. 205 p.

STATISTICS OFFICE, 1994 —
Vanuatu National Agricultural Census 1993. National Planning and Statistics Office, Office of the Prime Minister, Port Vila, Vanuatu. Mimeo.par.var.

STATISTICS OFFICE, 1997 —
Vanuatu Facts and Figures 1996. National Planning and Statistics Office, Office of the Prime Minister, Port Vila Vanuatu.

THE WORLD BANK, 1999 —
Voices from the Village: A Comparative Study of Coastal Resource Management in the Pacific Islands. Summary Report. Pacific Islands Discussion Paper Series, Number 9A. East Asis and Pacific Region. Papua New Guinea and Pacific Islands Country Management Unit. Washington D.C. 20 p.

WHYTE J., SIWATIBAU S., TAPISUWE A., KALOTAP J., FRASER T., 1998 —
Participatory resource management in Vanuatu: research report. Report on research conducted by FSPI for ACIAR project ANRE96224 “Participatory planning and management of resource development in Vanuatu”.

WHYTE J., THAMAN B., TAPISUWE A., SIWATIBAU S., TAMATA B., KALOTAP J., 1999 —
Community based regimes for the management of marine natural resources: concepts of sustainability. Report to PISUN. October, 1999. FSPI Island Consulting, Port Vila, Vanuatu.

WILLIAMS, D. MCB., 1990 —
Shallow-water reef fishes. In T.J. Done and K. F Navin (eds.). Vanuatu Marine Resources: Report of a biological survey. A project of the Australian International Development Assistance Bureau. Australian Institute of Marine Science, Townsville, Australia. 66-76

WRIGHT A., In prep. —
Fisheries Sector: The Fisheries Component of a Broader Review of the Agriculture and Fisheries Sector Undertaken for the Asian Development Bank in March and April, 2000. Prepared for the Ministry of Agriculture, Foresty and Fisheries, Republic of Vanuatu.

YEUN T. L., 1980 —
Coastal Survey of Water Quality around Port Vila. Unpublished Technical Report, South Pacific Commission, Noumea, New Caledonia. 30 p.

Wallis et Futuna
Status report

Paino Vanai

Introduction

Wallis and Futuna Islands make up one of the three French overseas territories in the Pacific. They are located 2000 km north of New Caledonia and 3500 km northwest of Tahiti. The territory comprises two distinct archipelagoes situated 240 km apart : the Wallis Islands and the Hom Archipelago composed of Futuna and Alofi. The Wallis Islands are made up of the main island Uvea and 19 islets scattered throughout a lagoon which is 24 km long and 15 km wide. Futuna is high island without a lagoon and with a few areas of cliffs, surrounded by a fringing reef of varying width. Separated from Futuna by a channel of 1800 m width, Alofi is a high volcanic island surrounded by a variably developed fringing reef. The surface area of land is small (215 km^2) and coral reefs occupy about 300 km^2 ; immerged reefs are found to the north of Wallis Island. The Exclusive Economic Zone of the territory covers 300 000 km^2.

The climate is characterized by elevated mean temperatures (26 to 27°C), an average relative humidity and a typically tropical rainfall pattern. The territory has a population of 15 000, equivalent to a density of 60 inhabitants/km^2. Most of the population (74.4% of the active unemployed population) exploit marine resources for a significant part of their diet. Among reef resources, a large part is made up by fish, and shells and crustaceans to a lesser degree. The recent initiatives in favor of coral reefs both authorities about the importance of these environments in the future development of the territory.

Despite the low level of knowledge about coral reefs of the territory, this document aims to present the first status report of these environments. We will successively assess the state of the benthos, the state of fish and fishing, anthropogenic threats, impacts of climate changes, marine protected areas, regulations, and finally the gaps in the current capacity for management and conservation of the coral reefs of the territory.

State of coral reef benthos

Before 1998

Wallis

Around the central island of Uvea, the Wallis Islands have a regular and relatively wide (4 to 5 km) barrier reef dissected by four passes which are all located in the west (Fatumanini, fagauvea, Avatolu) or the south. The total surface area of coral reefs is about 220 km^2. The reef rim is highly asymmetric with the more exposed eastern side including all of the islets and the more sheltered western side including three passes. The lagoon is generally rather shallow and has a complex morphology, with

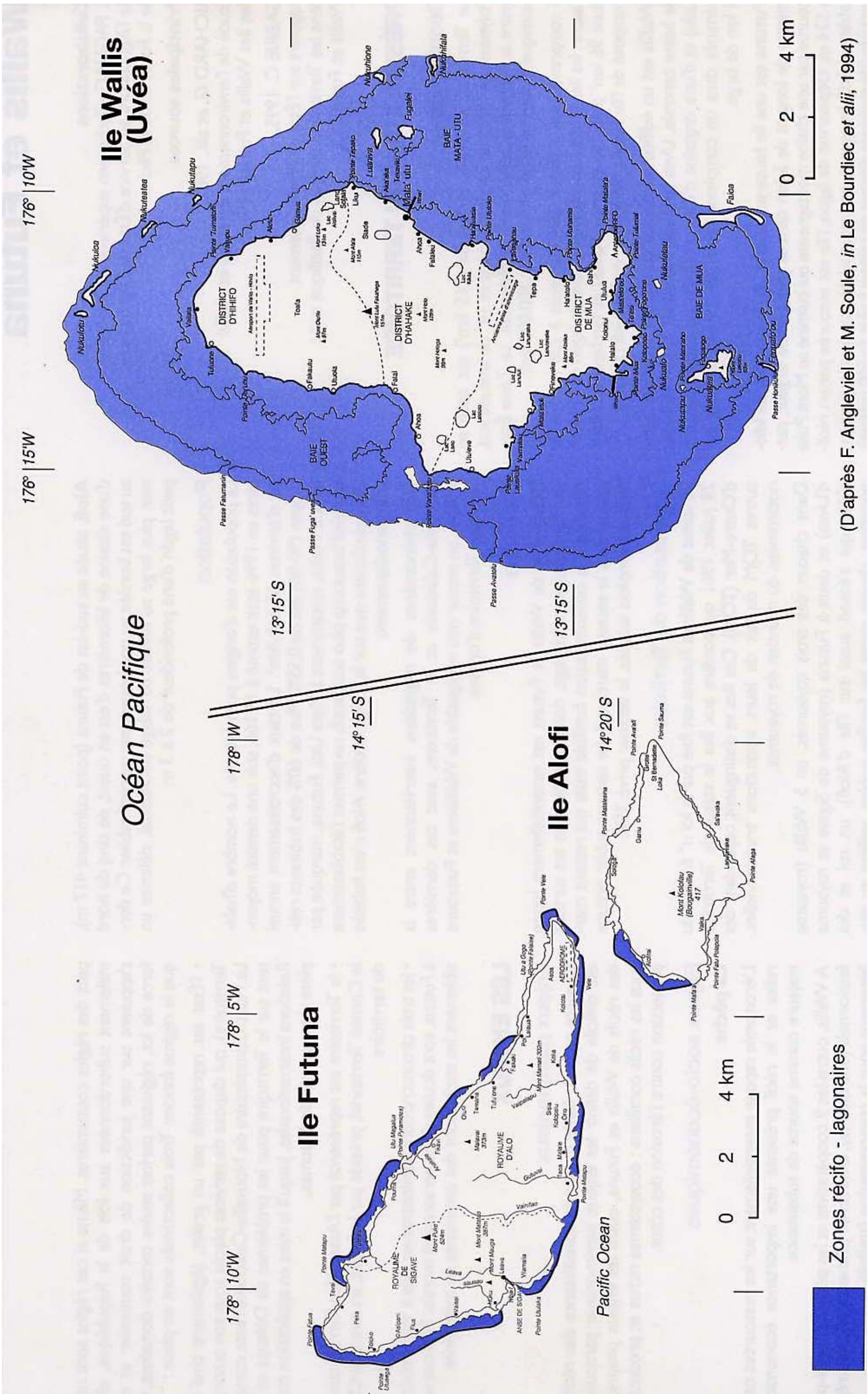

Figure 1
Map of Wallis, Futuna and Alofi Islands.

notably deep pools resulting from the hydrodynamic regime and partitioning corresponding to basaltic ridges. The eastern lagoon is on average deeper than the western lagoon where fringing reef in much wider. The principal biotopes foud in the reef-lagoon complex of Wallis are shown in (Figure 2).

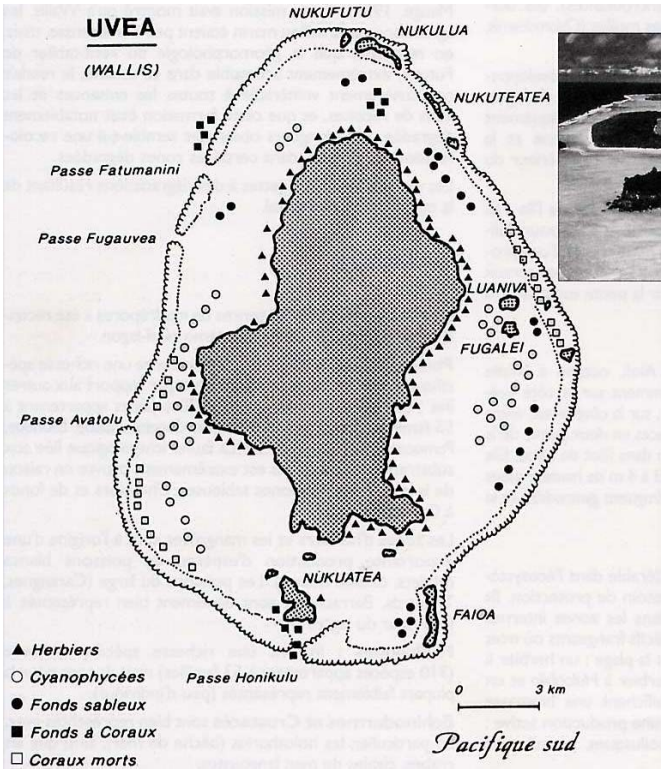

Figure 2
Simplified map of the major biotopes found in the reef-lagoon complex of Wallis.

The fringing reef zone is generally characterized by a succesion of three seagrasses on shallow (0.2 to 1 m), fairly heterogeneous sandy-muddy substrates. Moving from the shore, there is typically a *Halodule* seagrass bed, followed by a Halophila seagrass bed on coarser sand and frequently associated with *Halimenda*, and a *Syringodium* seagrass bed usually accompanied by *Turbinaria*. These formations are very important in the Wallis reef ecosystem because they cover a large part of the fringing reef zone. The flora associated with these seagrass beds is usually made up of Padina, *Turbinaria* and *Halimeda*. The associated benthic fauna is equally very rich and diversified. For all these reasons, the seagrass beds play a primary role in the reef-lagoon ecosystem of Wallis. The mangroves, located generally in the south and west of the central island, occupy a non neglogible surface area and are a fundamental component of the Wallis Island coral reef ecosystem. Moving from the shore, the following mangrove zonation can be observed: *Inocarpus edulis, then Barringtonia speciosa, Bruguiera eriopetala and Rhizophora mucronata.*

The lagoon itself is complex. There are coral alignments arising from coral growth on basaltic ridges, isolated coral patches, large pools, pavement with smaller pools, and abundant debris near the islets. Wide stretches of the lagoon floor, generally bordering seagrass beds and mainly on the western side

of the island, are carpeted by blue-green algae. A few algae are also foud there (*Enteromorpha, Hydroclathrus, Halimenda and Padina*) and the fish community of these lagoon bottoms is almost zero. Coral communities on the lagoon floor are scarce compared to the neighboring Fidji Islands. They are mainly the reef flats of scattered coral patches and a few pinnacles. The first studies show a low scleractinian coral cover in the lagoon, except in some places where coral cover of 40 to 90% has been observed. Coral construction is however active on the outer slope.

Evidence of coral sand extraction is visible on the northem and southrn fringing reef of the island. The negative consequences of these activites appear to be limited in the particular case of the fringing reef of Wallis, as it is primarily made up of seagrass beds and not coral formations.

Futuna and Alofi

Futuna and Alofi Islands do no have a lagoon but have variably developed fringing reefs. Near the shore, there is generally an accumulation of pebbles or sand. Subsequently there is a reef flat where algae are well represented (*Padina, Valonia, Caulerpa*…) and molluscs are often abundant. On the other hand, scleractinian corals are rare restricted to certain genera (*Pavona, Porites, Montipora*). On the reef front, zoanthids are present (*Palythoa*) and more corals. On the outer slope, corals are more numerous with cover varying from 30 to 50%. The most abundant genera are *Pocillopora, Acropora* and *Porites*.

The coral reefs of the Hom Archipelago already showed significat degradation in 1980. Desturctive fishing practices which were widespread at this time (use of poison) and physical destruction of corals (trampling, use of crowbars) are the causes of the degradation. Finally, no bleaching phenomenon has been observed.

After 1998

Monitoring results

The establishment in 1999 of a coral reef monitoring network employing the photographic method used in French Polynesia henceforth allows a more rigorous tracking of the state of health of coral reefs of the territory. The method used involves photographing a rectangular plot of reef 20 m long by 1 m wide, giving an area of 20 m^2. The photographic records (1 m^2/record) allow evoluation of the percentage coral cover in the chosen zone (quantitative variable) on the one hand, and, on the other hand, identification of coral genera to establish an inventory (qualitative variable). This information can be collected at the same place at different dates in order to assess temporal variation of the varibles measured.

At Wallis, two stations have been established, one on the outer slope of the western coast (to the north of Avatolu Pass) and the other in the lagoon on the eastern coast, in Mata-Utu Bay. At Futuna, one station has been set up on the outer slope in the northwest of the island at the place called “Sagole”; at Alofi, one station has been chosen on the western point of the island at the place named “Alofitai”. Relocating the position of the stations is facilitated by using GPS. The observations at the stations are complemented by an evaluation of substrate cover using manta tows.

The first qualitative and quantitaive results are shown below in Table 1.

The quantitative results show that the three outer slope stations studied have a scleractinian coral cover of a similar order of magnitude. The percentage cover is between 16.03 % (Futuna) and 21.79 % (Wallis) with an intermediate value of 19.45 % for Alofi. The Wallis lagoon station is characterized a

	% Recouvrement			
Genus	Alofi Outer slope	Futuna Outer slope	Wallis Outer slope	Wallis Lagoon
Acropora	9.88	9.75	1.48	-
Favia	0.43	1.60	13.02	0.74
Favites	0.19	-	-	-
Galaxea	0.19	-	-	-
Goniastrea	0.06	0.06	0.19	-
Leptastrea	2.47	0.19	0.19	-
Leptoria	0.56	1.60	0.93	-
Leptoseris	-	-	0.06	-
Lobophyllia	0.06	-	0.12	-
Montastrea	0.12	0.06	-	-
Montipora	1.05	0.31	-	-
Platygyra	0.74	0.86	0.06	-
Pocillopora	0.99	0.49	-	0.12
Porites	0.12	-	0.06	0.12
Seriatopora	0.37	0.06	-	-
Stylophora	-	0.19	-	-
Synaraea	-	-	4.07	-
Turbinaria	-	0.12	0.56	-
Others	2.22	0.74	1.05	-
Total % cover	19.45	16.03	21.79	0.98
Genéric richess	14	12	11	3
% manta tow	0 - 10	-		
Comments	-	Récent dead coral	Coral debris abundant	Soft corals 15.8%

Table 1
The first qualitative and quantitaive results are shown below.

very low coral cover (0.98 %); the community at this station is dominated by soft corals which occupy 15.80 % of the total surface area. These results confirm the observations of Richard *et al.* (1982). The qualitative results are also comparable with respect to the number of genera recorded on the outer slopes. There are 14 genera of scleractinian corals at Alofi, 13 genera et Futuna and 12 genera at Wallis. At Futuna and Alofi, the genus *Acropora* clearly dominates the community, and for Wallis the genus *Favia* is dominant. At the Wallis lagoon station, there are only 3 different general recorded from the photographic transect.

Transect method

To complement the monitoring observations, a study of the substrate has been undertaken using the "line intercept transect" method at Wallis. This method involves classifying the nature of the substrate according to different sedimentological criteria for the zones not colonized by living organisms and according to biological group and the form of the colonies for the living organisms. A diver recorded the percentage cover of each of the classes encountered along a transect of 50 m. The location of the stations studied is indicated below in Figure 3.

The first results are shown below in Table 2. The analysis of the results from the transects undertaken at the different stations at Wallis (Wantiez *et al.,* 1999) show four characteristic types of substrates. The substrate of the coastal reef stations is primarily sand with a mean cover of 55.55 %. This sand

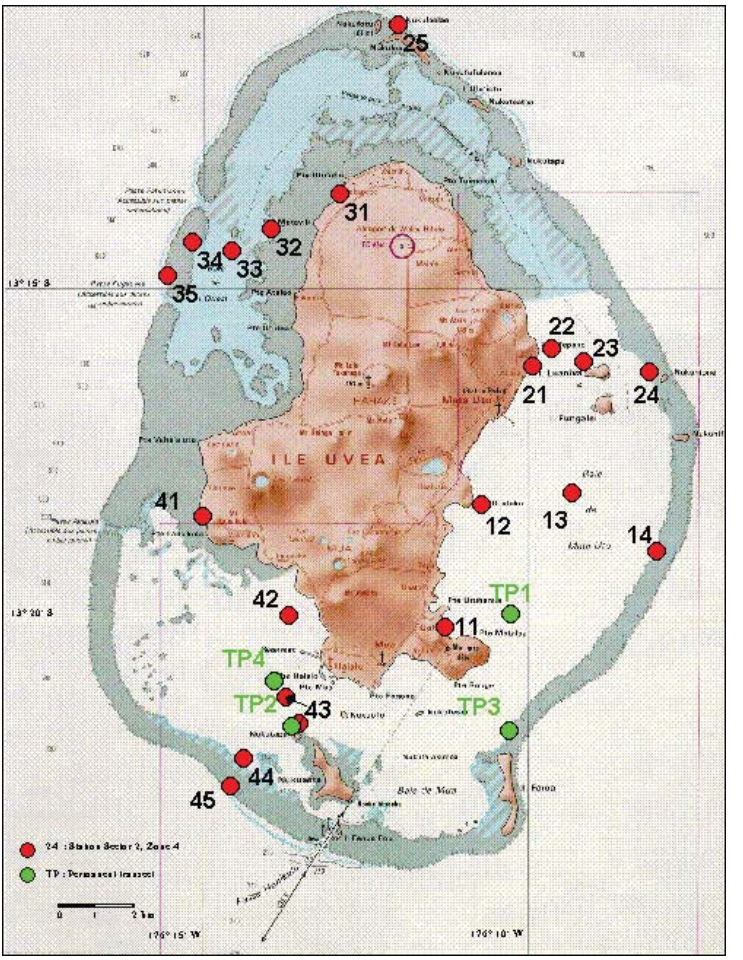

Figure 3
Location of stations studied at Wallis.

	Coastal Station	Intermediate Station	Inner barrier reef Station	Outer slope Station
Living coral	2,60	14.8	5 ,85	27,50
Algae	18,10	2,27	10,15	41,06
Dead Coral	12,65	17,00	23,5	23,67
Sand	55,55	23,67	26,3	1,33
Debris	2,20	4,33	26,4	3,33
Blocks, pavement	4,85	34,26	7,5	0,00
Crevices	0,05	0,00	0,15	0,60
Mud	0,00	0.00	0,00	0,00
Other	4,00	3,67	0,15	2,51
Total	100	100	100	100

Table 2
Mean substrate charcteristics of reef stations studied by the line intercept transect method at Wallis (% cover).

is often colonized by seagrasses or macroalgae. Living corals only occupy a small part of the substrate (2.6 %). The mean cover of dead coral is 12.65 %. Finally, algae occupy 18.10 % of the total surface area.

The intermediate reef stations show two different facies. Some stations are charcterized by pavement which is partly colonized by massive coral; other stations are characterized by a substrate composed mainly of sand and dead corals covered by an algal film. Some small formations of branching and sub-massive corals develop on these substrates.

The stations of the inner barrier reef have a substrate composed primarily of coral sand, debris and pavement. This substrate is colonized by algae and living corals, which have o low cover (5.85 %). The outer slope is characterized by a substrate made up primarily of encrusting, foliate and tabular living corals and calcareous algae. The mean cover of living corals is 27.50 %. These figures are slightly higher than those obtained by the photographic method.

This study shows that, despite the low cover of living coral recorded at Uvea, the substrate of the reef formations in characteristic of environments not subject to significant anthropogenic impacts. The percentage of living organisms is relatively high due notably to the presence of seagrasses in the lagoon and living corals on the outer slope. Moreover, the non-living substrate is primarily sandy. Further, no silted reef formation, the result of terrigenous pollution, has been recorded at Uvea. Finally, no bleaching phenomenon has been observed during these different studies, as well as during the dives indertaken by the Diving Club, which is responsible for the maintenance and monitoring of the network.

State of coral reef fish

State of fish populations

Species richness, density and biomass

The first study done in the territory in 1980, recorded 330 species of benthic fish distributed among 55 families. This fish fauna includes representatives of the diverse levels of the trophic pyramid of Indo-Pacific reef waters. The 1999 study (Wantiez *et al.*) only recorded 194 species from 32 families at Wallis. The difference between these two studies is probably related to the lower sampling effort in 1999 compared to 1980.

The general characteristics of the fish fauna are shown below in Table 3. The most diverse families are Labridae (wrasses, 34 species), Pomacentridae (damselfish, 33 species) and Chaetodontidae (butterflyfish, 23 species). These families are representative of reef environments in good health. On the other hand, some families are poorply represented in Uvea lagoon and some species abundant in the Western Pacific have not been recorded. They are notably species of commercial interest:

- Serranidae of the genus *Epinephelus* (groupers) and the coral trout (*Plectropomus leopardus*)
- Lethrinidae such as some emperors (*Lethrinus nebulosus, Gymnocranius spp*)
- Labridae, notably the goldpost hogfish (*Bodianus perditio*)
- Acanthuridae of the genus Naso, notably the buespine unicomfish (« dawa », *Naso unicomis*)
- Siganidae (rabbitfish, *Siganus spp*).

Stations	Species Richness	Density (fish/m²)	Biomass (g/m²)
Coastal	42,75	2,77	62.44
Intermediate	46,33	3,02	26.12
Inner barrier	44,50	3,20	28.12
outer-slope	56,33	1,80	56.94
Mean	47,47	2.69	43.40

Table 3
General characteristics of the fish fauna sampled in Uvea lagoon.

The results obtained at Wallis show that mean species richness per station (47.47 species/station) is within the range of values generally observed in the region. The mean density recorded is 2.69 fish per m? with a minimum of 1.18 fish/m² and a maximum of 5.43 fish/m² at two stations. The most abundant species are small planktophagic Pomacentridae. This value is with in the range generally observed in the Indo-Pacific region but at the lower end. The mean biomass is 43.40g/m². This figure is low compared to the values generally observed in the region.

In conclusion, the coral reef fish communities of Wallis have global characteristics consistents with those generally observed in the Indo-Pacific region, but they are among the most depauperate communities.

Community structure

The fish fauna shows four communities across a gradient moving offshore from the coast. The zonation appears to be related to oceanic and terrigenous influences on one hand and substrate characteristics on the other : a outer slope community, a seagrass bed community, and a lagoon community which can be split in two parts. The principal characteristics of these different communities are summarized below in Table 4.

Community	Species Richness	Density (fish/m²)	Biomass (g/m²)
Seagrass bed	38	2.14	8.47
Lagon 1	41.25	1.43	44.36
Lagon 2	47.5	3.69	42.46
Outer-slope	56.3	1.8	56.94

Table 4
Characteristics of different fish communities at Wallis.

The outer solpe community is characterized by many reef species associated with living corals, notably Chaetodontidae, Pomacanthidae and Pomacentridae. This community can further be distinguished by the presence of species associated with environments under an oceanic influence, typical of the outer sope, such as *Elagastis bipinnulata, Aphareus furca and Chaetodon ornatissimus*. The outer slope communities are divers (56.33 species/station), with an average density (1.80 fish/m²) and the highest biomass (56.94 g/m²).

The coastal seagrass bed community is distinguished by species characteristic of these environments, notably benthic carnivores which eat the numerous invertebrates foud in these biotopes. They are principally Lethrinidae (*Lethrinus spp*), Nemipteridae (*Scolopsis trilineatus*), Mullidae (*Parupeneus multifasciatus*), Labridae (*Novaculichtys taeniourus*), Balistidae (*Rhinecanthus aculeatus*) and Tetraodontidae (Arothron hispidus). This community is characterized by the lowest diversity (38

species/station), a relatively high density (2.14 fish/m^2) and the lowest biomass (8.47 g/m^2). These results thus indicate the presence of numerous individuales of small size the seagrass beds as a nursery.

The differences in structure berween the two lagoon communities reflect the differences in substrate characterestics. The first lagoon community was sampled at stations where algae and debris are more abundant.The second lagoon community was found at stations where living corals and reef pavement are more abundant. The first community is charcterized by species which are in part herbivores and common in the lagoons (Pomacentridae, Labridae, Scaridae and Acanthuridae). The species richness and biomass are average with values of 41.25 species/station and 44.36 g/m^2 respectively. The density is the lowest recorded (1.43 fish/m?). The second lagoon community is distinguished by the presence of other species common in the lagoons. They are planktophagic species, notably Clupeidae (*Spratelloides spp*), and Serranidea (*Pseudanthias spp*) and Pomacentridae usually associated with living coral. These communities are relatively rich compared to the others (47.5 species/station and 42.46 g/m^2) and have the highest density (3.69 fish/m^2).

Status of fishing

The fishing undertaken on the coral reefs of Wallis and Futuna is exclusively artisanal. The infrastructure currently used remains modest. The fishing techniques employed are mainly hand line fishing, speargun fishing and net fishing. Some destructive fishing parcties while banned (poison or dynamite) are still used from time to time. Many information campaigns have however raised the awareness of the population of the damage caused by these methods of fishing.

In 1997, the territorial fisheries department recorded 286 FAO type flat bottom boats used principally for lagoon fishing. As a result of the improvement in sea safety, fishing outside of the lagoon is developing but remains unimportant. The annual production of coral reef fish is estimated at about 300 tonnes, although demand reaches 900 tonnes according to the South Pacific Commission. The fish families which are the target of significant artisanal subsistence fishing are the following: Acanthuridae, Balistidae, Chaetodontidae, Cirrhitidae, Dasyatidae, Labridae, Lethrinidae, Lutjanidae, Malachanthidae, Mugilidae, Mullidae, Muraenidae, Ostraciidae, Pomacanthidae, Pomacantridae, Scaridae, Serranidae and Tetraodontidae.

For some years, commercial operations have been set up with the creation on Wallis Island of a few fish shops which offer greater capacities for preservation but also fresh seafood products.

It remains difficult to provide exact statistics on fishing, given the fact almost all of the population fish the lagoon either for recreation or as a means of subsistence. In addition to fish which represent a large part of the ressources extracted from the coral reefs by the population, there are two species which are currently exploited. They are trochus shells (*Trochus niloticus*) and more recently sea cucumbers. The quantities exported are estimated at a few tonnes per year.

Anthopogenic threats on reef biodiversity

Erosion and sedimentation

Agricultural practices based on slash-and-burn techniques and the multiplication of poorly constructed road infrastructure are the cause of an acceleration of erosion phenomena which have been observed in the territory for some time. During rainy periods, the lagoon waters of Wallis and the

coastal marine waters of Futuna become turbid. Laterites coming from deforested slopes or mountain tracks are therefore going to settlle on corals. These phenomena are seen at Futuna Island where muddy zones have formed opposite mountain tracks (Toloke, Vaisei). This types of degradation has not been observed on the neighboring Alofi Island, which does not have these types of infrastructure.

Coastal development

During the last ten years, the territory has undertaken a major program of shoreline protection. It consisted of building rockwalls along almost all of the eastern side of Wallis Island, thus about 15 km. The result of this activity has been the disappearance of all the beaches of the island. The conception of this construction work did not conforrm to any standards for maritime work. This coastal development was carried out without any preliminary impact study. Some mangroves have been completely destroyed by infilling and building.

Extraction of coral material (coral sand and beach sand) to be used as construction material or infilling is more and more frequent. The turbidity near extraction zones is high and the coastline has receded more than 100 m at certain places on Wallis Island (Utuleve area).

Pollution by solid or liquid wastes

The improvement in living conditions of the population has logically entrained a greater production of wastes. The quantity of household waste collected each year is estimated at about 300 t/y, equivalent to 200 kg/y per inhabitant. Currently, household waste is deposited at dumps without preliminary treatment. The current procedure used for treating domestic wastewater is that of autonomous sanitation. Unfortunately, these installations do not meet standards and the quality of the wastewater at the outlet of the tanks does not conform with national recommendations for discharge of water in the wild. These septic tanks, which are generally made of concrete blocks, are not adequately sealed to allow normal functioning.

Finally, no water treatment system for septic tank discharge is envisaged.

The wastewater from piggeries (25 000 head), which are usually set up near housing, is a source of major pollution of terrestrial and coastal marine water resources. The liquid manure is not treated and is directly discharged in the lagoon at a number of places in the same outfalls a rainwater. The quality of lagoon waters is currently being analysed for bacterial numbers and the first results indicate a significant faecal pollution in the inhabited coastal zones and in paricular in “Malaefoou” village (Wallis) where there are many piggeries.

The risks of hydrocarbon pollution also exists as a result of the significant increase in maritime traffic notably in the lagoon waters of Wallis Island.

Resource exploitation

The level of exploitation of lagoon resources is not known. The first estimates in 1980 (Richard *et al.*) and in 1999 (Wantiez *et al.*) noted a fish fauna characterized by a small number of individuals of small size. The risks of overexploitation are therefore of concem if fishing pressure was to becom great.
The development of fishing outside of the lagoon through increase in the number of fish aggregation

Figure 4
Coastal development - diverse construstion activities within a mangrove forest.

Figure 5
Wastewater outfall at Lalaleu.

devices (FAD) may result in a reduction of the exploitation of lagoon resources. This development must be considered in the Hom Archipelago where the reef surface area is small.

Current and potential impacts of climate changes

There has been no study to evaluate the impacts of climate changes. Scientific monitoring of this aspects should be considered within the framework of regional cooperation.

Marine protected areas and management and conservation capacity

There are no official marine protected areas in the territory. In practice, it is the customary authorities, being responsible for land tenure matters, who are involved in the management of coastal marine resources, for example in the case of marine aggregates. As a result, they would be in a position to draw up suitable regulations for the creation of marine protected areas and develop the management and conservation capacities.

The territorial authorities themselves plan to increase scientific and technical knowledge which will allow the customary authorities to draw up management and conservation programs for these marine protected areas.

Territorial regulations

Local regulations

The territory is responsible for environmental matters. However, no specific territorial regulations have as yet been developed concerning the environnement. The territorial chief has passeed a certain number of decrees which mainly regulate fishing. They concern regulations prohibiting destructive fishing practice (use of explosives, poison, crowbars,), and governing speargun fishing with or without breathing equipment and the commercial size of some fished species. These regulations are not enforced due to the lack of means for surveillance by the administration.

The customary authorities issue bans where necessary to prohibit various activities but this procedures is rarely used. Moreover , the absence of means for surveillance by the customary authorities renders these directives ineffective.

International conventions

There are 22 international conventions which apply to the French overseas territories. In Wallis and Futuna, no measures have yet been taken to apply these provisions locally. Such measures represent an important body of work to be undertaken so that the territory conforms with these international conventions.

Gaps in the current capacity to manage and conserve coral reefs

The local authorities, like the majority of the territory's population, generally have little awareness of the need for environnental protection. The ressources devoted to environmental matters in the devel-

opment programs elaborated up until now are insignificant. Further, the actions undertaken have been isolated and the results are sometimes the opposite of what was expected. The best example is that of shoreline protection which has resulted in organized infilling of the fringing reef. Reinforced concrete structures and infilling by laterite along a large part of the shoreline have contributed to the acceleration of erosion processes and lagoon pollution by sedimentation.

The territory of Wallis and Futuna also has a considerable gap in its knowledge of coral reef environmets. Therefore decisions. This situation greatly disadvantages the implementation of some development projects like fishing an aquaculture. The grey areas regarding the distribution of powerq and lagoon pollution by sedimentation.

The territory of Wallis and Futuna also has a considerable gap in its knowledge of coral reef environments. Therefore decision-makers do not have objective information to support their decisions. This situation greatly disadvantages the implementation of some development projects like fishing and aquaculture. The grey areas regarding the distribution of powers between the French state, the territory and the customary authorities do not facilitate the management and conservation of these environments. Indeed, this lack of clarity does not permit the development of pertinent and applicable regulations under the right conditions, particularly with respect to zonation and protection of natural sites. The long-standing lack of coordination between different administrative departments of the territory has slowed the set-up under the right conditions of some projects, notably in the domain of sanitation. Final ly, lack of financial resources does not always allow the implementation of action programs in favor of protecting coral reefs.

Conclusions and recommendations for the conservation of coral reefs

This first assessment while incomplete reveals the gaps accumulated up until now by the territory of Wallis and Futuna Islands in the protection of the environment in general and of coral reef environments in particular. The first studies have however allowed an initial assessment of the state of the environment. The first results show that coral reefs of the territory of Wallis and Futuna are characterized by a naturally low living coral cover. With respect to the fish fauna, it has a low species richness and a low biomass compared to other Indo-Pacific regions. At Wallis Island, coral reef degradation is primarily due to the extraction of marine aggregates and the anarchic carrying out of many coastal construction activities which aggravate the erosion processes in some areas. At Futuna ISIdnd, where the coral reefs are easily accessible by the population and once upon a time by pigs, major anthropogenic degradation has been observed for 20 years. This degradation is mainly due to coral trampling and terrigenous pollution.

To improve its performance in environmental matters, the territory of Wallis and Futuna is beginning to equip itself with the resources to promote environmental protection. In 1997, a territorial environment department was created and is responsible for coordinating activities supporting environmental protection and improvement of the quality of life.

The creation in 1999 of the French national committee IFRECOR, on which the territory is represented, has raised the awareness of authorities on the importance of coral reefs in the development of the territory. In the next StatefTerritory development agreement (2000-2004), financing for the study and monitoring of coral reefs is provided. The implementation of a territorial policy with respect to

the management of liquid wastes (creation of a treatment plant) and solid wastes (better management of wastes) will reduce significantly the effects of chronic pollution on coral reefs. Reforestation programs and particularly improvements in yields of agricultural production will undoubtedly bring about the beginning of the answer to the problems of soil erosion and coral reef sedimentation.

This first assessment of the state of coral reefs of the territory of Wallis and Futuna Islands shows that in order to assure the long-term conservation and use of these environments it is primordial to reinforce the knowledge of these ecosystems, clarify the jurisdictional powers of the different authorities, draw up local legislation with respect to the environment, and finally to actively involve local communities in the management of these environments.

Bibliography

RICHARD G., BAGNIS R., BENNET J., DENIZOT M., GALZIN R., RICARD M. AND SALVAT B., 1982 — Etude de 1'environnement lagunaire et récifal des îles Wallis et Futuna (Polynésie Occidentale).

WANTIEZ L., COUTURE E., ALLENBACH M., CHAUVET C., I999 — Expertise biologique du lagon d'Uvea (Wallis et Futuna).

ALLENBACH M., 1999 — Mission d'expertise sur l'érosion du linéaire côtier de l'île de Wallis. Evolution naturelle et anthropisation, gestion et aménagement littoral.

CHANCERELLE Y., 1999 — Réseau de surveillance des peuplements de coraux scléractiniaires à Wallis, Futuna et Alofi installation et relevés initiaux.

État des récifs coralliens de Wallis et Futuna

Paino VANAI

Introduction

Les îles Wallis et Futuna forment le troisième territoire français du Pacifique. Il est situé à 2000 km au Nord est de la Nouvelle Calédonie et à 3500 km au Nord-Est de Tahiti. Il est composé de deux archipels distincts situés à 240 km l'un de l'autre : les îles Wallis et l'archipel de Horn composé de Futuna et de Alofi. Les îles Wallis sont composées d'une île principale Uvea et de 19 îlots disséminés dans un lagon de 24 km de long et de 15 km de large. Futuna est une île haute sans lagon, entourée par un récif tablier au développement variable, comportant quelques zones de falaises. Séparée de Futuna par un chenal de 1800 m, Alofi est une île haute volcanique entourée d'un récif frangeant plus ou moins développé. Les terres émergées sont peu importantes (215 km^2) et les surfaces de récifs représentent environ 300 km^2 ; des récifs immergés sont situés au nord de l'île de Wallis mais leur étendues ne sont pas connues. La zone économique exclusive du territoire est de 300 000 km^2.

Le climat se caractérise par des températures moyennes élevées (26 à 27°C), une humidité relative moyenne et un régime pluviométrique de type tropical. Le territoire compte 15 000 habitants soit une densité de 60 ha/km^2. La population, dont seulement 10 % dispose d'un emploi salarié, tire des ressources marines une partie significative de sa nourriture. Parmi ces ressources récifales, une grande partie est assurée par les poissons et dans une moindre mesure par les coquillages et les crustacés. Les récentes initiatives en faveur des récifs coralliens aussi bien au niveau national qu'international ont permis de sensibiliser les autorités locales sur l'importance de ces milieux dans le développement futur du territoire.

Malgré le faible niveau de connaissance des récifs coralliens du territoire, le présent rapport tente de présenter un premier état des lieux de ces milieux. Nous ferons le point successivement sur l'état du benthos, sur l'état des poissons et la situation de la pêche, sur les menaces anthropiques, sur les impacts des changements climatiques, sur les zones marines protégées, sur les règlements et enfin sur les lacunes dans la capacité actuelle de gestion et de conservation des récifs coralliens du territoire.

État du benthos des récifs coralliens

Avant 1998

Wallis

Les îles Wallis possèdent, autour de l'île centrale d'Uvea, une barrière corallienne régulière et relativement large (4 à 5 km) coupée de 4 passes toutes situées à l'Ouest (Fatumanini, Fugauvea, Avatolu)

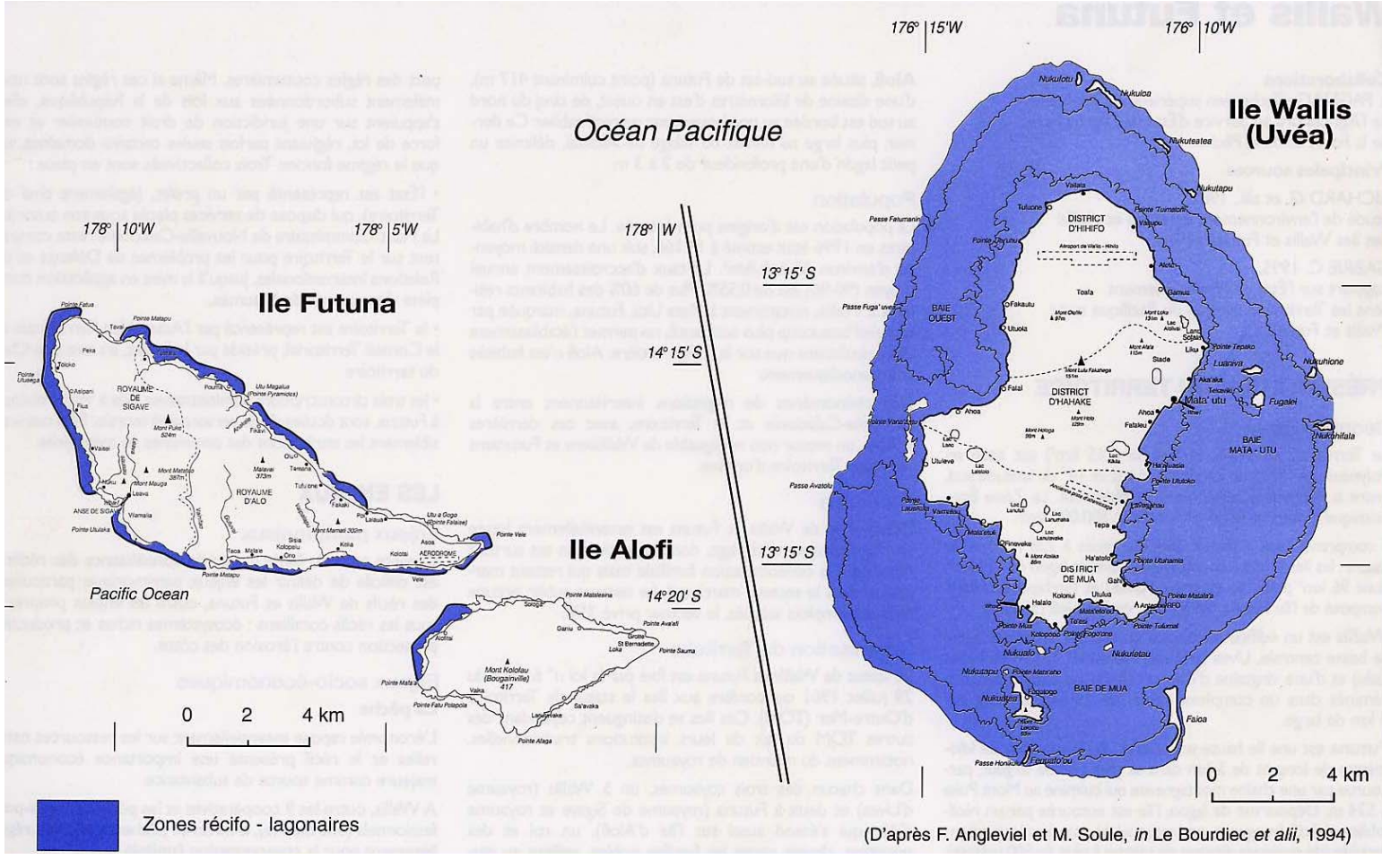

Figure 1
Cates de Wallis et Futuna et de l'île Alofi.

ou au Sud (Honikulu). La seule passe praticable par les gros navires est celle de Honikulu au Sud. La surface totale de récifs coralliens est évaluée à environ 220 km^2. La couronne récifale est fortement dissymétrique, le côté Est, plus battu, comporte tous les îlots et la côte Ouest, plus abritée, comprend les 3 passes. Le lagon est en général, assez peu profond et de morphologie compliquée, avec notamment des cuvettes résultant de l'hydrodynamisme et des cloisonnements correspondants à des arêtes basaltiques. Le lagon oriental est plus profond en moyenne que le lagon occidental où le récif frangeant est beaucoup plus étendu. Les principaux biotopes représentés dans le complexe récifo - lagonaire de Wallis sont présentés dans la figure 2.

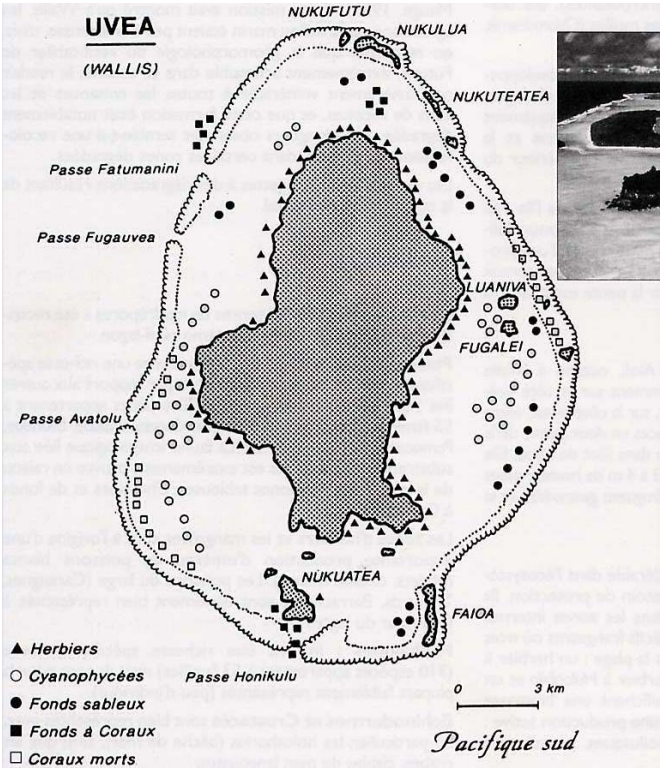

Figure 2
Cartographie simplifiée des grands biotopes représentés dans le complexe récifo lagonaire de Wallis (source : Richard *et al.,* 1980).

La zone frangeante est d'une manière générale, caractérisée par la succession de trois herbiers, sur des fonds sablo-vaseux assez hétérogènes, à faible profondeur (0,2 m à 1 m). En règle générale, en partant de la côte, on observe un herbier à *Halodule*, puis un herbier à *Halophila*, sur des sables plus grossiers, fréquemment associés à des *Halimeda* et un herbier à *Syringodium*, accompagné le plus souvent de *Turbinaria*. Ces formations ont une importance considérable dans l'écosystème wallisien car elles couvrent une grande partie des zones frangeantes. La flore associée à ces herbiers est composée le plus souvent de *Padina*, *Turbinaria* et *Halimeda*. La faune benthique associée est également très riche et diversifiée. Pour toutes ces raisons, les herbiers jouent un rôle de tout premier plan dans l'écosystème récif–lagon de Wallis. Les mangroves, situées généralement dans le Sud et l'Ouest de l'île centrale, occupent une surface non négligeable et constitue une composante essentielle de l'écosystème

corallien de l'île de Wallis. On observe la zonation suivante en partant de la terre : *Inocarpus edulis* puis *Barringtonia speciosa, Bruguiera eriopeta* et *Rhizophora mucronatata.*

Le lagon, proprement-dit, est une formation complexe. On observe des alignements coralliens résultant de la croissance des madrépores sur les arêtes basaltiques, des pâtés isolés, de vastes cuvettes, des fonds de dalle à micro cuvettes et à nombreux débris à proximité des îlots. De grandes étendues de lagon, généralement en bordure des herbiers et principalement sur la bordure occidentale de l'île, sont recouvertes par des tapis de cyanophycées. On y trouve en association quelques algues (*Enteromorpha, Hydroclathrus, Halimeda* et *Padina*) et le peuplement icthyologique de ces fonds est quasi nul. Les fonds coralliens au niveau du lagon sont peu nombreux comparativement aux îles Fidji voisines. Ce sont principalement les platiers à pâtés dispersés et quelques pinacles. Les premières évaluations montrent des taux de recouvrement en coraux scléractiniaires faibles dans le lagon, sauf à certains endroits, où des taux de recouvrement de 40 % à 90 % ont été observés. La construction madréporique est en revanche, active au niveau de la pente externe.

Des traces d'extraction de soupe de corail sont visibles sur le récif frangeant au Sud et au Nord de l'île. Les conséquences négatives de ces activités semblent être limitées dans le contexte particulier de la zone frangeante de Wallis, constituée essentiellement d'herbiers et non de formations madréporiques.

Futuna et Alofi

Les îles de Futuna et de Alofi sont dépourvues de lagon mais, possèdent des récifs tabliers au développement variable. Côté île, on observe généralement une accumulation de galets ou de sables. Fait suite un platier où les algues sont bien représentées (*Padina, Valonia, Caulerpa…*) et les mollusques sont souvent abondants. En revanche, les Madrépores sont rares et limités à certains genres (*Pavona, Porites, Montipora*). Sur le front récifal, on constate la présence de Zoanthaires *(Palythoa*) et davantage de Madrépores. Sur la pente externe les Madrépores sont plus nombreux avec des taux de recouvrement variant de 30 à 50 %. Les genres les plus répandus sont *Pocillopora, Acropora et Porites*.
Les récifs coralliens de l'archipel Horn présentaient déjà en 1980 un état de dégradation significative. Des pratiques de pêche destructrices, largement répandues à l'époque (utilisation de poison) et la destruction physique des coraux (piétinement, utilisation de barre à mine) sont à l'origine de ces dégradations. Enfin, aucun phénomène de blanchissement n'a été observé.

Après 1998

Observations à partir du réseau de surveillance

La mise en place, en 1999, d'un réseau de surveillance des récifs coralliens avec la méthode photographique utilisée en Polynésie Française, permet dorénavant un suivi plus rigoureux de l'état de santé des récifs coralliens du territoire. La méthode utilisée consiste à photographier une parcelle récifale rectangulaire de 20 m de long sur 1 m de large (soit 20 km^2). Les relevés photographiques (1 m^2/relevé) permettent d'une part, d'évaluer des pourcentages de recouvrement en coraux de la zone choisie (variable quantitative) et d'autre part, de distinguer les genres de coraux pour en établir le recensement (variable qualitative). Ces informations vont pouvoir être récoltées au même endroit à différentes dates afin d'évaluer l'évolution temporelle des variables mesurées.

A Wallis, deux stations ont été mises en place, l'une sur la pente externe de la côte Ouest (au Nord de la passe « Avatolu »), et l'autre dans le lagon sur la côte Est, dans la baie de Mata-Utu. A Futuna, une

station a été mise en place sur la pente externe au Nord-Ouest de l'île au lieu dit « Sagole » et à Alofi, c'est dans la pointe Ouest de l'île au lieu dit « Alofitai » que la station a été choisie. La recherche des stations est facilitée par l'utilisation du GPS. Les observations au niveau des stations sont complétées par une évaluation de recouvrement par « manta tow ».

Les premiers résultats qualitatifs et quantitatifs sont présentés dans le tableau 1 ci-dessous.

	% Recouvrement			
Genre	Alofi Pente externe	Futuna Pente externe	Wallis Pente externe	Wallis Lagon
Acropora	9.88	9.75	1.48	-
Favia	0.43	1.60	13.02	0.74
Favites	0.19	-	-	-
Galaxea	0.19	-	-	-
Goniastrea	0.06	0.06	0.19	-
Leptastrea	2.47	0.19	0.19	-
Leptoria	0.56	1.60	0.93	-
Leptoseris	-	-	0.06	-
Lobophyllia	0.06	-	0.12	-
Montastrea	0.12	0.06	-	-
Montipora	1.05	0.31	-	-
Platygyra	0.74	0.86	0.06	-
Pocillopora	0.99	0.49	-	0.12
Porites	0.12	-	0.06	0.12
Seriatopora	0.37	0.06	-	-
Stylophora	-	0.19	-	-
Synaraea	-	-	4.07	-
Turbinaria	-	0.12	0.56	-
Autres	2.22	0.74	1.05	-
% R total	19.45	16.03	21.79	0.98
Richesse générique	14	12	11	3
% manta tow	0 - 10	-		
Remarques	-	Corail mort récent	Débris de coraux nombreux	Corail mou 15.8%

Tableau 1
Premiers résultats du taux de recouvrement en corail vivant par genre sur les trois îles du territoire.

Les résultats quantitatifs montrent que les 3 stations de pente externe observées présentent le même ordre de grandeur en terme de recouvrement en coraux sclératiniaires. Les pourcentages en taux de recouvrement sont compris entre 16,03 % (Futuna) et 21,79 % (Wallis) avec une valeur intermédiaire de 19.45 % pour Alofi. La station lagonaire de Wallis est caractérisée par un très faible taux de recouvrement en corail (0.98 %) ; le peuplement de cette station est dominé par les coraux mous qui occupent 15,80 % de la surface totale. Ces résultats confirment les observations de Richard *et al.* (1982). A Wallis, deux stations ont été mises en place, l'une sur la pente externe de la côte

Les résultats qualitatifs sont eux aussi comparables en ce qui concerne le nombre de genres recensés sur les pentes externes. On dénombre 14 genres de coraux sclératiniaires à Alofi, 13 genres à Futuna et 12 genres à Wallis. Sur Futuna et Alofi, c'est le genre *Acropora* qui domine nettement le peuplement et sur Wallis c'est le genre *Favia.* Sur la station lagonaire de Wallis, on ne dénombre que 3 genres différents dans le transect photographique.

Méthode des transects

Pour compléter les observations sur le réseau, une étude du substrat a été réalisée selon la méthode du « line intercept transect » à Wallis. Elle consiste à classer le type de fond selon différents critères sédimentologiques, pour les zones non colonisées par des organismes vivants, et selon le groupe biologique et la forme des colonies, pour les parties vivantes. Un plongeur a noté le pourcentage de couverture de chacune des classes rencontrées le long d'un transect de 50 m. La localisation des stations d'observations est précisée dans la figure 3 ci-dessous. Les premiers résultats sont présentés dans le tableau 2 ci-dessous. L'analyse des transects réalisés sur différentes stations à Wallis (Wantiez, 1999) montre 4 types de substrats caractéristiques. Le substrat des stations coralliennes côtières est essentiellement sableux avec un taux de recouvrement moyen de 55,55 %. Ces sables sont souvent colonisés par des phanérogames ou des macro-algues.

Les coraux vivants n'occupent qu'une faible partie du substrat (2,6 %). Le corail mort présente un taux de recouvrement moyen de 12,65 %. Enfin, les algues occupent 18,10 % de la surface totale. Les stations coralliennes intermédiaires présentent deux fasciés différents. Certaines stations se caractérisent par de la dalle colonisée en partie par des coraux massifs ; et d'autres se différenciant par un substrat principalement constitué de sables, de coraux morts recouverts d'un voile algal. De petites formations de coraux branchus et submassifs se développent sur ces fonds. Les stations du récif barrière interne présentent un substrat composé essentiellement de sable de coraux morts, de débris et de dalle. Ce substrat est colonisé par des algues et des coraux vivants avec un taux de recouvrement faible (5,85 %). La pente externe est caractérisée par un substrat constitué essentiellement par des coraux vivants encroûtants, foliaires et tabulaires et par des algues calcaires. Le taux moyen de recouvrement par les coraux vivants est de 27,50 %. Ces valeurs sont légèrement supérieures à celles obtenues par la méthode photographique.

Cette étude montre que malgré les faibles taux de recouvrement par les coraux vivants observés à Uvéa, le substrat des formations coralliennes est caractéristique des milieux ne subissant pas d'impacts anthropiques significatifs. Le pourcentage d'organismes vivants est relativement important en raison notamment de la présence d'herbiers dans le lagon et de coraux vivants sur la pente externe. De plus, la partie abiotique du substrat est essentiellement sableuse. Par ailleurs, aucune formation récifale envasée, conséquence d'une pollution terrigène, n'a été observée à Uvéa. Enfin, aucun phénomène de blanchissement n'a été constaté lors de ces différentes études, ni lors de plongées réalisées par le Club de plongée, chargé de l'entretien et de la surveillance du réseau.

Etat des poissons des récifs coralliens

Etat des populations de poissons

Richesse spécifique, densité et biomasse

La première étude réalisée sur le territoire en 1980 a recensé 330 espèces de poissons benthiques réparties dans 55 familles. Cette ichtyofaune couvre les divers étages de la pyramide alimentaire des eaux récifales indo-pacifiques. L'étude de 1999 (Wantiez *et al.*) a recensé sur Wallis uniquement 194 espèces réparties en 32 familles. La différence entre ces deux études est liée probablement à l'effort d'échantillonnage plus faible en 1999 qu'en 1980.

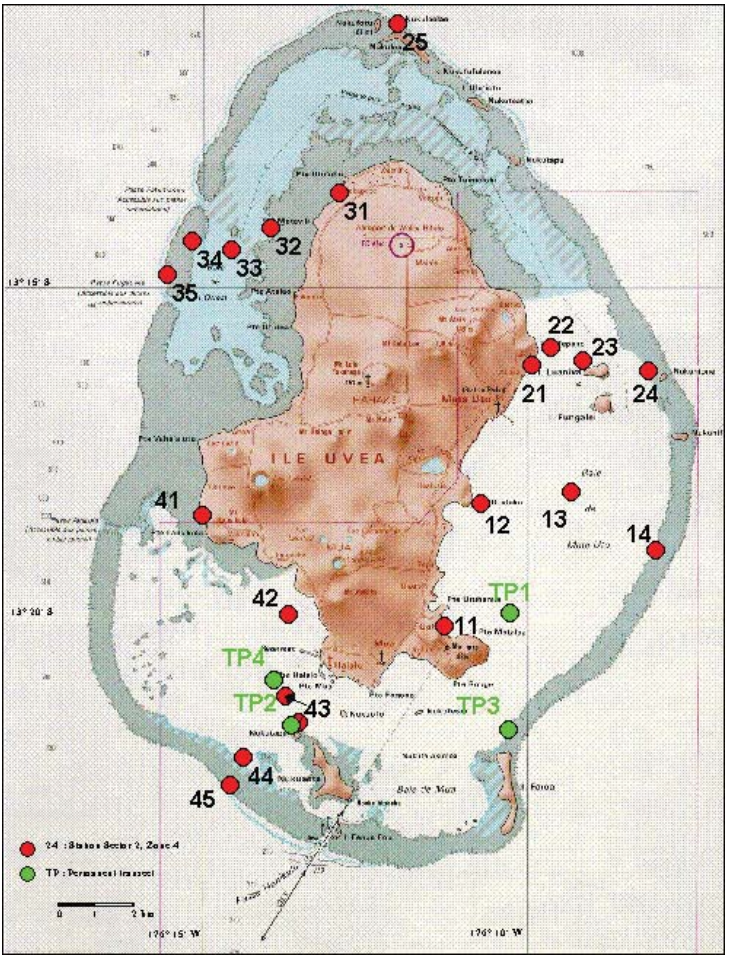

Figure 3
Location of stations studied at Wallis.

	Station côtière	Station intermédiaire	Station récif barrière interne	Station pente externe
Corail vivant	2,60	14.8	5 ,85	27,50
Algues	18,10	2,27	10,15	41,06
Corail mort	12,65	17,00	23,5	23,67
Sable	55,55	23,67	26,3	1,33
Débris	2,20	4,33	26,4	3,33
Blocks, dalles	4,85	34,26	7,5	0,00
Crevasses	0,05	0,00	0,15	0,60
Vase	0,00	0.00	0,00	0,00
autre	4,00	3,67	0,15	2,51
Total	100	100	100	100

Tableau 2
Mean substrate charcteristics of reef stations studied by the line intercept transect method at Wallis (% cover).

Les caractéristiques générales de l'icthyofaune sont présentées dans le tableau 3 ci-dessous. Les familles les plus diversifiées sont les Labridae (labres et girelles, 34 espèces), les Pomacentridae (poissons demoiselles, 33 espèces) et les Chaetodontidae (poissons papillons, 23 espèces). Ces familles sont représentatives des environnements coralliens en bonne santé. En revanche, certaines familles sont peu représentées dans le lagon d'Uvea et des espèces abondantes dans le Pacifique Ouest n'ont pas été recensées. Il s'agit notamment d'espèces d'intérêt commercial :

- les Serranidae du genre *Epinephelus* (loches) et la saumonée (*Plectropomus leopardus*)
- les Lethrinidae tels que le bec de cane (*Lethrinus nebulosus*) et certains bossus (*Gymnocranius spp*)
- des Lutjanidae, notamment le perroquet banane (*Bodianus perditio*)
- des Acanthuridae du genre *Naso*, notamment le Dawa (*Naso unicornis*)
- des Siganidae (picots, *Siganus spp*)

Stations	Richesse spécifique	Densité (poisson/m²)	Biomasse (g/m²)
Côtière	42,75	2,77	62.44
Intermédiaire	46,33	3,02	26.12
Barrière-interne	44,50	3,20	28.12
Pente externe	56,33	1,80	56.94
Moyenne	47,47	2.69	43.40

Tableau 3
Caractéristiques générales de l'Icthyofaune échantillonnée dans le lagon d'Uvea.

Les résultats obtenus à Wallis montrent que la richesse spécifique moyenne par station (47,47/st) est dans la gamme des valeurs généralement observées dans la région. La densité moyenne observée est de 2,69 poissons au m² avec un minimum de 1.18 poissons/m² et un maximum de 5,43 poissons/m². Les espèces les plus abondantes sont des petits Pomacentridae planctophages. Cette valeur se situe dans la gamme généralement observée dans la région indo-pacifique mais dans les valeurs les plus faibles. La biomasse moyenne est de 43,40 g/m². Cette valeur est faible par rapport aux valeurs généralement observées dans la région.

En conclusion, les peuplements de poissons coralliens de Wallis présentent des caractéristiques globales conformes à ce qui est généralement observé dans la région indo- pacifique mais, ils font partie des communautés les plus pauvres.

Structure des communautés

La faune ichtyologique présente 4 peuplements selon un gradient côte – large. La répartition semble liée aux influences océaniques et terrigènes d'une part, et des caractéristiques du substrat d'autre part : un peuplement de pente externe, un peuplement d'herbier et un peuplement lagonaire qui peut être scindé en deux peuplements. Les principales caractéristiques de ces différents peuplements sont résumées dans le tableau 4 ci-dessous.

Le peuplement de pente externe se caractérise par de nombreuses espèces coralliennes associées aux coraux vivants, notamment les Chaetodontidae, Pomacanthidae et Pomacentridae. Cette communauté se distingue par ailleurs par la présence d'espèces associées aux environnements sous influence océanique, typique de la pente externe, telles que *Elangatis bipinnulata*, *Aphareus furca* et *Chaetodon*

Peuplement	Richesse spécifique	Densité (poisson/m²)	Biomasse (g/m²)
Herbier	38	2.14	8.47
Lagon 1	41.25	1.43	44.36
Lagon 2	47.5	3.69	42.46
Pente externe	56.3	1.8	56.94

Tableau 4
Caractéristiques des différents peuplements de poissons à Wallis.

ornatissimus. Les communautés de la pente externe sont diversifiées (56,33 espèces/station), la densité est moyenne (1,80 poisson/m²) et la biomasse est la plus importante (56,94 g/m²).

Le peuplement d'herbier côtier est déterminé par des espèces caractéristiques de ces environnements, notamment des carnivores benthiques, consommateurs des nombreux invertébrés. Il s'agit principalement de Lethrinidae (*Lethrinus sp*), Nemipteridae (*Scolopsis trilineatus*), Mullidae (*Parupeneus multifasciatius*), Labridae (*Novaculichthys taeneatus*) Balistidae (*Rinecanthus aculeatus*) et Tatraodontidae (*Arathron hispidus*). Ce peuplement est caractérisé par la diversité la plus faible (38 espèces/station), une densité relativement élevée (2,14 poisson/m²) et la biomasse la plus faible (8,47g/m²). Ces résultats montrent donc la présence de nombreux individus de petite taille qui utilisent ces herbiers comme nurserie.

Les différences de structure entre les deux peuplements lagonaires reflètent des différences de caractéristiques du substrat. Le peuplement de type 1 a été échantillonné sur des stations où les algues et les débris sont plus nombreux. Le peuplement de type 2 a été observé dans des stations où les coraux vivants et la dalle corallienne sont plus abondants. Le premier type se caractérise par des espèces partiellement herbivores et commune dans les lagons (Pomacentridae, Labridae, Scaridae et Acanthuridae). La richesse spécifique et la biomasse sont moyennes avec des valeurs de 41,25 espèce/st et de 44,36 g/m² respectivement. La densité est la plus faible enregistrée. Le second type se distingue par la présence d'autres espèces communes dans les lagons. Il s'agit d'une part, d'espèces planctophages, notamment une Clupeidae (*Spratelloides sp*), des Serranidae (*Pseudanthias sp*) et des Pomacentridae généralement associés aux formations coralliennes vivantes. Ces communautés sont relativement riches comparativement aux autres (47,5 espèce/st, 42,46 g/m²) et présentent la densité la plus forte (3,69 poisson/m²).

Situation des pêcheries

La pêche pratiquée sur les récifs coralliens de Wallis et Futuna est exclusivement artisanale. Les moyens de production mis en œuvre restent peu importants. Les techniques de pêche utilisées sont principalement la palangrotte, la pêche au fusil sous-marin et la pêche au filet. Certaines pratiques de pêche destructrices, pourtant interdites, (poison ou dynamite) sont encore de temps en temps utilisées. De nombreuses campagnes d'information ont cependant permis de sensibiliser la population sur les dégradations provoquées par ces méthodes de pêche.
Le service territorial de la pêche a recensé en 1997, 286 embarcations à fonds plat de type FAO destinées principalement à la pêche lagonaire. Grâce à l'amélioration des conditions de sécurité en mer, la pêche hors du lagon se développe mais reste peu importante. La production annuelle en poissons coralliens est évaluée à 300 tonnes environ alors que la demande atteint 900 tonnes selon la CPS. Les familles de poissons qui font l'objet d'une pêche alimentaire artisanale significative sont les suivantes : les Acanthuridae, les Balistidae, les Chaetodontidae, les Cirrhitidae, les Dasyatidae, les

Labridae, les Lethrinidae, les Lutjanidae, les Malachanthidae, les Mugilidae, les Mullidae, les Muraenidae, les Ostraciontidae, etc.
Depuis quelques années, un circuit de commercialisation s'est mis en place avec la création sur l'île de Wallis de quelques poissonneries qui offrent des capacités de conservation plus importantes mais également des produits frais transformés. Il est encore difficile de donner des statistiques sûrs sur les pêches, compte tenu du fait que la quasi totalité de la population pratique la pêche dans le lagon soit pour le loisir soit comme moyen de subsistance. En plus des poissons qui représentent une grande partie des ressources prélevées par la population dans les récifs coralliens, il y a deux espèces qui font actuellement l'objet d'une exportation. Il s'agit du troca nacrier (*Trochus niloticus*) et plus récemment de l'holothurie. Les quantités exportées sont évaluées à quelques tonnes par an.

Menaces anthropiques sur la biodiversité récifale

L'érosion et la sédimentation

Les pratiques culturales par brûlis et la multiplication d'infrastructures routières mal réalisées sont à l'origine d'une accélération des phénomènes d'érosion observés sur le territoire depuis quelques temps. En période de pluies, les eaux du lagon de Wallis et les eaux marines littorales de Futuna deviennent turbides. Les latérites provenant des pentes dénudées ou des pistes de montagnes vont alors sédimenter sur les coraux. Ces phénomènes sont visibles sur l'île de Futuna où des zones de vasières se sont formées au droit des pistes de montagnes (Toloke, Vaisei). Ces dégradations ne sont pas constatées sur l'île de Alofi voisine grâce à l'absence de ces types d'infrastructures.

Les aménagements côtiers

Le territoire a entrepris depuis une dizaine d'années un programme important de protection du littoral. Cette action a consisté à réaliser, des enrochements sur la quasi totalité de la façade est de l'île de Wallis, soit environ 15 km. Le résultat de ces actions s'est traduit par la disparition de toutes les plages de l'île. La conception des ouvrages ne correspondait à aucune norme pour les travaux maritimes. Ces aménagements côtiers ont été réalisés sans étude d'impact préalable. Certaines mangroves ont été complètement détruites par des remblais et des constructions (figure 4).
Les extractions de matériaux coralliens (soupe de corail et sable de plage) utilisés comme matériaux de construction ou de remblai sont de plus en plus nombreuses. La turbidité au niveau des zones d'extractions est importante et le trait de côte a reculé de plus de 100 mètres à certains endroits de l'île de Wallis (zone de Utuleve).

La pollution

L'amélioration des conditions de vie de la population a naturellement engendré une production de déchets plus importante. Cette production est évaluée à environ 3000 t/an soit 200 kg/an/ha. A l'heure actuelle, les déchets ménagers sont collectés et mis en décharges, sans traitement préalable. Pour les eaux usées domestiques, le procédé utilisé pour leur traitement est celui l'assainissement autonome. Les installations actuelles ne répondent pas aux normes et le traitement des eaux usées reste insuffisant. Les fosses septiques, réalisées généralement en parpaing, ne garantissent pas une étanchéité suffisante et aucun système d'épuration des eaux en sortie de fosse n'a été prévu.

Figure 4
Aménagements côtiers : ouvrages divers au sein d'une mangrove.

Les eaux usées des élevages de porcs (25 000 têtes) qui sont généralement installées à proximité des habitations sont à l'origine de pollutions importantes au niveau des ressources en eau terrestres et marines littorales. Les lisiers ne font l'objet d'aucun traitement et ils sont directement déversés dans le lagon à certains endroits (figure 5). La qualité des eaux du lagon fait actuellement l'objet d'analyses bactériologiques et les premiers résultats font état d'une pollution fécale significative dans les zones littorales habitées.

Des risques de pollutions par les hydrocarbures doivent être également signalés en raison de l'accroissement significatif du trafic maritime dans les eaux lagonaires de l'île de Wallis notamment.

Figure 5
Exutoire d'eaux usées à Falaleu.

L'exploitation des ressources

Le niveau d'exploitation des ressources lagonaires n'est pas connu. Les premières évaluations faites en 1980 (Richard et al) et en 1999 (Wantiez et al) font état d'une ichtyofaune caractérisée par un petit nombre d'individus de petites tailles. Des risques de surexploitation sont par conséquent, à craindre si la pression de la pêche devenait importante.

Le développement de la pêche hors du lagon avec la multiplication des dispositifs de concentration de poissons (DCP) permet d'envisager une réduction de l'exploitation des ressources lagonaires. Cette mesure doit être envisagée pour l'archipel de Horn dont les surfaces coralliennes sont faibles.

Les impacts actuels et potentiels des changements climatiques

Aucune étude pour évaluer les impacts des changements climatiques n'a été réalisée jusqu'à présent. Un suivi scientifique dans ce domaine devrait être envisagé dans le cadre de la coopération régionale.

Les zones marines protégées et les capacités de gestion et de conservation

Le territoire ne dispose pas officiellement de zone marine protégée. Dans la pratique, ce sont les autorités coutumières, compétentes en matière foncière, qui interviennent dans le cadre de la gestion des ressources marines littorales, comme les granulats marins, par exemple. Elles seraient, par conséquent, en mesure d'élaborer un règlement adapté pour créer des zones marines protégées et de développer les capacités de gestion et de conservation.

Le territoire, pour sa part, envisage de développer les connaissances scientifiques et techniques qui permettront aux autorités coutumières d'élaborer les programmes de gestion et de conservation de ces zones marines protégées.

Les réglements du territoire

La réglementation locale

Le territoire est compétente en matière d'environnement. Cependant, aucune réglementation territoriale spécifique n'a été élaborée à ce jour en la matière. Le chef du territoire a pris un certain nombre d'arrêtés qui réglementent essentiellement la pêche. Il s'agit de règlements interdisant les pratiques de pêche destructrices (utilisation d'explosifs, de poison, de barre à mines), d'autres réglementant la pêche sous marine autonome ou en scaphandre, la taille commerciale de certaines espèces pêchées. Ces réglementations restent inappliquées par manque de moyens de surveillance.

Les autorités coutumières édictent en cas de besoin des interdictions de certaines activités mais cette procédure est rarement utilisée.

Les conventions internationales

Les convention internationales s'appliquant aux territoires d'outre mer sont au nombre de 22. Sur le territoire, aucune mesure d'application locale de ces conventions n'a encore été prise. C'est un travail important à réaliser pour que le territoire soit en conformité avec ces conventions internationales.

Les lacunes dans la capacité actuelle de gestion et de conservation des récifs coralliens

Les autorités locales comme la majorité de la population du territoire sont, d'une façon générale, peu sensibles à la protection de l'environnement. Dans les projets de développement élaborés jusqu'à présent, les moyens affectés pour l'environnement sont insignifiants. Par ailleurs, les actions engagées étaient isolées et les résultats sont parfois à l'opposé de ce qui a avait été prévu. Le meilleur exemple est celui de la protection du littoral qui s'est traduit dans la réalité par une dégradation importante des récifs frangeants ; des ouvrages en béton armé ou des enrochements se sont multipliés sur tout le littoral et les remblais en latérite ont contribué à la pollution du lagon.

Le territoire de Wallis et Futuna présente par ailleurs, un retard considérable en matière de connaissance des milieux coralliens. Les décideurs ne disposent donc pas d'éléments objectifs pour appuyer leurs décisions. Cette situation pénalise grandement la mise en œuvre de certains projets de développement comme la pêche ou l'aquaculture. Le flou existant en matière de compétence entre l'Etat, le Territoire et les autorités coutumières ne facilite pas la gestion et la conservation de ces milieux. En effet, cette absence de clarté ne permet pas l'élaboration dans de bonnes conditions de réglementations pertinentes et applicables, notamment en matière d'installations classées ou en matière de protection des sites naturels. Le manque de coordination, pendant longtemps, entre les différents services administratifs du territoire a retardé la réalisation dans de bonnes conditions de certains projets dans le domaine de l'assainissement notamment. Enfin, le manque de moyens financiers ne permet pas toujours la mise en œuvre des programmes d'actions en faveur de la protection des récifs coralliens.

Conclusions et recommandations pour la conservation des récifs coralliens

Ce premier bilan, bien qu'incomplet, met en évidence les lacunes accumulées, jusqu'à présent par le territoire des îles Wallis et Futuna en matière de protection de l'environnement en général et des milieux coralliens en particulier. Les premières études ont cependant permis de faire un premier état des lieux. Les premiers résultats montrent que les récifs coralliens du territoire de Wallis et Futuna sont caractérisés par un taux de recouvrement en coraux vivants faible naturellement. En ce qui concerne la faune ichtyologique, elle présente une faible richesse spécifique et une faible biomasse

comparativement aux autres régions indo- pacifiques. Sur l'île de Wallis, les dégradations des récifs coralliens sont essentiellement dues à l'extraction de granulats marins et à la réalisation anarchique de nombreux ouvrages sur le littoral qui aggrave, dans certaines zones, les processus d'érosion. Sur l'île de Futuna, où les récifs coralliens sont facilement accessibles par la population et, autrefois par les cochons, des dégradations anthropiques importantes ont été constaté depuis 20 ans. Ces dégradations sont dues pour l'essentiel, au piétinement des coraux et à la pollution terrigène.

Pour combler son retard, le territoire de Wallis et Futuna commence à se doter de moyens en faveur de la protection de l'environnement. En 1997, un service territorial de l'environnement a été créé et il est chargé de coordonner les actions en faveur de la protection de l'environnement et de l'amélioration du cadre de vie. La création du comité national de l'IFRECOR en 1999, où le territoire est représenté, a permis de sensibiliser les autorités sur l'importance des récifs coralliens dans le développement du territoire. Dans le prochain contrat développement Etat/Territoire (2000-2004) des financements sont prévus pour l'étude et la surveillance des récifs coralliens. La mise en œuvre d'une politique territoriale en matière de gestion des déchets liquides (création d'une station d'épuration) et solides (meilleure gestion des déchets) permettra de réduire significativement les effets des pollutions chroniques sur les récifs coralliens. Les programmes de reboisement mais surtout d'amélioration des rendements des productions agricoles apporteront sans aucun doute un début de réponse aux problèmes d'érosion des sols et de la sédimentation au niveau des récifs.

Ce premier bilan de l'état des récifs coralliens du territoire des îles Wallis et Futuna montre que pour assurer la conservation et l'utilisation à long terme de ces milieux, il est primordial de renforcer la connaissance de ces écosystèmes, de clarifier les compétences des différentes autorités, d'élaborer une réglementation locale en matière d'environnement et enfin, de faire participer activement les communautés locales à la gestion des ces milieux.

Références page 382.