The status of coral reefs and marine resources of Samoa

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Introduction

The Samoan Islands

Samoa (previously known as Western Samoa) consists of two large islands and several small ones (14) with a total land area of 2935 km^2, located between latitudes 13-17 degrees South and longitudes 171-173 degrees West (Figure 1). The exclusive economic zone (EEZ) is a mere 120 000 km^2 and the coastline is estimated at about 403 km (Pernetta 1990). The two larger islands are formed from the outpourings of volcanoes, the mouths of which are aligned approximately east-west along the high central spines (*tuasivi*) of the islands (Nunn 1998). The smaller islands are the remains of individual cones.

Samoa is located near the southern edge of the intertropical convergence zone. The southeast trades blow for 82 per cent of the dry season and 54 per cent of the wet season. According to Wright (1963), the fact that the island chain lies parallel to these trade winds results in the absence of the strong 'windward' and 'leeward' effect found in most other Pacific islands. During the wet season, the trade winds are periodically displaced by the eastern extension of the Australasian low-pressure

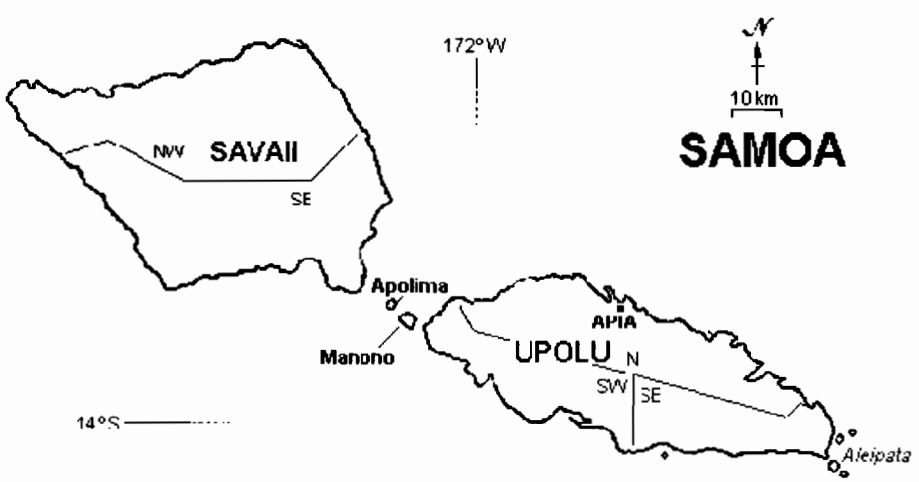

Figure 1
Map of Samoa.

area and by cyclone systems generated near Kiribati and Tuvalu. These have their greatest impact on the weather on the north-western and western sides of Upolu and Savai`i Islands. The annual temperature variation is 1-2°C, averaging 26-27°C at sea level. The range of mean daily temperatures is 6-8°C in January, and 7-9°C in July in most places (Chase and Veitayaki 1992).

The Samoan coral reefs and marine habitats are summarised in Krämer (1902-1903, 1994-1995); Mayor (1924); Dahl (1972), Johannes (1982); Wells and Jenkins (1988); Morton *et al.* (1989), Taule`alo (1993); Anon (1993), Zann and Mulipola (1995); Green (1996) and Zann and Vuki (1998). The coral reefs are limited and fringing in nature, due to the past volcanic activities and the subsequent sea level rise. Previous barrier reefs were covered by lava flow and deep-sided volcanic cones prevented coral reef formations. The shallow and usually murky lagoons on the northern side of the islands (to 2 m depth) are often encircled by fringing reefs, which can extend seaward to 3 km. On the southern, windward shores the lagoons are 2-3 m deep and clearer. The reef systems around Samoa were severely affected by the two major cyclones, *Ofa* and Val in the early 1990s. Some of the reef systems, however, recovered relatively fast and five years later lush coral diversity were seen in most front reef areas.

The Samoans have continued to rely on their coral reef ecosystems for their well-being. As Krämer (1995) stated; "Samoan coral reefs, which may be looked upon as the natives' pantry and are thus in the economy of that people of greatest significance". The inshore reefs are becoming severely degraded and threatened mainly by human activities (Green 1996). In 1974, Samoa was the first Pacific Island country to set up a national marine reserve, the Palolo Deep National Marine Reserve. Other marine conservation initiatives are currently undertaken by the Fisheries Division (FD) of the Ministry of Agriculture, Forestry, Fisheries and Meteorology (MAFFM), and under the International Union for Conservation of Nature (IUCN) within the Division of Environment and Conservation (DEC) of the Department of Lands, Surveys and Environment (DLSE).

Acknowledgments and arrangements

The Tables and the map of Samoa (Figure 1) are found after the Reference section. This report although generally follows a format developed by previous neighbouring countries, modifications were needed to address the local scenario. Efforts were made to compile and up-to-date status of coral reefs and marine resource issues that are affecting the Samoa islands.

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Coral reef biodiversity

Background

The current knowledge on marine biodiversity in Samoa, is inadequate in most areas. The majority of research on the marine fauna and flora was carried out by overseas scientists during the colonial era. In the early 1900's, Samoa became one of the most researched and well-known areas in the Pacific

(Schmidt 1928). However, most of the published studies were written in foreign languages or are not accessible by locals. It is therefore, difficult to compile an up-to-date database of what is known from the islands, with the exception of marine algae, and mangrove forests.

Fragmented reports on some marine biota from Samoa are cited here (see bullet points below), though the authors have not seen most of these reports. The need to document and create a database on the biodiversity of Samoa is most important and must be made a priority for the Government. It is a sad fate for Samoa to see many marine animals and plants becoming extinct with little or no effort made to document or conserve them. Too often traditional songs, poems and tales recite the abundance of many marine species that are no longer seen today. Fishing methods that were often associated with certain marine species are fast becoming a thing of the past, and it is further exacerbated by the lack of interest by the youths of today.

Fauna

Garlovsky (1972) documented a vernacular listing of Samoa's fauna, including marine organisms, in a teacher's handbook, which included English, scientific and Samoan names. Zann (1989) compiled a scientific checklist in English and Samoan, of marine fishes and other marine organisms excluding the plants. This list is very much incomplete, however it is an ideal beginning for a marine biodiversity database for Samoa. The status of important marine and fresh-water fishery resources (including fin-fishes, crustaceans, molluscs, seaweeds, bêche-de-mer, sea urchins, *palolo*, and jellyfish) have been documented by Bell and Mulipola (1995); see section 3.1.1. The list below briefly summarises some of the past research on marine organisms from Samoa.

- Shrimp – Banner (1966), King (1980, 1984);
- Rock (spiny) lobsters – George (1972); King and Bell (1991);
- Deep-water and Reef slope Snappers – Mizenko (1984), King *et al.* (1990);
- Palolo worm – Gray (1847); Mac Donald (1858); Stair (1897); Friedländer (1898); Burrows (1945); Caspers (1961, 1984); Smeltzer (1969);
- Corals – Eade (1980); Krämer 1995;
- Crown-of-thorns Starfish – Garlovsky and Bergquist (1970);
- Ostodes (mollusca) – Girardi (1973);
- Poisonous fishes – Jordan (1929);
- Flying fish – Toloa *et al.* (1998);
- Fresh and brackish water gastropods – Starmuhler (1986);
- Turtles – Hirth (1970); Witzell (1972); Witzell and Banner (1980);
- Foraminifera – Cushman (1924);
- Nautilus – Saunders *et al.* (n.d);
- Fisheries Resources - Bell and Mulipola (1995).

Fishes

Fishes of Samoa were first reported from the middle of the 19th Century (Hombron and Jacquinot (1853). Since then a number of scientific expeditions have been made to research fishes from Samoa. The latest compilation by Wass (1984) summarises most of the fishes of Samoa. Although Wass's collections were mostly from Tutuila Island, American Samoa with few from Upolu Island, the two groups (Samoa and American Samoa) may be considered to be geographically and biologically similar (Skelton 2000). Wass (*ibid.*) listed 991 species representing 113 families and 284 new records for

Site	Area surveyed	Fish species richness	Fish density	Fish biomass	Coral cover
Faleasi'u	Reef front, Depth: 10 m	Moderate	moderate	low	moderate
Vaitele	Reef front, Depth: 10 m	Moderate	high	moderate	high
Fagaloa	Reef front, Depth: 10 m	Moderate	moderate	moderate	high
Eva	Reef front, Depth: 10 m	Low	low	low	moderate
Lefaga	Reef front, Depth: 10 m	Moderate	moderate	moderate	moderate
Sa'anapu	Reef front, Depth: 10 m	Moderate	moderate	low	low
Poutasi	Reef front, Depth: 10 m	High	high	moderate	low

Table 1
Fish communities and habitat characteristics at survey sites on the island of Upolu. (source: Green 1996).

Samoa. Of the total, 890 are considered shallow-water or reef-inhabiting species (generally found at depths <60 m); 56 are considered deeper bottom fishes (associated with the bottom at depths of 60-500 m); and 45 are considered pelagic surface species (frequenting offshore waters above the thermocline at depths < 200 m). About 40 fishes are known only from Samoa and most are undescribed. Wass (*ibid.*) noted that it is likely that the "endemic" fishes of Samoa will be found once extensive collections are carried out in neighbouring archipelagos. This number will need to be revised once smaller fish species such as gobies and blennies are identified. The numbers may well be 200-300 more than those currently known (Seeto pers. comm.). The fishes of Samoa are now included in FISH BASE™ a software programme developed by the International Centre for Living Aquatic Resource Management (ICLARM).

A status report of reef fishes undertaken by Samoilys and Carlos (1991), highlighted a reduction in biomass and size of fish in shallower and more heavily fished areas, while high biomass was found in less fished and deeper reef slopes. This was confirmed by Green (1996) after surveying seven sites on Upolu island. She observed an increase of fish species richness with depth, with deeper habitats having more species than shallower sites (Table 1).

Corals

Little is known of the diversity and the number of coral species found in Samoa and their status needs to be confirmed with modern treatment. Krämer (1995) and Gosliner *et al.* (1996) listed about 50 hard coral species from Samoa. This number is low, as neighbouring archipelagos such as Fiji contains 163 species (Seeto pers comm.).

The state of coral communities of Samoa was said to be severely impacted by recent cyclones (Zann 1991). A survey of several sites of Upolu island conducted by Green (1996) reported that despite the cyclones and other impacts on the coral reefs, the reef fronts were in reasonably good condition (Table 1). Most of the sites surveyed supported healthy coral assemblages, with dense stands of plate corals present, which were not observed in any of the other islands in the archipelago. Furthermore, the reefs at Fagaloa and Vaitele, were exceptionally in good condition with lush coral communities and diverse fish communities (Green 1996). The shallower lagoonal sites were severely affected indicating an

immediate threat as compared with the front reef sites. Some dead corals and structural damage were observed at some reef sites, and Green (1996) suggested that it may be due to crown-of-thorns starfish outbreaks and dynamite fishing.

Reptiles

Three species of marine turtles are reported from Samoa: Green, Hawksbill and the Olive Ridley. In 1999 a leatherback turtle was caught on a longline for tuna in Samoan waters (Bell, pers comm.). The Hawksbill turtle feeds and breeds mainly on the small islands off Aleipata district, while the Green and the Olive Ridley is known to feed but not breed in Samoa. Turtles are considered as important tokens or taboo animals to many coastal communities. Although it used to be a delicacy of the local people, conservation efforts have managed to protect them from being harvested. A tagging programme initiated by SPREP is still ongoing with fishers bringing caught turtles to the Fisheries Division to be tagged. A tagged turtle from Samoa is reported to be breeding in the French Polynesia area (Toloa 2000), and turtles tagged in Tahiti have been caught in Samoa. There are two sea snake species reported, however, little is known of their status.

Flora

Reviews of early botanical research of Samoa may be found in Reinecke (1896), Krämer (1902-1903, 1994-1995) and Schmidt (1928). Further reference to the Samoan marine plants is to be found scattered among literature from the middle of the last century to the middle of this century. Mangroves are uncommon, but the Vaiusu mangal near Apia, Upolu Island is considered to be the largest in eastern Polynesia. The Sa`anapu mangal is considered to be an important fish nursery habitat in Samoa (Chase and Veitayaki 1992). Samoa is not well endowed with seagrass beds with only two species of seagrass recorded (Hartog 1970; McMillan and Bridges 1982). These marine ecosystems are poorly understood (Taule`alo 1993) but are increasingly degraded by anthropogenic activities (Horsman and Mulipola 1995; King and Fa`asili 1998).

Algae

The recent compilation of algae from Samoa and American Samoa by Skelton and South (1999) listed 198 taxa, comprising 15 Cyanophyceae, 89 Rhodophyceae, 33 Phaeophyceae and 61 Chlorophyceae. This represents about 50-60 percent of the potential algal flora from Samoa (Skelton and South 1999). Furthermore, a floristic survey of the algae of the Palolo Deep National Marine Reserve is nearing completion (Skelton 2000), and preliminary results reveal a total of 128 species of which 89 are new records, bringing the total of known marine algae from Samoa to 287. Four red alga from Palolo Deep are recognised as new to science, *viz Amansia paloloensis, Ceramium upolense, Ceramium kramerii* and *Ceramium rintelsianum* (South and Skelton 1999; 2000). *Ceramium rintelsianum* is found only from Palolo Deep Reserve, however, extensive research of the flora of neighbouring islands may reveal the presence of this alga. A floristic survey of the algae of Samoa is currently being proposed and will begin in mid-2000 (Skelton, in prep.).

Coral reef scientists have often overlooked the important role of algae in tropical marine environments. Recent research has emphasised the important role of algae in the marine environment, primarily as primary producers, which form complex associations with high species diversity (Dahl 1972). Coralline algae are important in cementing coral reefs (Keats 1996). The shading provided by some large algae often helps cool some benthos during hot sunny weather (Jompa and McCook 1999).

There are three kinds of algae that are consumed by the people: *Caulerpa racemosa*, *Caulerpa* sp., and *Halymenia durvillei* (previously reported as *Gracilaria verrucosa*) (Bell and Mulipola 1995). Two seaweeds were introduced to Samoa for aquaculture purposes from Fiji: *Kappaphycus alvarezii* and *K. denticulatum* (Bell and Ropeti, 1995). Their establishment was not successful.

Seagrasses

The distribution of seagrasses throughout the Pacific region is patchy, with Samoa having two seagrass species reported: *Halophila ovalis* and *Syringodium isoetifolium* (Hartog 1970). McMillan and Bridges (1982) were of the opinion that *H. ovalis* reported by Hartog (1970) from Samoa is probably endemic or belongs to *Halophila minor*. Furthermore, a recent collection was made of a species of *Halophila* from the Palolo Deep Marine Reserve at 25 m depth, which morphologically resembled *H. minor* (Skelton 2000).

Seagrass beds are limited in Samoa, with perhaps the best community found around Manono Island and in the northern part of Upolu Island, where the substratum is generally of soft muddy sand. Although Zann and Mulipola (1995) reported an increase in seagrass and algal community as a result of high nutrients, prolonged exposure to such environment can result in the eventual death of seagrass and algae (Coles and Long 1999). More research is needed to document the distribution and the productivity of seagrass beds in coral reef ecosystems from Samoa.

Mangroves

Samoan mangroves are at the eastern limit for the Indo-Pacific distribution of this group (Vodonaivalu 1983; Woodroffe 1987; Boon 1997). Most of the mangrove forests occur on the coastal areas of Upolu Island with only a few in Savaii Island (probably because of recent volcanism in destroying major habitats). The greatest mangrove forests occurs on the north-west coasts of Apia at Vaiusu Bay (the largest of the eastern Polynesia; Anon 1991) and the south coast at Safata village (Boon 1997). The uses of mangroves in Samoa include: fishing grounds, charcoals, mending canoes, poles for fish traps, tool handles, dye, tannin, nets and artwork, bird hunting ground, medicine, childrens' playground, coastal protection and others.

According to Vodonaivalu (1983), Samoan mangle (which includes mangroves, shrubs and epiphytes - 36 species in total) is highly specialised. Three mangrove communities are recognised: mangrove forest consisting mostly of *Bruguiera gymnorrhiza*, mangrove scrub (rarely more than 5 m high) consisting of a mixture of both *Rhizophora mangle* (= *Rhizophora samoensis*) and *Bruguiera*, and *Xylocarpus* mangrove (Pearsall and Whistler 1991; Schuster 1993). Schuster (1993) and Boon (1997) stated that the mangrove ecosystems of Samoa are suffering from inappropriate land development especially around Apia. For example, in 1978 about 0.65 ha of mangroves were cleared for aquaculture development, which subsequently closed in 1983 (Schuster 1993). In addition, alteration of river courses, in-filled lagoons, dumping of rubbish and industrial wastes, and the discharge of raw sewage into mangrove ecosystems exacerbate the problem. The protection of mangrove ecosystems is controlled under the Lands and Environment Act 1989. Samoa is yet to establish a National Mangrove Management Plan (Schuster 1993).

Littoral plants

Whistler (1992) has documented the littoral or coastal (littoral) plants of Samoa. A total of 76 species are recorded, which includes trees, shrubs, herbs, vines and grasses. The status and role of these littoral plants is not fully understood and research into this area is recommended.

Endemic, extinct and endangered species

Endemic marine species in Samoa are relatively rare or not well documented. Some marine animals and plants like the 40 fish species reported only from Samoa (Wass 1984) and a red alga, *Ceramium rintelsianum* found from Palolo Deep Reserve (South and Skelton 2000) may well be present in neighbouring islands. Research into many of the neighbouring islands fauna and flora is lacking and should be encouraged. It can be safely said that endangered or threatened marine organisms include most of the animals and few plants targeted by the people from the inshore and the coral reefs. The lack of knowledge of the biodiversity of the coral reef and related ecosystems will no doubt hindered conservation efforts and thus more and more species will become extinct.

Zann and Mulipola (1995) reported *Tridacna squamosa* as functionally extinct from Samoa. Extinct species may possibly include the giant clam *Hippopus hippopus* with only shell remains found, however, very little information is known of this species from Samoa. It has been re-introduced and the Fisheries Division currently hold a few mature specimens at its lagoon nursery.

The grey mullet, *Mugil cephalus* and milkfish, *Chanos chanos*, seem to have seriously declined. The populations of the giant triton *Charonia tritonis*, a predator of the crown-of-thorns starfish, have reduced dramatically due to over-fishing for the ornamental trade. The mangrove crab *Scylla serrata*, is facing localised threats from being over-fished, e.g. within the Safata Bay. The boom in the bêche-de-mer industry in the early 1990's caused a decline in the numbers of target species, and thus the industry collapsed a few years after.

Introduced species

Introduction of aquatic species in Samoa began in the early 1900s, when mollies (*Poecilia mexicana*) were introduced to control mosquitoes. Numerous projects and undertakings involving the introduction of marine organisms have since taken place and are outlined in Tables 9 and 10 (Bell and Ropeti 1995; Bell and Mulipola 1998). In 1999, 300 green snails (*Turbo mamoratus*) were introduced from Tonga for reef stocking purposes, while over 10 000 giant clams were introduced from American Samoa and Fiji in the 1998/1999 period. The impact of these introductions on the marine environment is not known.

Threats to coral reef biodiversity

Fishing

The decline in marine resources is attributed to overexploitation and the use of destructive and overly efficient fishing practices and environmental degradation (King *et al.*, 1995). Furthermore, population increase will play a major part to the deterioration of the marine environment.

Subsistence, artisanal and commercial fishing

The reliance of the people of Samoa on seafood goes back to the settlement of the island some 2500 years ago. The varieties of marine organisms that are used are many, and were easily obtained from shallow lagoons and relatively accessible reefs. Exploitation of these areas has traditionally been for subsistence purposes. Varying degrees of commercialisation are now a major factor in the exploitation of these marine resources.

The state of the inshore fishery is documented and analysed by Bell and Mulipola (1995), Horsman and Mulipola (1995) and the Fisheries Division Annual Reports (Fisheries Division 1999; see Table 2-6). According to Horsman and Mulipola (1995) fish landings have declined dramatically from 250 mt in 1986 to just over 50 mt in 1994. The two cyclones *Ofa* and *Val* devastated and affected much of the inshore fishery in 1990-1992 as well as the offshore fishing fleet. Funding aid in the development of the fishing fleet saw the increase in offshore and bottom fish landings. Bottom-fish were over-fished by an estimated 30 per cent of the maximum sustainable yield (MSY) in 1992, which eventually lead to the collapse of the fishery.

Tables 2-6 outline the estimated total volumes and values of reef and lagoon finfishes as well as other marine products sold in the domestic market in the 1998/99 period. Finfishes from the reef and the lagoon are the major fishery that contributes approximately 65 % to the domestic market as shown during the 1998/99 statistics of total fishery landing volumes. The dominant fish species is the parrotfish (*fuga*) 24.8 %, unicornfish (*`ume*) 17.6 %, emperorfish (*mata`eleele*) 11. 8%, surgeonfish (*`alogo, pone*) 11.4 % and mullet (*`anae*) 10.9 % (Table 2).

The two marine crustaceans that are commonly sold domestically are *Panulirus* lobsters and the mangrove crab, *Scylla* sp., which comprise 58 % and 35 % respectively of the total estimated landings (Table 3). It is estimated that 14 mt of crustaceans were sold at the Apia Fish Market in 1998/99. Giant clams was the dominant bivalve harvested and sold, while octopus was the dominant species sold domestically for the molluscs group during 1998/1999 period (Tables 4 and 5).

Fin-fish major groups	Tot Wt (kg)	Tot Value (SAT)	1998/99 Wt (%)	1997/98 Wt (%)
Bigeye scad	545.63	3,137.37	1.1	1.7
Emperors	6,012.05	34,569.29	11.8	13.1
Goatfish	1,461.26	8,402.25	2.9	2.4
Groupers	1,904.70	10,952.03	3.8	2.6
Milkfish	92.31	530.78	0.2	0.3
Mojarras	86.68	498.41	0.2	0.3
Moray eel	2,048.31	11,777.78	4.0	5.1
Mullets	5,510.36	31,684.57	10.9	20.7
Other fish	570.14	3,278.31	1.1	1.4
Parrotfish	12,576.11	72,312.63	24.8	14.8
Rabbitfish	490.53	2,820.55	1.0	1.2
Snappers	722.97	4,157.08	1.4	1.5
Soldierfish	1653.8	9,509.35	3.3	1.5
Surgeonfish	5,763.04	33,137.48	11.4	9.9
Topsail drummer	374.62	2,154.07	0.7	0.7
Trevally	1,424.00	8,188.00	2.8	4.2
Unicornis	8,917.25	51,274.19	17.6	18.1
Wrasses	598.03	3,438.67	1.2	0.7
Cooked wrapped fish		14,121.11		
Coconut cooked moray eel		57,029.03		
Total	50,751.79	362,972.95		

Table 2
Total volume of main finfishes landed and sold at the Apia Fish Market and other outlets (Fugalei, Retailers, Roadsides, etc.) in 1998/1999 (source: Fisheries Division 1999).

Species	Total Wt (kg)	Total Value (SAT)	1998/99 Wt (%)	1997/98 Wt (%)
Freshwater crayfish (Ulavai)	541.09	4,328.72	3.9	
Lobsters (Ulasami)	8,124.43	64,995.44	58.0	33.5
Mud crabs (Pa`alimago)	4,912.51	39,300.08	35.1	57.2
Reef crabs (Kuku)	219.34	1,754.72	1.6	7.1
Slipper lobsters (Papata)	206.43	1,651.44	1.5	1.8
Other crabs (Isi pa`a)	2.10	16.8		0.4

Table 3
Total volume of main crustaceans landed and sold at the Apia Fish Market and other outlets (Fugalei, Retailers, Roadsides, etc.) in 1998/1999 (source: Fisheries Division 1999).

Species	Total Wt (kg)	Total Value (SAT)	1998/99 Wt (%)
Giant clams (faisua)	5,910.2	70,922.64	51.0
Cockle (tugane)	5,677.7	7,097.12	48.0
Other bivalves	0.92	11.04	1.0
Bottled items (fole/fatuau/tio)		743.06	
Total	11,588.82	78,773.86	

Table 4
Total volume of main bivalves types landed and sold at the Apia Fish Market and Other Outlets (Fugalei, Retailers, Roadside, etc.) in 1998/99 (source: Fisheries Division 1999).

Other Mollusc species	Tot Wt (kg)	Tot Value (SAT)	1998/99 Wt (%)	1997/98 Wt (%)
Octopus (fe`e)	7,802.19	35,109.86	97.8	99
Turbo shell (alili)	146.03	657.14	1.8	
Others	32.38	145.71	0.4	1
Cooked turbo		3,356.13		
Cooked octopus		52,770.35		
Cooked sea-hare		8,140.53		
Total	7,980.6	100,179.72		

Table 5
Total volume of other mollusc by species landed at the Apia Fish Market and Other Outlets (Fugalei, Retailers, Roadside, etc.) in 1998/99 (source: Fisheries Division 1999).

The estimate for the subsistence (village-based) fishery landings for 1998/99 period was 4,400 mt (Fisheries Division 1998/1999). In 1990, the subsistence fishery landings were between 3,200 mt to 4,600 mt (King 1990; Zann and Mulipola 1995). Mulipola (1997) estimated the subsistence fishery landings to be around 4,200 mt for 1996, while King and Fa'asili (1997) suggested a value of 4,600 mt for the subsistence fishery landings for the whole of Samoa in 1997.

Fishery Products	Tot Value	Avg. price (WST)
Jellyfish (Ofu alualu)	5,941.8	4.52
Gonads (Fagu ape)	3,527.0	11.70
Sea cucumbers (Fagu fugafuga)	14,862.6	9.80
Digestive of curryfish (Fagu sea)	90,667.8	15.00
Lollyfish (Fagu loli)	20.3	2.00
Scylomia/Anemone (Ofu lumane/matalelei)	33,715.1	6.00
Sea urchins (Tuitui, Sava'e)	555.1	3.60
Caulerpa (Ofu limu)	70,051.96	5.60
Total	219,341.66	6.47

Table 6
Total volumes of other invertebrates sold in processed and cooked forms at Fugalei Market and Roadsides (Vaiusu) in 1998/99 (source: Fisheries Division 1999).

Aquarium fish trade

The export of aquarium fish from Samoa began in 1986, however, the operation was only active for one year. The development was started again at the end of 1992 by one operator. The 1993/94 period export of aquarium fish amounted to 65 527 fishes comprising mainly of *Pomacentrus* and *Chrysipttera* sp., *Labroides* spp., *Amphiprion* spp., and *Paracirrhitus* spp. The same company continued to operate in the 1994/95 period, exporting 30 405 fish specimens consisting mainly of assorted damsels, wrasses and angelfish. During the 1996/97 period, two licenses were issued for the export of aquarium fish. One of these operators was also licensed to export a limited amount of corals. Table 7 summarises aquarium organisms exported for the 1996/97 period.

One exporter was in operation in the 1997/98 period, exporting «bio-rock». The exporter was licensed to export 200 pieces of bio-rock, each measuring not more than 30 cm x 30 cm x 30 cm, per week. A total of about 3,890 pieces were exported during the year.

The 1998/99 period saw two exporters in operation with licences granted to harvest and export a maximum of 200 pieces of bio-rock each per week. A total of 7526 pieces were exported. At the beginning of the year 2000 two exporters have been granted licences to export aquarium products. One operator is permitted to export only bio-rocks while the other can export fishes and other organisms including live corals and bio-rocks.

Pollution

The threats to the marine environment by various forms of human induced pollution are unfortunately becoming too big a problem to comprehend. Since 1954 or possibly earlier, pollution and sediment deposition have resulted in a steady replacement of corals with seagrasses and algae. This has resulted in a collapse of some reef species and a tenuous future for others (Zann 1991). The

Organism category	1996 Quantity (# pieces)	Value (USD)	1996/97 Quantity (# pieces)	Tot. Value (SAT)
Tropical fish	183	164.12	183	126.48
Algae	5	1.25	5	3.00
Anemones	730	798.70	880	1383.60
Bio-rocks	495	437.00	2729	8931.24
Crab	22	1.10	22	2.64
Live corals	1677	4 472.25		
Sea cucumber	128	38.49	128	248.38
Sea urchin	10	4.90	10	11.76
Shellfish	272	1,071.60	1504	4255.20
Snail	1025	51.25		
Soft coral	40	124.90	40	159.60
Starfish	40	28.05	90	96.84
Sand			5	2.40
Unidentified	397	455.00	397	1090.80

Table 7
List of species quantity and value exported during 1996 and 199/97 for the Aquarium Market (source: Mulipola unpubl.).

high frequency and unregulated use of pesticides, herbicides and other chemical poisons will undoubtedly be a major factor in the destruction of the coastal ecosystem.

At present the public solid waste collection only covers the Apia urban area and excludes most of the rural areas. Consequently, many households dispose off their wastes either by burning them, or discarding them on the river banks, streams, mangroves or beaches. The increase in demand for imported products (which are mostly packaged in non-biodegradable material), and subsequent burning or dumping them in the current manner will contribute to the demise of the marine environment. Direct pollution as a result of sewerage out-falls, oil spills , and industrial wastes will further exacerbate the problem. This can be highlighted by a recent solvent spill from a leaked fuel tanker docked at the Apia Wharf, in August 1999. Efforts to contain the spill were limited to basic material (cloths), and the extent of the impact to the marine environment is unknown due to lack of equipment and expertise.

Sedimentation and siltation

Poor land practices in some places in Samoa have caused high siltation and eutrophication in lagoonal areas from run-offs. Zann and Mulipola (1995) commented that increased sediment and nutrients were probably responsible for the widespread die-back between 1970 and 1985 of lagoon corals on the northern reefs. Land based activities are the main causes of this problem, which include poor agricultural and forestry practices, land clearing, housing, road construction activities and lagoon dredging.

Development

Coastal and land developments are increasing almost daily, and as such the marine environment becomes more stressed. The building of coastal roads or housing developments can often result in the

destruction of coastal areas, wetlands and other natural areas. Furthermore, sand, coral and gravel mining is often carried out locally or on a nation-wide scale. The alteration of coastal areas is often part of foreshore development that is associated with some tourism developments. This will continue to be a threat to marine biodiversity unless immediate actions are taken. Environmental impact assessments may help to reduce such threats as well as giving control to village chiefs for monitoring.

Tourism

Tourism has been recognised as one of Samoa's principal growth sectors. In 1997 the gross foreign exchange earnings from tourism was SAT$101.8 million, which is four times larger than export earnings. This significant contribution to the national economy as well as the local economy through employment and income has brought strong support from the Government. Key steps and measures are taken to enhance and entice investors and the tourism industry.

The potential risk to the marine ecosystem from tourism is a result of poor planning, especially in foreshore land development (reclamation). Waste and sewerage disposal and management could become a major problem as the size of tourist facilities expands without any effective regulatory framework. Furthermore, an increase in careless tourists trotting over corals and taking marine organisms can exacerbate the problem. Although environmental impact assessments are required for every tourism project, the absence of relevant effective regulations and procedures have often resulted in this requirement not being strictly administered (Va'ai 1998). There is a need to develop a code of conduct for tourists, similar to that developed in Fiji (Carswell pers comm.).

Climate change

The fist Intergovernmental Meeting on Climate Change and Sea Level Rise for the South Pacific Region was held in Majuro, Marshall Islands in 1989. Subsequently, SPREP was mandated to undertake preparatory missions to prepare reports on the impacts of climate change. Chase and Veitayaki (1992) prepared this report for Samoa, and their findings are incorporated below. Furthermore, Samoa is party to the United Nations Framework Convention on Climate Change (UNFCCC). Like all signatory parties to the UNFCCC, Samoa is obligated to provide National Communications, which, include amongst other things, a national greenhouse inventory, plans and measures for implementing the UNFCCC. In 1999, two Samoan Government officials attended the SPREP sponsored Vulnerability and Adaptation Assessment course held at the University of the South Pacific, in preparation for National Climate Change Planning (Nunn and Tuqiri 1999).

Potential impact of climate change in Samoa

Chase and Veitayaki (1992) outlined three major potential impacts of climate change: sea level rise; increasing temperature, rainfall and evapo-transpiration; and increase in frequency and severity of cyclones. Some additional impacts of climate change are included below.

Sea level rise

Sea level rise is likely to be associated with many climate-related factors such as the rise in sea surface temperatures (SSTs), the increase in frequency and severity of cyclones and high levels of carbon dioxide in the atmosphere and in the marine environment. The response of coral reefs of Samoa to sea level rise is therefore, difficult to ascertain. Chase and Veitayaki (1992) pointed out that sea

level rise might be a 'powerful force' in improving the conditions of the lagoonal environment. Given various climatic factors that are associated with sea level rise and their consequences, which may include the weakening and degradation of reefs, the above scenario is unlikely.

The lowlands and intertidal areas along the coast will be affected by sea level rise. Ports, landings, harbours, breakwalls and buildings on reclaimed lands will need to be relocated or raised. Apia, which is largely built on encroached coastal land and marshes, could be inundated by a significant rise in sea level. The Faleolo international airport, which is located at about 1 m above sea level, could also be at risk. Some village areas may become uninhabitable and need to be relocated.

Increase in temperatures, rainfall and evapo-transpiration

The effect of increased air temperature is perceived to be minimal according to Chase and Veitayaki (1992). This is evident by current moves to adapt to hot situations. The increase in air-conditioned buildings, and adoption of new planting techniques in the plantation are some of the measures that Samoa is resorting to. The increase in SSTs will be a major factor that will affect the livelihoods of many Samoans. The inshore and offshore fishery is expected to be severely impacted, and coral bleaching will become prevalent.

Samoa has a relatively high annual rainfall and this is predicted to increase if global temperatures rise. The poor water retention of the Samoan soil due to its volcanic history will likely result in increased water run-off resulting in soil erosion and high sedimentation in freshwater and in lagoonal waters. Flooding will be a major problem for those living in low lying areas as well as those living by rivers.

Between rainfall periods, dry periods will become drier facilitating greater evapo-transpiration rates. Water catchment areas will rapidly dry up and hydroelectric stations will become ineffective. The supply of freshwater to the public will be compromised.

Increase in cyclone frequency and severity

The continuing stresses imposed by various climatic factors and anthropogenic activities on coral reefs will lead to their becoming non-resilient to strong wave action. Some parts of Upolu Island along Luatuanu`u and Solosolo are constantly affected by strong wave action due to the lack of protection from coral reefs. The back-to-back severe cyclones *Ofa* and *Val* in 1990-92 caused widespread damage to the marine environment. Live corals were uprooted from the front reef slope and dumped along the leeward side of the reef crest mainly to the northern part of Savai`i and Upolu islands, creating emerged "coral islets". The frequency and severity of cyclones will no doubt accelerate destruction in low-lying areas affected by sea level rise. Strong winds may assist in water circulation however, they are most likely to create havoc for coastal inhabitants.

Coral bleaching

The 1997-1998 period revealed a high incidence of coral bleaching due to elevated sea surface temperatures (SSTs) in the Indian Ocean and some parts of the Pacific Ocean (Wilkinson 1998). The central part of the South Pacific escaped the brunt of the bleaching although some localised bleaching was seen in inshore areas as a result of prolonged exposure to extremely low tides. This was seen at Palolo Deep National Marine Reserve, which suffered bleaching on the eastern side of the main Deep from early 1998. The front reef slope was surveyed in July and September with no bleaching event seen (Skelton 1998). It is interesting to note a recent report from Australia by Jompa and McCook (1999) highlighting the importance of *Sargassum* canopy in lessening the impact of coral bleaching

on inshore reefs. Samoa has in the past experienced coral bleaching due to high SSTs, although this has not been documented.

The recent coral bleaching event in the southcentral Pacific had insignificant effect to Samoan coral reefs, as compared to Fiji. There are reports of coral bleaching around the Apia vicinity and in some rural areas, both the intertidal and subtidal zones (Trevor and Toloa pers comms).

Mechanisms to address climate change impacts

The Division of Environment and Conservation plays an active role in raising public awareness in climate change issues. Newspaper articles, weekly radio programmes and frequent visits to schools are part of this campaign. Some of the mechanisms that have been proposed include the following:

formulation of regulations which stipulate the need for environmental impact assessments (EIAs) for all Government projects;
- National Disaster Plan;

- preparing material for Cabinet discussion;

- documenting and evaluation of mangrove swamps and other marine nurseries;

- installing of equipment to monitor sea level rise in collaboration with the Flinders University, Australia.

Further possible actions may include:

- human resource development within the Government departments;

- closer collaboration between Government departments, the private sector, non governmental organisations (NGOs) and regional and international organisations;

- voicing concerns to the international community through existing mechanisms;

- leadership seminars;

- workshops at the village level;

- enhance and strengthen monitoring efforts on land, in the atmosphere and in the marine environment.

Conservation and monitoring initiatives

The need to develop long term monitoring sites is important for the future management of marine resources. The participation of villagers in monitoring activities is paramount and should be encouraged. Furthermore, the need to develop more conservation areas must be encouraged with the support of all concerned persons.

To date, only one national marine reserve is recognised, the Palolo Deep National Marine Reserve. There are plans to extend the Reserve to become a coastal marine park (Galuvao pers. comm.). A number of proposed national parks and reserves were highlighted by Wells and Jenkins (1988) and are listed below:
- Aleipata and Nu`utele Islands. This is now a marine park and is part of the IUCN project;
- Cape Puava Forest in northern Savai`i, covers approximately 800 acres and has fringing reefs off its narrow coastline;
- Satuimalufilufi/Fuailolo`o reef on Upolu (about 3.2 km straight-line length and in good condition) has been proposed as a coral sanctuary; it is associated with the proposed Apolimafou reserve (120 acres)

which is primarily a bush and reed swamp). The area is close to a hotel development and the airport;
- Fusi/Tafitoala fringing reef on Upolu (3.2 km) is a proposed coral sanctuary associated with a proposed 120 acre reserve of mangrove forests;
- Aganoa (200 acres) on Upolu is a coastal beach with associated fringing reef;
- Salamumu (240 acres) on Upolu is also a coastal beach with fringing reef and a small rocky islet (Nu`unavasa Island);
- Nu`usafe`e Island proposed reserve (230 acres) off Upolu is believed to be of coral origin. The 3.2 km fringing reef has been proposed as a coral sanctuary;
- Leanamoea (340 acres) on Savai`i is a coastal area which includes a freshwater spring; the associated 3.2 km fringing reef, reportedly in a moderately good condition, has been proposed as a coral sanctuary.

The status of these proposed sanctuaries or reserves is not known at this stage. Two important initiatives are currently underway for the establishment of marine conservation areas in Samoa. The AusAID-assisted Village Extension Programme under the Fisheries Division and the IUCN project under the Division of Environment and Conservation are largely built on a similar platform and are outlined below.

Marine protected areas

Palolo deep national marine reserve

The Palolo Deep Reserve was established and formalised in 1974 and proclaimed on the 5th December 1979. The Reserve encompasses an area of 137.5 ha (1.38 km^2) comprising the Deep, a small land area, a fringing reef, shallow inshore flats; it extends seaward to 500 metres. The Reserve is administered by the Division of Environment and Conservation, and is managed by Siaki Laban To`omalatai and his family who reside on site.

This unique Marine Reserve is likely to be affected by pollution and siltation, and Hunter (1977) reported a decline in visibility between 1970 and 1977, because of sedimentation from neighbouring land development. The proximity of Palolo Deep to the main Apia Harbour increases its vulnerability. The Reserve's accessibility coupled with the colourful thriving corals, array of marine life and calm and safe water makes it one of the top attractions to visitors (Dahl 1978).

The Palolo Deep Reserve was surveyed by Lovell and Toloa (1994) as part of a management plan development. The status of the management plan is unclear and a new survey was carried out in 1999 (Toloa pers. comm.). The benthic marine algae of Palolo Deep has been thoroughly documented by Skelton (2000). The Palolo Deep received severe bleaching of up to 70 per cent of live corals in the inshore reef flats during the severe el Nino southern oscillation (ENSO) weather in February 1998 (Wilkinson 1998). A field report by Skelton (1998) found a high coral recovery in the inshore flats, some five to six months after bleaching, while the front reef slope corals were not affected.

AusAID-assisted fisheries division's village extension programme

The Village Extension Programme is a community-focussed fisheries project, which encourages villages to define key problems, discuss causes, propose solutions and take appropriate actions. Information at each of these stages is provided by various village groups, including women's groups and untitled men's groups, and is recorded by trained facilitators. The extension process is lengthy, as customary protocols need to be followed in each village; thus it may take up to several months for the whole process. At the completion, a Village Fisheries Management Plan (VFMP) is produced. This (VFMP) is an agreement between the village and the government and it sets out the resource man-

agement conservation undertakings of the community, and the servicing and technical support required from the Fisheries Division.

The Programme initially had 62 villages participating, however, three withdrew due to internal disputes within the village and the remaining villages have established 54 fish reserves, 35 in Upolu, 15 in Savaii and 4 in Manono (Table 8). The village undertakings ranged from enforcing government legislation to the protection of critical habitats such as mangrove forests. Some villages have chosen to establish fish reserves, which bans all fishing activities from certain parts of their traditional fishing areas. Some villages have allowed their fish reserves to be fished only on special occasions to provide food for example a village meeting (*fono*), church activity, or the *Palolo* (Palolo worm spawning) season.

Village	Date Established or Surveyed	Village	Date Established or Surveyed
Matafa`a	?/97	Satapuala	?/97
Safa`ato`a	14/01/97 14/04/99	Fasito`outa	?/97
Gagaifo	30/07/98	Tauo`o	21/06/96
Sa`anapu	?/97	Moamoa	21/06/96
Poutasi	16/07/97	Fasito`otai	22/06/98
Mulivai	?/97	Vailuutai	28/07/98
Fusi, Safata	30/01/97 09/07/97	Faleula	12/05/99
Fausaga, Safata	?/97	Fagali`i	30/11/98
Tafitoala	16/01/97 07/97	Faleapuna	23/03/98
Saleilua	01/09/99	Saoluafata	22/06/98 02/03/99
Salua tai	?/97	Solosolo	07/05/98
Lepuia`i	15/11/96	Sato`alepai	13/12/96
Apai	27/11/96	Sale`aula	13/12/96
Faleu Tai	15/11/96	Puapua	?/97
Faleu Uta	15/04/98	Fagamalo	?/97
Salua Uta	27/11/96 14/07/97 02/03/99	Fagasa	?/97
Samatau	14/09/98	Vaito`omuli	?/97
Lalovi, Mulifanua	17/06/99	Papa	06/08/99
Fuailolo`o, Mulifanua	17/06/99	Auala	18/12/96
Saleaumua	?/97	Asaga	?/97
Mutiatele	04/02/97	Falealupo	27/02/97
Lotopue	02/04/97	Sapapali`i	06/08/98
Vailoa	14/05/98	Lelepa	15/04/99
Malaela	02/05/97	Manase	21/07/99
Satitoa	04/02/97	Fagae`e	02/11/99
Ulutogia	?/97	Vaovai	01/12/99
Utufaalalafa	24/08/98	Eva	02/12/98

Note: (*) indicates no report or record of survey found, but the year is given in the management plan. Villages with more than 1 date, are re-surveys.

Table 8
List of villages with Fish Reserves established under the Fisheries Division Extension Programme (source: Trevor unpub.).

The Fisheries Division reciprocates by providing technical advice on how to care for the marine environment and the development of alternative sources of seafood. The Research Unit within the Fisheries Division undertakes surveys of Fish Reserves in participating villages. A general survey of the area normally takes into account the physical characteristics of the propose reserve. The technique used are subjective and the need to standardised a survey and monitoring method was realised and thus the Village Level Coral Reef Monitoring Project was initiated (South *et al.*, 1998: see section 4.2).

IUCN conservation areas

The International Union for the Conservation of Nature is currently working with the Division of Environment and Conservation of Samoa in identifying and establishing conservation areas in Samoa, under a 5-year project called, *Samoa-Marine Biodiversity Protection and Management.* The project goal is to provide for the protection and sustainable use of threatened coastal marine biodiversity in Samoa. Its objective is to empower local communities at the Aleipata and Safata districts to effectively protect and manage coastal marine biological diversity and help them achieve sustainable use of marine resources. Phase 1 of the project deals with Management Planning with expected outputs to include:
- preparation of Marine Protected Area Management Plan;
- designing alternative income generating (AIG) activities;
- strengthening capacity and building environmental awareness.

Phase 2 deals with management implementation with outputs including:
- implementing MPA Management Plan;
- implementing AIG activities;
- strengthening capacity and building environmental awareness.

Monitoring programmes

Monitoring of reef resources targeted by artisanal and commercial operators is the responsibility of the Fisheries Division. All marine products sold at the Fish-Market, the Fugalei Market and the Salelologa Market are recorded by the Fisheries Division. These market surveys are carried out weekly and the results are summarised in the Fisheries Division's annual reports.

Fisheries division monitoring programmes

As part of the Village Extension Programme villages are encouraged to establish fish reserve. The fish reserve site and size is determined by the villagers with assistance from the Research Unit of the Fisheries Division. The Fisheries staffs are now trained in the Australian Institute of Marine Science (AIMS) monitoring methodologies and carry out baseline surveys to determine the suitability of a site. The fish reserves are normally resurveyed on a yearly basis.

The data collected from the baseline surveys are entered into a Microsoft Access™ database. A report is written usually by the survey team leader and this information is then relayed back to the village through the Extension Unit of the Fisheries Division, and a copy is also available for public perusal at the Fisheries Library.

Village level coral reef monitoring project

In 1998, a pilot Village Level Coral Reef Monitoring Project was initiated in collaboration between the Fisheries Division, the Division of Environment and Conservation and the International Ocean Institute – Pacific Islands. The project provided monitoring equipment and assisted in training

Fisheries and Environment staff in scientific monitoring methodologies. In turn, the staff trained 46 villagers from six villages from the islands of Upolu, Savai'i and Manono. The project aims to encourage villagers to monitor their own resources with minimal assistance from the Government, and to establish a sustainable monitoring programme that is transferable to other sites. The results are yet to be analysed, however, it is important to note that most of the sites monitored are in lagoonal areas where coral growth is usually limited.

Project	Species	Year started	Responsible agencies	Purpose	Organism source	Status
Turtle hatchery	Hawksbill *(Eretmochelys i mbricata)*	1970/1971	Fisheries Division	Augment local turtle populations	Local (turtle eggs dug up from nests)	Closed in 1983
Seaweed culture	*Kappaphycus alvarezii* and *K. denticulatum*	1975	??	Culture experiment? Details not known.	Introduced but details not known	
Marine shrimp	Tiger prawn, *Penaeus monodon*	1979	Fisheries Division/FAO	Experiment on growth in baitfish ponds for commercial	CNEXO (now AQUACOP), Tahiti	Never developed
Mussel (marine)	Philippine green mussel, *Perna viridis*	1981	Fisheries Division/Canadian Aid/UNDP	Culture/feasibility experiment Tahiti	CNEXO (now AQUACOP), spats source identified	Discontinued by 1990 but plans to re-visit if
Giant clams	*Tridacna* spp. & *Hippopus* spp.	1987	Fisheries Division/SPADP	Restocking/farming Solomon Islands, Fiji, American Samoa	Palau, Tokelau, Australia,	On-going
Oyster	Pacific oyster, *Crassostrea gigas*	1990	Fisheries Division/SPADP	Culture trials for commercial	Kuiper Mariculture, California, USA	No follow-up after harvest in 1991 but plans to re-investigate.
Top shell	Trochus *Trochus niloticus*	1990	Fisheries Division/FAO	Seeding for resource enhancement	Fiji	plans to continue
Seaweed	Euchema	1991	Fisheries Division/SPADP	Culture trials	Fiji	Discontinued in 1992
Giant clam	*Tridacna derasa*	1995	Fisheries /SPADP/AusAID/Villages	Reserve stocking & Aquarium	American Samoa	on-going
Mullet/rab bit-fish		1997	Fisheries/AusAID	Culture trials	Local	just started
Green snail	*Turbo marmorata*	1999	Fisheries/SPADP	Reef stocking	Tonga Fisheries	just started

Table 9
Chronology of mariculture and resource enhancement activities/projects in Samoa (source: Bell & Ropeti, 1995; Bell & Mulipola, 1998).

It is pertinent to report here the results made during the training of the Fisheries Division and the Division of Environment and Conservation staff in July 1998 (see South *et al.*, 1998 for more detail). The training was carried out at the main reef surrounding the capital, Apia (Mulinu`u reef), employing manta towing technique and under water visual census (UVC). Mulinu`u reef was one of the most badly affected areas during cyclones *Ofa* and *Val*, but now has recovered rapidly with fast growing *Acropora* species. Upturned table corals were seen in many parts of the reef front, with turf algae rapidly colonising them. The training results revealed the percentage of live coral cover as patchy, mostly in the 11-30 per cent cover. Dead coral cover was low at 1-10 per cent. The presence of coral scars from crown-of-thorns starfish was noted but the scars were relatively small. The UVC was carried out along a 50 m transect, counted an average of 18 butterfly fish (Chaetodontidae), 45 surgeonfish (Acanthuridae) and 20 parrotfish (Scaridae). The main fish sizes seen were less than 20 cm with only a few between 21-40 cm size. The presence of goatfishes (Mullidae) was poor with a total of 5 fishes seen by one of the participants. This is possibly attributed to the habitat of goatfishes, preferring relatively calm lagoons with sandy substrata.

IOI-Pacific islands global coral reef monitoring network node

Samoa is part of the newly established South-central Pacific Node under the Global Coral Reef Monitoring Network (GCRMN). It is envisaged that the National Co-ordinator will be identified and formalised soon and that coral reef monitoring activities to start. It is anticipated that the National Co-ordinator will be based at the Fisheries Division, however, close collaboration will be formed with local NGOs and other government departments. The priority for Samoa is to form an enthusiastic team of coral reef surveyors, identify sites and to begin monitoring. Monitoring equipment and qualified staff already exist within the Fisheries Division and the Division of Environment and Conservation, therefore costs will be minimised. The data will feed directly into the Node Centre, co-ordinated by the International Ocean Institute – Pacific Islands at the Marine Studies Programme of the University of the South Pacific, and will also be kept at the Fisheries Division.

Management capacity

The managing of the marine resources is improving mainly due to the harmonising of State laws and customary system. The Government have recognised the importance of involving the village chiefs and the public in management and conservation efforts. In turn, the village chiefs are encouraging their people to heed national laws and regulations for the betterment of the nation. The proactive approach taken by the Fisheries Division, the Division of Environment and Conservation as well as some NGO's such as the Si`osi`omaga Society and the Fa`asao Savai`i can only enhance the current efforts in management of the marine ecosystem.

The increased in qualified personnel in Government departments and easy communication with regional and international organisations mean there is no time better to enhance and promote marine management and conservation efforts like now. There is however, limited expertise in some areas such as marine taxonomists. This problem is perhaps not unique to Samoa as often overseas experts are brought in from America, Australia, New Zealand, Japan or Europe and often at great expense, to assist countries in the region. Good leadership in all aspects of conservation, monitoring and management is a must and support must be forthcoming from politicians, the chiefs and everyone in Samoa. The promotion of research must be encouraged as it is often difficult to manage resources without understanding the overall process.

The use of legislation to regulate fishing and promote research, development, conservation and monitoring efforts must recognised the *fa`a Samoa* (Samoan way). Importantly is the need for legislation to be formulated with the involvement of the people from the beginning and they need to be practical and enforceable.

Legislation

There is a need to co-ordinate and combine many sections relevant to marine resource conservation and management that are scattered in different legislation. Such a guide will assist the public and Government staff in understanding the law better, and by the same token manage the resources effectively. The following legislation pertains to the management and conservation of marine resources.

- Samoan Constitution 1960 (stipulates that all land lying below the line of high-water mark shall be public land);

- Land Ordinance 1959 (amended in Fisheries Act 1988, part VIII: 27 [2a-b]; controls coastal aquaculture activities);

- Agriculture, Forests and Fisheries Ordinance 1956;

- The National Parks and Reserves Act 1974 (provides for the establishment of Marine Parks and Reserves);

- Fisheries Act 1988 (promotes the conservation, management and development of fisheries and the licensing and control of foreign fishing vessels, as well as the protection and preservation and development of fisheries: the Act is in the process of being repealed);

- The Lands, Surveys and Environment Act 1989 (to ensure and to promote the protection of natural resources and environment);

- Village Fono Bill 1990; (verifies the power and authority of the village *fono* in the management of marine resources and also considers some of the decisions or penalties handed out by village councils that are appropriate to traditional culture);

- The Water Authority Act 1992/1993 (controls the discharge of pollutants into coastal waters);

- Fisheries Regulations 1996 (sets out regulations for certain marine species, fishing practices and fishing aggregating devices);

- Village Bylaws 1998 (promote the protection, conservation, management and sustainable development of the fishery waters and marine environment of each individual village in the AusAID-assisted Fisheries Extension Programme; so far, 51 Fisheries By-laws have been gazetted).

In addition to the above, some new legislation is currently in progress, which includes the Shipping Bill (to incorporate international conventions dealing with marine pollution), Fisheries Bill (will repeal the Fisheries Act 1988) and the Ports Authority Act (to control ship borne pollution).

The national parks and reserves act 1974

The National Parks and Reserves Act 1974, provides empowering legislation for the establishment of Marine Parks and Reserves. Marine Parks are characterised as public lands of 600 hectares or more, or islands, to which the public is guaranteed freedom of entry and access subject to any controls necessary for the preservation of the park's features. Reserves (which may be nature reserves, recreational reserves, historic reserves, or 'others') may include areas of territorial sea, although customary

fishing rights are guaranteed, and the Minister of Agriculture, Forestry, Fisheries and Meteorology may restrict access to and activities within them (Wells and Jenkins 1989).

The fisheries act 1988

A new Bill is currently proposed to repeal the Fisheries Act 1988. The Fisheries Act 1998 incorporated a legislation that governed issues relating to the marine environment. Two previous Acts, namely the Fisheries Protection Act 1972 and Fish Dynamiting Act 1972 were repealed and amended were the Exclusive Economic Zone Act 1977 and the Land Ordinance 1959. The Fisheries Act 1988 has three important parts, relevant to marine conservation and monitoring. Part II, sections 3 and 4 gives the scope of the Act, and prohibits certain fishing activities. Part IV, section 10 authorises scientific research with approval of the Minister. Part VII, section 25 provides for Regulations to be made to, *inter alia*, to regulate and manage any fishery, control harvesting methods, prevent marine pollution and regulate aquaculture activities. The latter part outlined above has resulted in the formulation of the Fisheries Regulation 1996 and various Village By-laws.

The lands, surveys and environment act 1989

The Lands Surveys and Environment Act 1989 encompasses natural resource protection, environmental management and pollution control. The Act is the mandate of the Division of Environment and Conservation, which has two main sections: *Environmental Management, Planning and Education*; and *Biodiversity, National Parks and Reserves.* The Division of Environment and Conservation supervises environmental management activities of other departments, monitors and controls coastal pollution and the effects of climate change on key coastal ecosystems (including coral reefs and mangroves) and oversees natural resource management such as sand mining. It also has principal responsibility for the management of parks and reserves (including the Palolo Deep National Marine Reserve).

Village bylaws

Bylaws are important as they are the first step whereby a village lets the country know of their wish to protect, conserve and increase their marine resources. For this reason the Government and other villages will be aware of the problems and concerns this village has and can assist in the most appropriate ways. The Village Bylaws are formulated by the Attorney Generals office, after close collaboration and consultation between the village and the Fisheries Division. Once it is finalised, the signature of the Director of Agriculture, Forestry, Fisheries and Meteorology is needed, before it is gazetted for public scrutiny. The Bylaws are enforced after 7 days of being first publicised, and the enforcers are the village councils. The shortfall of Village Bylaws is that they only cover people of that village. The village council cannot arrest neighbouring villagers from fishing in their traditional fishing grounds as it would contravene the "public land section" of the Constitution (Skelton and South, 1998).

Customary marine tenure

Traditionally, the Samoans had elaborate customs of ownership and control of fishing rights (Bulow, 1902). The right to fish in reef, lagoon and mangrove areas was owned by adjacent villages, families or chiefs but these customs have largely disappeared as far as reefs and lagoons are concerned, in part

Common name	Species	Stage/Age	Date	Amt sent	Amt received/ alive	Agency responsible	Source	Purpose	Local distribution
Marine shrimp	*Penaeus monodon*	post-larvae	early 1979	~1,000	~1,000	Fisheries/FAO	CNEXO(AQUACOP), Tahiti	Culture trial	Vaitoloa baitfish ponds, Upolu Is.
Mussel, Philippine green mussel	*Perna viridis*	spats	June, 1982	40,000		Fisheries/FAO? or Canadian funds?	CNEXO(AQUACOP), Tahiti	Culture trials	Mulinuu lagoon & Fisheries harbour, Upolu
	Perna viridis	spats (93 days old)	February, 1983	70,000		Fisheries/FAO? or Canadian funds?	CNEXO(AQUACOP), Tahiti	Culture trials	Safata Bay on Upolu ; Asau Bay on Savaii
		spats	December, 1983	90,000		Fisheries	CNEXO(AQUACOP), Tahiti	Culture trials	Safata Bay on Upolu ; Asau Bay on Savaii
		spats	August, 1985	60,000		Fisheries	CNEXO(AQUACOP), Tahiti	Culture trials	Fagaloa Bay, Upolu Island
		spats	October, 1987	100,000	~50,000	Fisheries	CNEXO(AQUACOP), Tahiti	Culture trials	Asau Bay, Savaii Island
		spats	October, 1988	70,000	did not reach Samoa	Fisheries	CNEXO (now AQUACOP), Tahiti	Culture trials	shipment mistakenly off-loaded in Fiji/condemned
		spats	November, 1988	100,000	did not reach Samoa	Fisheries	CNEXO (now AQUACOP), Tahiti	Culture trials	shipment was not off-loaded in Wellington, NZ/lost
Seaweed	*Kappaphycus alvarazii & K denticulatum*		July & Dec., 1975	420 lb K. alvarazii , 80 lb K. denticulatum		?	?	Culture trials?	Vaiusu-Faleula Lagoon?
	K. alvarazii (Euchema)		25 March, 1991	10-20 kg	10-20 kg	Fisheries/SPADP	Fiji	Culture trials	Aleipata & Mulinuu, Upolu Island
	K. alvarazii (Euchema)		6 June, 1992	15 kg	15 kg	Fisheries/SPADP	Fiji	Culture trials	Aleipata, Upolu Island
	K. alvarazii (Euchema)		17 July, 1992	168 kg	168 kg	Fisheries/SPADP	Fiji	Culture trials	Aleipata, Upolu Island
	K. alvarazii (Euchema)		July, 1999	20 kg		Fisheries/SPADP	Fiji	Culture triala	Savaii Island: Asau; Upolu Island: Saluafata, Mulifanua
Trochus	*Trochus niloticus*	mainly juveniles	August, 1990 October, 1990	50 78	50 78	Fisheries/FAO	Fiji	Seeding	Namu'a and Nuutele Islands received 40 each
Oyster (Pacific)	*Crassostrea* gigas (had a few live spats of Manila clam)	single cultchless seeds (2-20 mm)	June, 1990	4,500 diploid 56,000 triploid	4,500 diploid 56,000 triploid	Fisheries/SPADP	Kuiper Mariculture, California, USA	Culture trials	Fusi Safata Bay, Upolu Island
Giant clams	*Tridacna derasa*	yearlings	May, 1988	983	423	Fisheries/SPADP	MMDC, Palau	Culture	Fisheries & Moataa Lagoon on Upolu Islan
	T. squamosa	broodstock	1989	21	21	Fisheries	Tokelau Islands	breeders	Fisheries hatchery
	T. gigas	juveniles	Sept., 1990	700	300	Namu'a Farm	Cairns, Australia	Culture	Namu'a Farm at Aleipata Upolu Is.
	Hippopus hippopus	post-larvae	Nov., 1990	150,000	?	Fisheries	ICLARM, Honiara	Culture	Fisheries hatchery but none survived
	T. gigas	juveniles	27 May, 1991	10,000	500	Namu'a Farm	Orpheus Island hatchery	Culture	Fisheries/Namu'a Farm at Aleipata, Upolu Islanc
	T. gigas	juveniles	July, 1991	10,000	10,000	Fisheries	Orpheus Island hatchery	Culture	Fisheries/Namu'a Farm at Aleipata, Upolu Islanc
	T. derasa	juveniles	July, 1992		4,950	Fisheries/SPADP	Fiji Fisheries	Culture	Fisheries/Namu'a Farm
	T. squamosa	juveniles	July, 1992		270	Fisheries/SPADP	Fiji Fisheries	Culture	Fisheries/Namu'a Farm
	T. derasa	juveniles	February, 1993		1,700	Fisheries/SPADP	Fiji Fisheries	Culture	Fisheries/Namu'a Farm
	T. squamosa	juveniles	February, 1993		50	Fisheries/SPADP	Fiji Fisheries	Culture	Fisheries/Namu'a Farm
	T. squamosa & T. derasa	juveniles	20 Sept., 1993	6.000	5,800	Fisheries/SPADP	Fiji Fisheries	Culture	Fisheries/Namu'a Farm
	T. derasa	juveniles	1995	10,000	10,000	Fisheries/AusAID	DMWR, American Samoa	Reserve stocking & development	Moamoa & Tauoo village reserves, Upolu
	T. derasa	juveniles	1996	10,000	10,000	Fisheries/AusAID	DMWR, American Samoa	Reserve stocking & development	Fasitoo (Upolu), Faleu, Lepuiai, Salua & Apai villages on Manono Island

Table 10
Marine organism introductions into Samoa for aquaculture, reef seeding and other purposes, sorted by organism common name (source: Bell & Ropeti, 1995; Bell & Mulipola, 1998). [1] Updated February 2000.

	T. derasa (with a few specimens of T. maxima and H. hippopus)	juveniles	August, 1997	20,000	20,000	Fisheries/AusAID	DMWR, American Samoa	Reserve stocking	Tafitoala, Fausaga, Fusi Safata villages on Upolu Island & Asau, Auala, Fagasa, Sataua, Fagamalo, Pu'apu'a, Asaga, Faala and Vaitoamuli villages on Savaii Island
	T. derasa & T. squamosa	juveniles	July, 1998	2,034	2,034	Fisheries/FAO	Fisheries, Fiji	Reserve stocking	Locall villages
	T. derasa	juveniles	July, 1998	1,500	1,500	Fisheries/AusAID	DMWR, American Samoa	Reserve stocking	Local villages
	T. derasa	juveniles	18 June, 1999	1,041	1,041	Fisheries/FAO	Fisheries, Fiji	Reserve stocking	Ulufaalalafa, Solosolc Sapapalii, Papa & FD nursery
	T. gigas	juveniles	18 June, 1999	1,026	1,026	Fisheries/FAO	Fisheries, Fiji	Reserve stocking	Ulufaalalafa, Solosolc Sapapalii, Papa & FD nursery
	T. derasa	juveniles	24 June, 1999	5,000	5,000	Fisheries/FAO	DMWR, American Samoa	Reserve stocking	14 villages & FD nursery
	T. derasa	broodstock	24 June, 1999	30	30	Fisheries/FAO	DMWR, American Samoa	broodstock	29 to FD nursery, 1 died during quarantine
Green snail	*Turbo marmorata*	Juveniles	April, 1999	300	300	Fisheries/SPADP	Tonga Fisheries	Reef stocking	quarantine at Fisherie for 3 weeks, released 1 at Papa Puleia on 18 M 1999, 50 to be release at Saluafata & 150 at Namu'a Is.

KEY: SPC = Secretariat for the Pacific Community; FAO = Food and Agriculture Organization;
SPADP = FAO South Pacific Aquaculture Development Project; DMWR = Department of Marine & Wildlife Resource.

Table 10 (suite)
Marine organism introductions into Samoa for aquaculture, reef seeding and other purposes, sorted by organism common name (source: Bell & Ropeti, 1995; Bell & Mulipola, 1998). [1] Updated February 2000.

because, following the constitution, all land lying below the line of high-water mark in now public land, and all people have the right to navigate over the foreshore and fish within the limits of the territorial waters of the state (Bell 1985). The recent introduction of modern technologies together with increasing population pressure has led to unsustainable practices, which is a result of western-style government.

The introduction of State rules often undermines the traditional custom, however in recognition of this conflict the State passed the Fono Act 1990, which gives the authority back to village chiefs to control their traditional fishing grounds. The recent introduction of Village By-laws through the AusAID-assisted Fisheries Extension Programme further promotes village "ownership" and management of adjacent lagoon and reef fishery resources.

Constraints

Some of the constraints that are faced include the poorly focused and over-taxed fisheries administration, lack of research and management capabilities, environmental deterioration, over-fishing through the use of destructive and overly efficient fishing methods, and the poor use of fisheries management tools and regulations (King *et al.*, 1995). The lack of qualified personnel in marine related positions and the lack of priority given to monitoring and conservation efforts further exacerbates the problem. In the early 1980s the Fisheries Division employed 96 staff, by mid 1990s only 30 employees were left with only 5 having specialised fisheries training (Mulipola *et al.*, 1995). The lack of coordination and collaboration between government departments and NGOs may also be a constraint to coral reef conservation and monitoring. The need to include stakeholders, council of chiefs (*ali'i ma*

faipule), fishers, and the public is vital and must be integral to all monitoring and conservation efforts. The need to document the biodiversity of Samoa by reviewing past research and also by encouraging future scientific research with the involvement of locals is important.

Discussion

More research on the marine biodiversity of Samoa is needed. Very little is known with the exception of the fin-fishes and the flora which have been recently documented by reef scientists (Wass 1984; Zann 1989; Whistler 1992; South and Skelton 1999, 2000; Skelton 200). The coral reef system was severely affected by cyclones *Val* and *Ofa* in the early 1990s, however, a recent survey undertaken by Green (1996) revealed a fast recovery rate for most of the corals in the front reef. Industrialised areas such as Vaitele and Fagaloa were found to be in extremely good condition as were many other sites on Upolu island. By contrast the inshore lagoons were found to be much degraded and are threatened by coastal activities (Green 1996).

Although no endemic or rare species are found, this may merely reflect our current lack of knowledge of the coral reef biodiversity. Endangered animals, which include *Tridacna* spp., *Mugil cephlaus*, *Chanos chanos*, *Charonia tritonis* and *Scylla serrata* continue to decline in numbers as no nation-wide conservation effort is identified. This may result in the extinction of some animals such as the giant clam *Hippopus hippopus*, and the collapse of some fisheries, such as the bottom water fish and the bêche-de-mer fisheries. The decline in fishery stocks may be attributed to over-fishing, pollution, sedimentation and siltation, inappropriate development, careless tourism development and climate change. Over-fishing is a major problem; as the population increases, food consumption will also increase, the number of fishers will increase and the efficiency of fishing gear will improve. Pollution in rural communities will increase due to the increase of non-biodegradable products. The predictions that climate change effects will become more frequent, unpredictable and more severe need to be considered by leaders of the country and solutions should be highlighted and made known to the community.

The marine resources from the inshore and reefs are documented by the Fisheries Division through data collecting at local sites (markets, retailers and roadsides). This is carried out on a weekly basis throughout the year. The knowledge of the wild stock in most species is not known but downward trends can be seen over the years with the decline in fish catches.

Marine conservation efforts are currently being addressed through two different initiatives by two different government departments. There is a clear need for these conservation efforts to work together to achieve maximum success. Through these conservation efforts, sound monitoring activities must also be recognised and be part of management plans. The notion of including village participants as part of the monitoring activities should be encouraged as efforts have already been made through the Village Level Coral Reef Monitoring Project and the Village Extension Programme. Long term monitoring sites should be established in some of the proposed conservation areas. There is also a need to survey much more and in detail the coral reefs and threats to the inshore fishery of Samoa as advocated by Green (1996). In particular, a detailed survey of the condition of the shallow lagoons around the island would be invaluable.

Training of Fisheries and Environment staff in marine biota must be emphasised. Taxonomists, ecologists and biologists are lacking in government departments and this should be addressed.

Recommendations

The following lists some of the important issues that need to be considered for the better management of the coral reefs and the marine resources of Samoa.

- Appoint a National Coordinator responsible for coordinating all coral reef activities, including monitoring, training, research and liasing with all concerned parties;
- Establish a database to document the biodiversity of the marine resources of Samoa, which should include *inter alia* previous research, lists of organisms reported, distribution of organisms, results of monitoring activities, etc.;
- Efforts be made to enhance and build up human resource development, which must include specialised training and higher levels of education in taxonomy, scientific research, management and policy making;
- Develop and implement an Integrated Coastal Management (ICM) National Plan, which should define the roles of each Government department, local NGOs and regional/international NGOs, as well as including a synopsis of all relevant legislation dealing with marine resource conservation and management;
- Encourage the formulation of a National Sustainable Development Bill or Resource Management legislation, which should restate and reform the law relating to *inter alia* the use of marine and coastal resources;
- Activate previous recommendations made by UNEP/IUCN (1988) on proposed conservation areas in particular coral reefs;
- Identify long-term conservation areas and carry out baseline studies;
- Encourage and develop appropriate curriculum for schools at all levels;
- Encourage participation in all international Conventions and Agreements that Samoa is party to, including the Convention on Biological Diversity, the Ramsar Convention, and the United Nations Framework Convention in Climate Change;
- Establish a national action plan to prevent, reduce or minimise the deterioration and degradation of the marine and coastal environment from pollutants, including household refuse, industrial and agricultural waste and oil spills. The national action plan should also stipulate fines for those responsible for the offence as well as holding them responsible for any costs incurred in preventing, reducing, minimising or removing such pollutants;
- Include climate change issues in management and conservation efforts.

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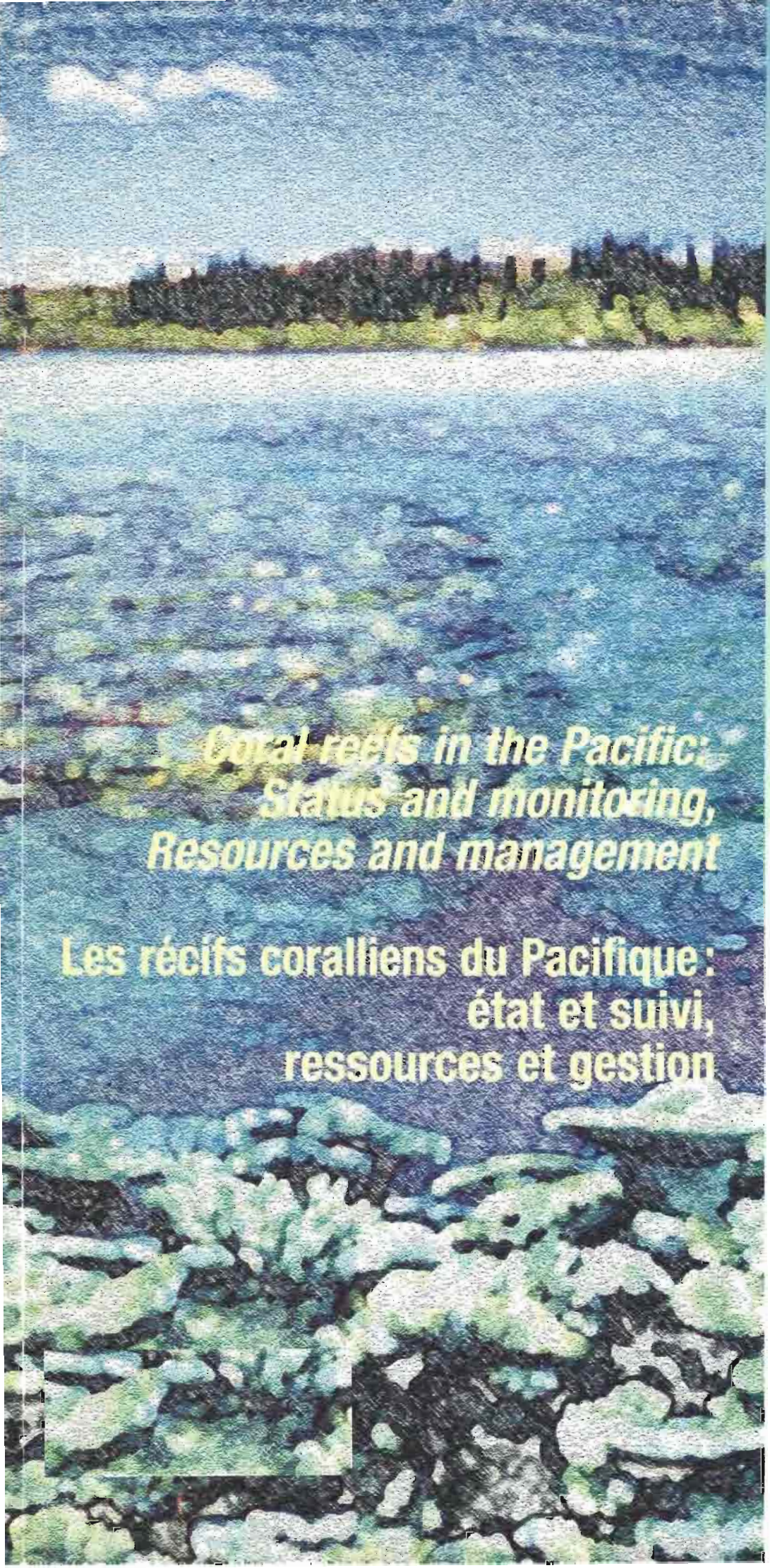

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