COMPONENT 2A - Project 2A2

Knowledge, monitoring, management and beneficial use of coral reef ecosystems

CRISP

Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique

January 2009

REEF MONITORING

SOUTH-WEST PACIFIC STATUS OF CORAL REEFS REPORT 2007

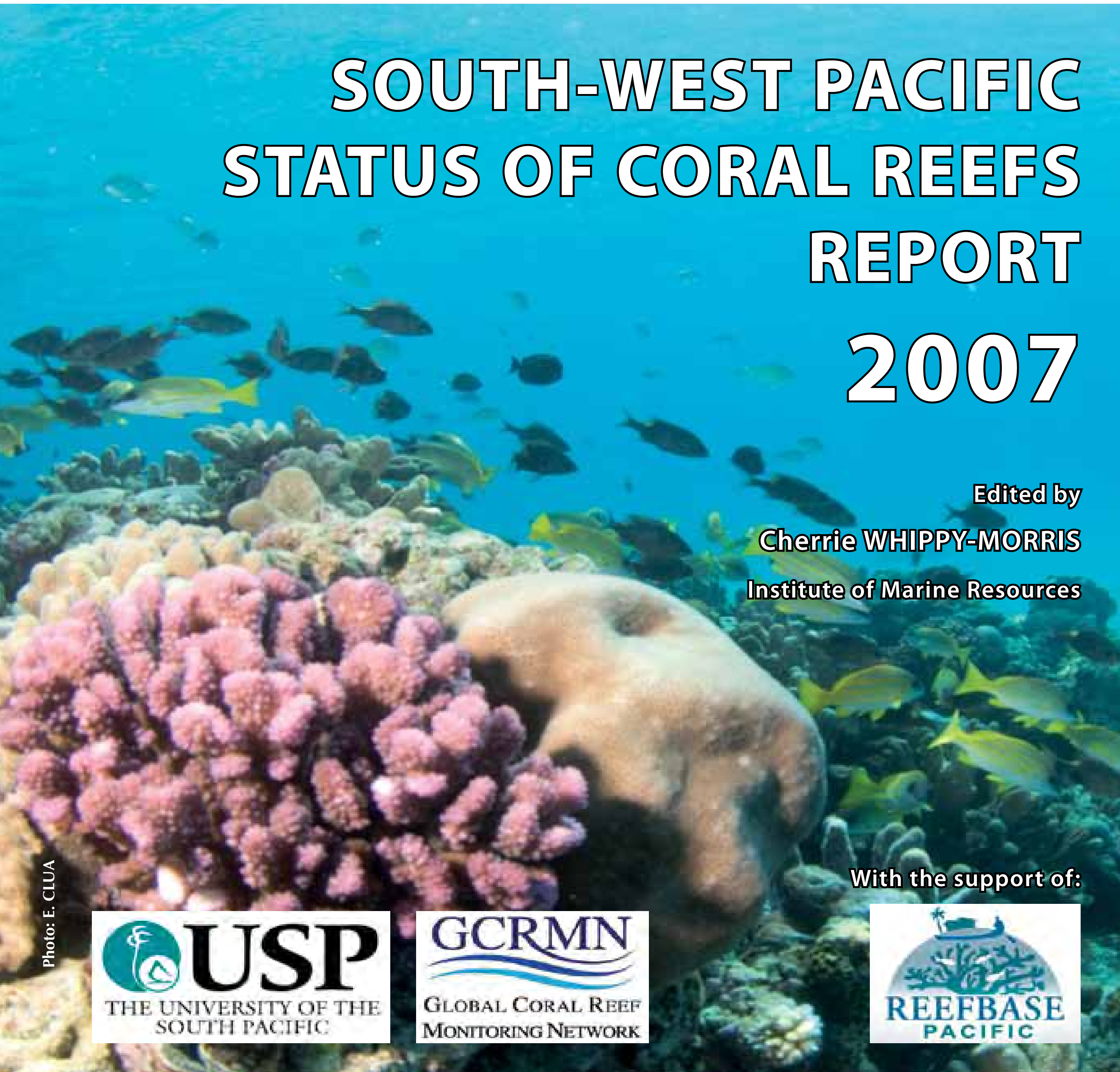

Photo: E. CLUA

Edited by

Cherrie WHIPPY-MORRIS

Institute of Marine Resources

With the support of:

USP
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GCRMN
GLOBAL CORAL REEF MONITORING NETWORK

REEFBASE PACIFIC

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Coral Reef InitiativeS for the Pacific
Initiatives Corail pour le Pacifique

SPREP/PROE

The CRISP programme is implemented as part of the policy developped by the Secretariat of the Pacific Regional Environment Programme for a contribution to conservation and sustainable development of coral reefs in the Pacific

The Initiative for the Protection and Management of Coral Reefs in the Pacific (CRISP), sponsored by France and prepared by the French Development Agency (AFD) as part of an inter-ministerial project from 2002 onwards, aims to develop a vision for the future of these unique eco-systems and the communities that depend on them and to introduce strategies and projects to conserve their biodiversity, while developing the economic and environmental services that they provide both locally and globally. Also, it is designed as a factor for integration between developed countries (Australia, New Zealand, Japan, USA), French overseas territories and Pacific Island developing countries.

The CRISP Programme comprises three major components, which are:

Component 1A: Integrated Coastal Management and watershed management
- 1A1: Marine biodiversity conservation planning
- 1A2: Marine Protected Areas
- 1A3: Institutional strengthening and networking
- 1A4: Integrated coastal reef zone and watershed management

Component 2: Development of Coral Ecosystems
- 2A: Knowledge, monitoring and management of coral reef ecosytems
- 2B: Reef rehabilitation
- 2C: Development of active marine substances
- 2D: Development of regional data base (ReefBase Pacific)

Component 3: Programme Coordination and Development
- 3A: Capitalisation, value-adding and extension of CRISP Programme activities
- 3B: Coordination, promotion and development of CRISP Programme

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COMPONENT2A

Knowledge, monitoring and management of coral reef ecosytems

PROJECT 2A-1 :
Postlarvae (fish and crustacean) capture and culture for aquarium trade and restoking

PROJECT 2A-2:
Improvement of knowledge and capacity for a better management of reef ecosystems

PROJECT 2A-3 :
Synopsis and extension work on indicators for monitoring the health of coral ecosystems and developing a remote sensing tool

PROJECT 2A-4 :
Testing of novel information feedback methods for local communitis and users of reef and lagoon resources

PROJECT 2A-5 :
Specific studies on i) the effects on the increase in atmospheric CO2 on the health of coral formation and ii) the development of eco-tourism

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afd
Agence Française de Développement

FOREWARD

The South West Pacific has the highest diversity of coral reefs in the world. Coral reefs and their associated resources are essential to the livelihoods and well-being of people of the South West Pacific. Reef-associated resources form a critical part of the diet of populations of the small islands and atolls of the Pacific. Reefs support income- generating activities such as fisheries and tourism and are, therefore, a significant component of the economies of many Pacific Island Countries and Territories.

Monitoring of the status of the coral reefs in the South West Pacific node of the Global Coral Reef Monitoring Network (GCRMN) has shown that there have been variable changes (both positive and negative) in the composition of coral reef communities since 2004. In addition, there are special challenges due to the large area of reefs, remoteness, and limited monitoring resources. The quality and comprehensiveness of country reports presented here are a tribute to the hard work of the scientists, local communities, tourist resort staff, students and various other volunteers who have contributed and assembled monitoring data. Such data has provided important information to students, scientists and fisheries managers in the region and beyond.

The reports in this book, overall demonstrate that coral reefs of the Pacific are in good condition when compared to reefs in Asia and the Caribbean. Relatively fast rates of recovery seem to indicate that the reefs of the South West Pacific appear to be resilient in the face of continuing acute threats from increased sea surface temperature, cyclones, tsunamis, and crown of thorns. However, there are suggestions that reefs are experiencing an increase in exposure to chronic stresses such as overfishing, sedimentation, coastal development and nutrient enrichment. The impact of these factors remains difficult to measure.

The Institute of Marine Resources (IMR) of the University of the South Pacific has been pleased to act as coordinator of the South West Pacific Node of the GCRMN since 2000. IMR has coordinated monitoring activities, facilitated training, provided capacity building and functioned as a mentor to the authors of the individual chapters. We are pleased with the increase in capacity, frequency and coverage of monitoring that is reflected in this volume. We call for the continued support of our partners for both funding and collaborations that will ensure monitoring and documentation of the status of these critical habitats are possible into the future.

We acknowledge the initial support from the International Ocean Institute and the Canada-South Pacific Ocean Development Program that initiated this GCRMN node. The funding for coordination of the network since 2006 and publication of this book has come from the Coral Reef InitiativeS for the Pacific (CRISP) with considerable thanks to the French Government for this support, and the encouragement of Eric Clua the CRISP Programme Manager.

The development and production of the country reports presented here would not have been possible without the hard work and commitment of the volunteer country coordinators who are the authors of the individual reports. These reports have made an important contribution to the 2008 International Year of the Coral Reef. We are confidant that the information presented here will be useful to donors, researchers, policy makers, community members and all stakeholders involved in coral reef conservation and management.

Kenneth T MacKay, PhD

Former Coordinator of the South West Pacific Node GCRMN, and

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University of the South Pacific

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ACKNOWLEDGEMENTS

The coordination of the South West Pacific Node of the Global Coral Reef Monitoring Network (GCRMN) is part of component 2A (Knowledge, monitoring and management of coral reef ecosystems) of the Coral Reef InitiativeS for the Pacific (CRISP). We would like to acknowledge CRISP for providing financial support towards this coordination, the end result of which is this book.

Acknowledgement also goes to the other key agencies that have financially supported country-monitoring programmes. These include the following:

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Marine Ecology Consulting (Fiji)

The Government of Tuvalu and Funafuti Island Council (Tuvalu)

Sincere gratitude to the six country coordinators of the South West Pacific GCRMN Node who committed time and effort to coordinating and conducting monitoring activities, and collating all the information presented here. In addition, many thanks to the various government departments, non-government organisations and local communities in Solomon Islands, Vanuatu, Samoa, New Caledonia, Fiji and Tuvalu for their ongoing support.

Appreciation goes to Ms Philippa Cohen, of the World Fish Center, Ms Prerna Chand, a former staff of the University of the South Pacific, Emelita Wendt-Wilson and Matt Wilson of SAMBA! for their edits and proof reading of this report at various stages.

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STATUS OF CORAL REEFS IN THE FIJI ISLANDS, 2007

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CONTENTS

EXECUTIVE SUMMARY

The Fiji branch of the Global Coral Reef Monitoring Network (GCRMN) was started in Fiji in 2000, when Reef Check and the GCRMN began a co-operative project to train a network of survey teams that could report on the health of the country's coral reefs.

Fiji is a large archipelago with a great variety of reef types, in various states of health. By examining a network of sites across the country, it has been possible to determine the regional status and overall trends as well as local changes.

In 2000, the Fiji Islands were at the northern edge of a large pool of unusually warm water, and suffered extensive hard coral death due to coral bleaching. By 2007, coral health across the islands was generally good on most reefs monitored, with many areas recovered to, or even higher than pre-2000 bleaching levels. Where recovery was found to be slow, probable causes were that reefs were either physically remote from areas of healthy coral, and so from sources of new coral spawn, or that algae domination prevented coral settlement. Certain areas that escaped major bleaching have been seen to have regularly lower water temperatures than areas displaying more extensive bleaching.

Coral bleaching is not the only stressor on Fiji's reefs, which are also regularly affected by cyclones and large storms. There are, as well, more localised factors such as over-fishing, nutrification, algal overgrowth and coral predation from Acanthaster plancii (Crown of Thorns Starfish - COTS) and coral-eating snails such as Drupella. More serious factors threatening coral health are over-fishing, increased nutrients from land-based sources resulting in algal dominance (eutrophication) in coastal areas.

Across Fiji, on reefs close to villages, the numbers of large edible fish and invertebrates are relatively low as a large proportion of the populace depends on subsistence-level fishing. Giant Clams, Triton Trumpet Shell and decorator urchins are collected for food and, in some cases, for the tourism souvenir trade. In addition, sea cucumbers are gathered for the Asian market, and lobsters for local tourism.

Local subsistence fishers normally use spears, hand lines, or small nets, and often walk on the shallow reef tops. Destructive methods such as dynamite or poison fishing are not frequently used, with the exception of a plant poison used on shallow reef flats to stun fish. The collection of small fish and corals for the aquarium trade creates additional pressure on the reefs in limited areas.

The main finding from six years of monitoring since the 2000 bleaching is that, on the whole, Fiji's reef system has coped well and there has been coral re-growth in many areas. Many reefs returned to pre-bleaching coral cover levels in around five years. This would suggest that corals in Fiji can survive quite catastrophic events.

However, human-generated impacts such as over-fishing and poorly planned coastal development have the potential to seriously harm localised coral health in the long term, and need to be managed. In particular, Fiji's remaining stands of coastal mangroves are under serious threat from coastal development. This could possibly create widespread and long-term fisheries depletion.

It has become obvious from these studies that there is a need for continuity of long-term monitoring, if changes in coral reef assemblage are to be clearly understood. Six years of monitoring has shown recovery from a single bleaching event, and some consequences of storm damage, but it will probably take 10 to 15 years of data collection to make regular cycles apparent. Short-term projects allow snapshots of reef health but, without long-term support, these are only disconnected data spots. The value of long-term monitoring of regularly visited sites has become apparent, but cannot be carried out unless resources are committed well into the future.

I
COUNTRY INFORMATION

The Fiji archipelago has an estimated land area of 18,500 km^2, spread over 320+ islands and more than 500 islets and cays, with 106 of these being inhabited (South & Skelton, 2000).

Viti Levu and Vanua Levu are the two largest islands, followed by Taveuni and Kadavu, and the Mamanuca, Yasawa, Lomaiviti, Ringgold, and Lau island groups.

The archipelago extends from the island of Rotuma, with its inhabitants of Polynesian origin, (Long. 1770E; Lat 150'S) well north of the main group, to Ceva-i-Ra in the south (Long. 174036'E; Lat 210 45'S). To the west is Viwa I., part of the Yasawa Is. (Long. 176056.5'E; Lat 170 08'S). The easternmost extent is Vatoa I. in the Lau Group (Long. 178013'W; Lat 190 51'S).

The country's population increased by 52,823 over 11 years from 775,077 in 1996, to 827,900 in 2007 (Fiji Islands Bureau of Statistics, 2008). Fiji has a traditionally-governed marine tenure system whereby coastal waters are divided into customary fishing rights areas (i-qoliqoli), under traditional ownership of the indigenous population.

Fiji's diverse reef system includes fringing reefs, barrier reefs, platform reefs, oceanic ribbon reefs, drowned reefs, atolls and near-atolls, forming an estimated 10,000 km2 of coral reefs (Zann, 1992). The Cakaulevu Barrier Reef or Great Sea Reef, north of the two largest islands, is exceptional in that it is one of the world's longest barrier reefs. (Jenkins et al. 2004)

Fiji's reefs have a relatively high level of biodiversity (Lovell and Sykes, 2007) compared to other Pacific Island countries. To date, there have been 219 species of stony corals identified, but no endemic species, (Lovell, 2002; Obura and Mangubhai, 2003; Pichon, 1980 unpubl.), and 1198 species of coral reef fish, including at least 4 endemic species (South & Skelton, 2000) (Table 1).

Table 1: Biodiversity of marine faunal and floral groups in Fiji (Vuki et al.2001)

	Current information	**Sources (references)**
Vertebrates		
Bony fish	162 families, 1,198 species	Baldwin and Seeto (1986)
Reptiles	3 species	Guinea (1980)
Seabirds	10 species	Clunie (1985)
Whales	4 species	Zann (1992)
Invertebrates		
Stony Corals	219 species	Pichon 1980; Lovell 2002; Zann and Lovell 1992
Gorgonians	5 species	Muzik & Wainwright (1977)
Zoanthids	15 species	Muirhead & Ryland (1981)
Molluscs		
Gastropods	123 species, 12 families	Parkinson (1982)
Opisthobranch	253 species	Brodie & Brodie (1990)
Bivalves	102 species, 25 families	Parkinson (1982)
Ascidians		Kott (1981)
Sea squirts	60 species	Ryland et al.(1984)
Marine plants		
Algae	422 taxa 39 Cyanophyceae 113 Chlorophyceae 42 Phaeophyceae 228 Rhodophyceae	N'Yeurt et al. (1996)
Seagrass	4 species	Morton and Raj (1980)
Mangrove	9 species	Whippy-Morris & Pratt (1998)

2
CURRENT PHYSICAL CONDITION OF CORAL REEFS

2.1 Monitoring methods and issues

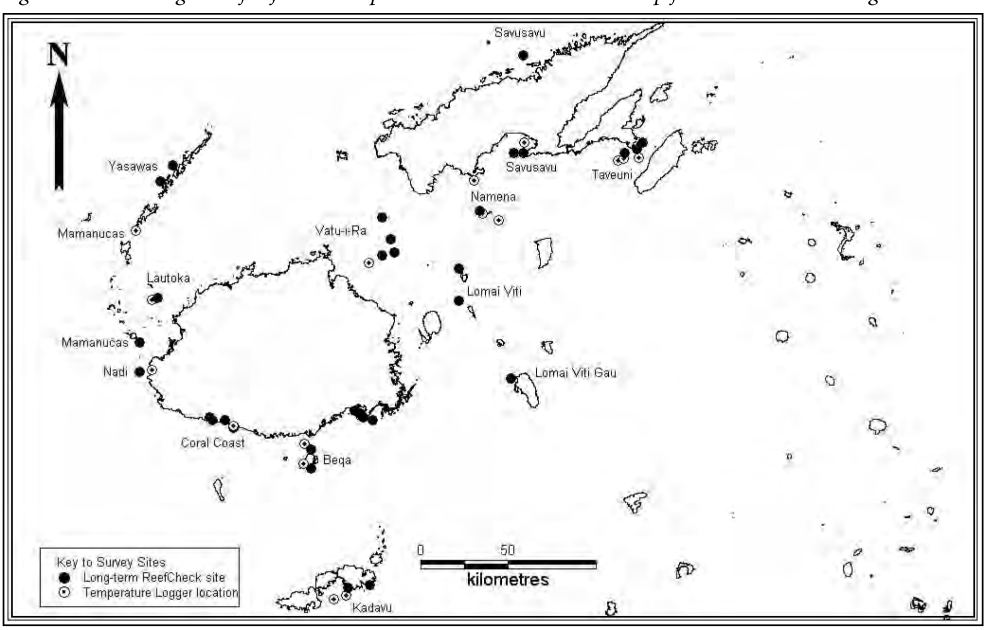
As the central base of the University of the South Pacific, Fiji has a considerable amount of data and reports on reef populations and condition. Monitoring methods have varied over time and geographic area, depending on the focus of monitoring programmes and contributing agencies.

Reef surveying has become more standardised and concentrated over the past eight years with the formation of the Fiji branch of the Global Coral Reef Network (GCRMN), and the Fiji Locally Managed Marine Areas Network (FLMMA). In addition there are now many marine conservation and research projects operating through educational and non-government organisations.

The surveys presented in this report are based on a suite of Point Intercept Transects (PIT) for benthic cover, and Belt Transects (BT) for fish and invertebrate marine life. In the 13 core regions of Fiji's islands (Figure1), permanent transects were set up for annual monitoring using four 20m Reef Check PIT and BT transects as a minimum standard survey (Reef Check 2007). Where possible this was expanded and enhanced to the Australian Institute of Marine Science (AIMS) benthic lifeform categories (English et al. 1997), and full fish species census. These surveys were carried out by the Fiji GCRMN coordinators and a team of contributing educational organisations, non-government organisations, and tourism resorts. In practice not all sites were visited annually, but have been surveyed frequently over several years (Appendix 1).

It has been possible to standardise data and compare sites at the levels of percentage cover and ani-

Figure 1: 13 core regions of Fiji's islands permanent transects were set up for annual monitoring.



mal density per 100m[2], since 1999. Data presented here is disaggregated into basic Reef Check categories (used for analysis of regional comparisons and over-time changes) and expanded life-form categories for benthic cover, and full fish species census (used for detailed analysis of changes in population diversity) (English et al. 1997) (Table 2).

Occasional data has been contributed by other organisations and single-case studies using other methods or transect sizes. In these cases, organisations were asked to supply data as summaries such as percentage coral cover, fish and invertebrate numbers per 100m[2].

Table 2: Categories used in PIT and BT reef surveys

Benthic cover (Reef Check)	Code	Benthic cover (Lifeform categories)	Code	Fish groups (Reef Check)	
Hard coral (live)	HC	Acropora branching	ACB	Butterflyfish	
Soft coral (live)	SC	Acropora digitate	ACD	Parrotfish	
Recently killed coral	RKC	Acropora tabular	ACT	Snapper	
Sponge	SP	Acropora encrusting	ACE	Sweetlips	
Nutrient indicator algae (all algae except Halimeda, coralline and short turfs)	NIA	Acropora submassive	ACS	Grouper (in size categories)	
Other biota	OT	Non-Acropora coral branching	CB	Moray eels	
Rock	RC	Non-Acropora coral massive	CM	Humphead wrasse (C. undulatus)	
Rubble	RB	Non-Acropora coral encrusting	CE	Bumphead Parrotfish (B. muricatum)	
Sand	SD	Non-Acropora coral foliose	CF	Fish groups (Expanded Reef Check)	
Silt	SI	Non-Acropora coral submassive	CS	Surgeon and Unicornfish	
		Non-Acropora coral fungoid (mushroom)	CMR	Goatfish	
		Non-Acropora coral Millipora (fire)	CME	Jacks and Trevallies	
		Non-Acropora coral Heliopora (blue)	CHE		
		Soft coral	SC	Invertebrate groups (Reef Check)	
		Sponge	SP	Banded Coral Shrimp	
		Zoanthid	ZO	Lobster	
		Other biota	OT	Sea Cucumbers (to species)	
		Coralline algae	CA	Crown of Thorns (COT)	
		Halimeda algae	HA	Giant Clam (in size categories)	
		Turf algae	TA	Triton Shell	
		Macro algae	MA	Sea Urchins:	Tripnuestes gratilla
		Algal assemblage	AA		Diadema spp
		Dead coral	DC		Heterocentrotus spp
		Dead coral + algae	DCA		
		Rock	RC		
		Rubble	RB		
		Sand	SD		
		Silt	SI		

In-water temperature loggers were deployed in certain sites from 1996 by Drs Norm Quinn and Peter Newell, in cooperation with the tourist diver live-aboard ship "Nai'a" (Barrell, R., personal communication, January 2002). This network of loggers was expanded in 2003 by the Fiji GCRMN, and by 2006 more than 15 loggers were set around the country. Initially loggers were set to record water temperature every four hours, in 2005, the recording period was then changed to sample every two hours and, in certain more detailed studies, water temperature was monitored every 15 minutes (Victor Bonito, personal communication, December 2007). These loggers were downloaded annually wherever possible, and less frequently in more remote areas.

2.1.1 Monitoring regions

Sites were selected for monitoring to provide a widespread picture of reef health across the country. "Core" monitoring sites are surveyed annually or bi-annually depending on logistics. Other, less frequent, opportunist surveys from more remote regions are incorporated as "one-off" reports, but not included in Fiji average figures.

2.2 Results

In this section, data from the current monitoring period, 2005 – 2007, is presented first. Additional long-term data is available for the years 1999 – 2004 (Lovell and Sykes. 2007). Sea surface temperature data is also available for the current monitoring period.

2.2.1 Current Monitoring Period (2005, 2006, 2007) by region

The following figures indicate the relative abundance of the substrate, fish and invertebrates in the various monitoring regions of Fiji over 2005 – 2007. However, as few regions were monitored in 2005, that data is not considered an appropriate comparison against the data of 2006 and 2007.

2.2.2 Substrate

Figure 2 is a representation of the average coral cover in regions of Fiji for 2005 - 2007. Highest coral cover was seen in Namena, Rotuma and Vatu-i-Ra Passage. Over most sites, from 2006 – 2007, there was a constant pattern of increasing hard coral cover. Three sites (Mamanuca, Savusavu and Suva) showed decreasing coral cover, coincident with high crown of thorns starfish (COTS) numbers (Figure 14). The bars represent +/- 1 standard deviation.

2.2.3 Fish

The average key fish density in regions of Fiji from 2005 to 2007 is shown in Figure 3. Fish counts were consistently higher in the Mamanuca and Taveuni Islands. In Lomaiviti, the Mamanuca Islands and Taveuni, large schools of snappers were seen. Apart from these schools, the greatest density per $100m^2$ of fish in most regions was represented by parrot fish and butterfly fish. Abbreviated region names are Ltka for Lautoka, Nma for Namena, and Rtma for Rotuma.

2.2.4 Invertebrates

Figure 4 indicates the average key invertebrates in regions of Fiji for 2005 to 2007. Macro-invertebrates are generally very sparse on Fiji's reefs, with the exception of a small Diadema-like urchin *Echinostrephalus aciculatus.* Sea cucumbers and giant clams were scattered in low numbers in most regions. No invertebrates were found at three sites surveyed (not represented in Figure 4). Large numbers of COTS were observed in the Mamanucas Islands in 2006 and 2007; their presence was significant in Lomaiviti, the Yasawa Islands, Suva and the Coral Coast by 2007.

The dominance of Diadema urchins masks the abundance of the other invertebrates, so it is presented separately in Figure 5. Significant numbers are shown for Yasawas, Savusavu and Taveuni reefs.

Figure 2. Average hard coral cover in monitoring regions of Fiji from 2005 – 2007

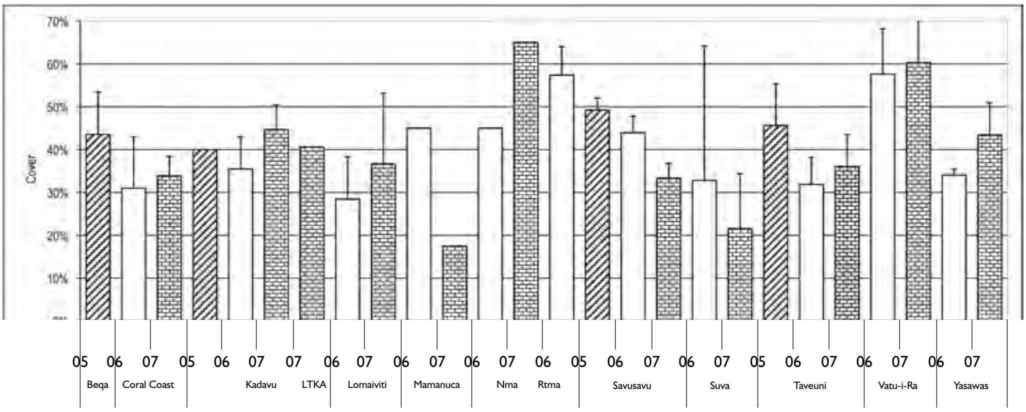


Figure 3. Average key fish density in regions of Fiji 2005 – 2007

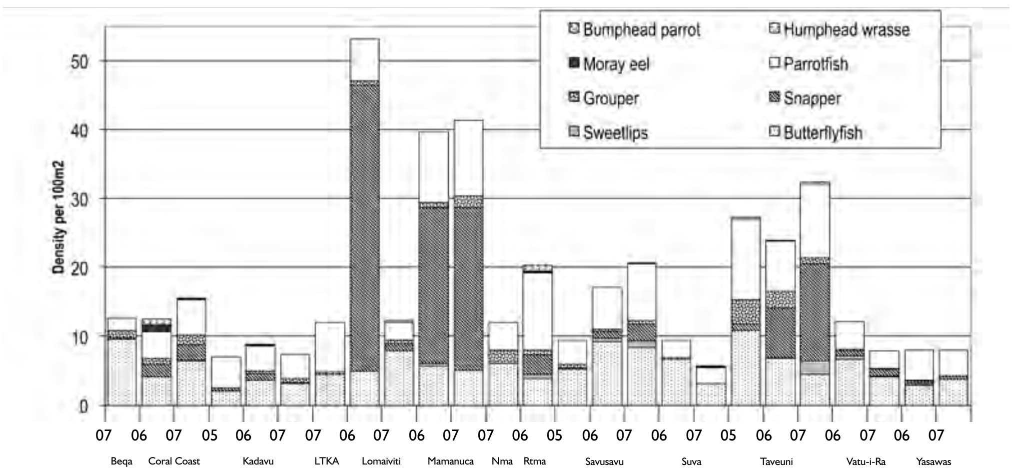
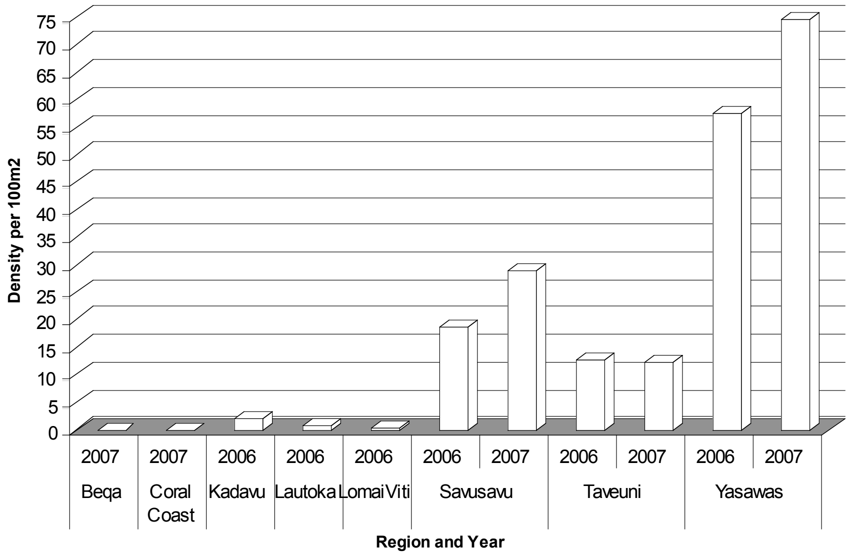


Figure 5. Average Diadema urchin density in regions of Fiji from 2006 – 2007



2.3 Long-term Monitoring

The various trends obtained from monitoring data over the years from 1999 to 2007 for the diverse regions around Fiji have been presented in this section. The graphs concentrate on trends observed throughout the above mentioned period. These are represented as averages of the relative abundance for substrate, fish and invertebrates for the regions monitored in Fiji.

2.3.1 Substrate

Figure 6 below presents the average coral cover from all core survey regions. There is a clear recovery trend following losses from bleaching and COTS, although high standard deviations reflect the considerable variation in reef types. The line is a (trend line) polynomial statistical analysis of coral cover.

At both depths, there was an observed decline in hard coral cover from 1999 - 2001, and a subsequent increase from 2002 – 2007 with the exception in 2005 of shallow reefs. These reached the lowest cover in 2001, while deeper reefs had the least hard coral cover in 2002. The average coral cover was around 45% with a range of 8% – 60% across all 13 regions.

The average algae cover in the regions surveyed was low compared to that of hard coral as shown in Figure 7. No algae were found in the two sites surveyed in 2001.

Figure 8 shows averages of the three main types of coral: Acropora, non-Acropora and soft coral. There was a sharp decrease in Acropora hard coral cover from 1999 - 2001, then a gradual increase between 2002 and 2007, with the exception of 2006, reflecting the impact, and then recovery from bleaching respectively. On the other hand, non-Acropora hard corals cover ranged from 17%-29% in the years from 1999-2007. Soft corals decreased in 2000 and from 2001 – 2003, and increased between 2003 and 2007.

Figure 6. Average hard coral cover on reefs across the monitoring regions from 1999 -2007

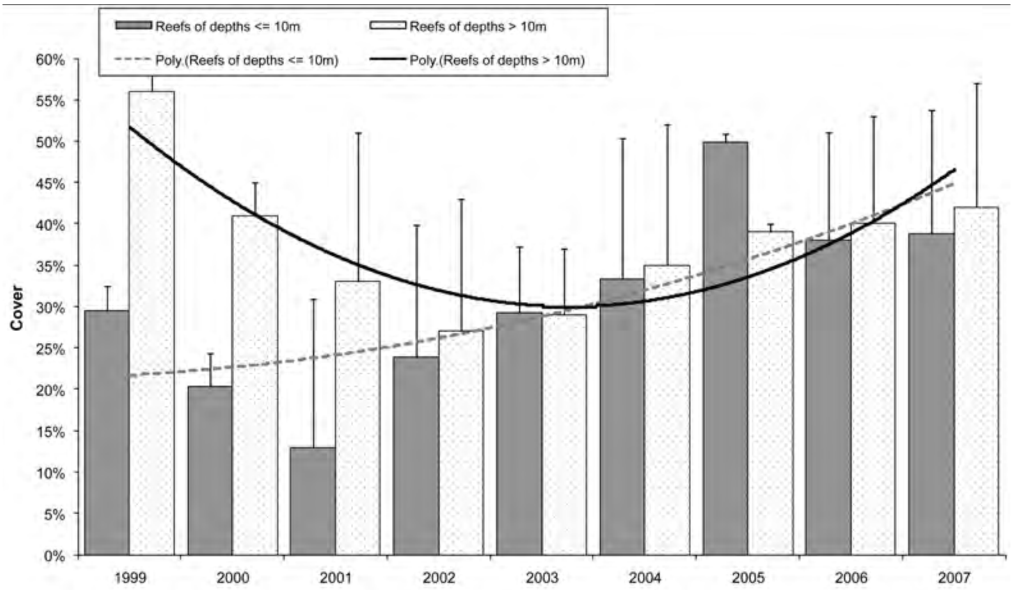


Figure 7. Average algae cover on reefs across the monitoring regions from 1999 -2007

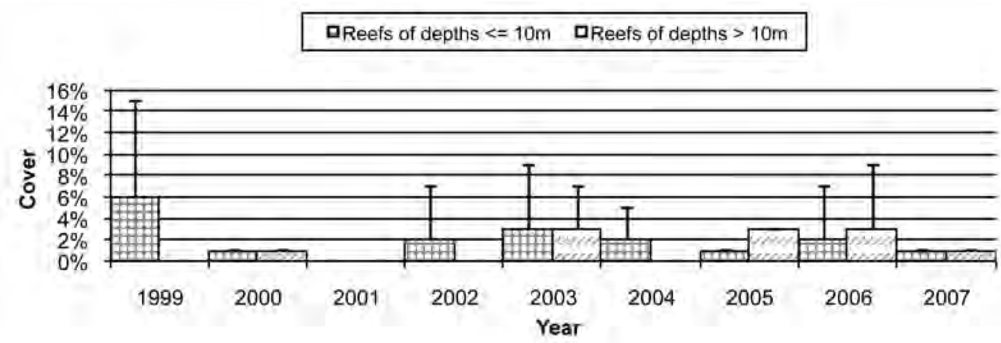
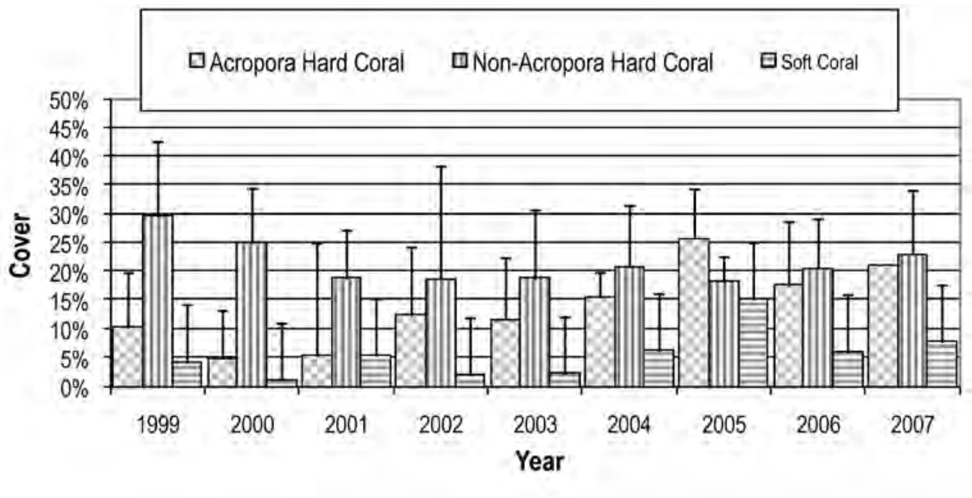


Figure 8. Average cover of Acropora coral, non-Acropora coral and soft coral across the monitoring regions from 1999 – 2007



2.3.2 Fish

Figure 9 shows the average indicator fish numbers from 2000-2007. There were no obvious patterns in fish quantities, apart from a sudden abundance of snapper in 2006, affected by a very large school occurring in one site (Vadravadra, a marine protected area on Gau Island, Lomaiviti). Numbers of large "food fish" such as grouper, sweetlips, large parrotfish and wrasse were low across the regions from 2002 to 2007.

2.3.3 Invertebrates

Figure 10 shows the average indicator invertebrate numbers per $100m^2$ of reef substrate across the monitoring regions from 2002 – 2007.

The data indicates that invertebrate numbers (especially Diadema urchins and sea cucumbers) have declined since 2002. Diadema urchins are presented separately in Table 3.

Figure 9. Average indicator fish numbers per 100m² of reef substrate across regions from 2002 – 2007

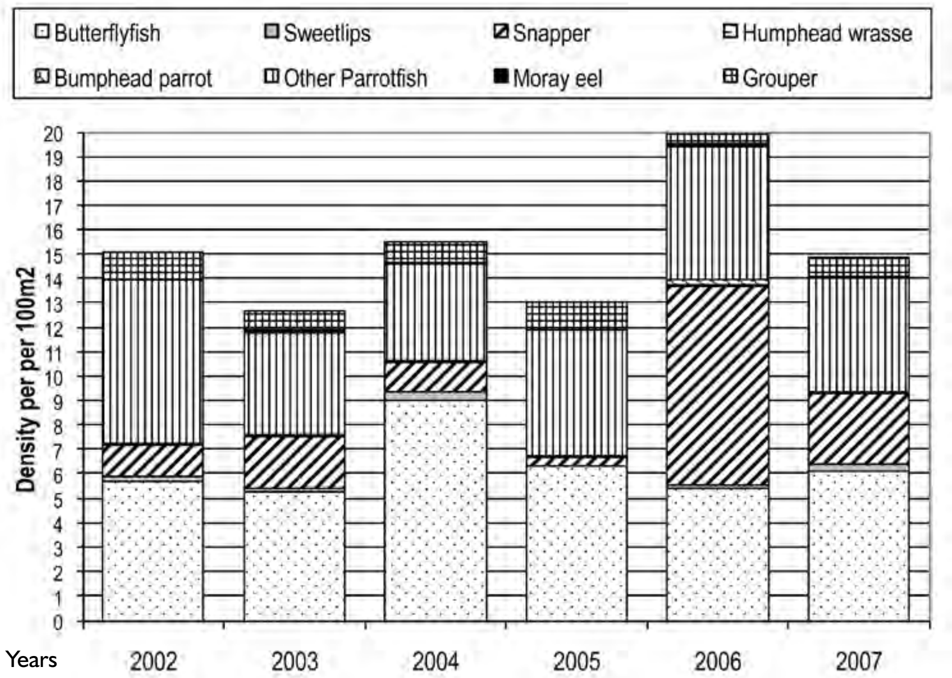


Figure 10. Average indicator invertebrate numbers per 100m² of reef substrate, across monitoring regions from 2002 - 2007

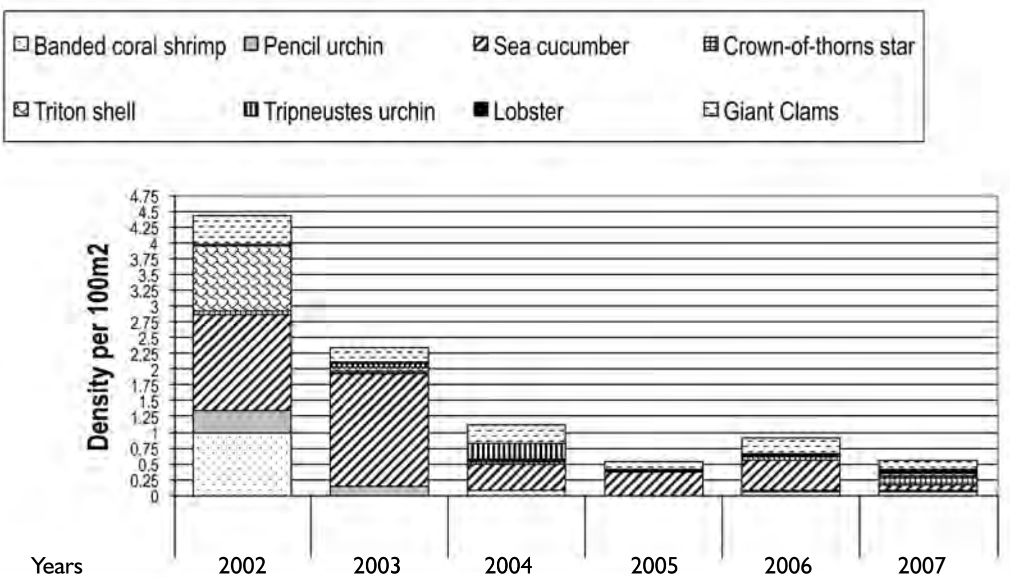


Table 3. Diadema urchin density across Fiji Islands 2002 – 2007

Year	2002	2003	2004	2005	2006	2007
Density: Number/100m^2	47.05	25.43	2.12	1.00	8.01	8.64
N sites	11	15	19	6	28	30

Table 4 shows the average density of COTS in monitoring regions from 2002 – 2007. (The 2005 data set has been omitted as the data from the few surveys carried out would not give a representation of Fiji COTS data as a whole). The data indicates that there has been a slight increase in COTS over the years 2002 to 2007.

Table 4. Average density of COTS in monitoring regions from 2002 - 2007

Year	2002	2003	2004	2005	2006	2007
Density	0.06	0.05	0.07	0.00	0.08	0.15
Std.Dev.	0.15	0.10	0.13	0.00	0.31	0.31
N sites	11	15	19	6	28	30

Table 5 shows the average catch per unit effort (COTS removed per minute of search) on four dive sites in the Mamanuca Islands between October 2006 and October 2007. There was a decrease in the numbers of COTS found per minute's search from October 2006 to October 2007.

Table 5. Catch per Unit Effort for COTS at four dive sites in the Mamanuca Islands between October 2006 and October 2007

Month & Year	Total No. COTS	CPUE
Sept. '06	99	0.24
Oct. '06	1766	0.81
Nov. '06	3429	0.49
Dec. '06	1052	0.16
Jan. '07	5623	0.17
Feb. '07	2310	0.26
Mar. '07	593	0.09
Apr. '07	457	0.08
May '07	276	0.15
June '07	1831	0.18
July '07	938	0.10
Aug. '07	1668	0.09
Sept. '07	1147	0.07
Oct. '07	1072	0.04

2.3.4 Water temperatures

The following graphs relate to the significance of sea surface temperatures and the percentage coral cover over an eight year period. An effort has been made to correlate the sea surface temperatures with the extent of coral bleaching events in one of the monitoring regions – Vatu-i-Ra.

Figure 11. Number of days with temperatures above 29°C in the Vatu-i-Ra Passage 1997 – 2007

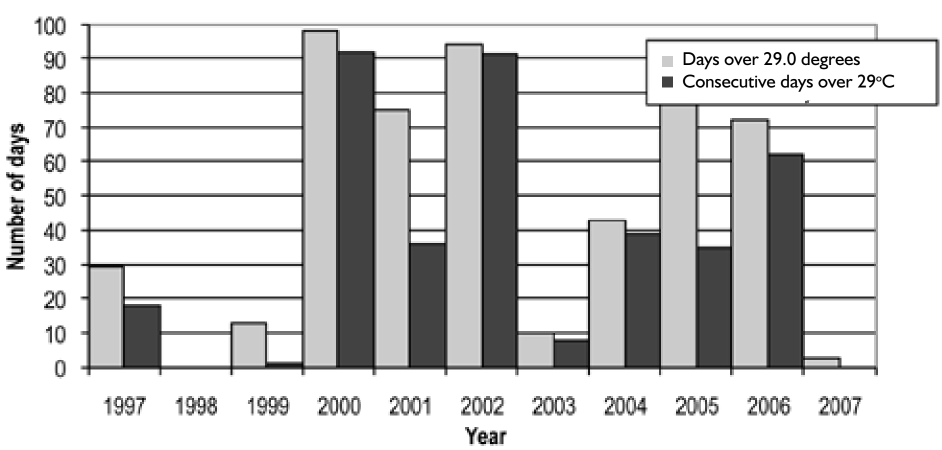
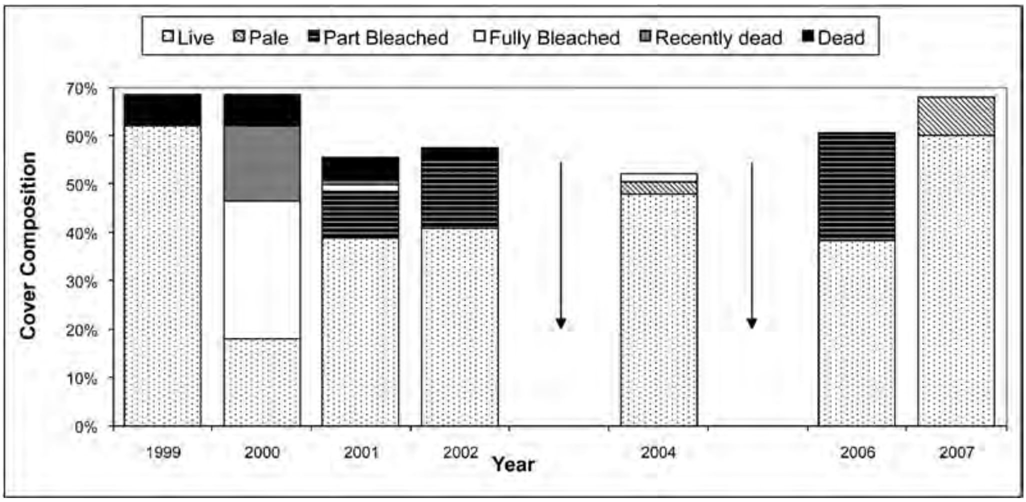


Figure 12. Hard coral cover and extent of bleaching at time of survey in the Vatu-i-Ra Passage 1999 - 2007



2.3.5 Water temperature related to Coral Bleaching and Coral Cover

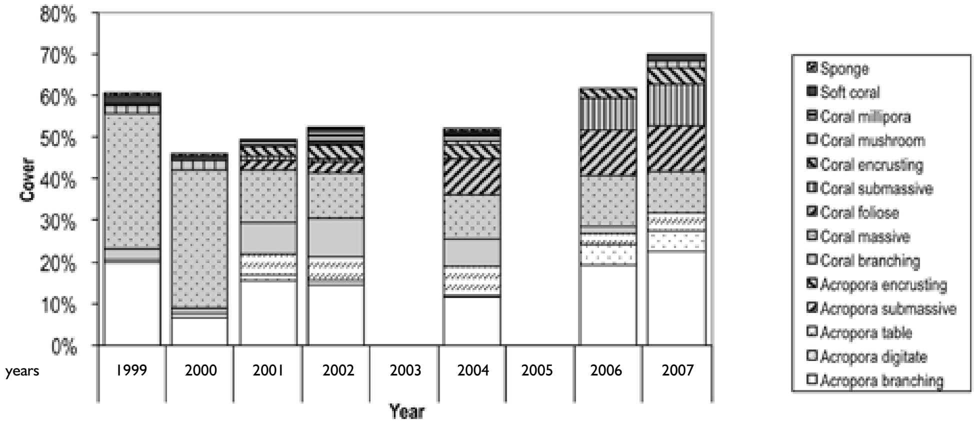
Figure 11 shows the number of days with average water temperatures above the bleaching threshold in Vatu-i-Ra. This also indicates that the longest periods with consecutive temperatures over 29°C were during the years, 2000, 2002 and 2005. The graph shows that in 2000, 2001, 2002, 2005 and 2006 a high number of days had temperatures over 29°C. The years with the highest number of consecutive days over 29°C were 2000 and 2002.

Figure 12 provides an indication of the condition of hard coral cover in the Vatu-i-Ra Passage from 1999 – 2007. There is an increase in fully bleached corals in 2000, and partly bleached hard coral cover is evident in 2001, 2002 and 2006, corresponding to the years with the highest number of consecutive days over 29°C evident in Figure 13.

Figure 13 shows the average main coral types in life-form categories on Mount Mutiny in the Vatu-i-Ra Passage 1999 – 2007. The graph indicates high percentage of data of massive coral and Acropora branching corals over the years 1999 to 2007. It is evident that reefs in the pre-bleaching year (1999) had a lower diversity of lifeform categories than reefs in post bleaching times (2006, 2007). (Note: there were no surveys in 2003 and 2005.)

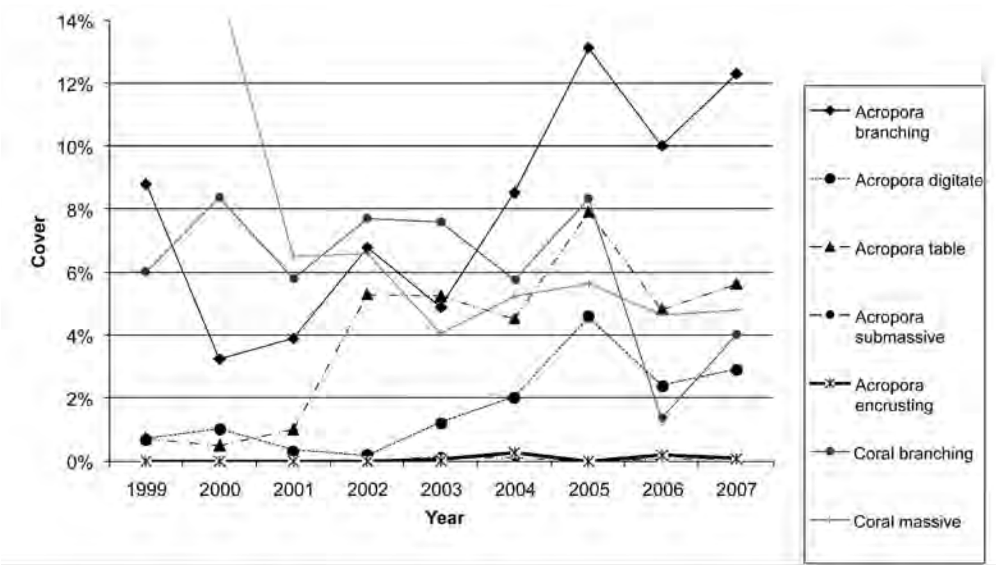
Figure 14 is the trend of hard coral lifeform cover over eight years in all monitoring regions. It clearly shows the sharp decline of the common coral types Acropora branching and coral massive in 2000. It is also indicative of the rate of recovery of the different lifeforms after the bleaching event.

Figure 13. Average main coral lifeform categories on Mount Mutiny in the Vatu-i-Ra Passage 1999 -2007



Note: "coral" life-form categories refer to hard corals other than Acropora species

Figure 14. Average Acropora lifeform categories across monitoring regions from 1999 – 2007



3

DISCUSSION

3.1 Substrate

The main issue of coral reef health in Fiji over the past seven years has been the recovery from mass bleaching in 2000 and 2002 when mortality of between 40% and 80% of hard corals was observed on some reefs across the country. These events relate to extended periods of water temperatures elevated above 29^{o}C, (Cumming et al. 2004; Lovell and Sykes, 2007). Smaller bleaching events in 2005 and 2006, cyclones in 2001 and 2004, and COTS outbreaks in 2005 and 2006 caused some further damage, but these occurred in certain regions of the archipelago, not across the country-wide reef system.

By 2005, individual regions showed between 20% and 60% coral cover. By 2006 coral cover of 80% on some individual reefs was observed. In brief, coral cover recovered from the mass bleaching within five years, indicating a high resilience to such events.

In 2007 some localised coral damaging factors, such as COTS and Drupella snail predation, and a small amount of White Syndrome Disease, were observed, and in some regions, coral cover had started to decrease (Mamanucas, Savusavu and Suva).

An increase in coral lifeform diversity was noticed from 1999 to 2007. This may be due to the "forest fire" effect, whereby large-scale removal of corals such as the fast growing *Acropora*, which normally occupy a large area of reef, allows settlement and new growth of a wider variety of coral forms. In time these corals may once more be overgrown by new *Acropora* growth, or out competed by other corals.

This pattern of increasing diversity was identified by the use of "Lifeform" categories of corals (English et al. 1997) during surveys, rather than simple "Reef Check" substrate categories (Reef Check, 2007). The "Reef Check" categories proved very valuable in allowing non-specialist divers to collect data from a wide variety of sites, thus allowing regional comparisons to be made. Where more specialised divers were in the field, "Lifeform" category data provided a much better picture of changes within the coral communities. In particular, the vulnerability of *Acropora* species to catastrophes such as bleaching, COTS and cyclones was evident, and the following swift recovery of these corals was documented (Figure 8). In some cases where overall coral cover did not change very much, alterations in community composition still showed responses to catastrophes that would not have been picked up by simpler surveys.

3.2 Fish

Fiji has a wide variety of coral reef fish species (Seeto, J. and Baldwin, W.J. Unpublished) and in many areas these occur in large numbers. The surveys in this report were limited to "Reef Check" indicator groups, which target the fish families most likely to be impacted by small scale local fisheries. Reefs in close proximity to villages showed the impacts of heavy subsistence and small-scale commercial fishing, in the lack of, or low numbers of grouper, sweetlips, parrotfish and wrasse of any size.

No major changes in fish assemblages were noticed over the period of survey, although more detailed surveys (Sykes, H. and MacKay, K., personal observations, January 2008) suggest that certain obligate corallivores and coral-dwellers were reduced in numbers in the years immediately following the mass coral bleaching of 2000 to 2002, but that numbers have since recovered.

Anecdotal accounts (Watts, A. and Hill, A., personal communications, December 2007) suggest that numbers of large pelagic fish such as mackerel, tuna and sharks are decreasing across the country, presumably due to over fishing by larger commercial boats such as long-liners.

3.3 Invertebrates

These surveys recorded "Reef Check" indicator groups, which target macro invertebrates most likely to be impacted by small scale local fisheries, and those which affect algal cover (Diadema urchins) and coral health (COTS). Reefs in close proximity to villages showed the impacts of heavy subsistence and small scale commercial fishing, in the lack of, or low amount of sea cucumbers and giant clams. Both sea cucumbers, which are actively collected, and Diadema urchins, which are not, decreased in density between 2002 and 2007.

Since October 2006, a dive operator in the Mamanuca Islands, (Mott, J., personal communication, January 2008) has been carrying out a COTS removal programme over four dive sites. They have kept excellent data of number of COTS removed and minutes of dive time spent, allowing calculations of total number of COTS seen, and also Catch Per Unit Effort (CPUE), expressed as number of COTS found per minute search (Appendix 18). Almost 2,000 COTS per month were removed from four dive sites, with the highest numbers seen in the warmer parts of the year, November to February (Appendix 19). CPUE suggested that by late 2007 more time was needed to find each COTS, indicating that density had reduced. This could be due to the combination of removal efforts and a decrease of desirable food (Acropora coral species).

3.4 Water Temperature

Normal average daily sea water temperatures in the Fiji Islands vary between 24 and 31°C annually, but through the day temperatures may rise as far as 36°C and fall as low as 22°C, particularly on shallow reefs (Bonito, V., personal communication, December 2007). Temperatures vary with latitude; reefs above 17° South experiencing temperatures one to two degrees higher than those at 19° South.

In the past there has been a correlation between elevated water temperatures in the South West Pacific and "La Nina" events associated with the ENSO oscillations. (Khan, Z., personal communication, December 2007). A strong La Niña is predicted for 2008, (McGree, S., Fiji Meterological office, personal communication, December 2007) and in 2007 the water temperature patterns were very similar to those of 1999, preceding the elevated water temperatures and mass bleaching event of 2000, supporting this prediction.

Extensive hard coral mortality due to coral bleaching has been experienced in Fiji when daily summer average water temperatures above 29°C occur for more than 75 consecutive days. This is predicted for 2008, unless cyclones and storms significantly lower sea water temperatures.

4

CURRENT RESOURCE USE

4.1 Community resource use

The Fiji Locally Managed Marine Area (FLMMA) network comprises resource practitioners from government, non-government organisations and communities, which started in 2001, but formally registered in 2004. Currently, FLMMA is working in around 270 villages throughout Fiji's provinces.

Averages of socioeconomic survey results from the 29 Institute of Applied Science (IAS) co-managed LMMA sites are presented.

For a typical site or village, the average number of houses 54 (SD of 73), with an average household size of five and an average village population of 312 people. Village composition by gender showed that around 64% of the village populations are females. In-migration into a village is low (5.2%) and is usually through marriage. Out-migration by village members is also low (7%) and can also be attributed to marriage and/or a search for better education and standard of living.

Average monthly income for all 29 villages is FJD$636, mostly from the sale of root crops (kava, taro, etc) and marine resources (fish, sea cucumbers), and other paid employment. Most households in a village harvest marine resources for consumption at home and partially for selling, whilst a small proportion of a community are solely commercial fishers. The main fishing gear used by men include spear and nets, while women mainly use nets and fishing lines and glean the reef.

Major threats to fishing grounds, as noted from village management plans, include overfishing (resulting in the rare to no sighting of certain fish and invertebrates), dumping household wastes into the sea or along the coast, sedimentation as a result of logging and forest clearing, and poor farming practices. Poaching in marine protected areas is also a problem. Other threats include liquid pollution from piggery waste and washing effluents. Villages are working with partner organisations to implement practical solutions to such problems (Ron Vave and Alifereti Tawake, personal communication, September, 2008).

4.2 Coral Reef Species

Near-shore coral reefs are the most exploited marine ecosystems in Fiji, targeted by subsistence and small-scale commercial fisheries, coral harvesting, and tourism.

Customary marine resource owners rely heavily on the reefs for subsistence, livelihood and sources of income. Fishing is the main source of protein for rural communities, and as such finfish and macro-invertebrates, are actively harvested. In addition, licensed commercial fishers target finfish and invertebrates for local markets, sea cucumbers for the Asian market and Trochus shell for button production. An estimated 5,994 tonnes of fish and invertebrates were recorded from market outlets in 2005 (2005 draft Annual Report, Fiji Fisheries Department).

Small fish, invertebrates, corals, and fossil substrate covered with coralline algae ("Live Rock") are collected, mainly along the coast of the main island of Viti Levu, for the aquarium trade. This is managed under the Convention on International Trade in Endangered Species (CITES) (Lovell 2001, Sykes et al 2002,). In terms of volume, live rock and coral are two of the most important products in the marine aquarium trade, and interest in these two products, and in other ornamental species, is growing worldwide. In 2004 Fiji supplied about 161,927 pieces of hard and soft coral and 1.36 million pieces of live rock to overseas markets, mainly in the USA, Hong Kong, Japan and Europe. Fiji also exported 169,143 ornamental fish and 31,900 invertebrates (CITES database with the Fiji Fisheries Department, July 2005). There is a growing international concern over the environmental effects of live coral and live rock harvests from the wild. Worldwide, harvest of these products from the wild is generally considered to have detrimental effects on the ecology of coral reef ecosystems and on the coastal fisheries supporting many rural communities (Lal, P. and Cerelala, A., 2005).

Figure 18: Porites boulder corals for sale for septic tank construction in the Greater Suva district

In the vicinity of the capital city of Suva, there is a very active trade in extracting Porites boulder corals, which are used for lining septic tanks.

Tourism is the largest overseas income generator in the country, (Ministry of Information, 2005) and also the largest non-extractive user of the coral reef resource. Over 75% of all tourists entering the country experience some form of marine based activity, whether it be swimming, snorkelling or SCUBA diving, (Ministry of Lands, Industrial Relations, Tourism and Environment, 2007a), and the image of pristine beaches and clear water is central to the industry. Some extractive activities are involved in the trade, specifically hand-line fishing, game fishing, and shell market visits.

4.3 Turtles

Seven species of turtles inhabit the Pacific with five of these found in Fiji (Batibasaga et al., 2003). These are Green (*Chelonia mydas*), Hawksbill (*Eretmochelys imbricate*), Leatherback (*Dermochelys coriacea*), Loggerhead (*Caretta caretta*) and Olive Ridley turtles. The endangered marine turtle not only plays a key role in the ecology of the marine ecosystem but, importantly, is also revered in culture and customs around the globe (Guinea, 1993). Pacific Islanders have strong cultural relationships with, and traditional knowledge of marine turtles (Morgan, 2007; Guinea, 1993).

The noticeable decline in marine turtles in the Pacific has been a concern over the years (Weaver, 1996). Marine turtles have long been recognised as vulnerable to development impacts, as well as being of considerable cultural importance to many Pacific Island countries (Adam, 2003). Batibasaga et al. (2003) estimated the population number of nesting marine turtles in Fiji as follows: 50-75 nesting green turtles, 150-200 hawksbill turtles, and 20-30 leatherback turtles with no recordings of nesting loggerhead turtles.

In Fiji, there is a turtle moratorium in place under the Fisheries Act. The moratorium lays a total ban on the subsistence use of turtle, turtle egg and any commercial trading of its meat and derivatives. There is an exemption for traditional purposes or utilisation of turtles granted on request to the Minister. The continuing lack of enforcement of national legislation may enhance the increasing rate of exploitation leading to the ongoing decline in the turtle population (Jit, 2007; Laveti, 2008).

4.4 Mangroves

Mangrove forests fringe many of Fiji's coastlines, particularly in the north of Vanua Levu. Fiji has nine species of mangrove trees: *Rhizophora stylosa* (Tiri); *Rhizophora samoensis* (Tiri wai); *Rhizophora selala* (sterile hybrid); *Bruguiera gymnorrhiza* (Dogo); *Lumnitzera littorea* (Sagali); *Heritiera littoralis* (Kedra viv na yalewa kalou); *Excoecaria agallocha* (Sinu gaga); and *Xylocarpus granatum* (Dabi) (Watling, D. and Chape, 1992).

Coastal mangroves are now considered so important that in some areas attempts have been made to replant cleared areas. This has been carried out under projects run by organisations such as the Japanese NGO, the Organization for Industrial, Spiritual and Cultural Advancement (OISCA).

Traditional uses of mangroves include harvesting of invertebrates such as the Mangrove Crab *Scylla paramamosain* (Qari) and Mud Lobster *Thalassina anomala* (Mana), for subsistence and small scale commercial trade, and wood for fuel and building purposes. On larger islands, much of the back forest has been cleared to the high tide mark for agriculture, and coastal development is now threatening much of the remaining tidal and estuarine stands through clearance and reclamation.

A proposed mangrove management plan is being developed as a guideline for sustainable use of mangrove areas within tourism developments (Sykes, H. 2007a).

4.5 Seagrass

Fiji has extensive seagrass beds on sandy areas of the fringing reef flats. There are three main species, *Syringodium isoetifolium*, *Halodule uninervis* and *Halodule pinifolia*, plus smaller amounts of *Halophilia ovalis*. These areas are important habitats and traditional collecting grounds for many fish and invertebrates, including shellfish such as ark shells *Anadara cornea* (Kaikoso), edible sea urchins *Tripnuestes gratilla* (cawaki), and Sea Hares *Dolabella auricularia* (Veata). Fiji's seagrass beds are important feeding ground for turtles, and so are instrumental in the survival of these species, including those from as far afield as American Samoa and French Polynesia which do not have such feeding beds (Craig 2002, Craig et al. 2004).

The main impacts on seagrass beds over the past few years have been from coastal and over-water developments, mainly for tourism and residential properties, causing sedimentation from inadequately controlled construction activities and increased boat traffic. In addition channel blasting, lagoon dredging and over-water construction have destroyed some seagrass beds. (Sykes and Reddy, 2007).

4.6 Deepsea species

The tuna industry is the largest export section of the Fiji fisheries industry (Ministry of Information, 2005), and large scale commercial fishing exists in the region, ostensibly targeting tuna stocks, but also involving catches of non-target species such as dolphin-fish, mackerel and shark. The total catch by domestic long-line fleet (catches inside and outside the Exclusive Economic Zone) during 2005 was 13,010mt of which 11,313mt were tuna species and 1697mt were non-target pelagic species. There was a substantial reduction in albacore and bigeye tuna catches and under-reporting of non-target species during this year (2005 draft Annual Report, Fiji Fisheries Department).

4.7 Endangered species

The Fiji Endangered and Protected Species Act was passed by the government of the day in December 2002. This Act is a requirement of the Convention on International Trade in Endangered Species (CITES) in order to regulate and control the domestic and international trade of species protected under CITES.

The humphead wrasse *Cheilinus undulatus* (Varivoce) has recently been added to Appendix II of CITES, through which trade must be controlled in order to avoid utilisation incompatible with their survival (CITES 2007). Under this regulation, all trade in the humphead wrasse has been banned throughout Fiji although this species still appears in local market outlets.

The bumphead parrotfish *Bolbometopon muricatum* (Ula rua) is facing extinction in Fiji due to overfishing, and there has been an observed reduction in the past decade in areas where large schools were previously commonly sighted.

Turtles are heavily threatened in Fiji, as a result of a long standing tradition and interest in turtle hunting, despite several government attempts at bans and controls. (See previous section on turtles). In addition, many nesting beaches are being targeted by resort development, and there is no government legislation to control or ameliorate this.

Sea cucumbers have been over-collected in many areas (Batibasaga and Vana, 1995). Under present conditions, collectors, using SCUBA or "Hookah" surface supplied compressed air, travel to an area and collect large numbers of commercially valuable sea cucumbers in a short period, before moving on to the next location. This practice results in the removal of most sea cucumbers from a reef, resulting in adverse impacts on the reef ecosystem and a reduction in breeding stock. In addition, there have been human casualties in the form of permanent paralysis from decompression sickness.

Giant Clams *Tridacna squamosa* and *T. derasa* (vasua) are collected on shallow reef tops for subsistence use and for sale. As a result, numbers are reduced on many reefs.

Humpback whales pass though the islands in June and July on their way to the breeding grounds of Tonga. They do not remain in Fiji waters for long. Minke, Pilot and False Killer whales are frequently reported from scattered areas, as well as Bottle-nosed and Spinner Dolphins. Dolphins and all other Cetaceans (whales) are under Appendix 1 of CITES, as species threatened with extinction. As such, all trade in these species is banned, and they cannot be imported into, or exported or re-exported from, signatory countries, except in exceptional circumstances. In particular, they may not be traded in for commercial purposes.

5
THREATS TO CORAL REEFS/ MANGROVES/SEAGRASS

5.1 Integrated Threat Analysis

An Integrated Threat Analysis was carried out using a modification of the "Reefs at Risk" methods (Bryant et al. 1998; Burke et al. 2000). Modifications reflect local conditions in the small Island states of the South West Pacific Node, where detailed technical information is often not available, or where threats that may not apply in other regions may exist. In this analysis, potential threats to reef health in areas of the country where data is gathered are assessed in five categories, and then integrated into a single threat score, where threats are rated as High, Medium, Low or Very Low (Appendices 9-17).

The integrated threat analysis shows that areas under highest threat are those near centres of urban development, or concentrated agricultural use. The reefs with the lowest threat index are those remote from shore and population centres. It should be remembered that this index does not reflect current or past damage to reefs, but the potential damage that could occur from the factors considered. These threat ratings are a useful tool in reef management, as they may be used as a focus for reef conservation policies. This is discussed further in the section "Recommendations".

5.2 Coastal development

Coastal development does not affect all the reefs of Fiji, but has the potential to threaten reef health in areas around cities, townships, and the regions where large-scale tourism development is concentrated. In such regions, threats are largely related to physical construction practices which may involve direct reef degradation, reduced water quality due

Table 5: Integrated threat index for 15 regions of the Fiji Islands

INTEGRATED THREAT INDEX						
Reef Area	**Coastal Development**	**Pollution**	**Sediment Damage**	**Over-fishing**	**Destructive Fishing**	**Overall Threat Index Score**
Viti Levu, Suva	Medium	Very High	High	High	Medium	Very High
Viti Levu, Coral Coast	Medium	Medium	High	High	High	High
Viti Levu, Momi Bay	Medium	High	High	High	Medium	High
Viti Levu, Lautoka	Medium	Very High	High	High	Medium	Very High
Vanua Levu, Savusavu	Medium	Very High	High	High	Medium	Very High
Vanua Levu, Namena	Very Low	Very Low	Medium	Low	Very Low	Medium
Vatu-i-Ra	Very Low	Very Low	Very Low	Low	Very Low	Low
Lomaiviti	Low	Very Low	Medium	Medium	Low	Medium
Kadavu	Low	Very Low	Medium	High	Low	Medium
Beqa	Low	Very Low	Medium	High	Low	High
Mamanuca Is	Low	Medium	Medium	High	Low	High
Yasawa Is	Low	Low	Medium	High	Medium	High
Taveuni, Somosomo	Very Low	Low	Very Low	Low	Very Low	Low
Taveuni, Waitabu	Low	Very Low	Medium	Low	Very Low	Medium
Rotuma	Low	High	Medium	High	Medium	High

to inadequate sewage and waste water treatment, and increased usage of the reef resource, such as for subsistence, recreation swimming, and commercial exploitation.

In Fiji, development is largely concentrated on the coast, and is increasing rapidly, in particular for tourism. There is relatively little development inland. Increasing urbanisation means that a higher percentage of the population is concentrated in the towns and cities every year. In the Suva city area, "reclamation" of reef flats to create new coastal land is occurring and, in some tourism areas, there is an increase of reef flat dredging and channel cutting (Sykes, H. and Reddy, C., 2007).

There is a relatively new trend towards large "integrated resort developments" (IRDs), where resorts are paired with dense areas of residential house lots, involving concentrated development along coastal frontage. The new Tourism Development Plan for Fiji (Ministry of Labour, Industrial Relations, Tourism and Environment 2007a) suggests zoning these IRDs towards the Coral Coast and Nadi-Lautoka corridor on Viti Levu, and limiting development on more pristine areas to lower density developments.

5.3 Pollution

Fiji is fortunate in being physically remote from large industrialised landmasses, and in not having large-scale manufacturing processes. Industrial pollution is confined mainly to small industrial areas in the main cities and towns. In addition, decrepit boats litter areas of Suva Harbour, and regular groundings and sinkings occur, adding oil and other pollutants to the marine environment. In Lautoka and Savusavu, pollution risks are relatively low and limited to small-scale spillages from broken fuel drums etc, although occasional ferry groundings on reefs in Rotuma and Ba have occurred in recent years.

Large amounts of litter and rubbish can be found in port areas, often washed down from poor rubbish disposal in neighbouring urban areas. Inadequate sewage treatment has resulted in extremely high bacterial levels in many harbours (Coreless, M. 1995). Such poor waste management practices lead to high levels of domestic rubbish finding their way into the marine environment.

5.4 Sedimentation, nutrient enrichment and eutrophication

One of the largest threats to coastal fringing reefs, especially in the most populated and developed urban areas, the coral coast of Viti Levu, and the islands of the Mamanuca and Yasawa chains, is eutrophication (algal overgrowth). This is attributed to a combination of nutrient enrichment, over-fishing of herbivorous animals, and/or sedimentation. On the north and west coasts of the two largest islands, it is probably related to large-scale sugar cane agriculture. This has caused soil erosion into rivers and creeks, and an influx of nutrients from the use of chemical fertilizers, that wash into waterways during high rainfall (Mosley and Aalbersberg, 2003, Pareti, S., 2006).

These factors have resulted in long-term ecological shifts away from coral reefs to alga-dominated platforms along the coral coast, and large seasonal algal drifts in the Mamanucas and Yasawa Islands. In Beqa lagoon, water clarity is usually high, except at times of high rainfall, when sediment-loaded water from the Navua River on Viti Levu is washed down (Sykes, H., 2007b).

In more remote areas, the influence of these factors is minor, and water quality is high, except around bird islands, where sea bird nesting colonies have resulted in high levels of nutrients retarding coral growth (Sykes, H., 2007b).

5.5 Overfishing

As with other Pacific Island countries, a large proportion of Fiji's rural dwellers depend on subsistence fishing for their daily protein, and fishing on fringing reef flats is frequent (Bell et al. 2008). Fiji's population has increased dramatically, and fishing gear and techniques have improved, resulting in increased fishing pressures for subsistence and commercial purposes, ultimately leading to over-fishing of stocks, especially those of high commercial value. One of the major threats to customary owned fishing grounds, as noted from village management plans, included overfishing (resulting in the rare to no sighting of certain fish and invertebrates) (Ron Vave, personal communication, August 2008).

5.6 Destructive fishing and coral harvesting

Dynamite (blast) fishing is not normally used in Fiji, except for a small number of fishers in the northern and western parts of Viti Levu. The practice has diminished due to dynamite becoming harder to obtain (as mining decreases) and through better enforcement by the Fisheries Department. Cyanide fishing is not practiced, but "Duva" or Derris vine is used as an herbal fish-stunning poison in shallow rock pools. This practice may retard new coral settlement on limited areas of reef flats. In addition, household bleach is sometimes used to kill freshwater prawns in rivers.

The aquarium trade is responsible for removing ornamental fish and corals from collection areas around the coastline of Viti Levu, but this is largely done using best practices on a small scale in relation to the entire fishing ground. Collection of "live rock" from reef flats along the Coral Coast involves deliberate breakage of the fossil reef substrate in order to collect dead coral covered with pink and purple coralline algae. This results in localised damage to shallow areas of fringing reef flats. Some live coral is inevitably broken during this process, but is not deliberately targeted. Research into the impacts of this activity has suggested that it involves habitat disturbance (Lovell E., 2001a) and is certainly incompatible with tourism activities concentrated in the same areas. Some traders are now concentrating on culturing "artificial" live rock to reduce the amount of natural rock collected in this way.

Reef walking and coral trampling during subsistence fishing activities results in localised coral damage on shallow water reef flats close to communities. Anchoring of small boats for small scale commercial fishing also creates considerable coral breakage on near-shore reef slopes (Helen Sykes, personal observations, December 2007).

5.7 Bleaching, coral disease and predators

In 2000, 2002 and, to a smaller degree, in 2005, the South West Pacific was exposed to long periods of elevated sea water temperatures, resulting in differing degrees of coral bleaching across the region. In Fiji the 2000 event resulted in between 40% and 80% mortality of hard coral across the archipelago (Cumming et al. 2002). In 2002 another bleaching occurred in certain areas and in 2005 a much smaller event affected reefs surrounding only a few islands. The coral bleaching threshold for Fiji is considered to be 29.5°C (NOAA 2008), and large-scale mortality occurred when water temperatures remained consistently above 29°C for periods of three months (Lovell and Sykes 2007).

Long term monitoring of coral cover showed that on many reefs coral cover returned to pre-bleaching levels within five years of the main bleaching event (Sykes, H., 2006). NOAA Sea Surface Temperature Data (SST) suggests that the past decade has been significantly warmer than the previous one (NOAA 2008), and the trend appears to continue, with 2007 temperature data from in-water loggers being one, to one and a half degrees higher than the normal average (Appendix 6 and 7). Overall, Fiji's reefs appear to be very vulnerable to temperature-related coral bleaching, which probably occurs to some degree every year (Sykes, H., 2006 and personal observations Jan 2008). Fiji reefs also show resilience, with enough resistant and tolerant areas to assist full recovery from mortality within five years.

Little coral disease has been observed on Fiji's reefs, probably due in part to the physical remoteness from large land masses and other reef systems. White syndrome has been observed more since the 2000 bleaching, but it is possible that this is due more to increased levels of observance during reef surveys, than to an actual increase in incidence.

Predation from Crown of Thorns (COTS) and corallivorous snails occurs across the archipelago in what appears to be regular outbreaks, probably linked to increasing coral cover. This has been best documented on the Suva reefs (Zann and Brodie 1992) and in the Mamanuca Islands (Sykes, H., 2006; J Mott. Personal observations. January 2008) where there were outbreaks in times of high coral cover (pre bleaching mortality), followed by reduction in numbers when coral cover was low, and subsequent new outbreaks once coral cover, particularly Acropora corals, increased. This appears to occur every eight to 10 years, but is probably more closely linked to coral cover (ie. food supply) than any other factor. Removal and poisoning programmes have been tried in the Mamancua Islands, with limited success.

5.8 Hurricanes/tsunamis

As an island nation, Fiji is theoretically vulnerable to tsunamis, but these have not occurred very frequently or with major damaging consequences in the recent past. Two Tsunami warnings in the past five years did not eventuate in actual tsunami waves.

Eleven tsunamis have been recorded in Fiji, three of these generated within Fiji waters. The most damaging tsunami, caused by an earthquake offshore Suva, was in 1953 with wave heights in the capital of about 2m and about 5m in Kadavu. A small tsunami was generated in 1975 by a moderate earthquake in the Kadavu Passage. (Ministry of Lands and Mineral Resources, 2008).

The cyclone season is considered to be between November to April each year, although in reality cyclones rarely reach the islands outside January to May. They cause terrestrial damage to Fiji every two or three years. However, to date, cyclones have apparently not had major adverse impacts on the marine environment. (Fiji Meteorological Service 2008).

Cyclone and high storm wave damage was observed on limited areas of shallow reefs in 2001, 2003 and 2004 confined to small areas of shallow, Acropora-dominated coral, which have usually returned to high cover levels within a couple of years (Sykes, H., 2006).

After the mass bleaching-related mortality of 2000, Cyclone Paula of 2001 (Fiji Met. Service Office 2008) appeared to serve a positive function by removing dead coral rubble and scouring away algae, creating clean substrate for new coral settlement in 2002. (Helen Sykes, personal observation February 2002) In addition, this cyclone occurred at a time when water temperature had been elevated above 29^{o}C for over a month, and some coral bleaching had appeared. During the cyclone, the water temperature fell by over 1^{o}C and did not return to pre-cyclone levels, which may have prevented a more severe bleaching event (Appendix 6).

5.9 Outbreak of organisms

COTS and Drupella are discussed in the previous section.

Colonial Ascidians (*Didemnum spp*) occurred in large single-species overgrowths in some areas, particularly shallow, degraded reef flats. Initially this was presumed to be an end-stage of reef damage, as natural control mechanisms such as predators appeared to be small. However, in most cases, these overgrowths disappeared within four years of being noticed, although detailed surveys were not carried out and no explanation is available (Helen Sykes, 2005, personal observations, February 2001 and December 2007).

Encrusting sponges were also to be found in some reef flat areas and have the potential to smother new coral growth. To date such overgrowths have been locally confined and do not represent a large threat to coral reef health, but have presented a problem to some coral restoration projects.

6
CURRENT CORAL REEF CONSERVATION EFFORTS

Many NGOs and educational organisations (University of the South Pacific) are involved in their own conservation projects, and some coral culture and restoration projects are in their second or third years (Lovell and Sykes 2007).

Fiji is a signatory to several conservation-based conventions, including the Convention on International Trade in Endangered Species (CITES) and the Convention on Biological Diversity (CBD). Unfortunately, the country's political problems over the last few years have resulted in actions and legislation attached to such conventions being repeatedly deferred.

The Department of Environment produced a National Biodiversity Strategy and Action Plan (Ministry of Labour, Industrial Relations, Tourism and Environment 2007) which draws together several reports on Fiji's biodiversity, along with recommended plans of action, including an initial list of sites of national significance. This document could become the basis of future environmental protection plans.

The Department of Tourism has published a Tourism Development Plan to coordinate development policy over the next eight years (Ministry of Labour, Industrial Relations, Tourism and Environment 2007), which includes zoning tourism in different regions of Fiji. This is intended to minimise environmental impacts in the more pristine regions. The plan has been accepted in principle, but regulations have yet to be drawn up.

The Fiji government has committed to protect and sustainably manage 30% of its marine ecosystems by the year 2020 (Tawake A, personal communication April 2008). As yet a firm definition of exactly what this will entail has not been formulated, but a large part of the commitment is being met by government support of the Fiji Locally Managed Marine Areas network (FLMMA).

In the last 10 years, community-managed marine protection has spread across the islands through FLMMA. There are now more than 205 known community-managed marine sites in 116 of the 411 traditional fishing grounds (i-qoliqoli). These "tabu" or protected areas range in size from 0.3 to 40.5 km^2, with an average size of 9.7 km^2, involving 28.8% of Fiji's i-qoliqoli area (Tawake A, December 2007). Some are open-ended, fully protected no-take areas. Others are of limited duration, or for a limited number of species, but all involve utilising traditional systems of management to protect marine resources for both biodiversity conservation and preservation of future fishing stocks for the communities involved.

To date, full government recognition (gazetting) has been slow, but many areas are recognised at the level of their local provincial council and traditional leaders. Through these small reserves, adjoining fishing grounds, fish and invertebrates have the chance to grow to breeding size and populations may be preserved into the future. Although their ecological function may be slight, there is now a move to consolidate these areas into larger Ecological Based Management zones (EBMs) (Macuata WWF and WCS Fiji project). Small FLMMA sites are being organised into larger functional groups under Yaubula Management Support Teams in the provinces of Kadavu and Cakaudrove (Tawake, A., and Meo, S., personal communication, December 2007).

7
FUTURE OF CORAL REEF HEALTH

Fiji could be regarded as having two types of stressors on coral reef health: "chronic" and "acute".

The "chronic" conditions are local man-made continual stresses that occur over long periods of time, and vary only in severity of onslaughts. Into this category come over-fishing, coastal development, sedimentation and nutrient enrichment. The effects of these pressures are gradual, and insidious, slowly degrading coral health over time, thus creating a "shifting baseline". They are often treated as an unavoidable or even acceptable cost of economic development, and are often overlooked or unaddressed.

"Acute" problems are largely global issues impacting reef health quite severely but for short periods of time, allowing for some recovery between onslaughts. These include predation, variations in temperature, and cyclones. Because these stresses affect reef health suddenly, they are more dramatic, more noticeable, and attract more attention than the "chronic" conditions, and are frequently blamed for coral reef degradation.

It is likely that Fiji will experience one or two "acute" coral reef damaging events within the next 10 years, and cycles in coral cover will become apparent. Widespread coral bleaching and increasing COTS outbreaks are predicted for 2008 and/or possibly 2009/2010. If the reef follows the patterns observed since 1999, this would result in one or two years of poor reef health across the country in 2009/2010, after which a period of regeneration could return coral cover to current levels by about 2014. This presumes that COTS outbreaks and La Nina conditions do not start to occur more frequently than current observations suggest.

"Chronic" conditions could have greater effect than the more obvious "acute" events, particularly if political instability continues to hinder implementation of environmental measures to control impacts. Coastal development is expanding; without proper legislation and action, sedimentation, nutrient enrichment and overfishing are likely to reduce some coastlines currently enjoying reasonable or good coral reef health, to degraded and fish-poor areas similar to those already seen on the Coral Coast of Viti Levu. Uncontrolled mangrove clearing could be one of the greatest threats to Fiji's reef population in the next 10 years.

The FLMMA network expands exponentially, and this is probably the most effective measure in Fiji's reef "first aid kit". As community knowledge spreads, and customary owners of fishing rights become more active in conserving their own resources, more practical protection for reef populations is achieved. Small, isolated "tabu" areas are starting to join up into larger managed areas, as on the island of Kadavu and in the district of Cakadrove. Hopefully, as this trend continues, the people of Fiji will become responsible custodians of the reefs on a larger scale. In this case although overfishing and development may continue along much of the coastline, small "oases" of protected reefs may be able to conserve reef stocks, both for biodiversity and local fishing resource purposes.

8 RECOMMENDATIONS

Fiji's marine environment is constantly changing in response to the numerous stressors. However, its reefs have shown remarkable levels of resilience to various stresses and impacts. There is an urgent need for government policymaking support and commitment, but this can only be useful if it is coupled with adequate resources for education and compliance enforcement.

Reef management and conservation initiatives have proliferated in Fiji over the past decade, and within the FLMMA network the value of cooperation between agencies working in the field has been achieved. Better communications and cooperation between agencies reduces duplication of work and enables centralisation of data and lessons learned. If Fiji is to have an effective and united marine conservation policy, such cooperative efforts must be strengthened and enhanced.

It has also become obvious from these studies that there is a need for continuity of long-term monitoring if patterns are to be made visible. Six years of monitoring has shown recovery from a single bleaching event, and some consequences of storm damage, but it will most likely take 10 to 15 years of data collection to make regular cycles apparent. Short-term projects allow snapshots of reef health. Without long-term support, these are only disconnected data spots. The value of long-term monitoring of regularly visited sites has become apparent, but can only be realised if resources to fund monitoring are committed well into the future.

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APPENDICES

Appendix 1: Details of survey sites across the country

Site Names	Region	Latitude (WGS 84)	Longitude (WGS 84)	Reef Type	Reef Zone	Depth	Years Surveyed
E6	Vatu-i-Ra	17°19'S	178°35'E	Sea Mount	Slope	12m	1999, 2000, 2001, 2002, 2004, 2006, 2007
Mount Mutiny	Vatu-i-Ra	17°20'S	178°31'E	Sea Mount	Slope	7m	1999, 2000, 2001, 2002, 2004, 2006, 2007
Cat's Meow	Vatu-i-Ra	17°08'S	178°31'E	Patch	Flat	16m	2004, 2006, 2007
Human Nature	Vatu-i-Ra	17°08'S	178°31'E	Patch	Slope	5m	2004, 2006, 2007
Rob's Knobs	Vatu-i-Ra	17°15'S	178°34'E	Patch	Flat	12m	2000, 2001
Tetons	Namena	17°06'S	179°03'E	Sea Mount	Flat	5m	2004, 2007
Two Thumbs Up	Namena	17°06'S	179°03'E	Patch	Flat	16m	2001, 2004, 2006, 2007
Anthias Avenue	Lomai Viti Gau	17°58' S	179°13'E	Patch	Flat	7m	1999, 2000, 2001, 2002, 2004, 2006, 2007
Lion's Den	Lomai Viti Wakaya	17°34'S	178°56'E	Barrier	Flat	7m	1999, 2000, 2001, 2007
Rick's Rocks	Lomai Viti Makogai	17°24'S	178°56'E	Lagoon Patch	Flat	6m	2006, 2007
Samu's Reef	Lautoka	17°33' S	177°18'E	Patch	Slope	10m	2004, 2007
Great White Wall	Taveuni Somosomo Straits	16°47'S	179°54'E	Barrier	Flat	10m	2002, 2003, 2004, 2005, 2006, 2007
Rainbow Reef	Taveuni Somosomo Straits	16°45'S	179°56'E	Barrier	Slope	10m	2002, 2003, 2004, 2005, 2006, 2007
Waitabu Marine Park	Taveuni East	16°48"S	179°50'W	Fringing	Flat	5m	1998, 1999, 2002, 2003, 2005, 2006, 2007
Golden Nuggets	Savusavu	16°18'S	179°17'E	Patch	Slope	5m 10m	2002, 2003, 2004, 2005, 2006, 2007
Lighthouse	Savusavu	16°48'S	179°17'E	Barrier	Slope	5m 10m	2002, 2003, 2004, 2005, 2006, 2007
Mystery	Savusavu	16°48' S	179°14'E	Barrier	Slope	5m 10m	2002, 2003, 2004, 2005, 2006, 2007
Cousteau Jetty	Savusavu	16°48'S	179°17'E	Fringing	Flat	2m	2002, 2003, 2004, 2005, 2006, 2007
Fish Patch	Suva	18°09'S	178°24'E	Barrier	Slope	5m 10m	2002, 2003, 2004, 2006, 2007
Dennis Patch	Suva	18°10'S	178°25'E	Lagoon Patch	Slope	5m	2003, 2004
Muiavuso	Suva	18°08'S	178°22'E	Fringing	Flat	2m	2002, 2003, 2004
Nukuboca	Suva	18°11'S	178°28'E	Fringing	Flat	2m	2002
Sea Fan / Storm Island	Beqa	18°20'S	178°08'E	Patch	Slope	5m 10m	2007
Clint's Corner	Beqa	18°26'E	178°08'E	Fringing	Slope	5m	2007
Tukituki	Coral Coast	18°10'S	177°35'E	Fringing	Slope	10m 15m	2006, 2007
Cowrie Crawl	Coral Coast	18°11'S	177°36'E	Fringing	Slope	10m 15m	2006, 2007
The Edge	Coral Coast	18°10'S	177°40'E	Fringing	Slope	15m	2006, 2007
Eagle Rock	Kadavu	19°03'S	178°20'E	Barrier	Slope	10m	2005, 2006, 2007
Vesi Bay	Kadavu	19°02'S	178°27'E	Fringing	Slope	5m	2006, 2007
Momi Bay	Nadi	17°56'S	177°12'E	Barrier	Slope	5m	2000, 2001
Whiskey Reef	Yasawas	16°57'S	177°19'E	Patch	Slope	10m	2002, 2003, 2006
Wonderland	Yasawas	16°52'S	177°23'E	Patch	Flat	5m	2002, 2003, 2006
Sunflower	Mamanucas	17°47'S	177°12'E	Patch	Slope	7m	2005, 2006
Various coastal sites	Rotuma	12°30'S	179°04'E	Fringing	Slope	5m 10m	2003, 2006

Appendix 2: Survey methods used in regular survey regions

Region	Benthic cover	Fish	Invertebrates	In-water temperature loggers (depth)
Vatu-i-Ra	20m Reef Check and AIMS	20m Expanded Reef Check 45min or 50m Fish species census	20m Reef Check	At 5m since 1996
Namena	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 21m since 2005 and 1m and 16m since 2006
Lomai Viti	20m Reef Check and AIMS	20m Expanded Reef Check 45min or 50m Fish species census	20m Reef Check	At 2m since 2005
Lautoka	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	1.5m since 2004
Taveuni West	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 10m since 2003 and 30m since 2006
Taveuni East	20m Reef Check and AIMS	20m Expanded Reef Check 45min or 50m Fish species census	20m Reef Check	At 5m since 2003
Savusavu	20m Reef Check	20m Reef Check	20m Reef Check	At 7m since 2006
Suva	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 10m since 2003 At 5m, 14m and 30m since 2006
Beqa	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 8m since 2004, at 8m and 17m since 2007
Coral Coast	20m Reef Check	20m Expanded Reef Check	20m Reef Check	At 1m, 12m, and 30m since 2006
Kadavu	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 10m since 2005 and at 5m since 2006
Nadi	20m Reef Check	20m Reef Check	20m Reef Check	At 6m since 2005
Yasawas	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 5m and 10m since 2006
Mamanucas	20m Reef Check and AIMS	20m Expanded Reef Check	20m Reef Check	At 5m and 10m since 2006
Rotuma	20m Reef Check	20m Reef Check	20m Reef Check	Since 2003

Appendix 3: Survey teams contributing data and support

Region	Regular and annual surveys	Occasional and newly started surveys	One-off and opportunistic surveys
Vatu-i-Ra	Resort Support / Marine Ecology Consulting, Nai'a Cruises		
Namena	Resort Support / Marine Ecology Consulting, Nai'a Cruises	Wildlife Conservation Society	
Lomai Viti	Resort Support / Marine Ecology Consulting, Nai'a Cruises	Frontier Fiji	
Lautoka	Resort Support / Marine Ecology Consulting, Nai'a Cruises	Biological Consultants Walt Smith International	
Taveuni West	Resort Support / Marine Ecology Consulting, Aquatrek at Garden Island Resort		
Taveuni East	Resort Support / Marine Ecology Consulting, Waitabu Marine Park		
Savusavu	Jean Michel Cousteau Fiji Resort		
Suva	University of the South Pacific	Resort Support	
Beqa	Resort Support / Marine Ecology Consulting, Lalati Resort	Bruce Carlson	
Coral Coast	Resort Support / Marine Ecology Consulting, Aquasafaris Diveaway, Hideaway Resort		
Kadavu	Resort Support / Marine Ecology Consulting, Matava Resort	Coral Cay Conservation	Survey of North and Great Astrolabe Reef 2001 (Obura and Mangubhai 2003)
Nadi	Biological Consultants		
Yasawas	Resort Support / Marine Ecology Consulting, Nanuya Island Resort		
Mamanucas	Resort Support / Marine Ecology Consulting, Subsurface Fiji	Coral Cay Conservation	
Rotuma		Laje Rotuma	
Northern Vanua Levu		Greenforce	Survey of Great Sea Reef 2004 (Jenkins et al 2004)
Lau			Resort Support / Marine Ecology Consulting

Appendix 4: COTS outbreak levels recorded on FCRMN sites 2002 – 2007

(Where table is blank, surveys were not carried out)

	2002	2003	2004	2005	2006	2007
Beqa		None	Spot outbreak			Spot outbreak
Cakau levu			Non-outbreak			
Coral Coast	Spot outbreak				Non-outbreak	Active outbreak
Kadavu				None	None	Non-outbreak
Lautoka	None	None				Non-outbreak
Lomai Viti		Spot outbreak			Spot outbreak	Spot outbreak
Mamanuca Islands			Spot outbreak		Active outbreak	Active outbreak
Namena						Non-outbreak
Rotuma					Non-outbreak	
Savusavu	Spot outbreak	None	None	None	None	Spot outbreak
Suva Harbour		Spot outbreak	Spot outbreak		None	Active outbreak
Taveuni Somosomo						
Taveuni Waitabu	None	None	None	None	Spot outbreak	Spot outbreak
Vatu-i-Ra			None		None	None
Yasawas	None	None			None	Spot outbreak

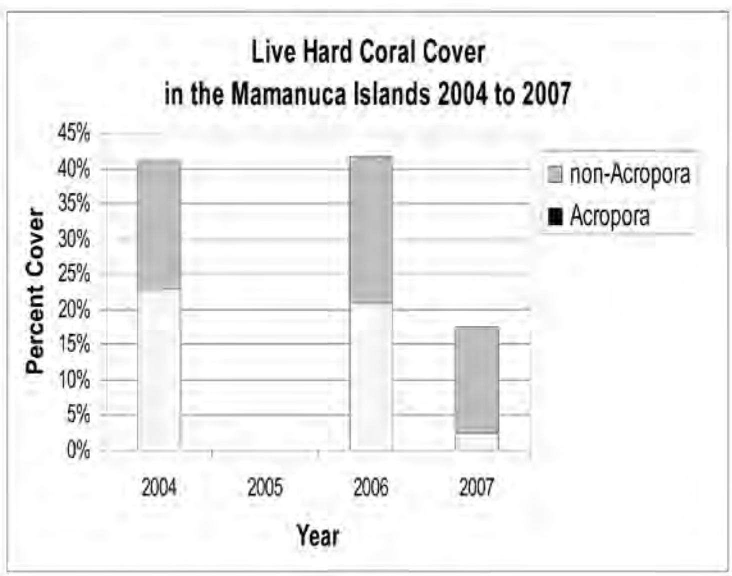
Non-outbreak = COTS present but <30 COTS /hectare (<0.3/100m^2)

Incipient outbreak = high density of juveniles

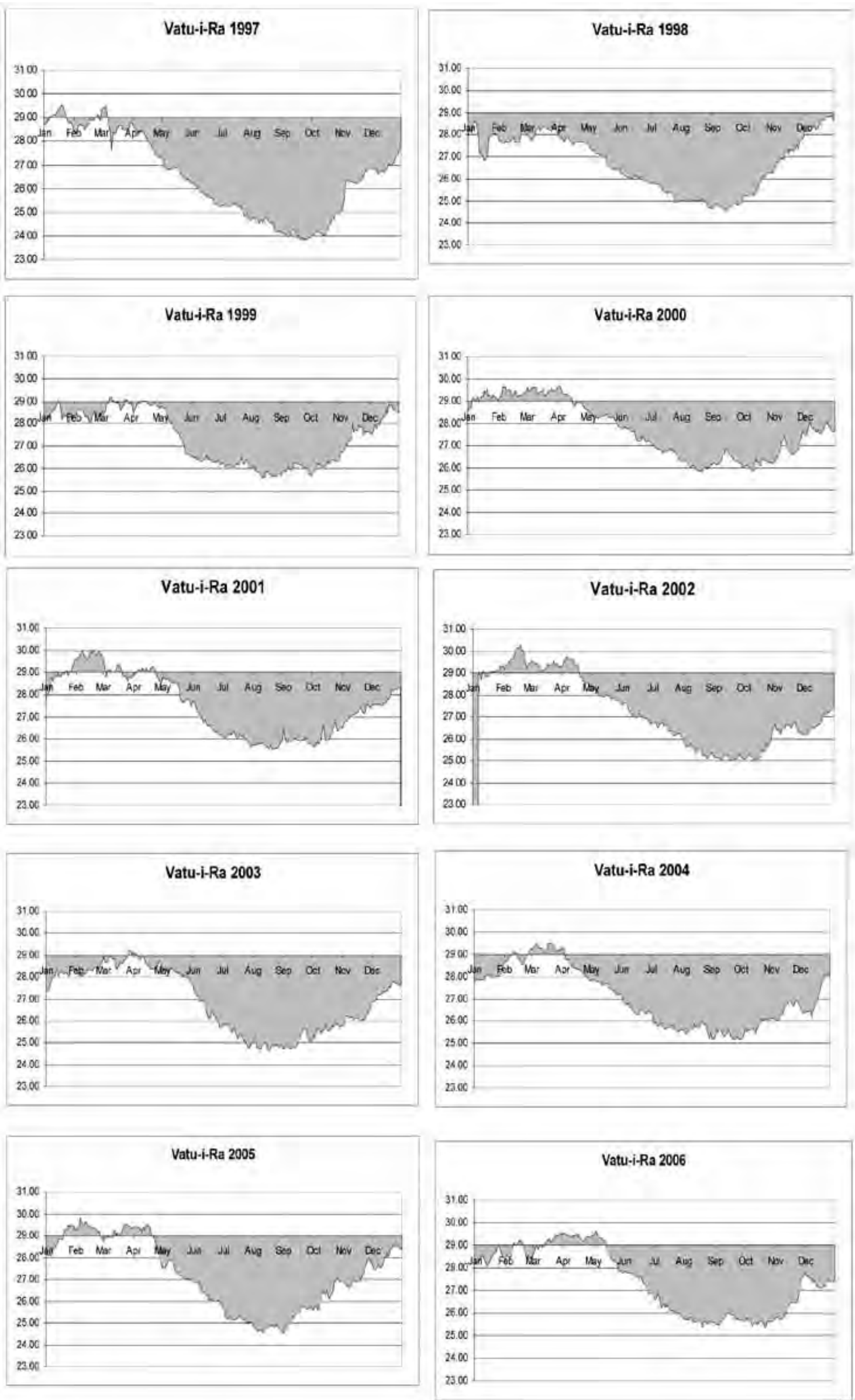
Spot outbreak = high density of COTS on parts of reef, low numbers elsewhere

Active outbreak = >30 COTS per hectare (>0.3/100m^2)

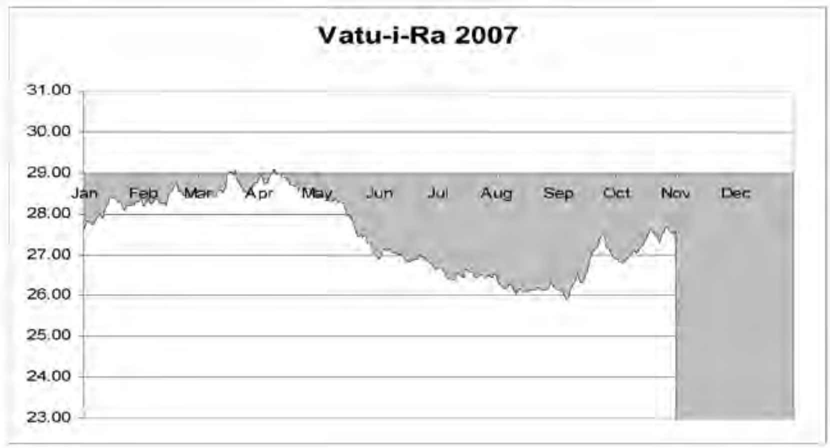
Appendix 5: Live hard coral cover in the Mamanuca Islands during the COTS outbreak of 2004 to 2007 (No survey was carried out in 2005)



Appendix 6: Daily average water temperature at 10m deep in the Vatu-Ra passage 1997 to 2006



Appendix 7: Daily average water temperature at 10m deep in the Vatu-i-Ra passage in 2007. Note the end of reading in Nov. as the logger was retrieved.



Appendix 8: : Threat index criteria for coastal development

	< 4km away	4 – 10km away	10 - 25km away	More than 25km away
Cities, Population > 100,000	High	High	Medium	Low
Cities, Pop 50,000 – 100,000	Medium	Medium	Low	Very Low
Towns, Population < 50,000	Medium	Medium	Low	Very Low
Airports (in use)	Medium	Medium	Very Low	Very Low
Mines	High	High	Very Low	Very Low
Tourist resorts and dive centres	Medium	Very Low	Very Low	Very Low
Any Coastline (shore)	Low	Very Low	Very Low	Very Low

Appendix 9: Threat index for coastal development for 15 regions of the Fiji Islands

a) Coastal Development							
Reef Area	**Cities**	**Towns**	**Airports**	**Mines**	**Tourism**	**Coastline**	**Overall Score (Highest record)**
Viti Levu, Suva	Medium	-	Very Low	-	Medium	Low	Medium
Viti Levu, Coral Coast	-	Very Low	Very Low	-	Medium	Low	Medium
Viti Levu, Momi Bay	-	Very Low	Very Low	-	Medium	Low	Medium
Viti Levu, Lautoka	-	Medium	Very Low	-	Medium	Low	Medium
Vanua Levu, Savusavu	-	Medium	Very Low	Low	Medium	Low	Medium
Vanua Levu, Namena	-	Very Low	Very Low	-	Very Low	Very Low	Very Low
Vatu-i-Ra	-	Very Low	Very Low	-	Very Low	Very Low	Very Low
Lomaiviti	-	Very Low	Very Low	-	Very Low	Low	Low
Kadavu	-	Very Low	Very Low	-	Very Low	Low	Low
Beqa	-	Very Low	Very Low	-	Very Low	Low	Low
Mamanuca Is	-	Very Low	Very Low	-	Medium	Low	Low
Yasawa Is	-	Very Low	Very Low	-	Medium	Low	Low
Taveuni, Somosomo	-	Very Low	Very Low	-	Very Low	Very Low	Very Low
Taveuni, Waitabu	-	Very Low	Very Low	-	Very Low	Low	Low
Rotuma	-	Low	Very Low	-	Very Low	Low	Low

Appendix 10: Threat index criteria for marine-based pollution

	< 4km away	**4 – 10km away**	**10 – 30km away**	**30 – 50km away**
Ports, Large (Container ships, tankers, fishing ships etc, e.g. Suva)	High	High	High	Medium
Ports, Medium (Fishing ships etc e.g. Port Villa)	High	High	Medium	Very Low
Ports, Small (Yachts and personal boats)	High	Medium	Very Low	Very Low
Ports, Very small (Local outboard boats)	Medium	Very Low	Very Low	Very Low
Oil storage tanks, refineries	High	Medium	Very Low	Very Low
Shipping Lanes	Medium	Low	Very Low	Very Low

Appendix 11: Threat index for marine-based pollution for 15 regions of the Fiji Islands

b) Marine-Based Pollution				
Reef Area	Ports	Oil Tanks	Shipping lanes	Overall Score (Highest recorded)
Viti Levu, Suva	High	High	High	Very High
Viti Levu, Coral Coast	Medium	Very Low	Low	Medium
Viti Levu, Momi Bay	High	Medium	High	High
Viti Levu, Lautoka	High	High	High	Very High
Vanua Levu, Savusavu	High	High	High	Very High
Vanua Levu, Namena	Very Low	Very Low	Very Low	Very Low
Vatu-i-Ra	Very Low	Very Low	Very Low	Very Low
Lomaiviti	Very Low	Very Low	Very Low	Very Low
Kadavu	Very Low	Very Low	Very Low	Very Low
Beqa	Very Low	Very Low	Very Low	Very Low
Mamanuca Is	Medium	Very Low	Low	Medium
Yasawa Is	Very Low	Very Low	Low	Low
Taveuni, Somosomo	Very Low	Very Low	Low	Low
Taveuni, Waitabu	Very Low	Very Low	Very Low	Very Low
Rotuma	High	Medium	Medium	High

Appendix 12: Threat index criteria for pollution and sedimentation

Vegetation type

Large scale croplands	High
Urban and built-up	High
Areas with little vegetation	High
Permanent wetland (Swamp)	Medium
Grassland	Medium
Open Shrubland mixed with grass	Medium
Cropland mixed with natural vegetation	Medium
Small, dry islands with coconuts and salt bush	Medium
Dense planted forest	Low
Mixed Forest	Low
Dense Shrubland	Low
Dense natural forest	Very Low

Steepness of land slope near reef

Steep	Medium
Moderate	Low
Slight	Very Low
Flat	Very Low

Other contributing factors

	Mining	**Deforestation**	**Agriculture**	**Livestock**
Commercial	High	High	Medium	Medium
Domestic			Low	Low

Appendix 13: Threat index for pollution and sedimentation for 15 regions of the Fiji Islands

c) Pollution and Sedimentation					
Reef Area	Vegetation		Steepness	Factors	Overall Score (Highest recorded)
	Type	Score	Score	Score	Score
Viti Levu, Suva	Urban	High	Medium	High	High
Viti Levu, Coral Coast	Cropland / Urban	High	Low	High	High
Viti Levu, Momi Bay	Cropland	High	Low	High	High
Viti Levu, Lautoka	Urban	High	Low	High	High
Vanua Levu, Savusavu	Urban	High	Medium	High	High
Vanua Levu, Namena	Island	Medium	Medium	Very Low	Medium
Vatu-i-Ra	-	Very Low	Very Low	Very Low	Very Low
Lomaiviti	Forest	Low	Medium	Low	Medium
Kadavu	Forest	Low	Medium	Low	Medium
Beqa	Forest	Low	Medium	Medium	Medium
Mamanuca Is	Island	Medium	Low	Low	Medium
Yasawa Is	Island	Medium	Medium	Low	Medium
Taveuni, Somosomo	-	Very Low	Very Low	Very Low	Very Low
Taveuni, Waitabu	Cropland mixed	Medium	Medium	Low	Medium
Rotuma	Forest	Very Low	Medium	Low	Medium

Appendix 14: Threat index criteria for artisanal overfishing

Record Threat as High, Medium, Low or Very Low

	Closer than 10km away	10 – 20km away	More than 20km away	Marine Protected Area within 10km
Coastal population	High	Medium	Low	Low

Appendix 15: Threat index for artisanal overfishing for 15 regions of the Fiji Islands

d) Overfishing (Local fisheries, not large-scale commercial)		
Reef Area	Score	Notes on Marine Protection
Viti Levu, Suva	High	
Viti Levu, Coral Coast	High	
Viti Levu, Momi Bay	High	
Viti Levu, Lautoka	High	
Vanua Levu, Savusavu	High	
Vanua Levu, Namena	Low	Large Recreational (diving) use Marine Protected Area (no take area)
Vatu-i-Ra	Low	Far from shore / inaccessible to most local fishing
Lomaiviti	Medium	
Kadavu	High	
Beqa	High	
Mamanuca Is	High	
Yasawa Is	High	
Taveuni, Somosomo	Low	Far from shore / inaccessible to most local fishing
Taveuni, Waitabu	Low	Small Locally Managed Marine Protected Area (no take area)
Rotuma	High	

Appendix 16: Threat index criteria for destructive fishing

	Several times a week	Several times a month	Several times a year	Never
Dynamite	High	Medium	Low	Very Low
Poison (Cyanide or Chlorox)	High	Medium	Low	Very Low
Poison (Herbal)	High	Medium	Low	Very Low
Direct coral breakage (trampling, excavation, harvesting)	High	Medium	Low	Very Low

Appendix 17: Threat index for destructive fishing for 15 regions of the Fiji Islands

e) Destructive Fishing (Poisons or blast) Note: herbal poisons refer to traditional "Duva" or Derris, only used on shallow reef tops, not deeper reefs.					
Reef Area	**Dynamite**	**Chemical Poisons**	**Herbal Poison**	**Breakage**	**Overall Score (Highest recorded)**
Viti Levu, Suva	-	-	Low	Medium	Medium
Viti Levu, Coral Coast	-	-	High	High	High
Viti Levu, Momi Bay	-	-	Medium	Low	Medium
Viti Levu, Lautoka	Medium	-	Low	Medium	Medium
Vanua Levu, Savusavu	-	-	Medium	Low	Medium
Vanua Levu, Namena	-	-	Very Low	-	Very Low
Vatu-i-Ra	-	-	Very Low	-	Very Low
Lomaiviti	-	-	-	Low	Low
Kadavu	-	-	Low	Low	Low
Beqa	-	-	Low	Low	Low
Mamanuca Is	-	-	Low	Low	Low
Yasawa Is	-	-	Medium	Low	Medium
Taveuni, Somosomo	-	-	-	-	Very Low
Taveuni, Waitabu	-	-	-	-	Very Low
Rotuma	-	-	Medium	Low	Medium

Appendix 18: Number of COTS removed from four dive sites in the Mamanuca Islands October 2007 to October 2007

Month	**Number COTS removed**
October 2006	1766
November 2006	3429
December 2006	1052
January 2007	5623
February 2007	2310
March 2007	593
April 2007	457
May 2007	276
June 2007	1831
July 2007	938
August 2007	1668
September 2007	1147
October 2007	1072
Total COTS removed in 13 months	22,261
Monthly average	1,712

Appendix 19: Average hard coral cover in regions of Fiji 2005, 2006 and 2007

Region	Year	Average	Std dev	N (Sites)
Beqa	2005			0
	2006			0
	2007	0.44	0.10	6
Coral Coast	2005			0
	2006	0.31	0.12	5
	2007	0.34	0.05	5
Kadavu	2005	0.40		1
	2006	0.35	0.07	5
	2007	0.45	0.06	2
Lautoka	2005			0
	2006			0
	2007	0.41		1
Lomaiviti	2005			0
	2006	0.28	0.10	5
	2007	0.37	0.16	2
Mamanucas	2005			0
	2006	0.45		1
	2007	0.18		1
Namena	2005			0
	2006	0.45		1
	2007	0.65		1
Rotuma	2005			0
	2006	0.57	0.07	2
	2007			0
Savusavu	2005	0.49	0.03	4
	2006	0.44	0.04	4
	2007	0.33	0.03	3
Suva	2005			0
	2006	0.33	0.31	2
	2007	0.22	0.13	2
Taveuni	2005	0.46	0.10	2
	2006	0.32	0.06	3
	2007	0.36	0.07	3
Vatu-i-Ra	2005			0
	2006	0.58	0.11	4
	2007	0.60	0.10	4
Yasawas	2005			0
	2006	0.34	0.01	2
	2007	0.43	0.08	2

Appendix 20: Average key fish density in regions of Fiji 2005, 2006 and 2007

Region	Year	Average							
		Butterfly fish	Sweetlips	Snapper	Grouper	Parrot fish	Moray eel	Humphead wrasse	Bumphead parrot
Beqa	2005								
	2006								
	2007	9.50	0.00	0.25	0.96	1.88	0.00	0.00	0.00
Coral Coast	2005								
	2006	4.05	0.00	1.90	0.85	3.80	1.00	0.00	0.90
	2007	6.40	0.15	2.10	1.45	5.20	0.05	0.10	0.05
Kadavu	2005	2.00	0.00	0.50	0.00	4.50	0.00	0.00	0.00
	2006	3.54	0.00	1.00	0.39	3.60	0.00	0.23	0.02
	2007	3.13	0.00	0.13	0.63	3.50	0.00	0.00	0.00
Lautoka	2005								
	2006								
	2007	4.50	0.00	0.00	0.25	7.25	0.00	0.00	0.00
LomaiViti	2005								
	2006	4.88	0.00	41.50	0.63	6.13	0.00	0.00	0.00
	2007	7.83	0.00	1.17	0.38	2.67	0.00	0.17	0.00
Mamanucas	2005								
	2006	5.67	0.33	22.67	0.67	10.33	0.00	0.00	0.00
	2007	5.00	0.00	23.67	1.67	11.00	0.00	0.00	0.00
Namena	2005								
	2006								
	2007	6.00	0.00	0.00	2.00	4.00	0.00	0.00	0.00
Rotuma	2005								
	2006	3.87	0.61	2.73	0.71	11.36	0.02	0.07	0.90
	2007								
Savusavu	2005	5.19	0.00	0.19	0.50	3.56	0.00	0.00	0.00
	2006	9.19	0.50	0.94	0.33	6.15	0.00	0.00	0.00
	2007	8.33	0.92	2.50	0.50	8.25	0.17	0.00	0.00
Suva	2005								
	2006	6.63	0.00	0.00	0.25	2.50	0.00	0.00	0.00
	2007	3.13	0.00	0.00	0.00	2.25	0.13	0.13	0.00
Taveuni	2005	10.75	0.00	1.00	3.50	11.75	0.00	0.25	0.00
	2006	6.75	0.13	7.13	2.50	7.25	0.00	0.13	0.00
	2007	4.50	1.83	14.17	0.83	10.67	0.00	0.25	0.00
Vatu-i-Ra	2005								
	2006	6.67	0.50	0.67	0.25	4.04	0.00	0.00	0.00
	2007	4.19	0.06	0.88	0.13	2.56	0.00	0.00	0.00
Yasawas	2005								
	2006	2.88	0.25	0.38	0.13	4.38	0.00	0.00	0.00
	2007	3.75	0.00	0.50	0.00	3.75	0.00	0.00	0.00

Appendix 21: Site numbers (n) and standard deviations key fish density in regions of Fiji 2005, 2006 and 2007

Region	Year	N	Stdev							
			Butterfly fish	Sweetlips	Snapper	Grouper	Parrot fish	Moray eel	Hump-head wrasse	Bumphead parrot
Beqa	2005	0								
	2006	0								
	2007	6	5.00	0.00	0.50	1.24	1.46	0.00	0.00	0.00
Coral Coast	2005	0								
	2006	5	3.09	0.00	2.07	1.05	3.33	2.24	0.00	2.01
	2007	5	3.69	0.22	1.72	0.99	4.00	0.11	0.22	0.11
Kadavu	2005	1								
	2006	4	0.49	0.00	1.45	0.12	0.42	0.00	0.35	0.03
	2007	2	1.24	0.00	0.18	0.18	1.41	0.00	0.00	0.00
Lautoka	2005	0								
	2006	0								
	2007	1								
LomaiViti	2005	0								
	2006	4	4.40	0.00	83.00	0.75	6.28	0.00	0.00	0.00
	2007	2	6.36	0.00	0.24	0.18	0.00	0.00	0.24	0.00
Mamanucas	2005	0								
	2006	1								
	2007	1								
Namena	2005	0								
	2006	0								
	2007	1								
Rotuma	2005	0								
	2006	2	0.42	0.36	1.73	0.41	1.57	0.02	0.10	0.89
	2007	0								
Savusavu	2005	4	2.18	0.00	0.24	0.58	3.01	0.00	0.00	0.00
	2006	4	0.38	0.46	1.09	0.47	2.02	0.00	0.00	0.00
	2007	3	0.38	0.52	2.41	0.25	1.32	0.14	0.00	0.00
Suva	2005	0								
	2006	2	4.07	0.00	0.00	0.35	1.77	0.00	0.00	0.00
	2007	2	0.18	0.00	0.00	0.00	1.41	0.18	0.18	0.00
Taveuni	2005	1								
	2006	2	0.00	0.18	9.02	1.41	2.47	0.00	0.18	0.00
	2007	3	2.88	3.18	13.63	0.88	6.39	0.00	0.00	0.00
Vatu-i-Ra	2005	0								
	2006	2	0.47	0.71	0.94	0.35	3.24	0.00	0.00	0.00
	2007	4	0.55	0.13	0.25	0.25	1.20	0.00	0.00	0.00
Yasawas	2005	0								
	2006	2	0.88	0.00	0.53	0.18	0.88	0.00	0.00	0.00
	2007	2	1.77	0.00	0.71	0.00	0.35	0.00	0.00	0.00

Appendix 22: Average key invertebrate density in regions of Fiji 2005, 2006 and 2007

Region	Year	Average								
		Banded coral shrimp	Diadema urchins	Pencil urchin	Sea cucumber	Crown-of-Thorns star	Triton shell	Tripneustes urchin	Lobster	Giant Clam
Beqa	2005									
	2006									
	2007	0.00	0.04	0.00	0.08	0.00	0.04	0.00	0.00	0.08
Coral Coast	2005									
	2006	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05
	2007	0.00	0.05	0.00	0.00	0.10	0.00	0.00	0.05	0.05
Kadavu	2005	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	2006	0.00	2.07	0.00	0.06	0.01	0.02	0.00	0.00	0.32
	2007	0.00	0.00	0.13	0.00	0.13	0.00	0.00	0.00	0.13
Lautoka	2005									
	2006									
	2007	0.00	0.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Lomaiviti	2005									
	2006	0.00	0.25	0.13	1.13	0.25	0.00	0.00	0.00	0.63
	2007	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.25
Mamanucas	2005									
	2006	0.00	0.00	0.00	0.33	1.33	0.00	0.00	0.00	0.00
	2007	0.00	0.00	0.00	0.33	1.00	0.00	0.00	0.00	0.00
Namena	2005									
	2006									
	2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Rotuma	2005									
	2006	0.00	0.00	0.00	0.29	0.00	0.00	0.02	0.00	0.12
	2007									
Savusavu	2005	0.00	1.00	0.00	0.50	0.00	0.00	0.00	0.06	0.13
	2006	0.44	18.69	0.00	0.38	0.00	0.00	0.00	0.06	0.31
	2007	0.67	29.25	0.08	0.42	0.08	0.17	0.00	0.50	0.50
Suva	2005									
	2006	0.00	0.00	0.00	0.88	0.00	0.00	0.25	0.00	0.00
	2007	0.00	0.00	0.00	0.00	0.38	0.25	0.00	0.00	0.00
Taveuni	2005	0.00	2.00	0.00	0.25	0.00	0.00	0.00	0.00	0.25
	2006	0.00	12.63	0.00	0.00	0.00	0.00	0.00	0.00	0.63
	2007	0.00	12.50	0.00	0.17	0.00	0.08	0.00	0.08	0.08
Vatu-i-Ra	2005									
	2006	0.00	0.00	0.00	0.13	0.00	0.00	0.00	0.00	0.13
	2007	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Yasawas	2005									
	2006	0.00	57.50	0.00	2.00	0.00	0.00	0.00	0.00	0.00
	2007	0.00	75.00	0.00	0.00	0.50	0.00	0.00	0.00	0.13

Appendix 23: Site numbers (n) and standard deviations key invertebrate density in regions of Fiji 2005, 2006 and 2007

Region	Year	N	Stdev								
			Banded coral shrimp	Diadema urchin	Pencil urchin	Sea cucumber	Crown-of-thorns star	Triton shell	Tripneustes urchin	Lobster	Giant Clam
Beqa	2005	0									
	2006	0									
	2007	6	0.00	0.10	0.00	0.20	0.00	0.10	0.00	0.00	0.13
Coral Coast	2005	0									
	2006	5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
	2007	5	0.00	0.11	0.00	0.00	0.22	0.00	0.00	0.11	0.11
Kadavu	2005	1									
	2006	4	0.00	3.03	0.00	0.08	0.02	0.02	0.00	0.00	0.22
	2007	2	0.00	0.00	0.18	0.00	0.18	0.00	0.00	0.00	0.18
Lautoka	2005	0									
	2006	0									
	2007	1									
Lomaiviti	2005	0									
	2006	4	0.00	0.50	0.25	1.03	0.50	0.00	0.00	0.00	0.75
	2007	2	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.35
Mamanucas	2005	0									
	2006	1									
	2007	1									
Namena	2005	0									
	2006	0									
	2007	1									
Rotuma	2005	0									
	2006	2	0.00	0.00	0.00	0.30	0.00	0.00	0.02	0.00	0.01
	2007	0									
Savusavu	2005	4	0.00	1.08	0.00	0.54	0.00	0.00	0.00	0.13	0.14
	2006	4	0.38	28.78	0.00	0.60	0.00	0.00	0.00	0.13	0.31
	2007	3	0.72	28.01	0.14	0.29	0.14	0.14	0.00	0.25	0.25
Suva	2005	0									
	2006	2	0.00	0.00	0.00	0.88	0.00	0.00	0.35	0.00	0.00
	2007	2	0.00	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00
Taveuni	2005	1									
	2006	2	0.00	15.73	0.00	0.00	0.00	0.00	0.00	0.00	0.88
	2007	3	0.00	19.53	0.00	0.29	0.00	0.14	0.00	0.14	0.14
Vatu-i-Ra	2005	0									
	2006	2	0.00	0.00	0.00	0.18	0.00	0.00	0.00	0.00	0.18
	2007	4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.31
Yasawas	2005	0									
	2006	2	0.00	60.10	0.00	2.47	0.00	0.00	0.00	0.00	0.00
	2007	2	0.00	35.36	0.00	0.00	0.71	0.00	0.00	0.00	0.18

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Kadavu Astrolabe	Simon Harding, Coral Cay Conservation Ltd. sh@coralcay.org, www.coralcay.org
Mamanucas COTS	Jodie Mott, Reef Safaris gm@reefsafari.com
Rotuma	Teri Tuxson. Monifa Fiu, Sydney Malo LajeRotuma Initiative www.rotuma.net/os/lajerotuma.htm
Savusavu	Mike Greenfelder, Johnny Singh, Marine Biologists; Jean-Michel Cousteau Resort Fiji Islands, fiji4fun@connect.com.fj, biologist@fijiresort.com
Suva Harbour	Ed Lovell, Yashika Nand, University of the South Pacific Lovell_e@usp.ac.fj, yashika_nand@yahoo.com.au
Weather and La Nina	Simon McGree Principal Scientific Officer, Climate Services Division, Fiji Meteorological Service simon.mcgree@met.gov.fj, www.met.gov.fj
All other data	Helen Sykes, Director Chinnamma Reddy, Field Scientist Marine Ecology Consulting, Resort Support Helen@marineecologyfiji.com www.marineecologyfiji.com, www.resortsupportfiji.com
Turtle information	Merewalesi Laveti, Marine Science Researcher, Institute of Marine Resources, USP. laveti_m@usp.ac.fj
Diving support	
Beqa	Lalati Resort, www.lalati-fiji.com
Coral Coast	Diveaway/Hideaway Resort, www.diveaway-fiji.com Aquasafari, www.aquasafarifiji.com
Mamanucas	Subsurface/Musket Cove Resort, www.fijidiving.com
Yasawas	Nanuya Island Resort, www.nanuyafiji.com
Vatu-i-Ra, Namena, Lomai Viti – Gau	Nai'a cruises, www.naia.com.fj
Taveuni – Ss Straits	Aquatrek/Garden Island Resort, www.aquatrek.com
Taveuni – East	Waitabu Marine Park, www.boumafiji.com
Kadavu – South	Matava Resort, www.matava.com

THE STATUS OF CORAL REEFS IN NEW CALEDONIA 2007

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Funded by IFRECOR

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EXECUTIVE SUMMARY

One of the world's largest coral reef systems is to be found in New Caledonia. With 150 reef types, 7,284km of coral constructions and approximately 40,000km of lagoon area, this seascape was considered for World Heritage listing in 2007.

The country's first coral reef observatory, Reseau d'Observation des Recifs Coralliens (RORC), was founded in 1997 in the South Province, and was responsible for coral reef monitoring using Reef Check methods adapted to the local environment. Its operations ceased two years later due to a lack of funding. However, with financial support from IFRECOR (French Initiative for Coral Reefs), the observatory (30 stations) was reactivated in 2003 and the sampling zone extended to all of New Caledonia's reefs. To reinforce capacity and motivation for monitoring on a long-term basis, two facilitators were recruited as resource persons for training and data processing.

In 2006-2007, 10 sites (and 30 stations) were monitored. From samplings taken, the overall coral reef health status was considered good for eight stations (27%), satisfactory for 18 stations (60%), and average for four stations (13%). Reefs in average stations had high sedimentation from estuaries where there were mining activities, fishing, or particular geomorphologic characteristics. The status of most of the stations remained stable during the period from 2003-2006, with a few exceptions. There was deterioration at three stations and improvements at two. The long-term variations observed since 1997 at the Nouméa site (6 stations) have been satisfactory since the first survey in 1997, with the exception of Maitre. Ten years later, in 2007, the station had improved from average to satisfactory.

In 2001, 1,212 tonnes of marine resources, mainly fish (690 tonnes) were exploited.. The main effects of tourism are to be felt around the capital, Nouméa, and on islands that are cruise ship stopovers. Yachting has a higher impact on coral reefs close to Nouméa and the major villages. MPAs (covering more than 420km^2) have been created, most of them with moorings, to limit damage. Coral reefs are also affected by mining activities and sewage. However, new management policies (extracting procedures, wastewater treatment plant and disposal areas) are being implemented to limit these impacts.

I
COUNTRY INFORMATION

New Caledonia is located in the South West Pacific, 1,500km east of Australia and 2,000km north of New Zealand. The New Caledonia archipelago is comprised of the Main Island (Grande Terre), the four Loyalty Islands (Ouvéa, Lifou, Tiga and Maré), the Belep archipelago, the Isle of Pine, the Entrecasteaux reefs, the Chesterfield archipelago and some remote reefs (Durand, Walpole, Mathew and Hunter). The country has a tropical climate cooled by the trade winds.

New Caledonia's population was 230,789 - 9.5% in the Loyalty Islands, 19.3% in the Northern Province of the Main Island, and 71.2% in the Southern Province of the Main Island. Forty per cent of inhabitants live in the capital, Nouméa. The gross domestic product (16,900 per habitant) is similar to West European countries. New Caledonia holds 25% of the known nickel reserves, with nickel exports accounting for 90 to 95% of the country's total exports.

It has one of the largest and the most diversified coral reef systems in the world totaling 7,284km of coral constructions (Andrefouet et al. 2006) and around 40,000km of lagoon area (Clavier et al. 1995), of which 23,400km surrounds the Main Island (Testau and Conand 1983). One hundred and fifty reef types are to be found (Andrefouet et al. 2006), from fringing reefs to oceanic reefs, and the longest continuous, and second largest barrier reef (1,600km length) in the world.

Background

A monitoring initiative launched in 1997 used Reef Check methods adapted to the local environment (Wantiez in press). The study area was limited to the Southern Province of New Caledonia that funded the programme (18 stations). Surveys were completed in 1997, 1998, and 2001.

In 2003, IFRECOR (French Initiative for Coral Reefs) financed a new phase of the programme for four years, and the sampling zone was extended to all New Caledonia reefs. Between 2003 and 2006, 30 stations were assessed each year. Six of these stations have been sampled since 1997.

2
CURRENT PHYSICAL CONDITION OF CORAL REEFS

2.1 Monitoring

2.1.1 Issues

The Southern Province authorities funded the first monitoring initiative in 1997 and created the Observatoire des Récifs Coralliens (ORC), which carried out surveys using a modified Reef Check version. A private consulting agency (T&W Consultants) was responsible for recruitment and training of volunteers, and monitoring and data analysis. Stations were selected in sites affected by agricultural, mining or urban activities as well as their respective control sites. However, the operation of the ORC was not successful resulting in the surveys being interrupted.

In New Caledonia, definitions of the sampling unit are slightly different from the other node countries. Where the other countries refer to region, New Caledonia refers to it as site. Where the other countries mention site, New Caledonia refers to it as station.

In 2001, the authorities of the Southern Province reactivated the survey of the site located near Nouméa (6 stations). This was done by Laurent Wantiez (University of New Caledonia), who trained the guards of the South Lagoon Marine Park and wrote the status report. Mr Wantiez began conducting the surveys in 2002. From 2003 to 2005, he received assistance from Aquarium des Lagons of the Réseau d'Observation des Récifs Coralliens (RORC), which was created and funded by IFRECOR (French Initiative for Coral Reefs) for four years. The surveys were extended to all New Caledonian coral reefs. Volunteers (trained by Garrigue and Virly Consultants) participated in the surveys and in compiling the status report. Twenty-four stations were sampled each year between 2003 and 2005. From 2006 to 2007, IFRECOR decided to fund the RORC for two more years hence the survey continued.

Results of the 2006-2007 survey are pooled by site and presented.

2.1.2 Method

A modified Reef Check method was used. At each station a 100m long transect was laid on the reef at a constant depth. Four 20m sections were identified along the transect with a 5m gap between sections. Fish, invertebrates and substrate were sampled within the four sections.

Fish abundances are sampled per species group within each section in a 2.5m width each side of the transect line. The size is estimated in 4 size-classes: 0-5cm, 6-15cm, 16-30cm and >30cm. The following species groups and codes are recorded:

- Butterfly fish (Chaetodontidae): CHA.
- Painted sweetlips (*Diagramma pictum*): CAS.
- Other sweetlips and grunts (Haemulidae): AGL.
- Coral trout (*Plectropomus leopardus*): SAU.
- Humpback grouper (*Cromileptes altivelis*): TRU.
- Speckled grouper (*Epinephelus cyanopodus*): BLE.
- Other groupers (Epinephelinae): ALO.
- Humphead parrotfish (*Bolbometopon muricatum*): BOS.

- Other parrotfish (Scaridae): APE.
- Humphead wrasse (*Cheilinus undulatus*): NAP.
- Emperors (Lethrinidae): BEB.
- Bluespine unicornfish (*Naso unicornis*): DAW.
- Other surgeonfish and rabbitfish (Acanthuridae and Siganidae): API.

Invertebrates abundances are sampled per species group within each section in a 2.5m width each side of the transect line. The following species groups were recorded:

- Giant clams (*Tridacna spp*): BEN.
- Trochus (*Trochus niloticus*).: TRO
- Triton trumpet (*Charonia tritonis*): TOU.
- Spiny lobsters: LAN.
- Slipper lobsters: CEP.
- Crown-of-thorns starfish (*Acanthaster planci*): ACA.
- Other starfish: AEM.
- Greenfish (*Stichopus choloronotus*): STI.
- Sand fish (*Holothuria scabra*): HOL.
- Prickly redfish (*Thelenota ananas*): THE.
- Other sea cucumbers: ABM.
- *Diadema setosum*: DIA.
- Pencil urchins (*Heterocentrus mammilatus*): CRA.
- Other urchins: AOU.

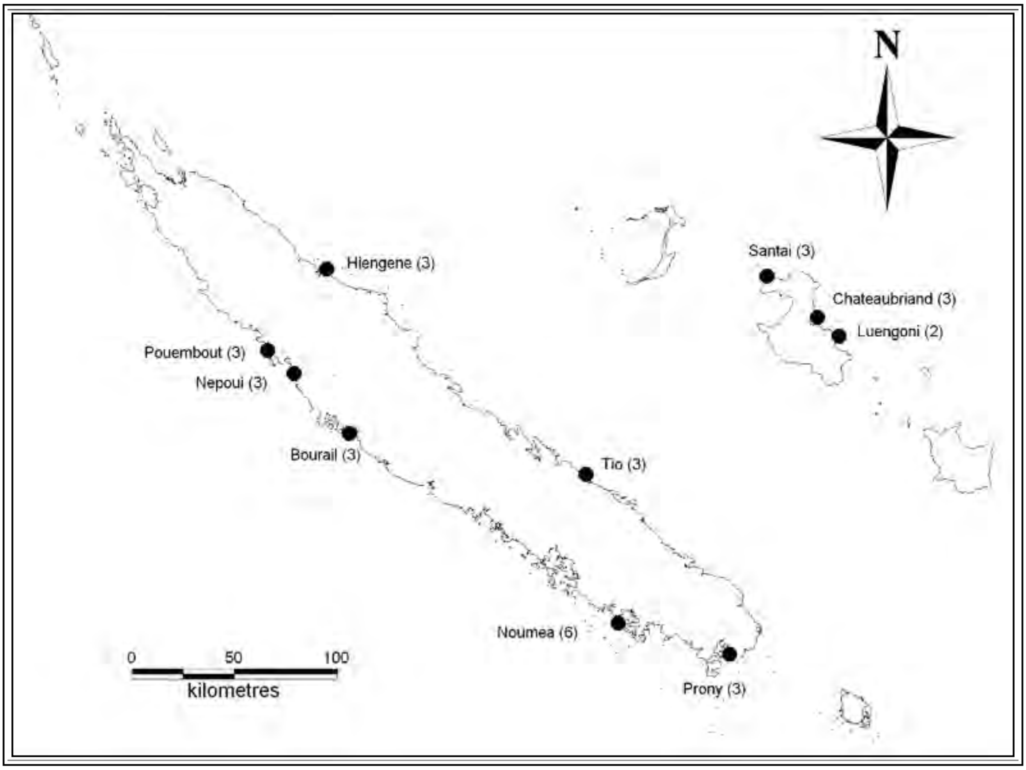
Substrate type was recorded every 50cm within each section. The following substrate classes were recorded:

- Live branching corals: HCB.
- Live massive corals: HCM.
- Live tabular corals: HCT.
- Other live corals: HCO.
- Soft corals: SC.
- Fresh dead corals (white): DC.
- Large seaweeds: FS.
- Sponges: SP.
- Rocks and dead corals with algae (size > 15cm): RCK.
- Rubble (stet) (size < 15cm): RB.
- Sand: SD.
- Silt: SI.
- Other substrate: OT.
- Coral bleaching: BLA.
- Fresh broken coral: RKC.
- Abandoned fishing gear: PEC.
- Other detritus (bottles, cans, etc.): DET.

2.2 Monitoring sites

The sites remained the same as those that were monitored in 2003, as illustrated in Fig. 1 (See Appendix 1 for more details on survey sites).

Figure 1: Map showing the 10 survey sites and 31 stations across the country



2.3 Results and discussion

2.3.1 Nov 2006 – Apr 2007 Monitoring

A summary of results of the 2006-2007 survey is given in Fig. 2 (See Appendix 2 for additional details). Of the 30 stations sampled, the overall coral reef health was considered good for 8 stations (27%), satisfactory for 18 stations (60%) and average for 4 stations (13%).

Reasons for the average health status of the four stations were as follows: Grimault (Nepoui) - sedimentation due to mining activities in the area; Luengoni1 and Luengoni2bis - particular geo-morphological characteristics; Santal2 (Lifou) - density of invertebrates keeps reducing every year.

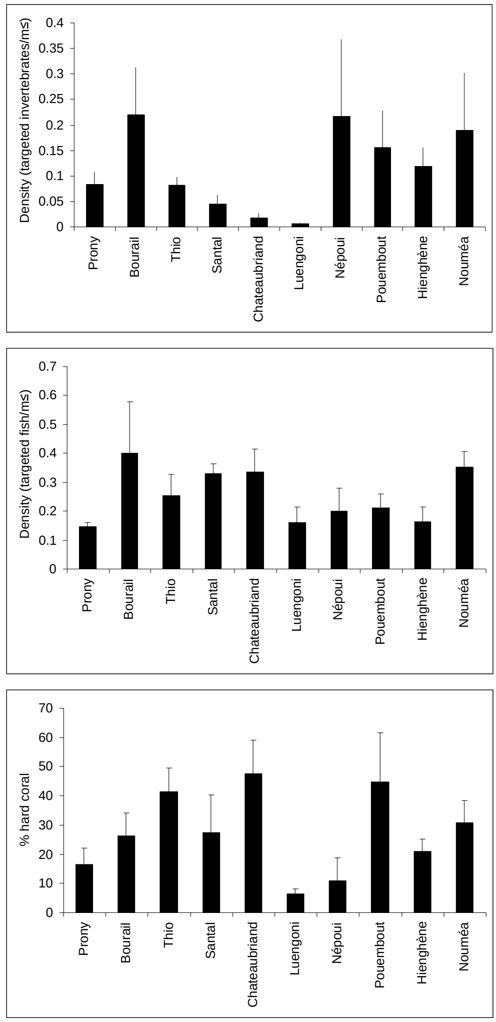


Figure 2: Density of invertebrates and fish (target species), and the % of hard coral cover on the 10 sites (30 stations) of the 2006-2007 survey in New Caledonia.

2.3.2 Temporal variations

Mid-term variations (2003-2006, all New Caledonia)

The overall status of the sampled sites throughout New Caledonia (24 stations) were satisfactory, with the exception of 3-4 stations affected by sedimentation from mining activities, or fishing (See Appendix 3 for more details). The status of most of the stations remained stable over the years with a few exceptions. There was deterioration at Santal2, Hiengabat and Donga Hienga, and improvement at Qanono and Récif intérieur.

Regionally, the density of commercial invertebrates (Kruskal-Wallis) and fish (Anova) did not change significantly between years ($p > 0.05$) (Fig. 3). However, at least one of these indices increased significantly on seven stations and decreased on only one station (Kruskal-Wallis, $p < 0.05$). Inside marine protected areas butterflyfish, commercial fish (groupers, parrotfish, surgeonfish and rabbitfish) and commercial invertebrates (giant clams, trochus, sea cucumbers) were present and common. Mean hard coral cover was stable over the years (mean = 24.6%; Anova, $p > 0.05$) (Fig. 3). However, one station was impacted by crown-of-thorns (COTs), with a significant decrease of hard coral cover from 64% (2003) to 6% (2005 and 2006) (Kuskal-Wallis test, $p < 0.05$). On the other hand, hard coral cover increased significantly (Anova, $p < 0.05$) on two stations (from less than 39% in 2003, to more than 53% in 2006).

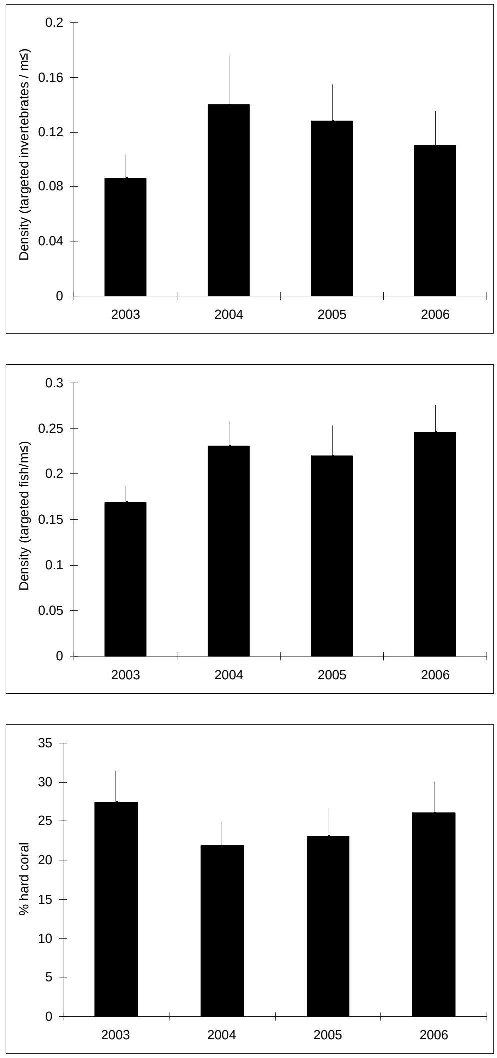


Figure 3: Mid-term variations of the density of invertebrates and fish (target species), and the % of hard coral cover (24 stations).

2.3.3 Long-term variations (Nouméa – SW lagoon)

The long-term variations observed since 1997 included only the Nouméa site (6 stations). The status of the 6 stations remained satisfactory since the first survey in 1997 with the exception of Maitre. However, this station's status improved in 2007 from average to satisfactory.

Fish densities remained relatively stable over the years until April 2007 (Fig. 4), when a significant increase was recorded (mainly butterfly fish and parrot fish; Anova, $p < 0.05$). The density of the invertebrates remained relatively stable since 1997 (Fig. 4), with a slight, but not significant, increase (Kruskal-Wallis, $p > 0.05$). The regional hard coral cover also remained relatively stable (Anova, $p > 0.05$) since 1997 (Fig. 4). It increased in December 2005 however, after COTs significantly impacted two stations. Signs of hard coral recovery were observed in Ricaudy and Maitre. On the other hand, a decrease of the coral cover was observed at Ever Prosperity and Signal. This affected the branching Acropora and specimens of COT Acanthaster were found on these stations.

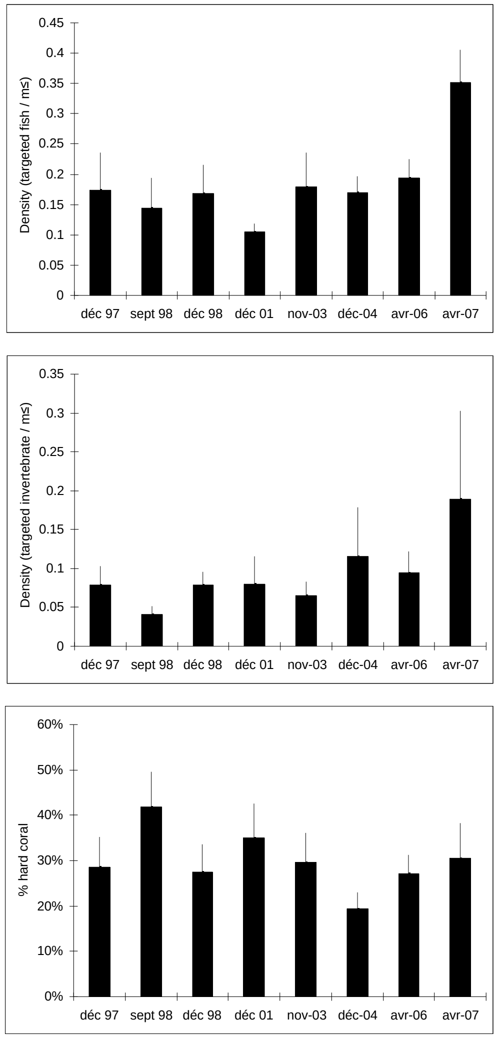


Figure 4: Long-term variations of the density of invertebrates and fish (target species), and the % of hard coral cover (Nouméa, 6 stations).

3
CURRENT RESOURCE USE

3.1 Coral Reef Species

3.1.1 Subsistence, Artisanal and Commercial Fisheries

Commercial fishing activities constitute a very small part of the gross domestic product of New Caledonia (3% for agriculture, aquaculture and fishing). However, fishing activities have a central position in New Caledonia society. Artisanal commercial fishing is made up of a small professional fleet (288 boats) comprising 144 boats in the Southern Province, 114 in the Northern Province and 30 in the Isle Province. This fleet steadily increased from 154 boats in 1976. The landings represented 1,212t in 2001 and remained relatively stable since 1989. In 2001, fish were the main target (690.5t) followed by lobsters and mud crabs (23t). In 2003, the main targets were sea cucumbers (69t dry) and trochus (100t shells).

Subsistence and recreational fisheries are important and difficult to discriminate. Recreational fishing is concentrated near urban centres, whereas subsistence fishing is practised over the entire territory. A survey in 2000 indicated that 50% of the fishers fished once to three times a week, and 70% used a boat. The principal fishing gears were hand lines and spear guns.

3.1.2 Tourism

Tourism constitutes between 3% and 4% of New Caledonia's GDP and employs 3,500 persons. The industry has stagnated since 2000 with around 100,000 visitors annually. Tourist activities (including cruise liner stopovers) on coral reefs are concentrated around Nouméa.

Recreational marine activities have considerable impact, particularly on the islets of the SW lagoon. More than 40 boats can be moored in one MPA at weekends. Anchor damage is limited in the MPAs of the South Lagoon Marine Park where moorings are available. Such damage can be significant in busy areas without moorings. These areas are near urban centers mainly around Nouméa and, to a lesser extent, Bourail, Koné and Koumac. However, the number of sites potentially affected remains low. Trampling is limited to fished reef flats near urban centers where fishing is allowed, and in two MPAs (Canard, Phare Amédé) visited by numerous tourists. There is little local interest in visiting the reef flats of the other MPAs.

3.1.3 Aquarium Trade

Fish aquarium exports represented 7.3t in 2001. For the moment, the aquarium trade is not a major concern in New Caledonia.

3.2 Turtles

Turtles are protected except for traditional celebrations. Each time traditional fishing is scheduled, an authorisation has to be given by local authorities.

3.3 Mangroves

Mangroves are affected by urbanisation but there is rising awareness for protection around Nouméa. New development projects would consider mangrove protection.

Mangroves are also impacted by sedimentation in some estuaries from mining activities, especially near old mines that have closed. This is because protection measures were not compulsory at the time.

3.4 Seagrass

Seagrasses are not used in New Caledonia. The impacts are limited to coastal areas where sedimentation is high, and to anchoring within frequented areas.

3.5 Deepsea species

No particular use, with the exception of a small artisanal fishing activity for outer slope fish (100-400m depth).

3.6 Endangered species

Exploited endangered species are submitted to regulations. Different regulations apply in the three Provinces. A new fishing regulation has been implemented in the Northern Province and is being finalized in the Southern Province.

4
THREATS TO CORAL REEFS/MANGROVES/SEAGRASS

4.1 Integrated Threat Index

An Integrated Threat Analysis was carried out using a modification of the "Reefs at Risk" methods (Bryant et al. 1998). Modifications reflect local conditions in the small Island States of the South West Pacific Node, where detailed technical information is often not available, or where threats that may not apply in other regions may exist. In this analysis, potential threats to reef health in areas of the country where data is gathered are assessed in five categories, (coastal development, marine-based pollution, pollution and sedimentation, artisanal fishing and destructive fishing), (See Appendices 4 to 8) and then integrated into a single threat score (Table 1). The sites that have undergone this threat assessment were: Lifou (grouping sites Santal, Chateaubriand and Luengoni), Hienghène, Pouembout, Nepoui, Thio, Bourail, Prony and Nouméa.

Hereafter, threat indices are calculated by site (and not by station), each site regrouping three stations from the coastline to the barrier reef. All sites would have a High artisanal overfishing threat index if the indices were calculated as directed. In New Caledonia the coastal population is spread in numerous small villages along the coast. There is "always" a coastal population within a short distance of the shore station of each site. Consequently, this index was artificially set to Low by the local coordinator.

Table 1: Integrated Threat Index for New Caledonian Sites

OVERALL: INTEGRATED THREAT INDEX						
Reef Area	**Coastal Development**	**Marine based Pollution**	**Pollution and Sedimentation**	**Artisanal Over-fishing**	**Destructive Fishing**	**Overall Threat Index Score**
Lifou	Medium	Medium	Low	Low	Low	Low
Hienghène	Medium	Very Low	Low	Low	Low	Low
Pouembout	Medium	Low	Medium	Low	Low	Medium
Népoui	High	High	High	Low	Low	High
Thio	High	High	High	Low	Low	High
Prony	High	High	High	Low	Low	Very High
Bourail	Medium	Very Low	Medium	Low	Medium	Medium/High
Nouméa	Medium	High	High	Low	Medium	High

It should be noted that this is an index of POTENTIAL THREAT, not one of current coral health.

Prony is the only site subjected to very high threat because it has a high biodiversity and is where a major industrial nickel complex is being developed. Three other sites are subjected to high threat: Népoui and Thio because of mining activities, and Nouméa because of urban development. Bourail is subjected to medium/high threat because of agricultural and pastoral activities, and urban development. Pouembout is subjected to medium threat because of agricultural and pastoral activities. This site will be subjected to very high threat in the next two years because of the development of a future industrial nickel complex. Two sites are subjected to low threat, Lifou and Hienghène. For these two sites the two major threats are the increase of the local population and tourism.

4.2 Coastal development

Coastal development is concentrated around Nouméa (urban development) and the future industrial complex (Voh-Koné-Pouembout and Prony). The mangroves are the first ecosystems affected.

4.3 Pollution

Pollution is affecting Nouméa and the major mining centres. Pesticides may affect near shore lagoon areas near agricultural centres along the West coast of the main island.

4.4 Sedimentation, nutrient enrichment and eutrophication

Sedimentation is mainly due to mining activities which affect fringing reef and coastal environment, particularly areas located downstream the catchment area of old mines when no regulations were applied. Now mining activity is regulated and measures are taken to limit sedimentation. The impact of the new mines is now limited to the loading port.

Urban development is also a source of pollution. Nutrient inputs are limited to the main urban centres. In Nouméa, sewage is a source of nutrient for the lagoon despite the presence of wastewater treatment plants. Treatment capacity is increasing but is still insufficient. Several villages (Bourail, Koné, Koumac, Poindimié, Wé) are reaching a threshold where they will need modern treatment plants as nutrient inputs are increasing in these areas.

4.5 Over fishing

Over fishing is not yet a major problem in New Caledonia. However, population increase will induce an increase of the fishing effort in the near future. Actually, the fishing effort is concentrated around Nouméa and the major concerns are for sea cucumbers, giant clams, trochus and fish.

4.6 Destructive fishing and coral harvesting

There is no destructive fishing and coral harvesting in New Caledonia.

4.7 Bleaching, coral disease and predators

No coral bleaching affected New Caledonia from 2005 to 2007.

4.8 Hurricane/tsunamis

New Caledonia recorded no hurricanes and tsunamis from 2005 to 2007.

4.9 Outbreak of organisms

There was no outbreak of organisms 2005 to 2007. Local limited COT outbreaks were observed in Pouembout (Pindaï station) and, to a lower extent, in Nouméa (Signal station).

5
CURRENT CORAL REEF CONSERVATION EFFORTS

5.1 Government Efforts

New Caledonia has proposed six coral reef areas to the world heritage (UNESCO). The record was submitted by the French government in 2007. The decision of the UNESCO will be known in 2008.

The coral reef MPAs in New Caledonia represent over 42,000 ha and are listed in Table 2. Nearly all of these are located in the Southern Province. Most are no-take zones with one (Merlet reserve) being a permanent closure.

5.2 Non Government Organisation Efforts

Several NGOs are involved in coral reef conservation in New Caledonia. WWF, for example, coordinated an eco-regional analysis of New Caledonia marine ecosystems, ASNNC (Association de Sauvegarde de la Nature de Nouvelle-Calédonie) is involved in turtle survey, and Opération Cétacés is involved in whale surveys.

Table 2. The Marine Protected Areas in New Caledonia

Name	Status	Area (ha)	Established
Bourail (3 sites)	No-take zone	2,339	1993
Dieppoise	No-take zone	13	1990
Ilot Amédé, récif Aboré	No-take zone	14,990	1981-96
Ilot Amédée	No-take zone	154	1989
Ilot Bailly	No-take zone	216	1989
Ilot Canard, récif Ricaudy	Fishing from land allowed (Ricaudy)	191	1989
Ilot Larégnère	No-take zone	665	1989
Ilot Maitre	No-take zone	628	1981
Ilot Signal	No-take zone	246	1989
Ilot Ténia	No-take zone	1,002	1998
Humbolt	No-take zone	13	1996
Kuendu	No-take zone	39	1998
Nékoro	No-take zone	1,260	2000
Ouano	No-take zone	2,980	2004
Prony (2 sites)	No-take zone	149	1993
Yves Merlet	Fully closed area	17,150	1970
Passe de Dumbéa	Fishing forbidden between 1st October and 1st March	542	2005
Grand Port (Prony)	Fishing forbidden between 1st September and 31 December	1,153	2006

6
FUTURE OF CORAL REEF HEALTH

New Caledonia's location means its coral reefs should be relatively protected from the effects of global warming. However, rising sea levels may affect the lowest coralline islands and Ouvéa atoll.

The main treats to coral reefs in the future will be related to industrial mining and urban development, as well as population increase. Sedimentation, pollution, coast line preservation, sewage treatment, waste management, fishing effort will be the main stakes for managers of New Caledonia's coral reefs.

7
RECOMMENDATIONS

The main recommendations are:

- to find a solution to perpetuate the monitoring program;
- to continue to enforce management and protection policies;
- to continue to develop research programmes on the structure and functioning of MPAs in order to optimise management policy of the South Lagoon Marine Park. The results of these programs will benefit other Provinces in adapting their management policies to their future development;
- to support a policy of sewage treatment and waste management for Nouméa and developing villages.

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APPENDICES

Appendix 1: Survey sites across the country between Nov 2006 and Apr 2007

Site	Station	Latitude	Longitude	Type of Reef	Years Surveyed
Santal	Jinek	20°47.273'S	167°07.307'E	fringing oceanic	2003 to 2006
Santal	Santal1	20°47.080'S	167°07.028'E	fringing oceanic	2003 to 2006
Santal	Santal2	20°47.637'S	167°09.416'E	fringing oceanic	2003 to 2006
Chateaubriand	Qanono	20°54.400'S	167°15.862'E	fringing oceanic	2003 to 2006
Chateaubriand	Wé port	20°54.940'S	167°16.444'E	fringing oceanic	2003 to 2006
Luengoni	Luengoni1	21°01.857'S	167°25.128'E	fringing oceanic	2003 to 2006
Luengoni	Luengoni2bis	21°01.568'S	167°24.722'E	fringing oceanic	2004 to 2006
Pouembout	Pinjien	21°05.228'S	164°45.748'E	fringing lagoon	2003 to 2006
Pouembout	Konieme	21°11.680'S	164°46.682'E	intermediate lagoon	2003 to 2006
Pouembout	Fausse passe	21°13.080'S	164°45.769'E	inner barrier lagoon	2003 to 2006
Népoui	Grimault	21°22.038'S	164°58.835'E	intermediate lagoon	2003 to 2006
Népoui	Pindaï	21°22.820'S	164°58.035'E	intermediate lagoon	2003 to 2006
Népoui	Béco	21°24.635'S	164°57.507'E	inner barrier lagoon	2003 to 2006
Hiengène	Koulnoué	20°41.435'S	164°59.546'E	fringing lagoon	2003 to 2006
Hiengène	Hienghabat	20°38.679'S	164°58.993E	intermediate lagoon	2003 to 2006
Hiengène	Donga Hienga	20°37.831'S	165°04.302'E	outer barrier oceanic	2003 to 2006
Prony	Casy	22°21.401'S	166°50.833'E	intermediate lagoon	2003 to 2006
Prony	Bonne Anse	22°23.647'S	166°52.971'E	fringing oceanic	2003 to 2006
Bourail	Akaïa	21°37.790'S	165°27.250'E	fringing lagoon	2003 to 2006
Bourail	Ile Verte	21°39.211'S	165°27.376'E	intermediate lagoon	2003 to 2006
Bourail	Siandé	21°39.698'S	165°27.198'E	inner barrier lagoon	2003 to 2006
Thio	Moara	21°38.530'S	166°18.200'E	fringing lagoon	2003 to 2006
Thio	Récif intérieur Thio	21°35.601'S	166°15.806'E	intermediate lagoon	2003 to 2006
Thio	Grand récif Thio	21°33.380'S	166°20.248'E	inner barrier lagoon	2003 to 2006
Nouméa	Ricaudy	22°18.96'S	166°27.32'E	fringing lagoon	1997, 1998, 2001, 2003 to 2006
Nouméa	Maitre	22°19.98'S	166°25.43'E	intermediate lagoon	1997, 1998, 2001, 2003 to 2006
Nouméa	Ever Prosperity	22°26.63'S	166°22.12'E	inner barrier lagoon	1997, 1998, 2001, 2003 to 2006
Nouméa	Nouville	22°15.48'S	166°23.14'E	fringing lagoon	1997, 1998, 2001, 2003 to 2006
Nouméa	Signal	22°17.63'S	166°17.79'E	intermediate lagoon	1997, 1998, 2001, 2003 to 2006
Nouméa	Mbéré	22°20.33'S	166°14.29'E	inner barrier lagoon	1997, 1998, 2001, 2003 to 2006

Appendix 2: Summary of the results of the 2006-2007 survey on the 30 stations sampled in New Caledonia

Site	Station	Fish			Invertebrates		
		Nb	Density	Major species	Nb	Density	Major species
Prony	Cas y	5	0,160	APE	4	0,108	ABM
	Bonne Anse	4	0,135	APE	7	0,058	ABM, DIA
Bourail	Akaia	4	0,105	APE, PAP	4	0,033	AOU
	Ile Verte	9	0,72	API, APE	7	0,315	AOU
	Siandé	5	0,38	APE , API	9	0,313	AOU, TRO
Thio	Moara	5	0,176	API	3	0,113	STI
	Récif Intérieur	5	0,183	APE	4	0,065	DIA
	Grand R écif	8	0,400	API, APE	5	0,068	ABM
Santal	Jinek	3	0,350	API	7	0,043	STI, BEN
	Santal1	6	0,378	API, APE	6	0,078	STI
	Santal2	4	0,265	APE	4	0,013	AOU
Chateaubriand	Luecilla2						
	Qanono	6	0,415	API	2	0,028	BEN
	Wé port	7	0,258	API	1	0,008	-
Luengoni	Luengoni1	3	0,108	API	3	0,008	BEN, ABM
	Luengoni2bis	4	0,215	API	2	0,005	DIA, CRA
Népoui	Grimault	3	0,050	API, PAP	4	0,135	DIA, AEM
	Pindaï	5	0,318	API, APE	1	0,010	BEN
	Beco	6	0,235	API	8	0,508	AOU, BEN
Pouem bout	Pinjen	3	0,305	PAP	3	0,017	AEM
	Konième	3	0,153	API	6	0,250	BEN
	Fauss e passe	5	0,175	API, APE	7	0,202	AOU, TRO
Hienghène	Koulnoué	3	0,063	PAP	3	0,050	AEM
	Hiengabat	5	0,193	API, APE	6	0,135	BEN
	Donga Hienga	4	0,233	API	7	0,173	AOU
Nouméa	Ricaudy	5	0.168	PAP, APE	3	0.070	AEM
	Maitre	4	0.398	APE	6	0.083	DIA
	Ever Prosperity	5	0.423	APE	3	0.020	ABM
	Nouville	4	0.218	PAP, API	4	0.753	DIA
	Signal	5	0.515	APE	6	0.108	DIA
	Mbéré	4	0.390	APE	6	0.100	AOU

Density	low	average	high
Fish	< 0,2	0,2 < <0,5	0,5 <
Invertebrates	< 0,15	0,15 < <0,3	0,3 <

Diversity (Nb)	< 5	5 < < 8	8 <

HC	< 20	20< < 40	40 <

Substrate				Others	Perturbation	Status
Nb	HC	Abiotic	Dominant			
7	11	71	36 RB , 22 RC	BRI +	+	satisfactory
9	22	72	39 RC, 21 RB	DET +, BRI +	+	satisfactory
7	40	54	40 HC, 41 RC	BRI +++, DET ++, PEC ++	++	satisfactory
8	26	71	67 RC, 25 HC	BRI+++	++	good
9	13	74	40 RC, 28 RB	-	+	satisfactory
12	57	24	57 HC, 17 RC, 11 SC	PEC +	++	satisfactory
11	30	66	30 HC, 36 RC, 15 SD	-	++	satisfactory
9	37	60	34 HC, 43 RC	-	+	satisfactory
8	53	44	53 HC, 33 RC	BRI ++	++	satisfactory
5	13	88	81 RC	PEC+	+	satisfactory
6	16	79	52 RC, 15 HC	BRI+	+	average
8	59	31	59 HC	DET, PEC	++	good
5	36	39	39 RC, 36 HC		++	good
6	8	71	44 RC, 21 FS	-	+	average
8	5	71	50 RC, 23 FS	-	+	average
8	1	91	50 SI, 18 SD	-	++	average
8	6	78	51 RC, 26 RB	-	++	good
8	26	73	50 RC	BRI +, BLA(ACA)	+	good
9	65	24	65 HC, 19 RC	-	+	good
7	58	27	57 HC, 20 RC	-	+	good
7	11	76	72 RC	BRI	+	good
11	19	43	36 FS, 29 SI	BRI ++, PEC+, DET	+	satisfactory
8	15	71	61 RC, 13 SC	BRI++, PEC, BLA(ACA)	+	satisfactory
9	29	66	64 RC	BRI++, BLA(ACA)+, DET, PEC	+	satisfactory
9	67	21	67 HC, 12 FS	BRI+++, BLA(ACA)+, PEC+	+++	satisfactory
9	20	51	26 FS, 21 RB	BRI++	+++	satisfactory
6	31	59	38 SD, 31 HC	BLA(ACA)+	+	satisfactory
9	28	66	29 RC, 28 SD	BRI+, PEC+	+++	satisfactory
7	15	83	39 RB, 27 SD	BRI+, BLA(ACA)+, DET+	+	satisfactory
9	24	70	32 RC, 24 HC		++	satisfactory

Others	-		+	++	+++
Nb occurrences	0	1	2-4	5-10	> 10

Appendix 3: Summary of the status of the stations sampled between 2003 and 2006 survey

Site	Station	Status 2003	Status 2004	Status 2005	Status 2005
Prony	Casy	satisfactory	satisfactory	satisfactory	satisfactory
	Bonne Anse	satisfactory	satisfactory	satisfactory	satisfactory
Bourail	Akaia	average	average		satisfactory
	Ile Verte	good	good	good	good
	Siandé	satisfactory	satisfactory	satisfactory	satisfactory
Thio	Moara	satisfactory	satisfactory	satisfactory	satisfactory
	Récif Intérieur	average	average	satisfactory	satisfactory
	Grand Récif	satisfactory	satisfactory	satisfactory	satisfactory
Santal	Jinek	satisfactory	good	good	satisfactory
	Santal1	satisfactory	satisfactory	satisfactory	satisfactory
	Santal2	satisfactory	satisfactory	satisfactory	average
Chateaubriand	Luecilla2	satisfactory	good		
	Qanono	satisfactory	good	good	good
	Wé port	good	satisfactory	good	good
Luengoni	Luengoni1	average	average	average	average
	Luengoni2bis	satisfactory	average	average	average
Népoui	Grimault	satisfactory	average	average	average
	Pindaï	good	good	good	good
	Beco	good	good	good	good
Pouembout	Pinjen	good		good	good
	Konìène	good	good	good	good
	Fausse passe	good	good	good	good
Hienghène	Koulnoué	satisfactory		satisfactory	satisfactory
	Hiengabat	good	good	satisfactory	satisfactory
	Donga Hienga	good	good	satisfactory	satisfactory

Appendix 4. Threat Index for Coastal Development

	Closer than 4km away	**4 – 10km away**	**10 - 25km away**	**More than 25km away**
Cities, Population over 100,000	High	High	Medium	Low
Cities, Population 50,000 – 100,000	Medium	Medium	Low	Very Low
Towns, Population under 50,000	Medium	Medium	Low	Very Low
Airports (in use)	Medium	Medium	Very Low	Very Low
Mines	High	High	Very Low	Very Low
Tourist resorts and dive centres	Medium	Very Low	Very Low	Very Low
Any Coastline (shore)	Low	Very Low	Very Low	Very Low

A) Coastal Development							
Reef Area	**Cities**	**Towns**	**Airports**	**Mines**	**Tourism**	**Coastline**	**Overall Score**
Lifou	-	Medium	Very Low	Very Low	Medium	Low	Medium
Hienghène	-	Medium	Very Low	Very Low	Very Low	Low	Medium
Pouembout	-	Medium	Very Low	Very Low	Very Low	Low	Medium
Népoui	-	Medium	Very Low	High	Very Low	Low	High
Thio	-	Low	Very Low	High	Medium	Low	High
Prony	-	Medium	Very Low	High	Medium	Low	High
Bourail	-	Medium	Very Low	Very Low	Medium	Low	Medium
Nouméa	High	-	Very Low	Very Low	Medium	Low	Medium

Appendix 5. Threat Index for Marine-Based Pollution

	Closer than 4km away	**4 – 10km away**	**10 – 30km away**	**30 – 50km away**
Ports, Large (Container ships, tankers, fishing ships, etc, e.g Suva)	High	High	High	Medium
Ports, Medium (Fishing ships etc, eg Port Villa)	High	High	Medium	Very Low
Ports, Small (Yachts and personal boats)	High	Medium	Very Low	Very Low
Ports, Very small (Local outboard boats)	Medium	Very Low	Very Low	Very Low
Oil storage tanks, refineries	High	Medium	Very Low	Very Low
Shipping Lanes	Medium	Low	Very Low	Very Low

B) Marine-Based Pollution				
Reef Area	**Ports**	**Oil Tanks / Wells Within 10km**	**Shipping lanes**	**Overall Score**
Lifou	Medium	Very Low	Low	Medium
Hienghène	Very Low	Very Low	Very Low	Very Low
Pouembout	Very Low	Very Low	Low	Low
Népoui	High	Very Low	Medium	High
Thio	High	Very Low	Medium	High
Prony	High	High	High	High
Bourail	Very Low	Very Low	Very Low	Very Low
Nouméa	High	Medium	High	High

Appendix 6. Threat Index for Pollution and Sedimentation

	High	**Medium**	**Low**	**Very Low**
Vegetation Type	Large scale croplands	Permanent wetland (Swamp)	Dense planted forest	Dense natural forest
	Urban and built-up	Grassland	Mixed Forest	
	Areas with little vegetation	Open shrubland mixed with grass	Dense shrubland	
		Cropland mixed with natural vegetation		
		Small, dry islands with coconuts and salt bush		
Steepness of slope		Steep	Moderate	Slight/Flat
Contributing factors	Deforestation	Commercial Agriculture	Domestic Agriculture	
	Mining	Commercial Livestock	Domestic Livestock	

Appendix 7. Threat Index for Artisanal Overfishing

	Closer than 10km away	10 – 20km away	More than 20km away	Marine Protected Area within 10km
Coastal population	High	Medium	Low	Low

D) Over fishing (Local fisheries not commercial)		
Reef Area	Score	Notes on Marine Protection
Lifou	Low	Traditional management
Hienghène	Low1	Traditional management
Pouembout	Low1	
Népoui	Low1	
Thio	Low1	
Prony	Low	MPA within the site
Bourail	Low	MPAs within the site
Nouméa	Low	MPAs within the site

Appendix 8. Threat Index for Destructive Fishing

Destructive Fishing	**Several times ……..**			**Never**
	Week	Month	Year	
Dynamite	High	Medium	Low	Very Low
Chemical Poison (Cyanide or Chlorox)	High	Medium	Low	Very Low
Herbal Poison	High	Medium	Low	Very Low
Direct coral breakage (trampling, excavation, harvesting)	High	Medium	Low	Very Low

E) Destructive Fishing (Poisons or blast)					
Reef Area	**Dynamite**	**Chemical Poison**	**Herbal Poison**	**Breakage**	**Overall Score (Highest recorded)**
Lifou	Very Low	Very Low	Very Low	Low	Low
Hienghène	Very Low	Very Low	Very Low	Low	Low
Pouembout	Very Low	Very Low	Very Low	Low	Low
Népoui	Very Low	Very Low	Very Low	Low	Low
Thio	Very Low	Very Low	Very Low	Low	Low
Prony	Very Low	Very Low	Very Low	Low	Low
Bourail	Very Low	Very Low	Very Low	Medium	Medium
Nouméa	Very Low	Very Low	Very Low	Medium	Medium

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Koulnoué Diving, Népoui plongée, le lagon Club de Koné, Photo Discount

& ALL THE VOLUNTEERS

The divers:

Thierry Baboulenne

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Rémi Dodemont

Sébastien Faninoz

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STATUS OF CORAL REEFS
IN SAMOA 2007

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FISHERIES DIVISION

Ministry of Agriculture and Fisheries

CONTENTS

EXECUTIVE SUMMARY

Samoa has the smallest coral reef area in the South West Pacific node extending over 490km^2. Coral reef monitoring began in 2001 when Samoa joined the node. Eight permanent sites are now monitored on an annual basis. The Ministries of Agriculture and Fisheries, and Natural Resource, Environment and Meteorology are the two main government bodies leading coral reef monitoring and conservation initiatives.

During 2005-2007, eight monitoring regions (also regarded as sites) were surveyed although only three were visited from 2005-2006. All three regions surveyed reflected coral recovery after damage by Cyclone Heta in early 2004. Survey results for this period revealed an average coral cover of 55%, with the highest cover being 65%. The 2006-2007 survey of eight regions showed an average coral cover of 42.8%, with the highest cover at 65.9%. The non-living substrate (abiotic) was also predominant with an average of 30%, followed by algae comprising 15%. Damsel fish, striated surgeonfish and parrot fish were the dominant fish families, and overall average fish density was 0.61 fish per m^2. On the other hand, several families were absent from a majority of the regions. Soldier fish, butterfly fish and damsel fish were each observed in one of the eight regions. Popular food fish families were generally low across all regions and absent in some. One sea cucumber species (black teat fish, density of 5m^2) and sea urchins were the dominant invertebrates across all regions for the entire monitoring period.

Inshore marine resources remain integral to the livelihood of the people of Samoa. The total estimate of subsistence fisheries for 2006/07 was 14,000 metric tones valued at USD34 million, and an average annual consumption of 56kg. The total inshore fisheries landed and sold domestically in the same year was 126.47 metric tones valued at USD0.6 million. The tourism industry, in which coral reefs are a major visitor attraction, has boomed with record earnings in 2007 of USD127 million.

Mangrove areas have been depleted over the years, due mainly to coastal development and reclamation. However, recent awareness and conservation programmes in local villages have resulted in most mangrove areas being declared reserves or national parks. Marine turtle species are continually exploited for commercial purposes. Over-hunting for their meat, their shells for handicrafts, and the collection of eggs from nests, are some factors attributed to the turtles' endangered status. According to the Ministry of Natural Resource, Environment and Meteorology, from surveys done over the years, there is a clear indication of low nesting densities for the critically-endangered hawksbill turtle (*Eretmochelys imbricata*) during the nesting season (October – June).

The major human-induced threats to coral reefs include coastal development, overfishing, coral bleaching and invasive species, all of which are localised. Two invasive seaweed species, *Codium arenicola* and *Codium prostratum*, have extended from Apia's harbour to reef slopes of nearby coastal villages (Vaiusu and Vaiala). These introduced seaweeds are forming large meadows in areas previously occupied by local animals and plants (Person-

al communication, Posa Skelton, December 2007).

The Samoan government is leading coral reef protection and conservation initiatives. Eighty-nine villages from both Savaii and Upolu, the two main islands, are part of the Fisheries Division's Community-based Fisheries Management Programme (CBFMP) which has produced village by-laws that are recognised by Samoa's legal system. Forty nine villages have opted to establish fish reserves. In addition, the Department of Environment and Conservation has assisted communities establish 20 MPAs in two districts and have also been involved in an ecosystem restoration project in areas that were affected by Cyclone Heta, by helping with coral and mangrove replanting and community awareness. Samoa has the oldest national marine reserve in the region. The Palolo Deep National Marine Reserve was established in 1974 and is one of the Global Coral Reef Monitoring Network (GCRMN) monitoring regions.

I
COUNTRY INFORMATION

Samoa (13-17^0 S, 171-173^0 W) consists of two main inhabited islands, Upolu and Savai'i, and other smaller islands. These are mountainous, of volcanic origin and occupy land area of 2,935 km^2 (1,093 sq m). The climate is tropical with an average annual temperature of 26° C (79° F).

Samoa has a population of 176,848 with overall population density of about 63 people per sq km (163 per square metre). According to the 2006 census, total population was 179,186, a population increase of 1.4% from the last census in 2001 (Statistics Department, Ministry of Finance, 2006).

The country's coral reefs are limited and fringing in nature, due to past volcanic activities and subsequent sea level rise. They cover a total area of approximately 10,000km^2 and 50metres depth. The 200 mile exclusive economic zone (EEZ) is one of the smallest in the region comprising 120,000km^2 (Skelton *et* al. 2000).

Background History

Coral reef monitoring has been ongoing in Samoa since the Year of the Coral Reefs in 1997. In 1974, Samoa was the first Pacific Island nation to set up a national marine reserve, the Palolo Deep National Marine Reserve. The Fisheries Division (FD) of the Ministry of Agriculture and Fisheries is promoting coral reef conservation through the Community-Based Fisheries Management Programme. The Division of Environment and Conservation (DEC) at the Ministry of Natural Resources, Environment and Meteorology (MNREM) currently undertakes other marine conservation initiatives (Samuelu & Solofa, 2007).

Samoa joined the GCRMN in 2001. A national taskforce was formed from government ministries and NGOs involved in coral reef initiatives, with the FD as coordinating agency. This taskforce underwent training in particular coral reef monitoring and assessments and, in 2002, 10 sites were initially selected as GCRMN permanent monitoring sites. When funding ended in 2005, the FD incorporated monitoring of these sites into its annual activities. Today, these sites are monitored through local budget on an annual basis.

2
CURRENT PHYSICAL CONDITION OF CORAL REEFS

2.1 Monitoring Issues

The health of coral reefs and the status of other biological diversity such as invertebrates and fish in Samoa's inshore waters were monitored periodically over the last decade.

Since funding from the Canada South Pacific Ocean Development Programme (CSPOD) ceased at the end of 2004, the Fisheries Division (FD) included annual monitoring in its activities for the 2005/06 fiscal year. However, as the monitoring team was involved in the Secretariat of the Pacific Community's (SPC) PROC-fish project, only three sites were assessed during this period (refer to Table 1).

The Department of Environment and Conservation (DEC) is also monitoring its MPAs. As it is doing this in conjunction with communities, the programmes are very basic. The DEC and the FD are yet to standardise their methods for better analysis and reporting purposes.

2.2 Method

Line transect methods were used to undertake baseline surveys and monitoring of the sessile benthic organisms and coverage of coral reefs.

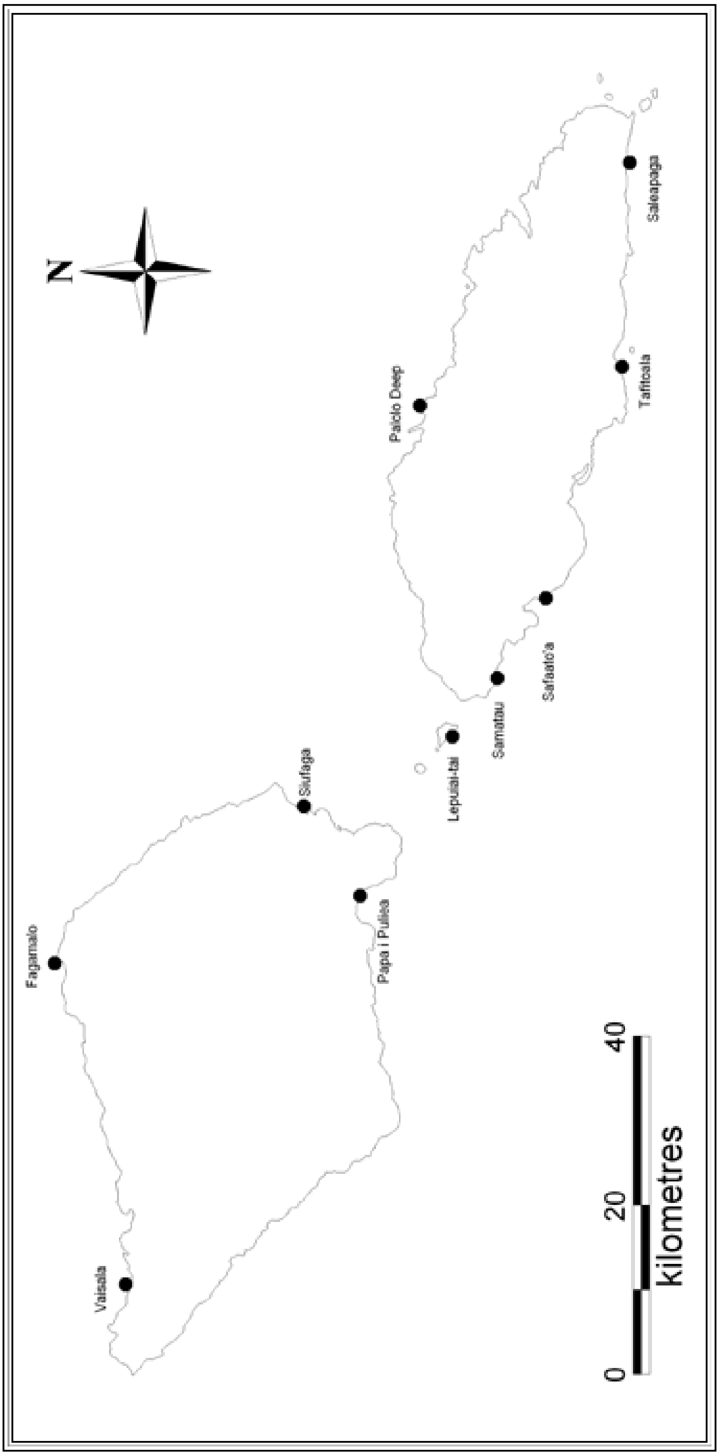
Benthic cover at each site was described using the 3 Point Intercept Transect (3 PIT) method. It provided an estimate of the percentage cover of each substratum type on each transect. At 2 metre intervals along the transect three sampling points perpendicular to the transect were used (one directly under the 50metre tape and one 1metre either side). Twenty-five 2metre intervals along the main transect were sampled in this manner yielding 75 sample points per transect. The cover of each category type can then be calculated as the percentage of the 75 points it occupies in each transect.

The underwater visual census technique of the Belt Line Transect (BLT) method is used to assess the number of individual fish species and invertebrates present. The method involves counting selected fish species indicators within the transect strip. The same five transects of 50m x 3m used for the substrate coverage assessment are employed. Prior to coral counts, fish are counted first because of their mobility, followed by the sessile and slow moving invertebrates.

Two people swim on either side of the person laying the tape and are 1.5 to 3metres from the tape. The same procedure is applied when counting invertebrates on the reverse. The samplers record fish and invertebrates by tallying them as they swim along. The observers are also instructed to note signs of coral bleaching.

In 2007, the fish and invertebrate count was modified to include length estimations. This was first done in the 2003 monitoring, but was later discontinued due to a lack of staff. Two additional people have now joined the staff team carrying out fish length estimations. These estimates will be included in the monitoring report for fiscal year 06/07.

Figure 1: Map showing survey sites across the country

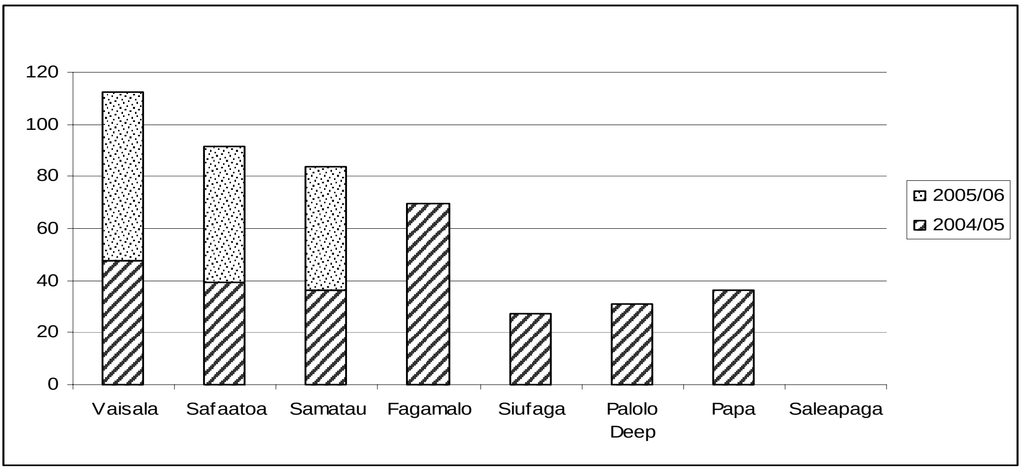


2.3.1 Monitoring sites

Table 1: Table of survey sites across the country

Sites	In Samoa	Longitude	Latitude	Years Monitored						
				01/02	02/03	03/04	04/05	05/06	06/07	07/08
Palolo Deep	North Upolu	S13°49.504'	W171°45.464'	*	*	*		*	*	*
Saleapaga	SE Upolu	S14°02.553'	W171°30.446'	*	*	*			*	*
Safaatoa	SW Upolu	S13°56.541'	W171°58.004'	*	*	*	*	*	*	*
Samatau	NW Upolu	S13°54.275'	W172°03.062'	*	*	*	*	*	*	*
Papa	SE Savaii	S13°46' 23.17"	W 172° 21'49.80"		*	*			*	*
Siufaga	North Savaii	S13°39' 34.87"	W172°10' 58.29"	*	*			*	*	*
Fagamalo	NW Savaii	S13°26' 19.40"	W172°20' 53.77"	*	*	*		*	*	*
Vaisala	SW Savaii	S13°31' 00.13"	W171°40' 24.39"	*	*	*	*	*	*	*

Figure2: The live coral comparison in eight sites for the monitoring periods, 2004 and the 2005.



Note: All monitoring was carried out in the back reef (near shore, lagoon, reef flat) in depths ranging from 2m to 5m mostly at low or medium tide. The 05/06 is referred to as the fiscal years from the month of July to June similarly with 06/07 and 07/08. For analysis purposes the 05/06 is 2005 monitoring, 06/07 is 2006 monitoring and 07/08 is 2007 monitoring.

2.4 Results

2.4.1 Substrate cover

2005 Monitoring

The 2005 monitoring was very poor given that only three sites were assessed. These represented North West and South West Upolu, and the South West of Savaii.

The substrate cover for all sites was dominant with live corals (45% - 65%), in particular the *Non-Acropora* with more than 20% in each site. The (non-living) abiotic group was also predominant with 23% in Safa'ato'a, 27% in Samatau and 30% in Vaisala. The algae group was moderate to low with Safa'ato'a 24%, the Samatau site with 22% and Vaisala with just 7% (Figure 1). The 'others' group consisted mainly of the zoanthid species *(Polythoa sp, Discosoma sp).*

In the live corals group, the *Non-Acropora* and *Acropora* branching were most common, followed by the foliose corals and the *Porites sp.* (Appendix 1).

There was an overall increase in live corals of more than 10% for each of the three sites compared with the last monitoring period. The Vaisala site, severely damaged by Cyclone Heta showed a 16% increase.

Compared with the 2004 monitoring, there has been an overall increase in coral cover of more than 10% (Figure 2). This is quite a recovery for the three sites since the average of damaged corals from the cyclone was 15%. The Vaisala site, which incurred 19% coral damage, has since exhibited a 16% increase in live corals (Samuelu & Tausa, 2004).

2006 Monitoring

The *Acropora* branching was the most common in all the eight sites. Fagamalo, Papa and Vaisala showed relatively high percentages of live coral cover with non-*Acropora* foliose dominant at Fagamalo and Vaisala, and *Acropora* tabulate dominant at Papa (Figure 3) (Appendix 2).

Compared to the two monitorings in 2005 and 2004, live corals showed an overall percentage increase, particularly the 2004 monitoring. The Saleapaga, Vaisala and Papa i Puleia sites had moderate recovery this year of more than 15% compared to 2004. All three sites assessed in 2005 exhibited a decrease in live coral percentage in 2006. The Siufaga site had low coral cover compared to other sites. (Figure 4).

The algae group is among the dominating substrate from the eight sites. However, from the table below, the most commonly found algae types are the turf algae and macro algae. The most common macro algae found in Samoa are *Sargasssum sp* and *Padina sp.* The most common coralline algae are the *Halimeda sp* and the *Actinotrichia sp.* The zoanthid *Protopalythoa sp* was recorded only in Safaato'a. Both Vaisala and Samatau recorded the most types of algae with the turf algae dominating its group in Vaisala, and the macro algae in Samatau (Appendix 3).

2007 Monitoring

The substrate cover for this year shows good coral cover in all, except the Siufaga site. The *Acropora*

Figure 3: The various types of substrate recorded in the year 2006-2007

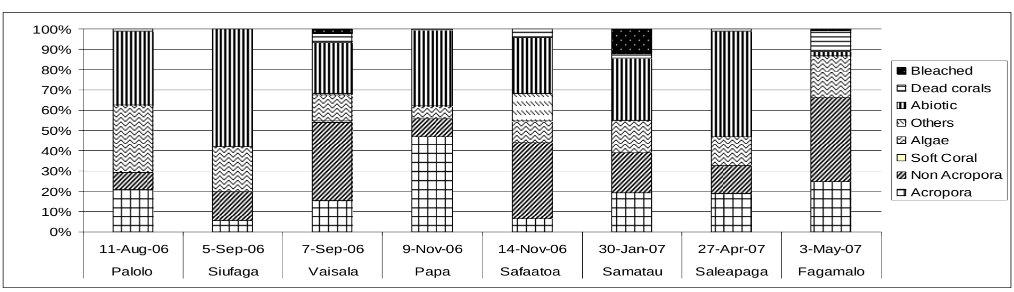
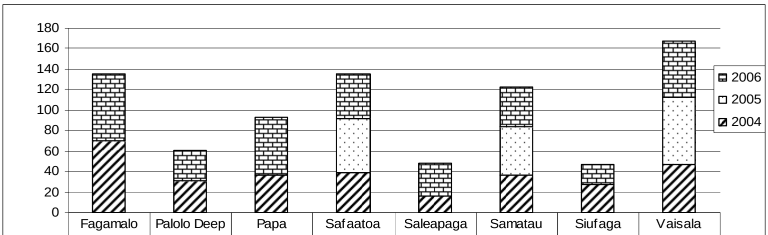


Figure 4: Comparison of live corals from three monitoring years 2004, 2005 and 2006



	Fagamalo	Palolo Deep	Papa	Safaatoa	Saleapaga	Samatau	Siufaga	Vaisala
2006	65.9	30.15	55.9	44.11	33.03	39.24	19.87	54.37
2005	0	0	0	52.32	0	47.43	0	65.15
2004	69.49	31.14	36.45	39.24	15.69	36.41	27.56	47.4

seems dominant at all sites, except for Safa'atoa where Non-*Acropora* corals dominate. The abiotic group dominates at sites with low coral cover such as Siufaga and Saleapaga. Fagamalo recorded the highest ever in coral cover of 80%, with more than 50% being Non-*Acropora* corals. The bleached corals are spot bleaching in Fagamalo, Papa and Vaisala, mainly because of the elevated growths of corals that are exposed at low tides (Figure 5).

The overall coral cover in three years has remained stable in all sites, except for a significant increase of 20% for the Samatau site in this year's monitoring. The status of the Siufaga site, with the lowest percentage of live corals, remained consistent over three years (Figure 6).

The abiotic group has shown constant percentages over the years, except at the Samatau site where a considerable drop was recorded in this year's monitoring. It can be attributed to the high percentage of corals in this site. However this varies at different sites from low cover in Samatu, to moderate in most sites, and the highest at Saleapaga (Figure 7).

The algae groups consist mainly of coralline algae, turf and seaweeds. They seem predominant in Palolo Deep in moderate percentages. Vaisala had a small constant increase over the three years, the result mainly of increased cover of seaweeds *(Caulepora sp)* and the *Halimeda sp.* A drop in algae cover over two years occurred at Siufaga, Papa Saleapaga and Fagamalo. These decreases are not significant, coming in at under 10%. (Figure 8).

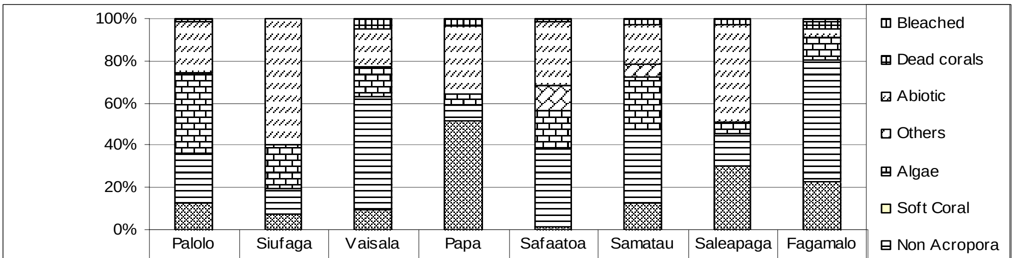
2.4.2 Fish & invertebrate 2005 Monitoring

The fish and invertebrate count is conducted prior to the substrate count. There are several fish species used as indicator species depending on their abundance within a site. Major fish indicators as representation of fish and invertebrate abundance per site are summarised in Appendix 4. Damsel Fish from the family Pomacentridae, the family Scaridae and the species *Acanthurus lineatus* are the most abundant in all three sites (Figure 9).

In comparing sites, Samatau records the highest fish density with 0.83 fish per square metre. However, an overall average density of 0.72 fish per square metre for this year is a good indication of the fish population for any area. (Figure 10).

Of the combined results, Damsel, Line Surgeonfish, Parrotfish, and Wrasses were the major fish types found. The high numbers of the line surgeons and the parrotfish, mainly juvenile fish, is an indication of their successful spawning which probably occurred two months prior to the assessments. The

Figure 5: Substrate coverage for the 2007 monitoring



	Palolo	Siufaga	Vaisala	Papa	Safaatoa	Samatau	Saleapaga	Fagamalo
Bleached	0.00%	0%	0.26%	0.26%	0.00%	0.00%	0.00%	1.54%
Dead corals	1.29%	0%	4.62%	3.33%	1.28%	2.56%	2.56%	3.07%
Abiotic	24.51%	59.48%	17.69%	32.05%	30.25%	18.71%	46.49%	4.36%
Others	0.00%	0%	0.26%	0%	12.31%	5.90%	0.00%	0.00%
Algae	37.76%	21.27%	13.84%	5.39%	18.21%	25.13%	5.13%	10.52%
Soft Coral	0.00%	0%	0.00%	0.00%	0.00%	0%	0.00%	0%

sea urchin and *Holothurians* were the most common groups of invertebrates seen within most of the sites (Appendix 4).

2006 Monitoring

In this year's monitoring the Acanthuridae and the Scaridae families are the most common. (Figure 11)

The fish identified during the assessments were mainly juveniles, and at the time of the assessments, these species were mostly the Bristle Tooth Surgeon and the Parrotfish in huge schools of 50s and 100s, averaging five to seven centimetres in size. It could have been the result of a natural spawning three months earlier.

Overall the fish density and diversity is moderate with an average of 0.49 fish/m^2. For this year's monitoring the food fish are targets as they indicate recovery of the inshore fisheries in the fish reserves involved (Figure 12).

2007 Monitoring

In this year's monitoring, the fish length estimations were resumed after being stopped in 2003. This modification was to provide more information regarding the biomass of the fish stock within the fish reserves.

The most abundant and most common fish were again the Scarus and the Acanthuridae species. The estimated biomass for the Acanthuridae was 150kg and the Scarus *sp* with 140kg in the total 6000m2 which was the assessed area. This is equivalent to 23 grams per square metre (Figure 13).

In fish density, the average for this year's monitoring is 0.6 fish/m^2 , almost the same as last year which was 0.66fish/m^2 (Figure 14).

2.4.3 Invertebrates

2005-2007 Monitoring

Generally the invertebrate population in Samoa, in particular the sea cucumber, has been found to be low. The exportation of sea cucumber has been banned since 1997. In 2006 a detailed assessment was carried out by the SPC team with the Fisheries Division mainly for the invertebrate. This was followed by an extension assessment co-conducted by a PhD student, Mr Hampus Eriksson, from Sweden's Uppsala University, and the Fisheries Division. Results from these two assessments further proved the low population of sea cucumbers in Samoa, particularly the commercially high-valued species.

Approximately 20 species of sea cucumber found in Samoa are commercially viable. However, density for one of these – the highly-valued black teat - was 5 species per hectare. This was an indication of the level of scarcity of the species, making it both uneconomical and undesirable for export (Friedman *et al.* 2006).

From our monitoring over the past three years, we have observed the low density of the invertebrates, in particular the most common species in our reserves. The average density for the lollyfish over the three years was 0.05species/m^2, the green fish 0.01species/m^2, and the brown sandfish with the lowest of 0.002species/m^2 (Figure 15). This is very low indeed, making it a priority area for further detailed monitoring by the Fisheries Division.

2.5 Discussion

2.5.1 Substrate Coverage

Live corals are mainly the dominant substrate within the permanent monitoring sites. *Acropora* and Non *Acropora* corals are found to have about the same fair percentage of abundance. Shallow sites show good coverage of live corals due to good light penetration and good water circulation.

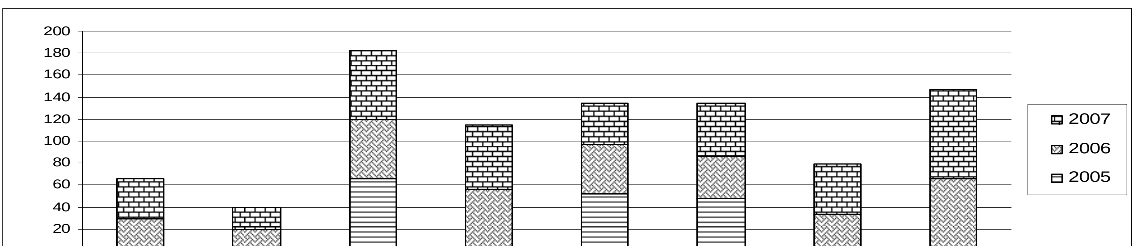
Exception is observed in certain sites where there is abundant algae and abiotic substrate, namely Palolo Deep and Siufaga. The Palolo Deep site is near the Vaisigano River which has the highest rate of nutrient influx towards the marine environment. Siufaga has been a dredging site for the past decade and so, with strong waves, the corals in this lagoon area where the reserve is established, have yet to recover.

Overall results show there has been slow coral recovery since 2005 in most sites after cyclone Heta. This is a positive sign given the main objective for establishing fish reserves is to conserve and protect marine habitats, including corals. Each site has its own unique marine environment. However, most have recorded high levels of live corals, algae and rubble that appear to be common to all sites.

The fish count and biomass estimation in this year shows an overall good density of fish, particularly the food fish. The length estimation is a modification to give us a better view of the biomass of these stocks in our reserves. It certainly serves its purpose when comparing the catch landings in our local markets, and in providing an understanding of the biomass of the stock that we have in our reefs in

2007
2006
2005

Figure 6: Live coral comparisons in past three years monitoring

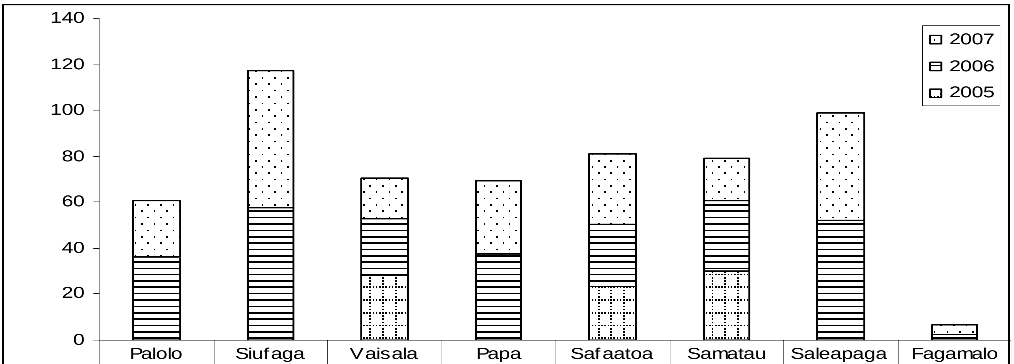


	Palolo	Siufaga	Vaisala	Papa	Safaatoa	Samatau	Saleapaga	Fagamalo
2007	36.44	19.23	63.04	58.97	37.94	47.44	45.82	81
2006	29.3	19.87	54.35	55.9	44.11	39.23	33.03	66
2005	0	0	65.15	0	52.32	47.43	0	0

relation to harvesting stocks. Our fish counts have also shifted to target the food species we can use to compare and consolidate monitoring data with the catch landings data. In the 2007 monitoring, the average fish lengths indicated the abundance of the juveniles in the reserves. The large commercial reef fish such as the Lethrinidae, Lutjanidae and the Serranidae, were all found in smaller numbers but in larger average size of 30cm. (Appendix 5)

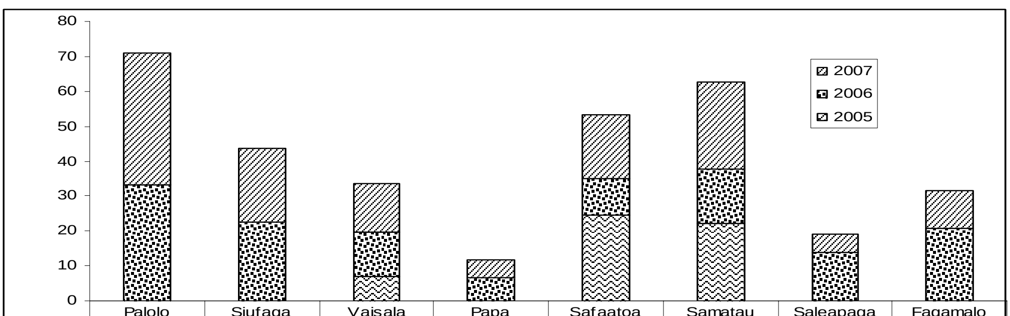
Monitoring results of invertebrates have indicated low density. This was further supported by the detailed assessments carried out by the SPC with the Fisheries Division in 2006. It has been reported that our sea cucumber stock never quite recovered from tropical cyclones in the early 1990s. This government considers this to be serious and has taken the precautionary approach of closing commercial harvesting of these species up to now.

Figure 7: Abiotic group comparisons in past three monitoring



	Palolo	Siufaga	Vaisala	Papa	Safaatoa	Samatau	Saleapaga	Fagamalo
2007	24.51	59.48	17.69	32.05	30.25	18.71	46.49	4.36
2006	36.24	57.69	25.14	37.18	27.44	30.52	52.23	2.30
2005			27.94		23.07	30.26		

Figure 8: Algae group comparisons in past three monitoring



	Palolo	Siufaga	Vaisala	Papa	Safaatoa	Samatau	Saleapaga	Fagamalo
2007	37.76	21.27	13.84	5.39	18.21	25.13	5.13	10.52
2006	33.33	22.44	12.82	6.41	10.51	15.63	13.78	20.9
2005			6.91		24.61	22.06		

3
CURRENT RESOURCE USE

3.1 Community Resource Use

A nationwide socio-economic study was undertaken in 2006 to assess the status of rural fisheries in Samoa. 939 households in 49 villages (26 on Upolu, 23 on Savaii) were interviewed about their household composition, income, education level, seafood purchasing and consumption habits, fishing preferences, catch, and whether they sell fish. Although this study incorporated data comparable to previous studies, it differed significantly from past surveys conducted in Samoa. Previous studies were composed of separate surveys for consumption, fishing, and selling, while the current study combined these various questionnaires into one and surveyed the household as a unit.

One of the main survey highlights was the fish consumption results. Based on age and gender, the quantity of fish people consumed varied. On average, people consumed finfish 2.8 times per week. People in villages with Fisheries Management Plans consumed more fish more frequently than those in villages without plans (3.0 times per week vs. 2.6). The frequency of consumption is higher on Upolu than on Savaii, and higher in villages that are farther away from Upolu. The per capita consumption is 59.4 kg per year, or 163 kg per day. The total consumption per year is estimated at 10,508mt (7900mt for Upolu, 2608mt for Savaii). The average market price for the 2005-6 year was $8.00 per kilogram. At this rate, the value of Samoa's finfish subsistence fishery is approximately $ST (Samoan tala) 84 million.

Tinned fish included canned tuna, wahoo, sardines, and the ever popular mackerel.

People reported consuming tinned fish 4.5 times per week on average. Tinned fish, canned mackerel spe-

Figure 9: The abundance of the fish sample during the 2005 assessments

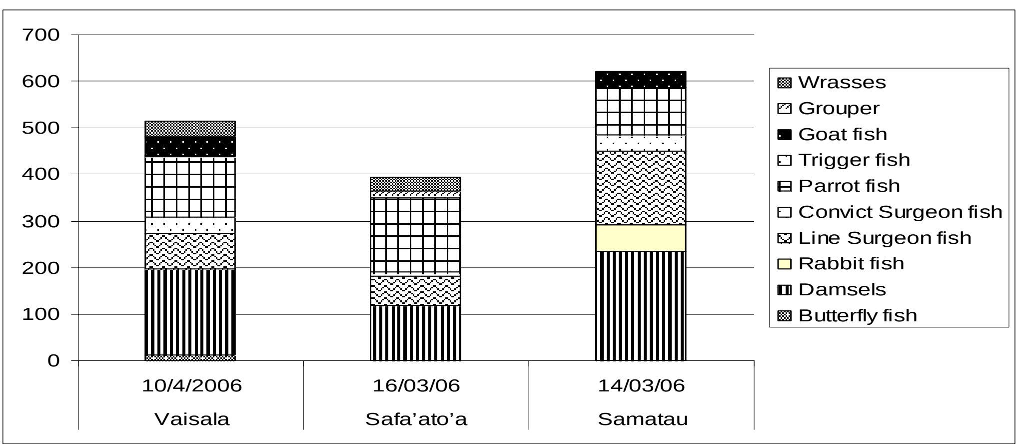
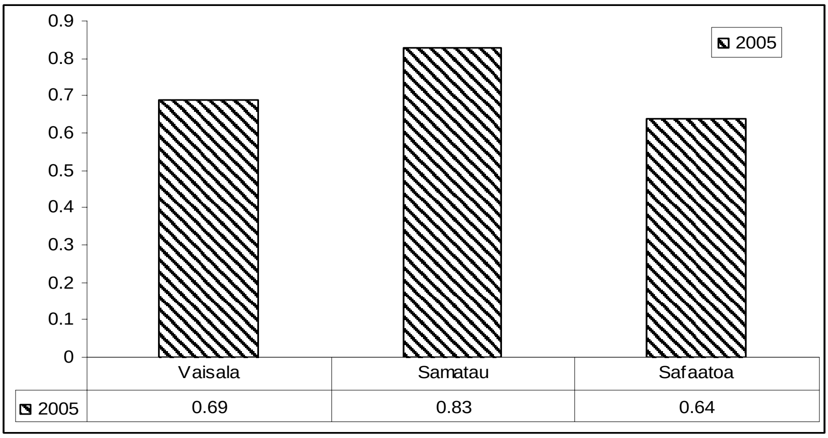


Figure 10: The fish density of the sample fish in the three sites assessed



cifically, is viewed as a low cost alternative to fresh fish, although its price per kilogram is $6.59 (about $1.50 less than fresh fish). The per capita consumption of tinned fish is 75kg per year, or 206g/day. This is the first time tinned fish consumption surpassed fresh fish. 13,268mt of tinned fish are consumed per year in Samoa, with almost $ST500 per person spent on tinned fish each year ($ST 87.4 million total).

This growing preference for canned fish may also be the result of having limited cash flow. Poor people often buy just enough of something to fulfill their needs at that moment, even when it is significantly cheaper to buy something in larger amounts, because they don't have the cash available for a larger purchase, or long term investment.

The findings of this survey supported many of the trends observed over the last few decades. In addition, the study provided clear indications that the villages participating in the Community Based Fisheries Management Program (CBFMP) are seeing real benefits to their conservation efforts in the form of increased CPUE, higher fishing incomes, and higher frequencies of fish consumption (Valencia,S., Mulipola,A., Tauaefa,A., Tuaopepe,O. 2007).

3.2 Coral Reef Species

3.2.1 Subsistence, Artisanal Fisheries

The subsistence and artisanal fisheries in Samoa within the inshore area remains very important for the livelihood of the people. There has been a slow but sure move of fishers from subsistence to artisinal as a result of money being the main drive for living. However the change has also put a strain on the inshore fisheries resources from over fishing and destructive fishing practices.

The total landings for the subsistence fisheries for the year 06/07 is 13,666 metric tonnes, this is equivalent to $ST84million (33.6 million USD). This means that average consumption for one person is 56kg/yr (Valencia *et al.* 2007).

The total inshore fisheries landed and sold at the domestic outlets for the year 06/07 is 126.47 metric tonnes which is value as $ST1.5 million (0.6 million USD). More than fifty percent of this total value is made up of finfish (Fisheries Division, 2007).

The value of these two fisheries in the year 06/07 total some $ST85.5 million (34.2million USD) which is an indication of the huge importance of these two fisheries to the population of Samoa.

3.2.2 Tourism

Tropical weather, crystal sea, and beautiful corals are some of the main features of tourism in Samoa as they are in the rest of the South Pacific. The natural environment in particular clear waters and healthy reefs are what Samoa has to offer to visitors from around the world. Many locals are building traditional Samoan housing on beaches to attract and accommodate tourists, with the reefs as the main attraction. In 2007 tourism earnings reached new heights of $ST282.3 million (107 million USD) (Appendix 6).

3.2.3 Aquarium Trade

There is currently no aquarium trade.

3.3 Mangroves

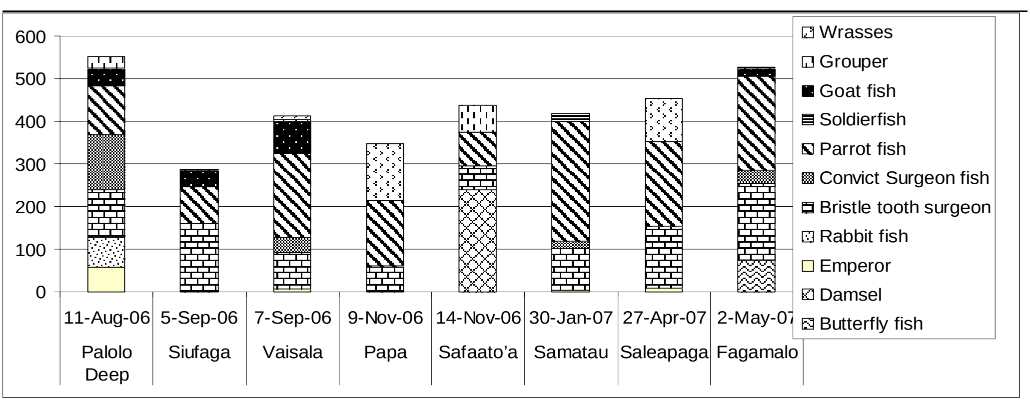
Three species are found within Samoa; the *Rhizophora samoensis*, *Bruguiera gymnorrhiza* and the rarest *Xylocarpus moluccensis* which is believed to be found only in a small one hectare of mangrove patch on the island of Savaii (Schuster, 1993). Currently, the total estimated area of coastal swamps and mangrove in Samoa is less than $10km^2$, with the largest area being the Vaiusu Bay which is also the largest in Eastern Polynesia. (Personal communication, Malaki Iakopo, November 2006).

There are many small mangrove areas in Samoa which have all shown signs of degradation or destruction from human activities. These are mainly uncontrolled cutting and clearing, rubbish disposal, land reclamation for housing and other developments, and pollution. The Moataa mangrove area, for example, occupied 9.1 hectares in the 1970s but was reclaimed for a hotel project in 1990. This has reduced the mangrove area to 5 hectares, a 45% reduction (Suluvale, 1997).

Mangroves play a vital role in the coastal environment, as they are shelters and nurseries for juvenile marine organisms. The trees also provide shelter and nesting for land and sea birds. The whole complex network of plants and mangroves provide a wide food web for both marine and land animals and humans. They are an ecological shoreline protection and a buffer zone filtering the excess nutrients from entering our vulnerable reefs.

The government is taking the lead role in conserving and protecting these ecosystems through regulations, by-laws and policies that safeguard any excessive harvesting in the future.

Figure 11: Fish abundance per 750m 2 in the eight permanent monitoring sites in the 2006 monitoring



3.4 Marine Mammals

Whale and dolphin watching operations are a rapidly growing industry in many parts of world, including the Pacific. Currently, Samoa does not have a commercial whale and dolphin watching operation. However, with the increase in tourist numbers there is potential for developing a whale and dolphin watching programme that would compliment the expanding tourism industry, and provide an alternative income for local fishermen.

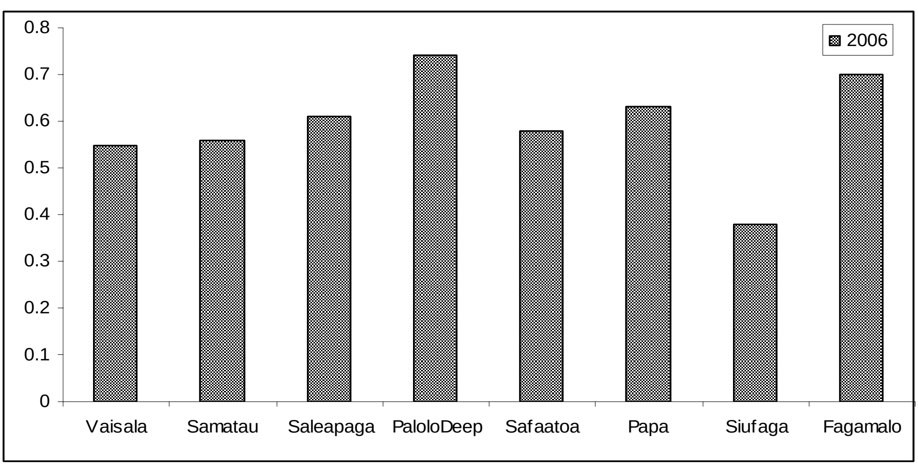
Information and knowledge on marine mammals were scarce until in 2001 when a collaborative project between the South Pacific Island Whale and Dolphin Program (SPIWDP) and the Ministry of Natural Resources and Environment (MNRE) conducted a dedicated cetacean survey in Samoa waters. This survey revealed that the northwest of Savaii Island had high cetacean density. In addition 10 different species of whale and dolphin were identified (Oremus *et al.* 2007).

3.5 Endangered species

Marine turtles are continually exploited for commercial purposes. Over-hunting for their shells for handicrafts, meat, and collection of eggs from nests are some factors contributing to their endangered status. According to MNRE surveys over the years, there is a clear indication of low nesting densities for the critically-endangered hawksbill turtle (*Eretmochelys imbricata*) during its nesting season (October – June). The hawksbill is the only species that nests in Samoa. Green turtles (*Chelonia mydas*) are commonly found foraging, while the leatherback turtle (*Dermochelys coriacea*) has only been found entangled in long line fishing lines. (Figure 15).

It is believed that the decline in turtle populations has been accelerated by the weakening of traditional conservation practices, habitat degradation, incidental by-catch in fishing gear, harvesting of eggs, and turtles caught for their shells. The continuation of such practices will result in marine turtle species eventually becoming extinct.

Figure 12: The fish density (fish/m 2) of the sample fish from the monitored sites in 2006



4
THREATS TO CORAL REEFS/MANGROVES/SEAGRASS

4.1 Integrated Threat Index

An Integrated Threat Analysis was carried out using a modification of the “Reefs at Risk” methods. Modifications reflect local conditions in the small Island states of the Southwest Pacific Node, where detailed technical information is often not available, or where threats that may not apply in other regions may exist. In this analysis, potential threats to reef health in areas of the country where data is gathered are assessed in five categories (Appendix 7a-e) and then integrated into a single threat score. The following is the key to sites that have undergone this threat assessment.

N Upolu - North Upolu (Palolo Deep)

SE Upolu - Southeast Upolu (Saleapaga)

SW Upolu - Southwest Upolu (Safa’ato’a)

NW Upolu - Samatau

N Savaii - North Savaii (Vaisala, Fagamalo)

SE Savaii - Southeast Savaii (Papa and Siufaga)

The Palolo Deep site which is located near the heart of town and ports is the only site subject to moderate threat due to its proximity to the main port of Samoa and the Vaisigano River, the principal nutrient provider to Apia’s marine environment. Other sites are subject to low threats as they are fish reserves and are further away from

Table 2: Overall Integrated Threat Index of the GCRMN permanent sites

OVERALL: INTEGRATED THREAT INDEX						
Reef Area	Coastal Development	Marine based Pollution	Pollution and Sedimentation	Artisanal Over-fishing	Destructive Fishing	Overall Threat Index Score
N Upolu	Medium	High	High	Low	Low	Medium
SE Upolu	Medium	Low	Low	Low	Low	Low
SW Upolu	Medium	Low	Medium	Low	Low	Low
N Savaii	Medium	Low	Low	Low	Low	Low
SE Savaii	Medium	Low	Low	Low	Low	Low

Figure 13: Total fish biomass in kilograms in 6000m2 (area assessed) and average length from all sites in the 2007 monitoring

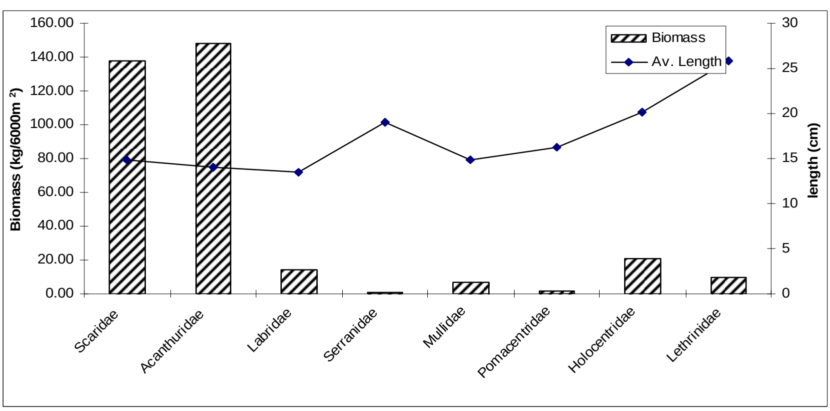
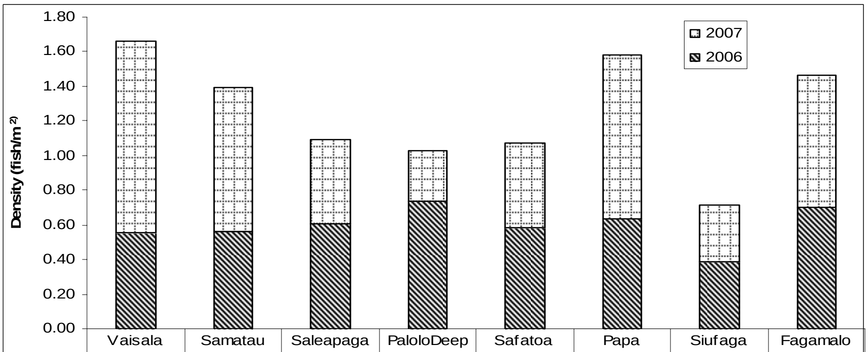


Figure 14: The fish density of the sample fish from the monitoring in 2006 and 2007



	Vaisala	Samatau	Saleapaga	PaloloDeep	Safatoa	Papa	Siufaga	Fagamalo
2007	1.11	0.83	0.49	0.29	0.49	0.95	0.33	0.76
2006	0.55	0.56	0.61	0.74	0.58	0.63	0.38	0.70

any major developments. The main minor coastal developments near these sites are the seawall constructions.

4.2 Coastal development

The major developments in coastal areas are the construction of seawalls to protect the coastline from further erosion, and in the effects of cyclones. However they also have negative impacts on the coastal area. These include erosion from the removal of seagrass beds and the coastline plants. There has also been reclamation of some coastlines for business or home development or expansion. The government has imposed some control on reclaiming of coasts, by allowing a landowner to reclaim only a ¼ acre of his/her land and no more. This is done through the issuing of a single permit per landowner.

4.3 Pollution

There have been many initiatives to control poor waste disposal and regulate use of pesticides and other chemicals. For instance, issuing licences for chemical users, landfills and clean up campaigns. However, mangrove swamps, drains and riversides are still used as waste dumps. The end product of this pollution mainly ends up on the coral reefs. These are important considerations for a country which also does not have a well-defined sewage system in the rainy season.

Marine pollution from dumping and littering is being reduced by awareness and community-base management programmes and by-laws.

4.4 Sedimentation, nutrient enrichment and eutrophication

Although 48 per cent of the island is forested, deforestation is reducing wildlife habitats and leading to soil erosion (Iakopo, 2006). With increasing development and deforestation this percentage may have declined considerably. Therefore during the rainy season (November and April) excess nutrients, pesticides from agricultural fields, and raw sewage are washed into the surrounding coral reefs. In addition good drainage and sewage systems (only septic tanks) have not been put in place. Hence there are many unknown outlets, other than river mouths, that contribute to sedimentation and eutrophication.

4.5 Over fishing

A recent social economic survey showed that 86% of fishing is carried out in the reef area, with 42%

of the average household containing at least one fisherman. The catch per unit effort from 1.8kg/hr in 1990, to 2.1kg/hr in 1997 and most recently has increased to 2.24kg/hr in 2007 (Valencia *et al.* 2007). This is an indication of over fishing compared to the limited coastal resources in Samoa.

4.6 Destructive fishing and coral harvesting

With the expansion of the community-based fisheries management programme in Samoa, and conservation efforts by the DEC, there has been widespread awareness of the negative impacts of destructive fishing and coral harvesting. Dynamite fishing and use of *Derris* root have been banned under Fisheries Regulations 2005 leading to a reduction in reported cases. However it is believed there are still minor infringements in some places amongst subsistence fishermen. Coral harvesting and exportation have been banned since 1997.

4.7 Bleaching, coral disease and predators

Bleached corals observations are also included in the substrate assessment of monitoring sites. The past three years (2005-2007) puts bleaching of branching and foliose corals at 15.5%. In comparison with past monitoring data this has increased from 4.9% (2003) to 26.4% in 2004. Bleaching in these spots is associated mainly with neap tides around August each year, except for 2004 when damage was the result of Cyclone Heta.

4.8 Hurricane/tsunamis

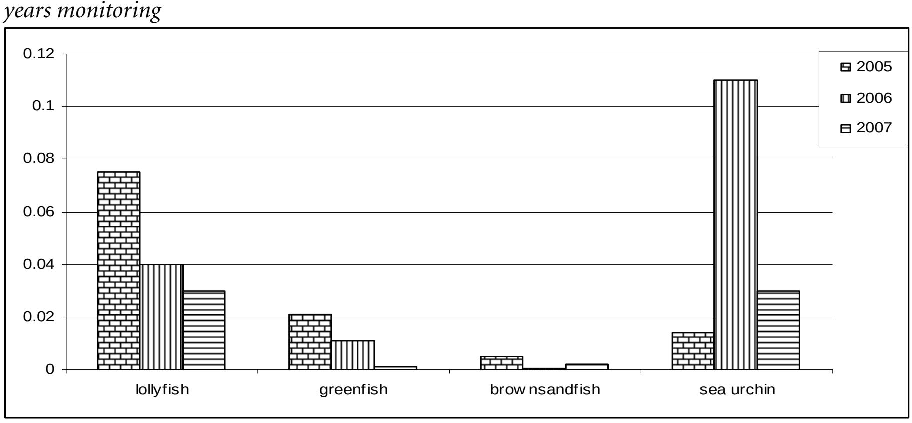
No hurricanes or tsunamis hit Samoa between 2005 and 2007.

4.9 Outbreak of organisms

There was no outbreak of crown-of-thorns starfish (COTS) *Acanthaster plancii* from 2005 to 2007. On the other hand a recent survey within the Apia Harbour area has identified several marine invasive species. These introduced species are often misinterpreted as new and curious discoveries, for instance the *Pinnaria disticha*, christmas tree hydroid, one of the species identified in the survey (South and Skelton, 2007). These species are often more resilient than local species in terms of space and food, hence they are a threat to the marine biodiversity.

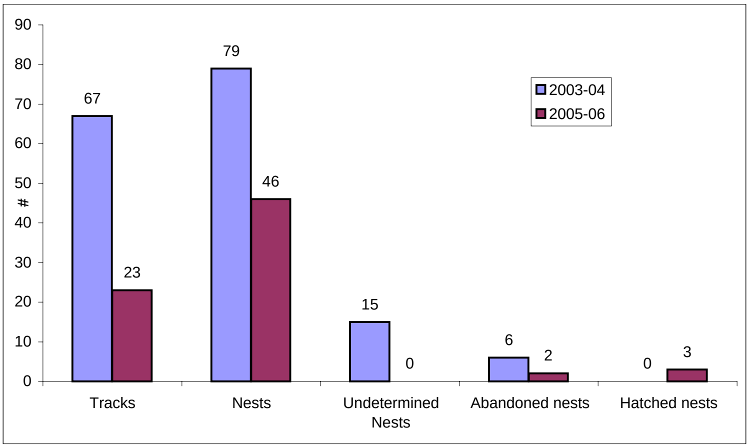
Many of these species are brought into the Samoan Archipelago from places as far away as the Caribbean, Western Atlantic, Australia and the Indian Ocean. Shipping is the likely cause of their intro-

Figure 15: The estimated density of the most common invertebrates sampled during the past three years monitoring



duction as most are found in the harbours. Two particular species *Codium arenicola* and *Codium prostratum* have now moved from Apia harbour and are growing on reef slopes of nearby coastal villages (Vaiusu and Vaiala). These introduced seaweeds are forming large meadows in areas previously occupied by local animals and plants (South and Skelton, 2007).

Figure 16: Turtle activities for the years 2003-04 and 2005-06



Source:Momoemausu et al, 2006

5
CURRENT CORAL REEF CONSERVATION EFFORTS

5.1 Government Efforts

5.1.1 Community-based Fisheries Management Programme

The Fisheries Division Community-based Fisheries Management Programme (CBFMP), which began in 1995, now covers 89 villages on both Savaii and Upolu. All of these villages have produced by-laws that are recognised by Samoa's legal system. Of these 89 villages, 49 have opted to establish fish reserves. Every fiscal year, 20 reserves are assessed and re-assessed including the eight permanent sites for the GCRMN. The programme is to assist the village communities with management measures and other necessary actions to effectively manage, conserve and protect their limited coastal resources.

5.1.2 Marine Protected Areas for the Aleipata and Safata Districts

The Districts of Aleipata and Safata established their marine environment as protected areas in 1999. These include 11 villages from Aleipata and nine villages from Safata. Both districts work in collaboration with the DEC so that their marine biodiversity is protected and used sustainably. Management plans and village by-laws have been developed to address issues/problems faced within the protected areas, and appropriate action to address them.

The DEC undertakes annual community-based monitoring to assess the current status of the marine resources within the respective no-take zones. These surveys involve community volunteers as part of their contribution to the management and protection of the area.

5.1.3 Coral Reef Related Projects

The United Nation Development Program (UNDP) is coordinating a small grant aid programme from USD1,500.00 to a maximum of USD26,000.00 for local communities to manage and protect their environment. The FD is assisting the villages within their CBFMP programme with the preparation of proposals, and awareness for coral reef rehabilitation projects. The FD also provides technical service through periodic monitoring of the resources and implementation of physical restoration of corals if this is required. The DEC is also providing the same assistances to the villages within their MPA programmes.

The Cyclone Emergency Recovery Project, a government initiative, is currently coordinated by the DEC. Its main objective is to improve the resilience of infrastructural assets, the livelihoods of the inhabitants, and ecosystems against natural hazards such as Cyclone Heta. Its main activities include the restoration of coastal ecosystems as soft solutions and the upgrading of drainages or crossings from mangrove areas to the sea as major work. Eight villages were selected for this ecosystem restoration, including replanting of corals and mangroves, improving community awareness, and upgrading of drainage systems. The project is for four years starting in June 2004 and ending in June 2008.

5.2 Acts and Legislations

The conservation, protection and management of coral reefs is the responsibility of the Fisheries Division and the Division of Environment, under the Fisheries Act 1988 and the Division of Environment and Conservation Act 1989.

5.3 NGOs Efforts

5.3.1 Matuaileoo Environment Trust Institute (METI)

The METI has been assisting with coral replanting in village reserves. The restoration of coral has been undertaken by experts in this NGO.

6
FUTURE OF CORAL REEF HEALTH

The suspected increase in sea levels in the future will surely have an impact on Samoa's reefs. Already the reefs are fringing and limited and rising sea levels will certainly affect temperatures and thus coral growth.

We are confident that within 10 years, there will be a detailed profile of Samoa's coastal resources, with coastal maps that clearly show the status of these resources, and a proper monitoring system that consistently monitors our reefs and provides up-to-date assistance with decision-making on the protection of reefs.

Lastly, and most importantly, we expect the whole of Samoa to participate in the protection and conservation of our reefs in one way or another. The ecosystem approach on fisheries is being drafted to include reef protection, so we are determined to have 100% participation of communities in coral reef protection and conservation.

7
RECOMMENDATIONS

Since 2004, concerted efforts have been made by both the MAF and MNREM to document the biodiversity of Samoa's marine resources. Assistance from international and regional organisations has enabled Samoa to respond to some of the recommendations of the 2004 report. The following are some of those recommendations:

Better collaboration from two leading government agencies

The signing of a memorandum of understanding (MOU) between the two agencies in 2006 was a successful move towards working together to protect the reefs. This MOU is designed for the coral reefs, in particular coral reef monitoring. It was a step towards standardisation of our monitoring activities and the sharing of information. It is recommended, therefore, that the two agencies use this MOU and work collaboratively in standardizing monitoring methods for better analysis and reporting.

Community involvement

It is important to always have the support of the local communities for the successful monitoring and protection of any reef project. The local people view the resource as their own, and authority of the *matai* (chiefs) provides the enforcement necessary for successfully managing these resources. Their involvement will certainly make conservation efforts easier and more likely to succeed.

Biodiversity of reef resources

Samoa is still without adequate knowledge of its reef biodiversity, therefore a combined effort by the two Ministries is necessary to collect and collate information for the establishment of a proper store or collection of information. The Division of Environment has started its coral collection, while the Fisheries Division has a collection from the early 80s which is now being revised and properly documented using a database.

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APPENDICES

Appendix 1: Summary of major coral reef groups at permanent sites monitored during 2005 period.

LONGTERM SITES	Vaisala	Samatau	Safa'ato'a
CORAL TYPES			
Acropora Braching	20.26	19.49	4.1
Acropora Tabulate	0.26	0.51	0
Acropora Digitate	0	0.51	0.52
Acropora Submassive	0	0.26	0
Acropora Encrusted	0	0.51	0
Coral Encrusted	0	0.51	0
Coral Branching	1.03	2.3	0.76
Coral Foliose	35.39	8.21	9.24
Coral Massive	4.62	4.1	18.2
Coral Submassive	3.59	11.03	19.24
Coral Mushroom	0	0	0.26
TOTAL (%)	65.15	47.32	52.32

Appendix 2: The live coral groups from the monitoring in 2006 monitoring.

LONGTERM SITES	Siufaga	Palolo Deep	Vaisala	Papa	Safaato'a	Samatau	Saleapaga	Fagamalo
Acropora Braching	5.77	20	15.6	7.69	6.67	18.72	9.94	19
Acropora Tabulate	0	0.51	0	36.92	0	0.26	8.34	6.2
Acropora Digitate	0	0.25	0	2.06	0	0.26	0.65	0
Acropora Submassive	0	0	0	0	0	0	0	0
Acropora Encrusted	0	0	0	0	0	0	0	0
Coral Encrusted	2.56	0	0.3	1.79	0	1.54	2.56	0.8
Coral Branching	0.32	1.28	0	0.51	0.25	2.30	1.60	1.7
Coral Foliose	0.96	0	27.2	3.33	0.52	1.79	8.34	31.5
Coral Massive	4.49	1.28	4.9	0.27	18.72	2.06	0.32	1.8
Coral Submassive	5.77	5.90	5.4	3.33	17.95	12.30	1.28	5.1
Coral Mushroom	0	0	0	0	0	0	0.32	0
TOTAL (%)	19.87	30.15	54.35	55.90	44.11	39.24	33.03	65.90

Appendix 3: The algae group from the monitoring in 2006 monitoring

LONGTERM SITES	Siufaga	Palolo Deep	Vaisala	Papa	Safaato'a	Samatau	Saleapaga	Fagamalo
Assessed Dates	05/09/06	11/08/06	07/09/06	09/11/06	14/11/06	30/01/07	27/04/07	02/05/07
Turf algae	11.22	4.36	7.9	0.26	7.17	1.79	9.61	5.4
Halimeda	-	-	0.3	-	0.52	-	-	0.3
Coralline algae	0.64	2.31	5.9	-	-	0.77	-	-
Macro algae	4.49	20.51	1.3	-	0.25	11.79	0.32	0.3

Appendix 4: Summary of the proportion of major fish and invertebrate indicators per site.

LONGTERM SITES	Vaisala	Safa'ato'a	Samatau
SURVEY DATES	**10/4/06**	**16/03/06**	**14/03/06**
FISH SPECIES			
Butterfly fish	12	0	0
Damsels	184	119	234
Rabbit fish	0	00	58
Line Surgeon fish	78	61	158
Convict Surgeon fish	34	10	34
Parrot fish	130	159	103
Trigger fish	2	0	0
Goat fish	43	0	34
Grouper	0	15	0
Wrasses	31	31	0
INVERTEBRATES			
Lollyfish	9	20	160
Sea urchin	13	126	53
Prickly fish	0	27	22
Blue starfish	0	2	3

Appendix 5: Summary of the proportion of major fish and invertebrate indicators per site in the 2006 Monitoring

LONGTERM SITES	Siufaga	Palolo Deep	Vaisala	Papa	Safaato'a	Samatau	Saleapaga	Fagamalo
SURVEY DATES	**05/09/06**	**11/08/06**	**07/09/06**	**09/11/06**	**14/11/06**	**30/01/07**	**27/04/07**	**02/05/07**
Fish Species								
Butterfly fish	0	0	0	0	0	0	0	76
Damsel	0	0	0	0	240	0	0	0
Emperor	0	58	7	0	0	4	8	0
Rabbit fish	0	69	0	0	0	0	0	0
Striated Surgeon fish	160	112	85	61	56	99	147	178
Convict Surgeon fish	0	129	35	0	0	15	0	32
Parrot fish	86	115	197	153	78	281	197	220
Soldierfish	0	0	0	0	0	19	0	0
Goat fish	40	42	77	0	0	0	0	18
Grouper	1	27	3	0	64	0	0	3
Wrasses	0	0	9	134	0	0	103	0
Invertebrate Species								
Lollyfish	7	0	3	3	17	260	3	0
Sandfish	0	0	14	0	0	0	0	0
Sea urchin	0	198	0	0	173	309	0	0
prickly fish	0	3	0	0	22	16	27	0
Blue starfish	0	3	4	0	1	0	1	0

Appendix 6: Total earnings in dollars from tourism over the years

Yr	SAT$	% growth	Yearly rates	US$
96	98.9	0	0.41	40.6
97	102	2.932255	0.36	36.8
98	115	13.16306	0.33	38.3
99	126	9.201389	0.33	41.7
00	134	6.3593	0.3	40.0
01	140	4.484305	0.28	39.4
02	152.6	9.155937	0.3	45.2
03	163.5	7.142857	0.33	54.5
04	193.1	18.10398	0.36	69.5
05	207.8	7.612636	0.37	76.9
06	248.9	19.77863	0.36	89.6
07	282.4	13.45922	0.38	107

Source: Research & Statistics Division STA, National Department of Statistics & Central Bank of Samoa

Appendix 7a: Threat Index for Coastal Development

	Closer than 4km away	**4 – 10km away**	**10 - 25km away**	**More than 25km away**
Cities, Population Over 100,000	High	High	Medium	Low
Cities, Population 50,000 – 100,000	Medium	Medium	Low	Very Low
Towns, Population under 50,000	Medium	Medium	Low	Very Low
Airports (in use)	Medium	Medium	Very Low	Very Low
Mines	High	High	Very Low	Very Low
Tourist resorts and dive centres	Medium	Very Low	Very Low	Very Low
Any Coastline (shore)	Low	Very Low	Very Low	Very Low

A) Coastal Development							
Reef Area	**Cities**	**Towns**	**Airports**	**Mines**	**Tourism**	**Coastline**	**Overall Score**
N Upolu	-	Medium	Very low	-	Medium	Low	Medium
SE Upolu	-	Very low	Very low	-	Medium	Low	Medium
SW Upolu	-	Very low	Very low	-	Medium	Low	Medium
N Savaii	-	Very low	Very low	-	Medium	Low	Medium
SE Savaii	-	Medium	Medium	-	Medium	Low	Medium

Appendix 7b: Threat Index for Marine-Based Pollution

	Closer than 4km away	**4 – 10km away**	**10 - 30km away**	**30 – 50km away**
Ports, Large (Container ships, tankers, fishing ships, etc, eg Suva)	High	High	High	Medium
Ports, Medium (Fishing ships etc, eg Port Villa)	High	High	Medium	Very Low
Ports, Small (Yachts and personal boats)	High	Medium	Very Low	Very Low
Ports, Very small (Local outboard boats)	Medium	Very Low	Very Low	Very Low
Oil storage tanks, refineries	High	Medium	Very Low	Very Low
Shipping Lanes	Medium	Low	Very Low	Very Low

B) Marine-Based Pollution				
Reef Area	Ports	Oil Tanks / Wells Within 10 Km	Shipping lanes	Overall Score
N Upolu	High	High	Medium	High
SE Upolu	Medium	Very low	Medium	Medium
SW Upolu	Medium	Very low	Very low	Medium
N Savaii	Medium	Very low	Very low	Medium
SE Savaii	Medium	Very low	Low	Medium

Appendix 7c: Threat Index for Pollution and Sedimentation

	High	**Medium**	**Low**	**Very Low**
Vegetation Type	Large scale croplands	Permanent wetland (Swamp)	Dense planted forest	Dense natural forest
	Urban and built-up	Grassland	Mixed Forest	
	Areas with little vegetation	Open Shrubland mixed with grass	Dense Shrubland	
		Cropland mixed with natural vegetation		
		Small, dry islands with coconuts and salt bush		
Steepness of slope		Steep	Moderate	Slight/Flat
Contributing factors	Deforestation	Commercial Agriculture	Domestic agriculture	
	Mining	Commercial Livestock	Domestic Livestock	

C) Pollution and Sedimentation					
Reef Area	Vegetation		Steepness	Factors	Overall Score
	Type	Risk			
N Upolu	Urban	High	Low	Low	High
SE Upolu	Mixed forest	Low	Low	Low	Low
SW Upolu	Mixed forest	Low	Medium	Low	Medium
N Savaii	Mixed forest	Low	Low	Low	Low
SE Savaii	Mixed forest	Low	Low	Low	Low

Appendix 7d: Threat Index for Artisanal Overfishing

	Closer than 10km away	**10 – 20km away**	**More than 20km away**	**Marine Protected Area within 10km**
Coastal population	High	Medium	Low	Low

D) Over fishing (Local fisheries not commercial)		
Reef Area	Score	Notes on Marine Protection
N Upolu	Low	Palolo Deep
SE Upolu	Low	Saleapaga
SW Upolu	Low	Samatau and Safaatoa
N Savaii	Low	Vaisala and Fagamalo
SE Savaii	Low	Siufaga and Papa

Appendix 7e: Threat Index for Destructive Fishing

Destructive Fishing	Several times ……..			Never
	Week	Month	Year	
Dynamite	High	Medium	Low	Very Low
Chemical Poison (Cyanide or Chlorox)	High	Medium	Low	Very Low
Herbal Poison	High	Medium	Low	Very Low
Direct coral breakage (trampling, excavation, harvesting)	High	Medium	Low	Very Low

E) Destructive Fishing (Poisons or blast)					
Reef Area	Dynamite	Chemical Poison	Herbal Poison	Breakage	Overall Score (Highest recorded)
N Upolu	-	-	Very low	Medium	Medium
SE Upolu	-	-	Very low	Low	Low
SW Upolu	-	-	Very low	Low	Low
N Savaii	-	-	Very low	Medium	Medium
SE Savaii	-	-	Very low	Medium	Medium

Note: poisons on shallow reef tops not deeper reefs.

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SOLOMON ISLANDS (WESTERN PROVINCE) CORAL REEF MONITORING REPORT FOR 2006 – 2007

Nelly Kere

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WWF Solomon Islands Country Programme

May 2008

CONTENTS

EXECUTIVE SUMMARY

Coral reefs have a very important role in the livelihood of about 80% of Solomon Islanders who are coastal dwellers. The reefs provide a source of wealth and food security. With increasing population and high demand for cash and food using marine resources, the coral reefs have come under great pressure from over fishing, coastal development, logging and natural disasters such as earthquakes and tsunami. Gathering data on the status of the coral reefs is important for the development of effective management plans to sustainably manage marine resources. A national coral reef monitoring network was established in 2003 for this purpose, through the support of the David & Lucile Packard Foundation.

The main objectives of the monitoring programme were:

1. To assess the substrate composition at two depth profiles at each site under six major life form categories;
2. To investigate fish abundance by counting fish by family and at species level for the commercially important reef food fish at two depths;
3. To estimate the size of some commercially important reef food fish.

Five permanent monitoring sites had been established since 2004. All the sites were situated around the Western Archipelagos of Solomon Islands covering two of the nine provinces. Arnavon Islands and Tetepare are two permanent marine protected areas that have been protected for 12 and five years respectively, while Gizo has proposed marine protected area sites and the other two sites are not protected. The reef habitat, oceanic currents and the influence of human activities within the surrounding area mainly determine the distribution of live coral cover.

Through the monitoring programme, results demonstrated that generally, fish of larger size and abundance were recorded in marine protected areas with less fishing pressure, compared to open access areas. The coral cover in all the five permanent sites were generally in healthy condition except for Marovo especially in the inner lagoon where there was very low live coral cover due to high sedimentation from nearby logging.

The 2007 earthquake and tsunami disaster had also greatly affected the coral reef structure and the substrate composition especially of reefs around Ghizo Island. Water temperature was found to be higher in 2007, compared to the same period in 2006. This might be due to the impact of climate change that is now a global issue.

The information gathered from this monitoring programme can be distributed to resource owners, researchers, reef managers and other stakeholders to develop management plans that are effective and practical, based on the status of the resources.

I
INTRODUCTION

Coral reefs form an integral part of the livelihoods of Solomon Islanders. About 80% of Solomon Islanders are coastal dwellers, scattered around the six main islands and numerous smaller islands and atolls. They depend on marine resources for their daily protein and food and for cash income to meet their subsistence needs. It is part of the cultural tradition of Solomon Islanders that the people are connected to their resource. The sea is seen as a "goddess of wealth".

With the high demand and relatively high cash return for marine products, increasing pressure is being exerted on marine resources. This combined with a rapidly increasing population and other human and natural threats to coral reef ecosystems, means that the future of coral reefs is at stake.

Gathering scientific information to enable monitoring of the status of coral reefs and the development of effective management plans, was identified by conservation practitioners as a priority area for an effective conservation effort in managing marine resources. Consequently, the Global Coral Reef Monitoring Network (GCRMN) was established. In 2002, WWF Solomon Islands Country Programme (WWF) received initial funding from the National Oceanographic and Atmospheric Administration (NOAA) of the United States Department of Commerce and GCRMN to establish a national Coral Reef Monitoring Network that would involve government departments, non-government organisations and representatives from the commercial and private sectors. The overall goal of the project was to collect standardised data on the composition and status of selected coral reefs around the country, including areas where partner organisations had active or planned projects. A taskforce comprised of individuals with prior experience in marine research activities in the region was appointed to oversee project objectives and achievements. In 2003, a GCRMN training workshop was co-hosted by WWF and the Department of Fisheries in Gizo to train representatives from partner organisations in the GCRMN survey protocol. The training provided individual and institutional capacity building to enhance coral reef research capabilities in the country.

Due to logistical difficulties of accessing divers, equipment and the closure of a number of dive organisations during times of ethnic tension, the national network was confined to working only in the Western Solomons. Coral reef monitoring activities began in earnest in 2004, with WWF taking the lead by establishing five survey locations in Gizo, Munda/Lola, Marovo, Tetepare and Arnavon Islands. The WWF marine team at that time was limited to three people, two of whom were qualified for underwater activities. WWF was therefore largely dependent on partners, the WorldFish Center and a local dive shop for the survey work. In phase 1 of the project each location was visited twice a year (Hughes et al., 2005).

Phase 2 of the project (reported on here) was made possible with two years of funding from the David and Lucile Packard Foundation in 2006. Survey sites were visited twice in 2006 and once in 2007.

2
OBJECTIVE

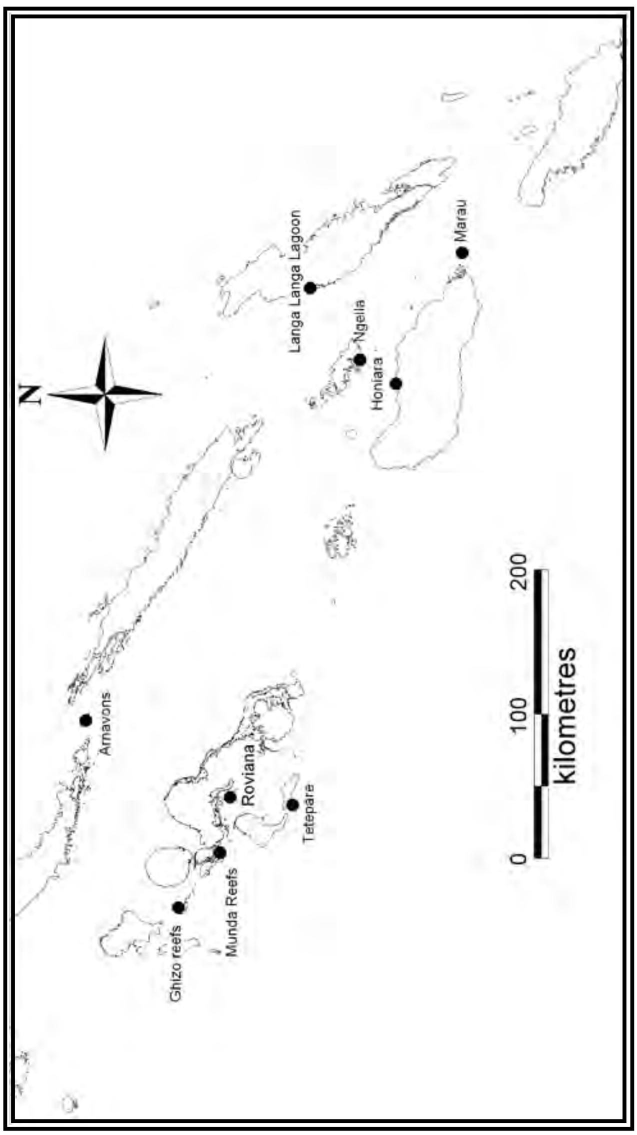
The main objectives of this survey were:

a) To assess the substrate composition at two depth profiles at each site under six major life form categories.

b) To investigate fish abundance by counting fish, by family, at two depths.

c) To estimate size of some commercially important reef food fish.

Figure 1. Coral reef monitoring locations within the Western Solomons



3
MONITORING SITES

The Solomon Islands Coral Reef Monitoring Network (SICRMN) implemented and administered by WWF, established five permanent monitoring locations in 2004; four in the Western Province (Ghizo Island, Munda, Tetepare, Marovo) and one in Ysabel Province (Arnavon Islands) (Fig 1). At each location four stations were identified (separate reefs) and at each of these stations two sites (representative of the reef habitat) were selected within which two depth profiles (5m and 10m) were surveyed. On each depth profile four 50m transects were laid and surveyed. All of the transects were laid on reef slopes.

The sites are situated in the Western Solomon Islands region for logistic reasons since most of the dive operators (and, therefore, access to equipment and staff) in the central and eastern region ceased operation due to ethnic tension in 2000.

Gizo sites are situated around Ghizo Island and surrounding islands. The reef types around Ghizo Island are fringing, barrier, patch and submerged reefs. The Rapid Ecological Assessment conducted in 2004 by The Nature Conservancy, WWF and international leading scientists (Green et al., 2006) found that one site, Njari Island, had the second highest fish diversity in the world, second only to Raja Ampat in Indonesia. The Gizo area has four known spawning aggregation sites for brown-marbled grouper (*Epinephelus fusoguttatus*), camouflage grouper (*Epinephelus polyphekadion*) and squaretail coralgrouper (*Plectropomus areolatus)* (Sulu 2004). They are popular sites for dive tourism.

Tetepare is the largest uninhabited island in the South Pacific. It also has nesting beaches for the critically endangered leatherback turtle *Dermochelys coriacea.* About 1100ha of the island is permanently protected while the rest of the island is open to resource owners for sustainable harvesting. The reefs at Tetepare are mostly fringing reefs. The fringing reefs on the southern part of the island are long stretches of reefs extending about 100metres from shore while on the northern part of the island, where shorelines are steep, reefs are relatively narrow sheltered fringing reefs.

Table 1. Months that the surveys were done at each location in 2006 and 2007

Locations	First round 2006	Second round 2006	Third round 2007
Gizo	March	August	June
Tetepare	March	December	October
Marovo	May	October	September
Munda Lola	February	September	September
Arnavon	September	No survey done	September

Marovo hosts the largest lagoon in the Solomon Islands, has an area of around 700km², and has the best defined double-barrier enclosed lagoon in the world. The reef types in Marovo are barrier, patch reefs and fringing reefs situated in both the inner lagoon and the outer lagoon areas. The outer lagoon reefs are mostly steep reef slopes and drop offs.

The Munda/Lola site is situated between Vona Vona Lagoon and the northern side of Roviana Lagoon. Munda/Lola is an urban area surrounded by coastal communities and villages. It consists of scattered islands, sand cays and islets skirted with fringing reefs, patch reefs and barrier reef types. One of the stations is situated on a barrier reef off Rendova Island on an exposed area.

The Arnavon Islands are included in the Arnavon Marine Conservation Area (AMCA) which has been in existence for more than 12 years. It has the largest rookery for the hawksbill turtle *Eretmochelys imbricate* in the Pacific region. The Arnavon Islands are situated between Choiseul and Ysabel Provinces and consist of three small low-lying islands named Kerehikapa, Sikopo and Maleivona. These are surrounded by coral reefs, and a mixture of rocky and sandy shorelines. The reef types around the Arnavon Islands are mostly fringing and barrier reefs.

4
SURVEY TIMETABLE

The table 2 shows the months in the years 2006 and 2007 that the surveys were carried out. The survey plan was to carry out monitoring on each location twice in one year. However, the Arnavon Islands were not able to be visited in the second round of 2006 owing to weather constraints and only one round of surveying was done in 2007, largely due to the major setback of the April 2007 earthquake and tsunami disaster.

Table 2. The six major life form categories and the corresponding AIMS life form categories

Dominant life forms	**Life forms**	**Code Description**
Acropora	ACB	*Acropora* branching
	ACE	*Acropora* encrusting
	ACD	*Acropora* digitate
	ACS	*Acropora* submassive
	ACT	*Acropora* tabular
Hard coral	CB	Coral branching
	CE	Coral encrusting
	CF	Coral foliose
	CM	Coral massive
	CS	Coral submassive
	CMR	Mushroom coral
	CHL	Blue coral
	CME	Fire coral
	CTU	Organ pipe coral
Soft coral	SC	Soft coral
Macroalgae	AA	Algal assemblage
	CA	Coralline algae
	HA	Halimeda algae
	MA	Macroalgae
	TA	Turf algae
	DCA	Dead coral with algae
Abiotic	S	Sand
	R	Rubble
	SI	Silt
	RCK	Rock
	DC	Dead coral
'Others'	ZO	Zoanthids
	OT	'Others' (include those not specified in the other life form)
	SP	Sponge

5
METHODS

The methods used in this study follow the modifications of the standard GCRMN survey methodology. The point intercept method was used for substrates and the Underwater Visual Census (UVC) for fish. Fish and substrate composition were recorded on the same belt transect.

On each site, four 50m transects were deployed on each of the two depth profiles. The shallow depth ranged from (3-5)m and deep depth ranged from (8-10)m. Global Position System (GPS) readings were recorded for each monitoring site for reference when returning to same sites.

5.1 Survey Protocol

The survey team consisted of six personnel, two fish recorders, two substrate recorders, one tape layer and a boat driver. The same sites were located using handheld GPS. The tape layer went into the water first to lay the tape at shallow depth and then to deep depth before returning to the boat. The two fish recorders started at the deep transect whilst the two substrate recorders started at shallow transect and then vice versa. When the fish and substrate recorders returned to the boat, the tape layer went into the water to retrieve all the tapes.

5.2 Substrate survey

A modified point based method was employed for the substrate survey. The substrate data was collected using a cross (X) with 35cm long arms at a 90o angle placed at every 1m interval along a 50m transect. Substrate readings were taken at each point of the X (4 points) and directly beneath the centre of the X (1 point). Therefore, a total of five points were collected every metre on each 50m transect (4 transects) totalling 1000 points per depth profile or 2000 points per site. Substrate composition along the transects was recorded according to the Australian Institute of Marine Studies (AIMS) life form categories (Table 2), which have been adopted by the Global Coral Reef Monitoring Network (GCRMN) as a standardised form of substrate collection (Hughes et al., 2005).

5.3 Fish survey

Fish data was collected using the Underwater Visual Census (UVC) technique. Every fish seen within 2.5m on either side of the 50m transect and 5m above was recorded. Fish size and abundance were recorded at species level for important reef fish families such as Haemullidae, Labridae, Lethrinidae, Lutjanidae, Mullidae, Scaridae, Serranidae and Carangidae. Fish abundance was recorded at family level for the reef indicators such as Pomacentridae, Pomacanthidae, Caesonidae, Acanthuridae, Balistidae, Ostracidae and Diotonidae.

Data was recorded onto underwater paper with the datasheet template photocopied on either sides of the paper.

The size estimation categories (Table 3) were decided upon on the basis of the accuracy with which our divers could estimate size.

5.4 Water temperature

Two temperature loggers were deployed on two SCRMN sites in Gizo, Njari and Kennedy. The two loggers were activated on August 2006. The Njari logger was placed on a star picket at a depth of 10m whilst the Kennedy logger was placed on the base of the mooring buoy at the same depth. The temperature loggers recorded the sea temperature every two hours.

Table 3. Size category and size range

Size category	Size range (cm)
1	<16
2	16-25
3	26-35
4	36-45
5	45-55
6	56-65
7	66-75
8	76-85
9	>85

6 RESULTS

6.1 Substrate

The substrate results are presented for each station within each location, and by depth (5 and 10m). Data was averaged over the four transects at each depth from two sites per station, i.e. n = 8. Results are presented for each of the three dates on which surveys were conducted (see Table 1). For substrate, the different life forms were grouped into six dominant life form categories (Table 2) for simplicity of discussion and data presentation.

The results are presented for each regional location in the following order, Gizo, Tetepare, Marovo, Munda and Arnavon Islands.

6.1.1 Gizo

Hard coral was the dominant life form around Gizo reefs at both 5 and 10m. The highest hard coral cover was at the shallow depth at Naru with a percentage cover of 61.30% (±4.03).

At the Gizo sites macroalgae was the second dominant substrate type with an average cover of 32.73% (±2.73) at shallow stations and 34.95% (±2.76) at deep stations. Acropora cover was very low (<5% for all stations except Njari shallow, where Acropora cover reached 22.80% (±4.53). Abiotic cover was more dominant in deeper water with an average cover of 16.41% (±1.79) and 8.99% (±1.12). The highest cover of the 'Others' category amongst the Gizo sites was at both depths at Nusa Agana (Fig. 7) (17.75% (±2.16) at 5m and 27.41% (± 3.15) at 10m). Soft coral cover was very low across all stations, never exceeding 10%.

On the second round of surveys (2006), a very similar pattern to the first round was seen for all sites (Fig. 8). Hard coral cover remained as the dominant cover at both depths with an average cover of 43.41% (±2.94) and 36.61% (±2.21) for shallow and deep strata respectively, for all stations. Macroalgae remained the second dominant substrate type with an average cover of 31.63% (±2.21) at shallow and 36.81% (±2.76) at deep strata. The abiotic category was more prevalent at deep strata for all stations with an average cover of 16.41% (±1.79). The 'Other' life form category remained high at Nusa Agana with 20.69% (±2.79) at shallow and 27.41% (±3.15) at deep strata, being less than 10% for all other stations. Soft coral cover was low across all stations (Fig. 8). The third round of surveys was conducted after the earthquake and tsunami disaster that hit the Western Province on 2nd April 2007. The shallow (5m) transects at Kennedy, Naru and Njari were not completed due to a very low tide at the time of survey, hence all shallow records refer to Nusa Agana only.

Major changes in substrate cover were seen after the disaster, compared to before the disaster (compare Figures 7 and 8, with Figure 9). Abiotic cover was the dominant cover across all stations with an average cover of 60.23% (±6.54) for all deep transects and 36.5% (±6.31) in shallow water for Nusa Agana (Fig. 9). The 'Other' life form category had an average cover of 16.94% (±2.11) at deep transects across all stations and 8.30% (±2.01) at shallow transects (Nusa Agana). Both hard coral (9.75% (±0.75) at deep) and Acropora cover (6.89% (±1.32) at deep) were markedly reduced after the earthquake and

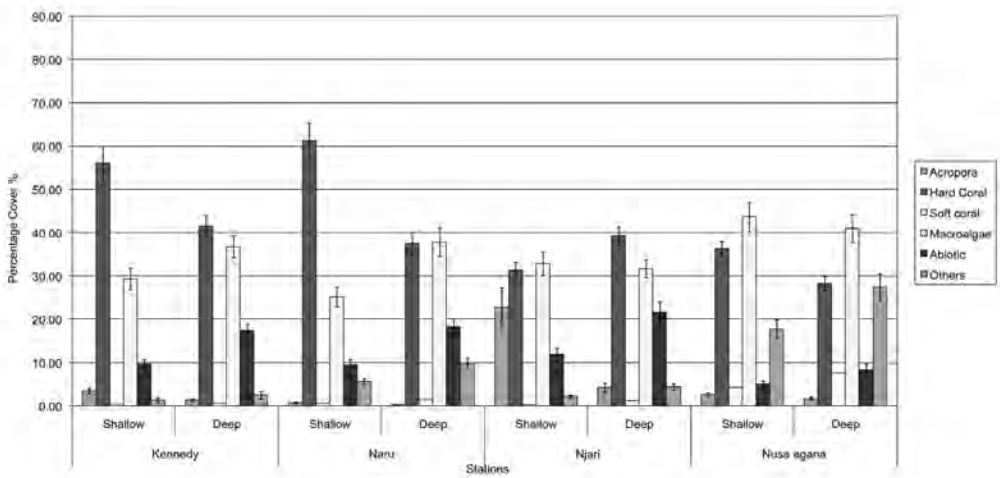


Figure 7. A comparison of the dominant life forms at four stations around Gizo on 1st survey (2006). Data is the average of four transects per depth for two sites (i.e. n = 8) ± SE

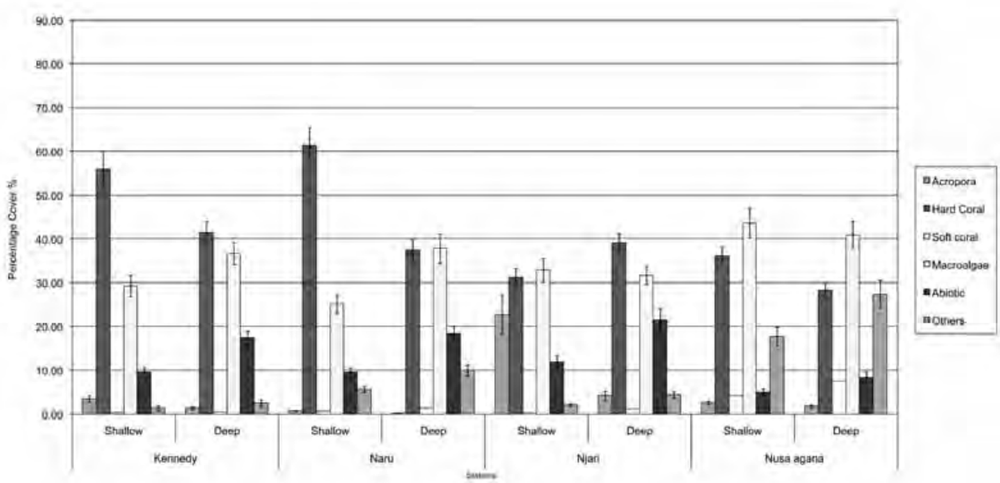


Figure 8. A comparison of the dominant substrate life forms at four stations around Gizo on 2nd survey, 2006

tsunami compared to before the disaster. Macroalgae cover was also reduced on average (12.85% (±1.70) at 10m.

6.1.2 Tetepare

In the first survey of 2006 at Tetepare Island, Acropora in general showed a higher percentage cover in shallow water as compared to the deep transects (Fig. 10). With the exception of sites T3 and T4, hard coral cover was not markedly different between depths. Macroalgae cover differed amongst stations but was not markedly different between coral was more dominant at 10m compared to 5m. Macroalgae cover was higher at 10m than 5m with a maximum average cover of 38%. Abiotic cover varied across depths and stations with a maximum average cover of 12%. 'Others' and Soft Coral had a low occurrence with less than 5% cover.

In 2007, shallow transects at three sites (T1 & T2, T3 & T4 and T7 & T8) were not carried out due to very low tide and storm surges. For the remaining sites Acropora cover ranged from 13% to 20% across depths and stations. Hard coral cover had a

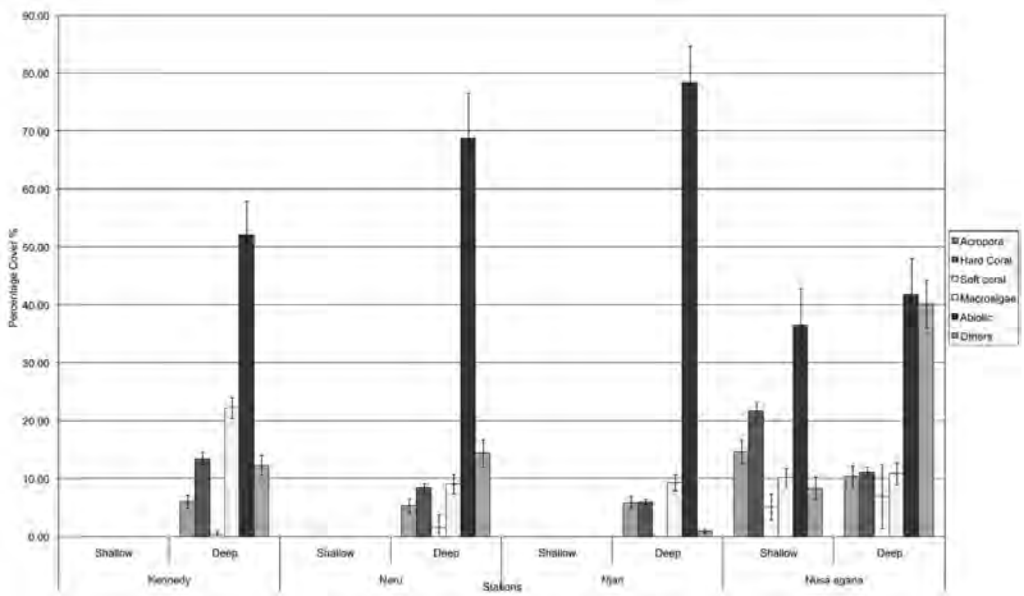


Figure 9. A comparison of the dominant substrate life forms at four stations around Gizo (3rd survey, 2007)

depths. Abiotic cover was consistently higher at 10m than 5m. Soft coral and 'Others' categories were less than 10% for all depths.

On the second 2006 survey, the shallow transect at site T1 & T2 and site T3 & T4 were not surveyed due to high wave surges and low tide. Acropora cover ranged from an average of 15% to 45% similar to ranges recorded earlier in the year (Fig. 11). Hard similar pattern. Macroalgae cover ranged from 8% to 41% across all stations (Fig. 12). Abiotic cover was on average, across all stations, high at shallow 36.60% (±4.70) transects as compared to deep 16.58% (±2.34) transects.

6.1.3 Marovo

There was very low occurrence of Acropora species across all stations in Marovo (Fig. 13) with a

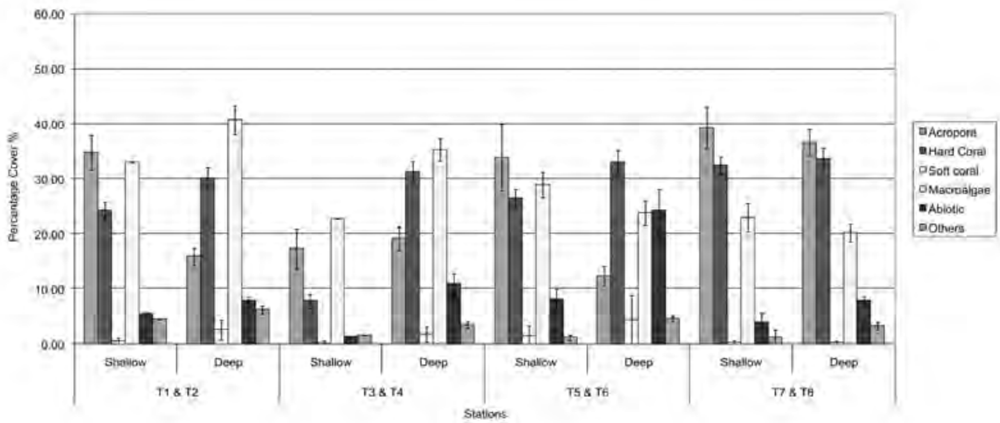


Figure 10. A comparison of the dominant life forms at four stations around Tetepare (1st survey, 2006)

percentage cover of less than 5%. There was a high abundance of hard coral cover and this was relatively similar at both depths (Fig. 13). Macroalgae had a similar pattern. Abiotic cover was more dominant at shallow depths. Soft coral cover had a high occurrence at Lumalihe, especially at deep transects 12.15% (±3.48), compared to shallow 6.90% (±6.47) transects while 'Others' percentage cover was consistently less than 10%.

On the second survey, hard coral had a relatively similar occurrence across depths averaging across all stations 33.49% (±2.14) at 5m and 32.78% (±2.00) at 10m. Abiotic cover was the more dominant life form at all stations and averaged across all cover, was slightly higher at 5m (38.66% (±3.37) than 10m

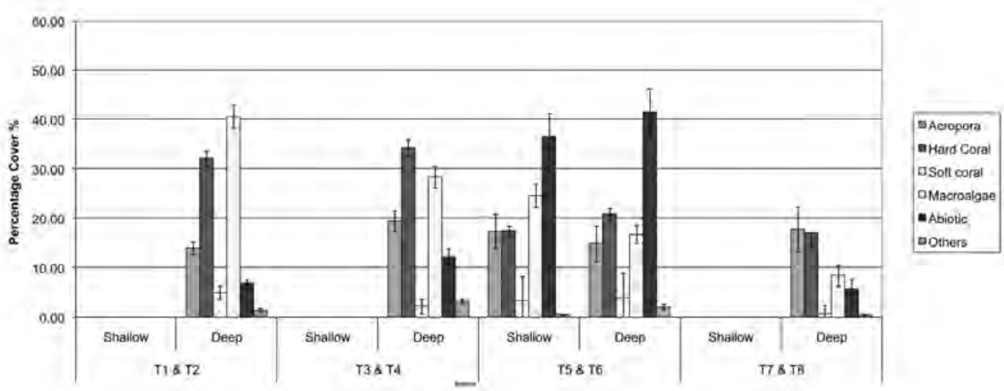


Figure 12. A comparison of the dominant life forms at four stations around Tetepare (3rd survey, 2007)

(29.03%) (±2.76). Macroalgae cover tended to be slightly higher in deeper water (Fig. 14). Soft coral cover was high at Lumalihe, similar to the previous survey. However, it was less than 5% cover for the other stations. 'Others' cover was recorded at each depth and station but did not exceed 10%.

6.1.4 Munda

Hard coral cover and macroalgae were the predominant life forms across all stations (Fig. 16). Hard coral cover across all sites averaged 38.26% (±2.20) at shallow transects and 39.01% (±2.13) at deep transects. Macroalgae cover ranged from 15 to 43% across all sites and depths. Acropora cover was reasonably similar at both depths, although was lower at the Pond site than other sites. Abiotic cover tended to be higher at 10m in three of the four sites ranging from 8% to 20% overall. 'Others' and Soft coral had relatively low occurrence (< 10%) across all stations.

Hard coral cover had a high occurrence across all stations, on average across all sites being more dominant at 10m (38.23% (±2.19)) than 5m (27.24% (±2.13)). Macroalgae also had a relatively high occurrence across all stations ranging from 15% to 45%.

Acropora had the highest cover at station Haipe at shallow depths 28.85% (±2.79) and deep depths 34.80% (±3.16) while the other stations had less than 10% cover. On average across stations, Abiotic cover was slightly higher in deep (11.59% (±1.71) rather than shallow transects (7.03% (±1.31)). 'Others' and Soft coral have a relatively very low occurrence across all stations.

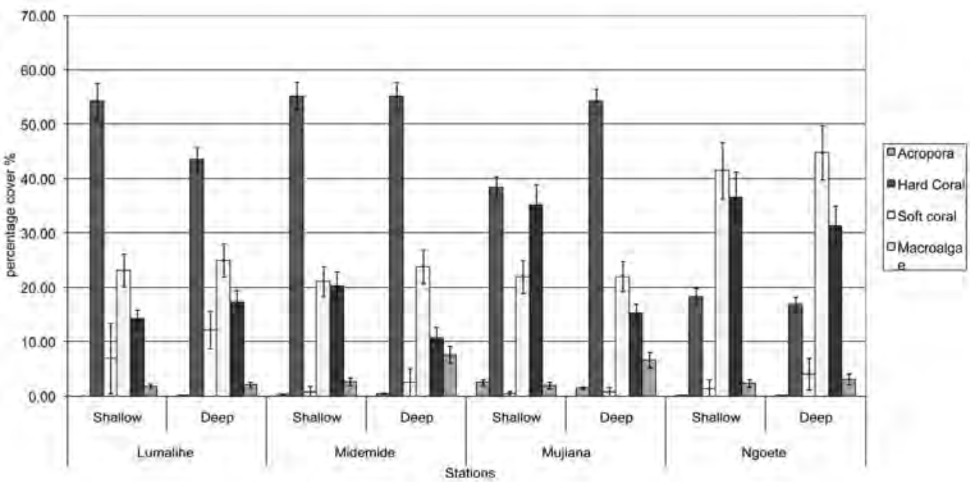


Figure 13. A comparison of the dominant life forms at four stations around Marovo (1st survey, 2006)

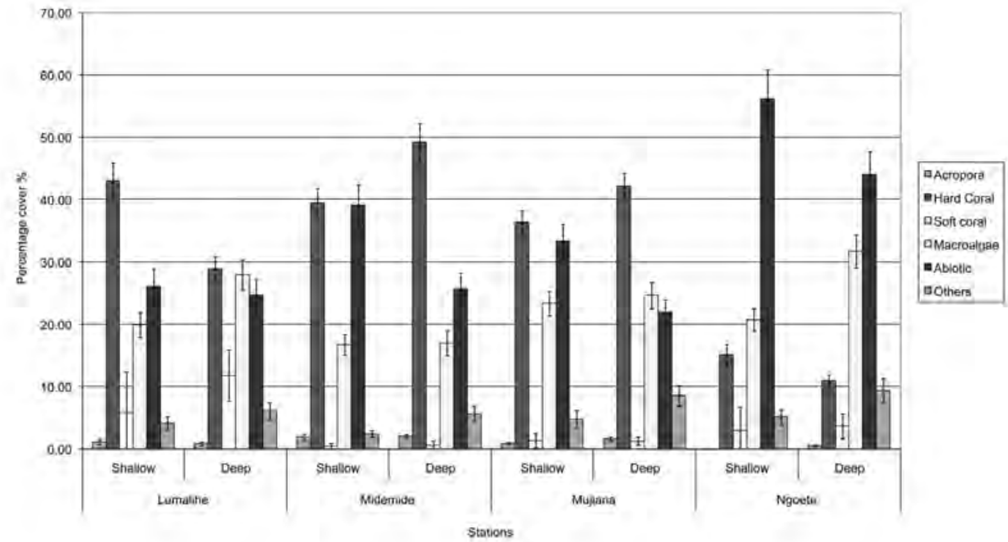


Figure 14. A comparison of the dominant life forms around Marovo (2nd survey, 2006)

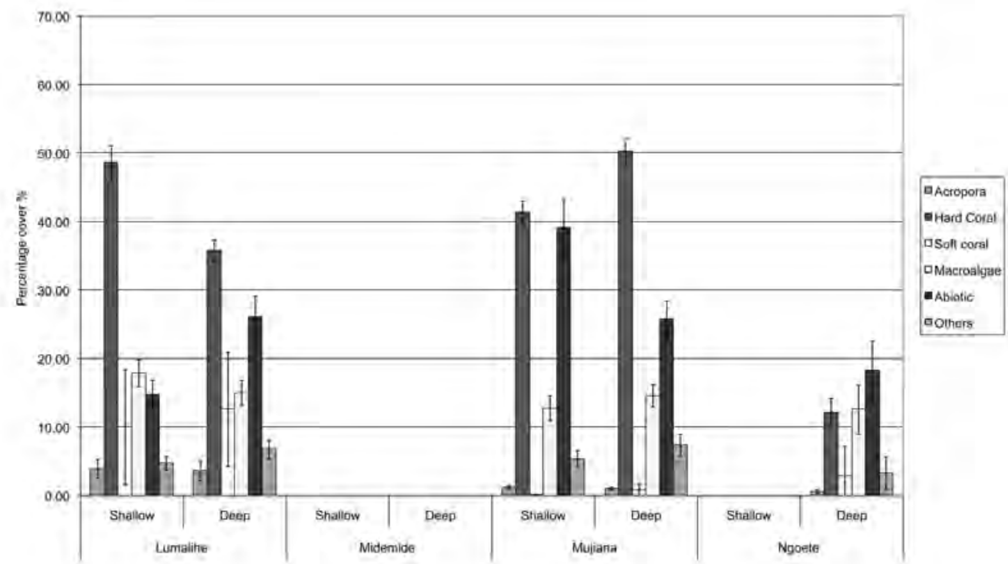


Figure 15. A comparison of the dominant life forms around Marovo (3rd survey, 2007)

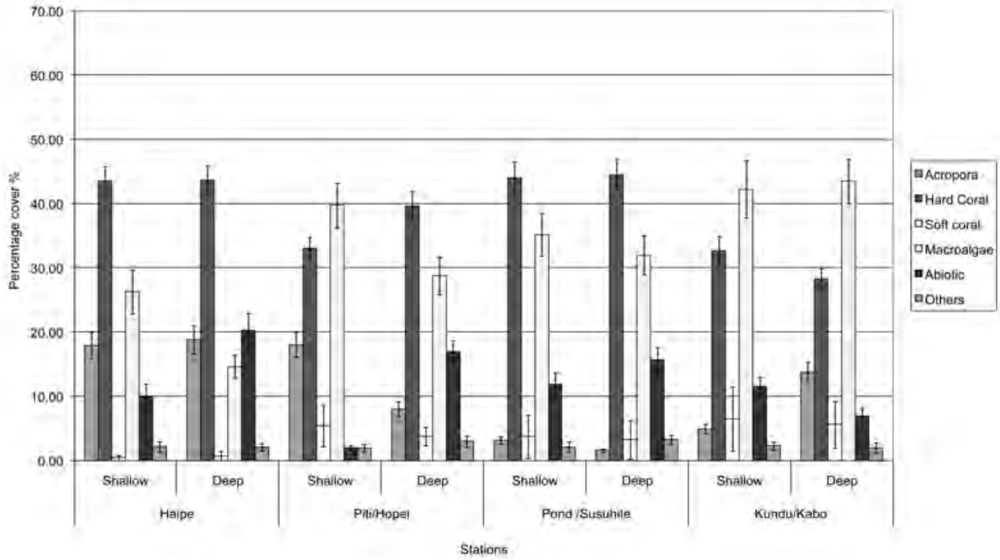


Figure 16. A comparison of the dominant life forms at four stations around Munda (1st survey, 2006)

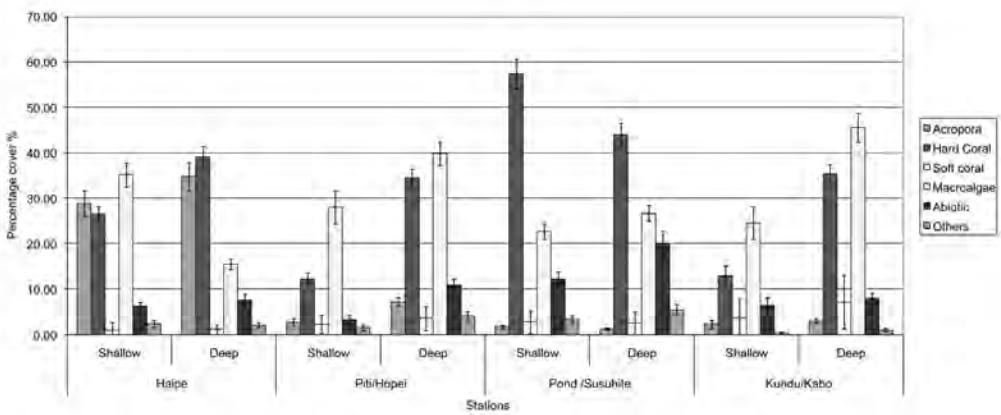


Figure 17. A comparison of the dominant life forms at four stations around Munda (2nd survey, 2006)

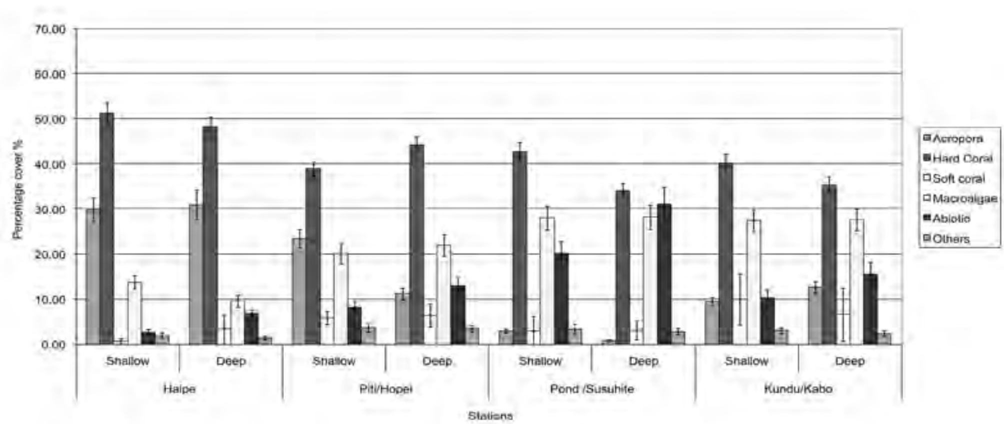


Figure 18. A comparison of the dominant life forms at four stations around Munda (3rd survey, 2007)

4.1.5 Arnavon Marine Conservation Area

The shallow depths at AMCA sites 3 and 4 were not surveyed in 2007 due to high wave surges. Abiotic cover was the predominant feature across all stations with the highest cover at AMCA 5 and 6 (Fig. 19). On average across all sites, it was more dominant at deep transects (57.65% (±8.09)) as compared to shallow transects (36.10% (±5.06)). Hard coral cover ranged from 15% to 48% across all sites and depths. Macroalgae cover ranged from 15% to 28% across all sites and depths. Soft coral had the highest occurrence at AMCA sites 5 and 6, where it was more predominant at shallow transects 17.70% (±15.04) as compared to deep transects 3.80% (±3.76). 'Others' life form category had the highest occurrence in shallow water at site AMCA sites 5 and 6 (Fig. 19).

In the second 2006 survey, hard coral, abiotic and macroalgae were the dominant substrate types amongst Arnavon stations (Fig. 20). Acropora was low across all stations, with a slightly higher average cover across all stations at shallow transects (8.78% (±0.90)) as compared to deep transects (4.06% (±054)). 'Others' cover was relatively similar across depths and stations.

6.2. Fish abundance

The fish result was calculated per 50m transect and averaged across sites (i.e. n = 8). The average values for shallow (5m) and deep (10m) transects for each station are presented on the graphs according to the three rounds of surveys done in 2006 and 2007.

6.2.1 Gizo

Fusiliers (Caesonidae) and damselfish (Pomacentridae) were the most common fish families around Gizo reefs (Fig 21). Surgeonfish (Acanthuridae) were the next most abundant fish around the Gizo reef area at both depths. A relatively low abundance of reef food fish such as Lutjanidae, Scaridae, Lethrinidae and Siganidae was recorded. After the earthquake and tsunami disaster most of the fish families showed a decline compared to 2006 and most tended to occur in high densities at deep transect (Fig. 23). Although abundance on the deep transects remained similar between surveys, there were no Lutjanidae recorded on the shallow transect in 2007 (Fig 25). Lethrinidae showed a higher abundance at shallow transects, compared to the deep transects before the disaster (Figs 23 to 25). The abundance of Lutjanidae was largely due to the large schools of the snapper *Lutjanus* gibbus sighted during the surveys.

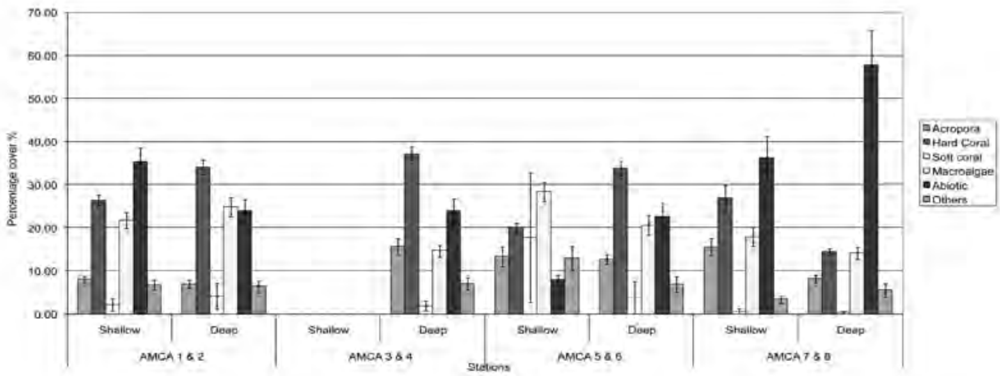


Figure 19. A comparison of the dominant life forms at four stations around Arnavon Marine Conservation Area (1st survey, 2006).

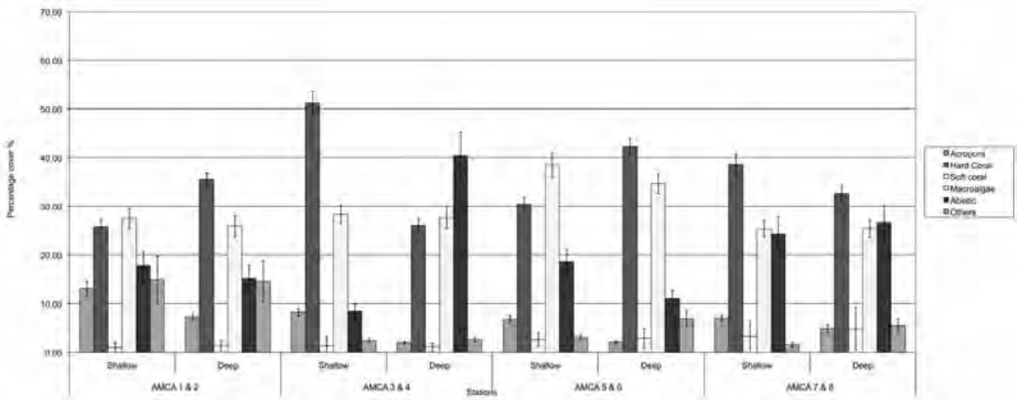


Figure 20. A comparison of the dominant life forms at four stations around Arnavon Marine Conservation Area (2nd survey, 2007)

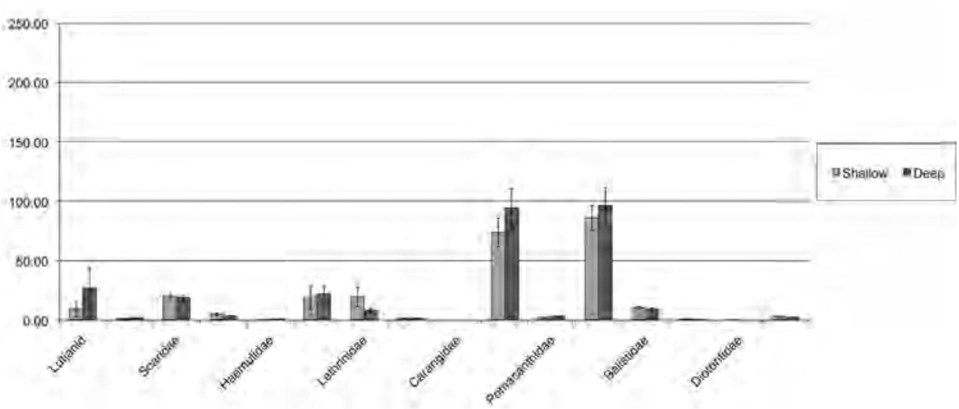


Figure 21. Mean fish abundance at two depth profiles around Gizo (1st survey, 2006)

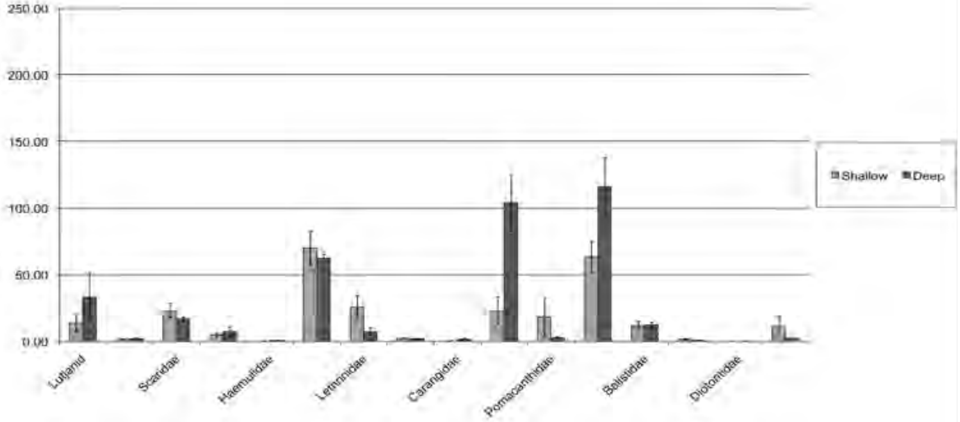


Figure 22. Mean fish abundance at two depth profiles around Gizo (2nd survey, 2006).

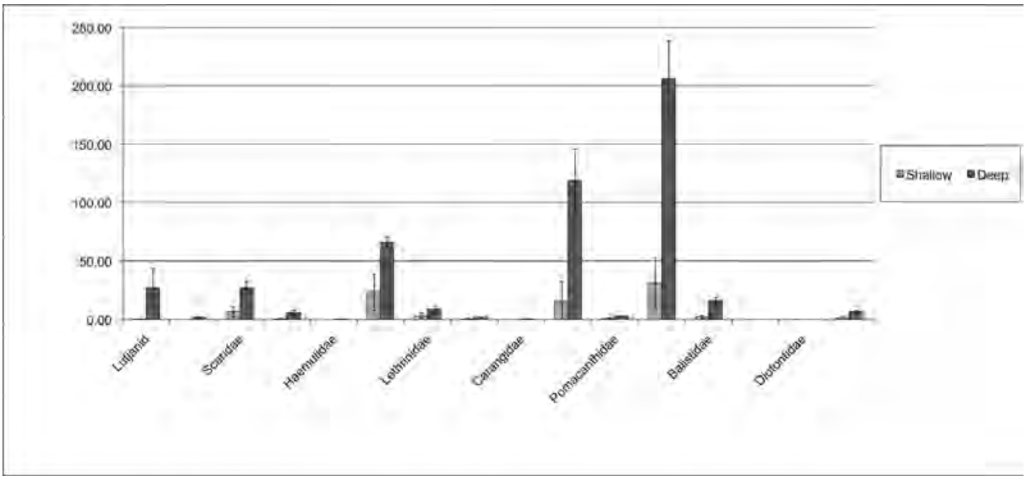


Figure23. Mean fish abundance at two depth profiles around Gizo (3rd survey, 2007).

6.2.2 Tetepare

Around Tetepare reefs Acanthuridae, Caesonidae and Pomacentridae were the dominant fish families similar to the other locations (Figs. 24 to 26). For the commercially important food fish families, abundances were relatively low. There was a low occurrence of Lutjanidae, Serranidae, Siganidae and Lethrinidae. Acanthuridae showed a higher abundance on the second round of surveys (Fig. 25) and then decreased on the third round of surveys (Fig. 26). Scaridae tended to be more dominant at deep transects.

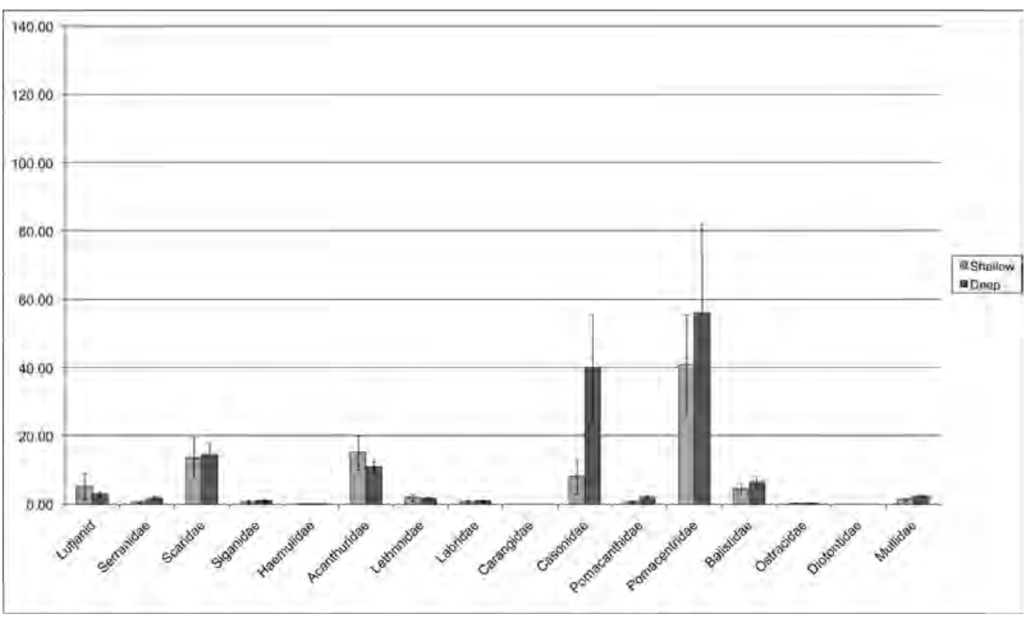


Figure 24. Mean fish abundance at two depth profiles around Tetepare (1st survey, 2006)

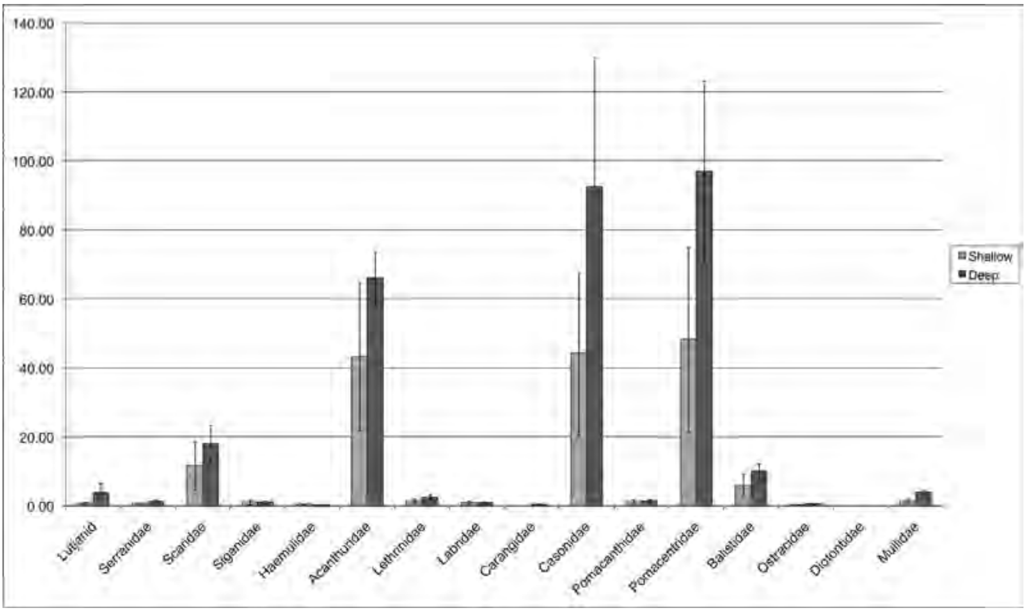


Figure 25. Mean fish abundance at two depth profiles around Tetepare (2nd survey, 2006)

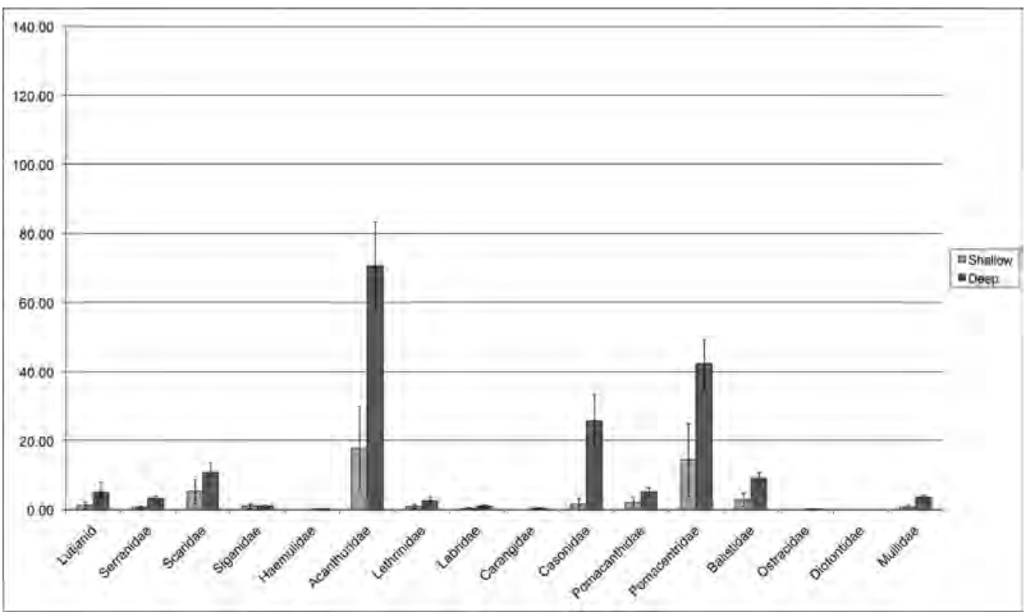


Figure 26. Mean fish abundance at two depth profiles around Tetepare (3rd survey, 2007).

6.2.3 Marovo

Marovo reef areas depicted a similar pattern as the other locations by having Acanthuridae, Caesonidae and Pomacentridae as the dominant fish families. These live in large schools, therefore account for the high abundance. For the commercially important food fish, Scaridae and Lethrinidae showed a slightly higher abundance compared to the Lutjanidae, Serranidae and Labridae and had a consistent abundance through all three rounds of surveys.

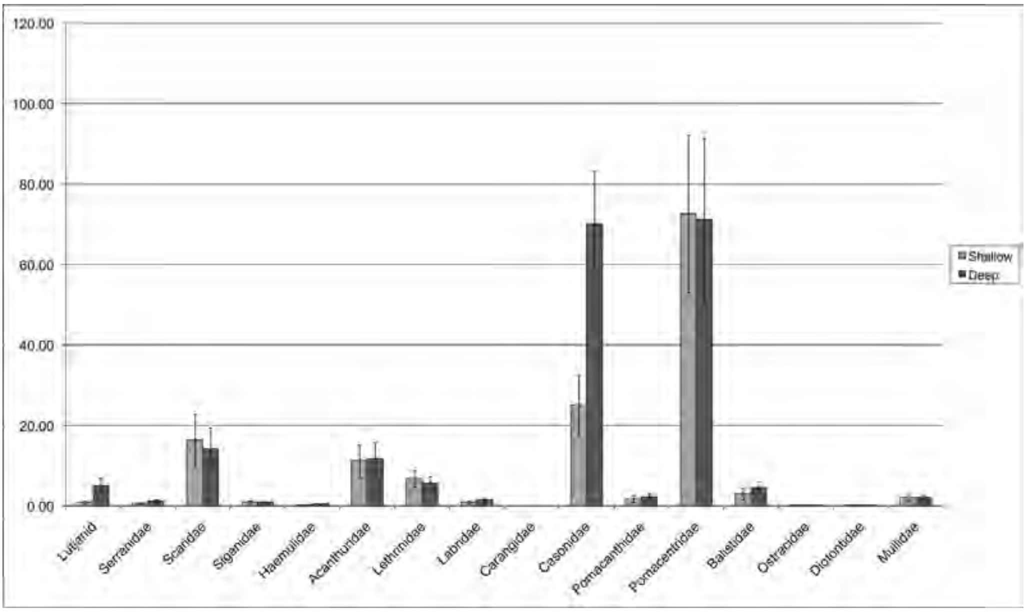


Figure 27. Mean fish abundance at two depth profiles around Marovo (1st survey, 2006)

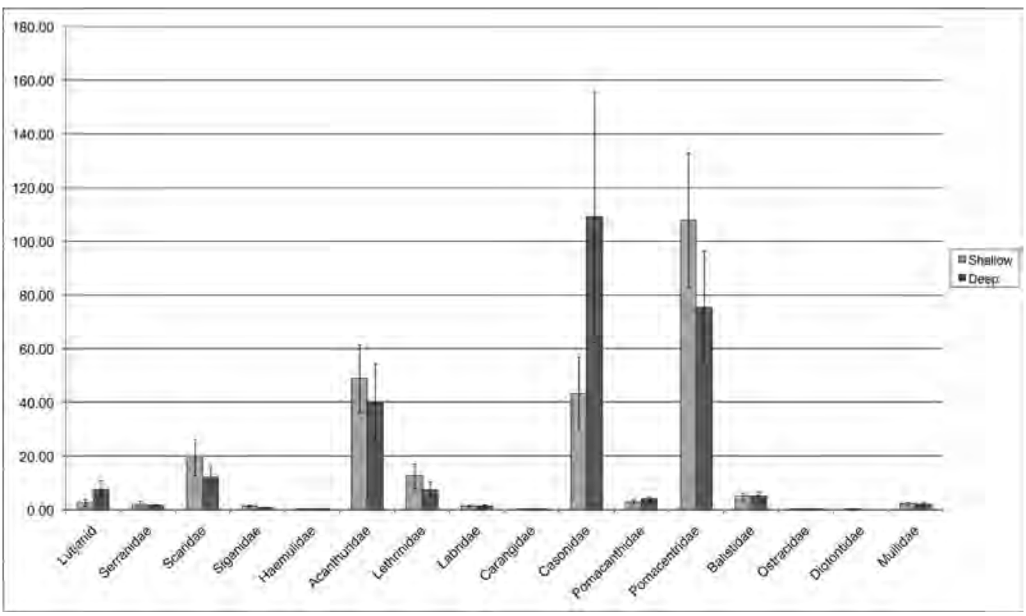


Figure 28. Mean fish abundance at two depth profiles around Marovo (2nd survey, 2006)

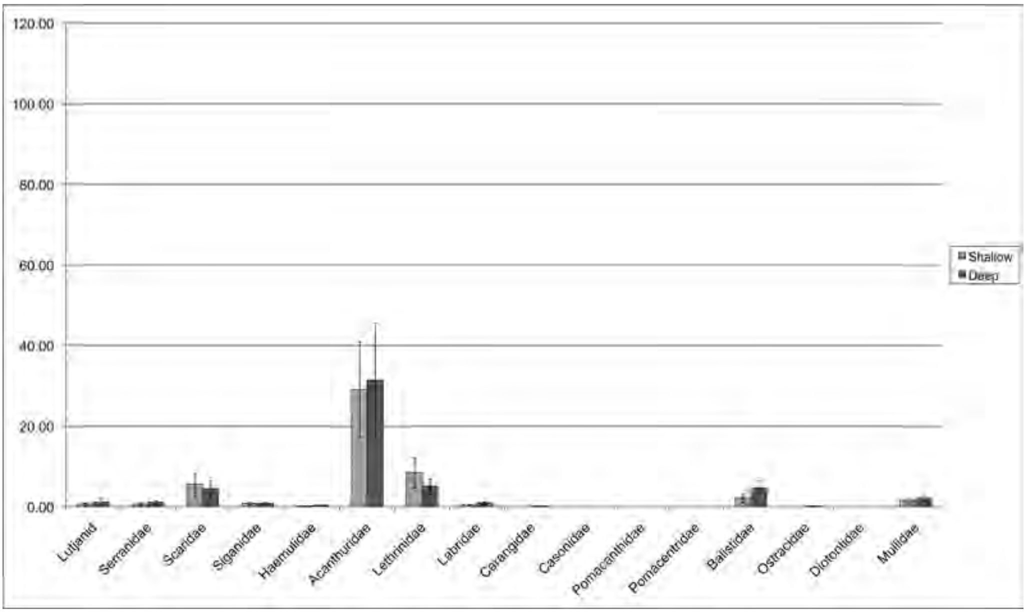


Figure 29. Mean fish abundance at two depth profiles around Marovo (3rd survey, 2007)

6.2.4 Munda

Munda area had a high diversity of fish. There was a high number of commercially important food fish such as Lujanidae, Scaridae and Lethrinidae although abundance was lower in the first round of surveys compared to later surveys (Figs. 30 to 32). The family Acanthuridae had a high abundance especially at station Haipe where large schools including Acanthuridae spp, Lined bristletooth (Ctenochaetus striatus), Mimic surgeonfish (*Acanthurus pyroferus*) and Vlaming's unicornfish (*Naso vlamingii*) were recorded. There was also a high abundance of the fish family fusiliers (Caesonidae) and damselfish (Pomacentridae), common for all locations.

Lutjanidae had a high abundance at deep transects as compared to shallow and showed a declining trend from the first round to the third round of surveys. Scaridae and Acanthuridae were more common on the shallow transects than the deep transects as were Lethrinidae. Balistidae showed a low abundance on the three rounds of surveys.

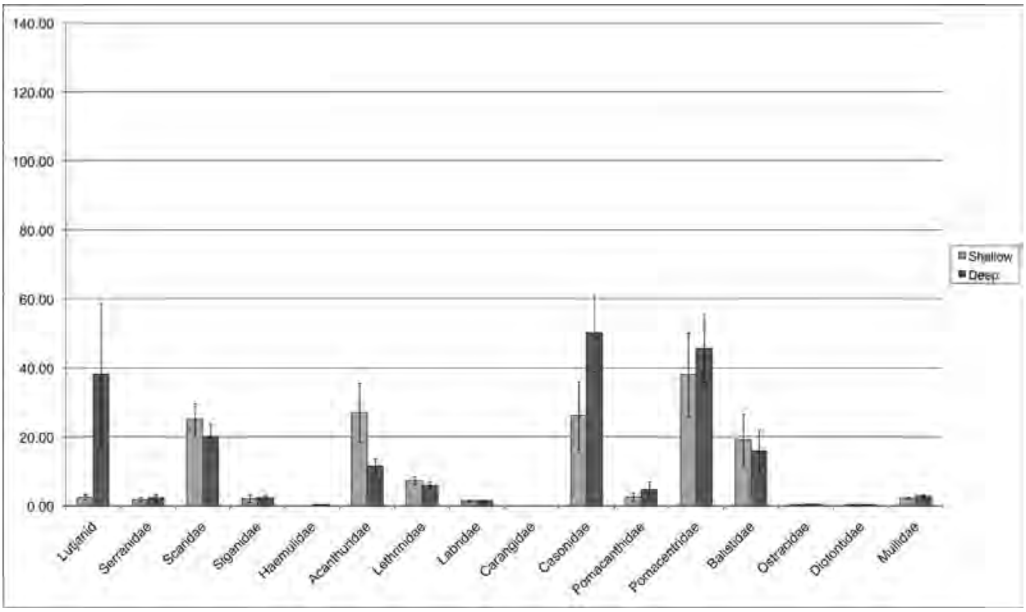


Figure 30. Mean fish abundance at two depth profiles around Munda (1st survey, 2006)

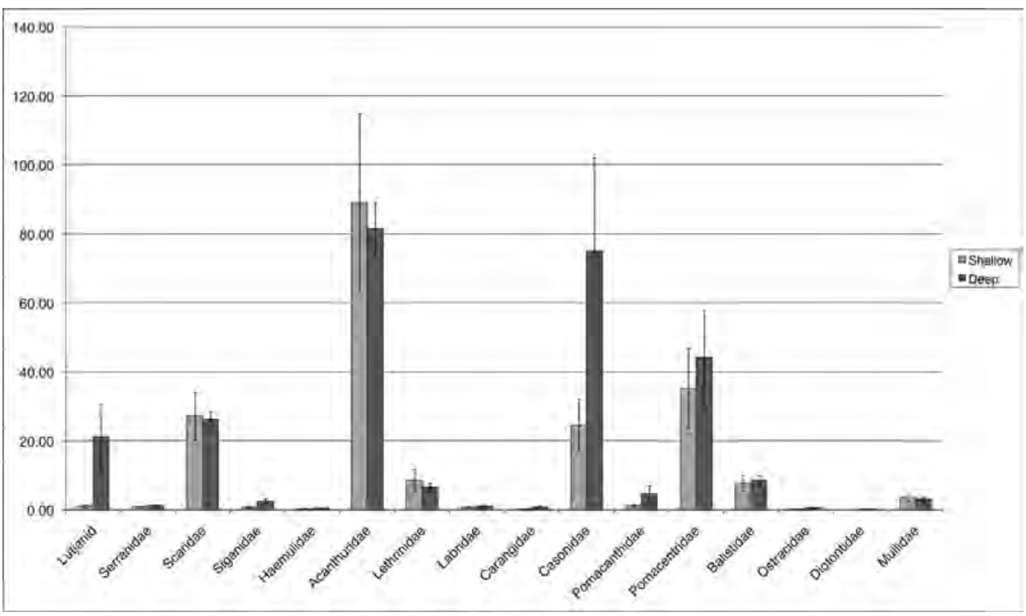


Figure 31. Mean fish abundance at two depth profiles around Munda (2nd survey, 2006)

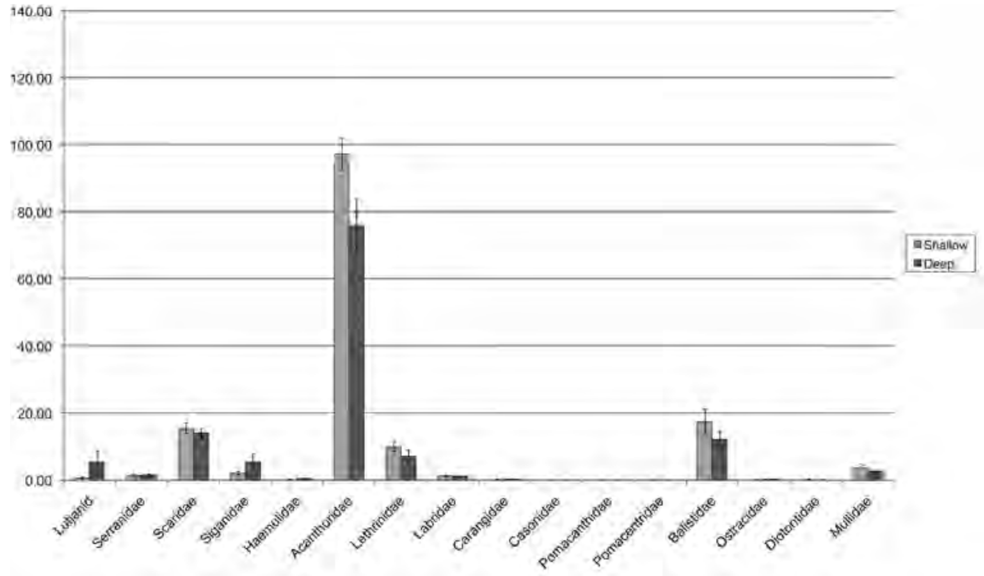


Figure 32. Mean fish abundance at two depth profiles around Munda (3rd survey, 2007)

6.2.5 Arnavon Marine Conservation Area

The dominant fish around the AMCA were the Pomacentridae, Caesonidae and Acanthuridae (Figs. 33-34). Higher numbers of Pomacentridae were recorded in the second survey of 2006 (Fig. 34) compared to the first (Fig. 33). Most of the fish families showed a slight increase from the previous survey. Generally the fish around the AMCA were larger than at other locations especially for the Bumphead parrotfish (*Bolbometopon muricatum*) and Maori wrasse (*Chelinus undulates*) (data not shown). The most common Serranidae species that occurred in the AMCA was the Yellow-margin tail grouper (*Variola louti*).

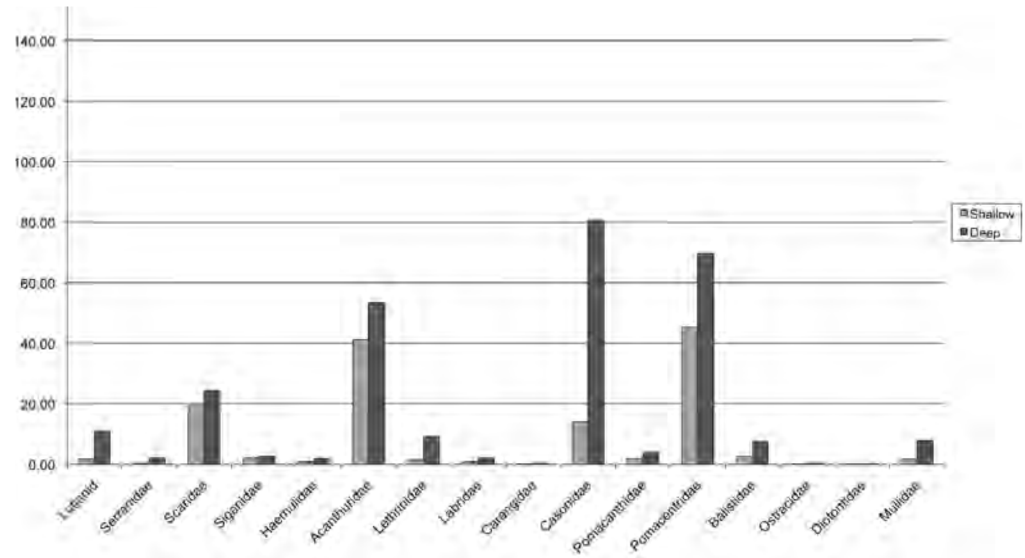


Figure 33. Mean fish abundance at two depth profiles around Arnavon Marine Conservation Area (1st survey, 2006)

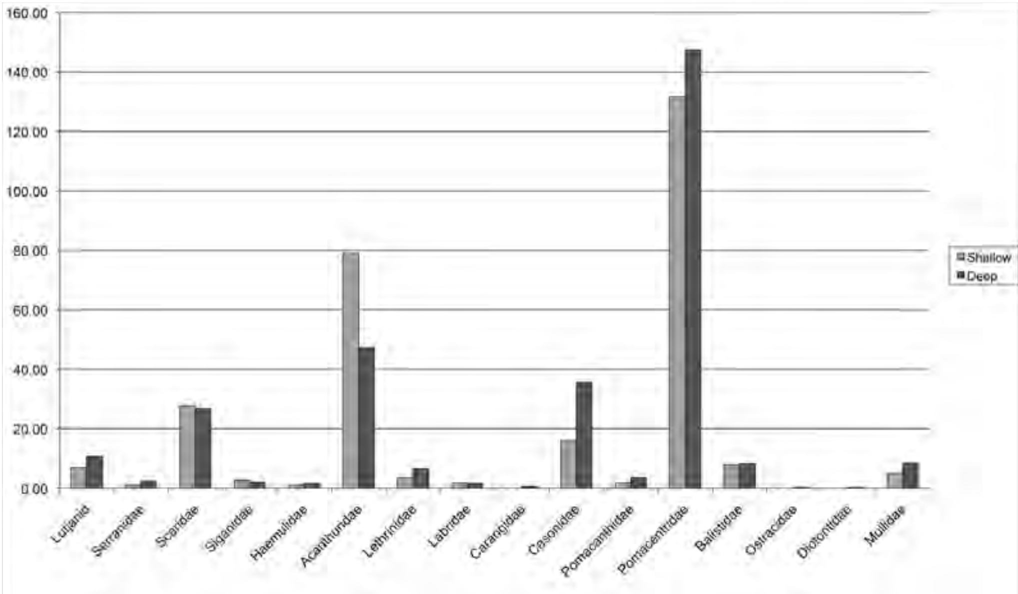


Figure 34. Mean fish abundance at two depth profiles around Arnavon Marine Conservation Area (2nd survey, 2006)

6.3 Fish size distribution

Size was measured in situ for some of the commercial fish species such as groupers (Serranidae), snappers (Lutjanidae), trevally (Caragnidae), emperor (Lethrindae), sweetlips (Haemullidae) and wrasse (Labridae).

One family that showed differences in abundance between locations was Scaridae. The Bumphead parrotfish (*B. muricatum*) was selected as a representative of this group to investigate whether abundance differences were reflected in fish size. For example, if numbers were high, was this due to many small fish or many large fish? The Bumphead parrotfish was selected because it has been found at each site and also had a large size range. This species has been identified as being vulnerable to over fishing due to high demand at restaurants and by consumers.

A range of sizes of Bumphead parrotfish was found across all locations from size category 1 (<16 cm) to 8 (76 – 85cm). Tetepare was found to have a full size range of *B. muricatum* from size category range 1 to 8 (Fig. 36) and the highest abundance recorded. This was followed by Munda which had a higher abundance across a size range from 1 to 7 (Fig 37) and had a high abundance for some size categories compared to the other locations.

AMCA tended to have fish within the bigger size categories with all fish recorded falling into the size categories 3 to 7 (Fig 39). Gizo had a size category range from 3 to 8 (Fig 35) while Marovo tended to have the lowest abundance and small size category range 2 to 5 (Fig 38).

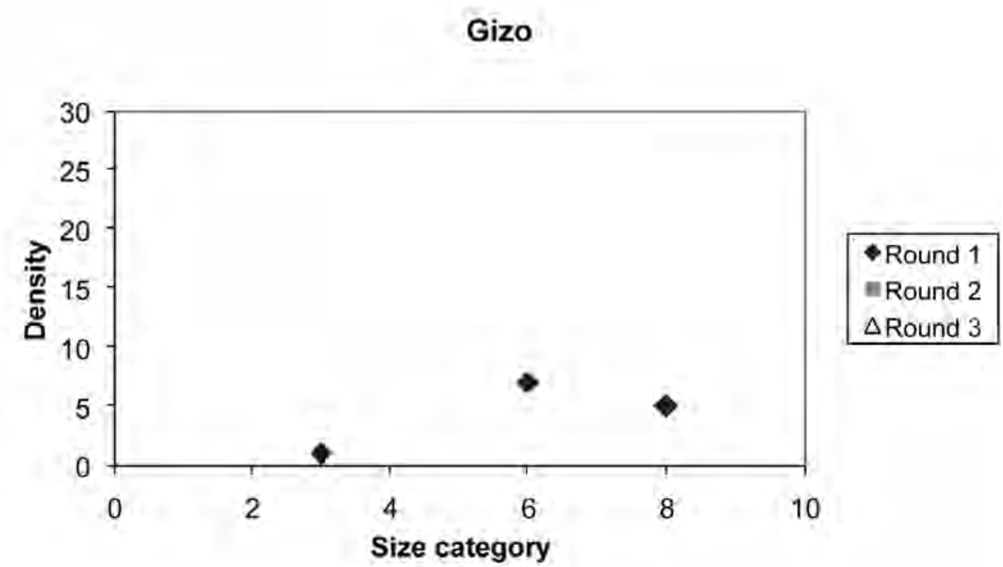


Figure 35. Size distribution vs abundance (density) of Bumphead parrotfish (B. muritacum) around Gizo

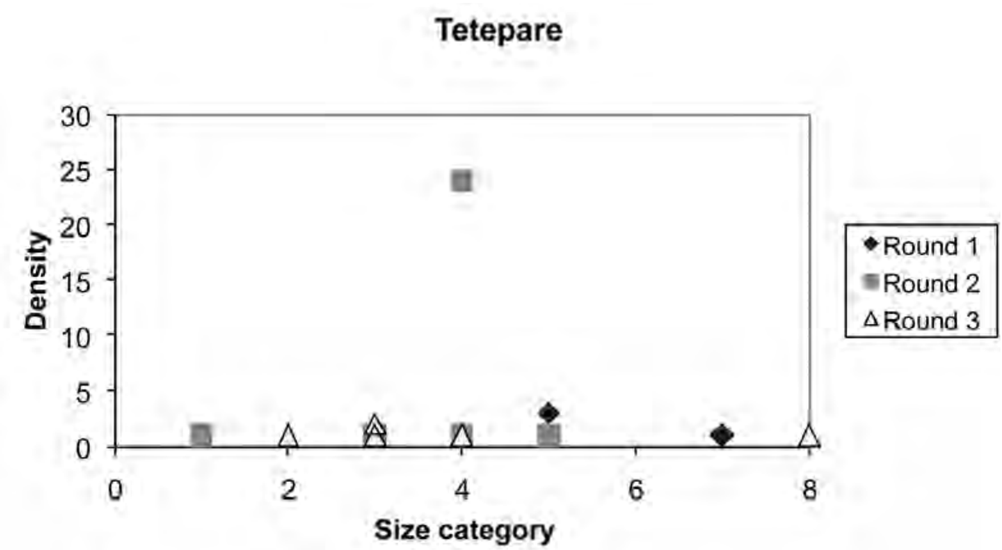


Figure 36. Size distribution vs abundance (density) of Bumphead parrotfish (B. muricatum) around Tetepare

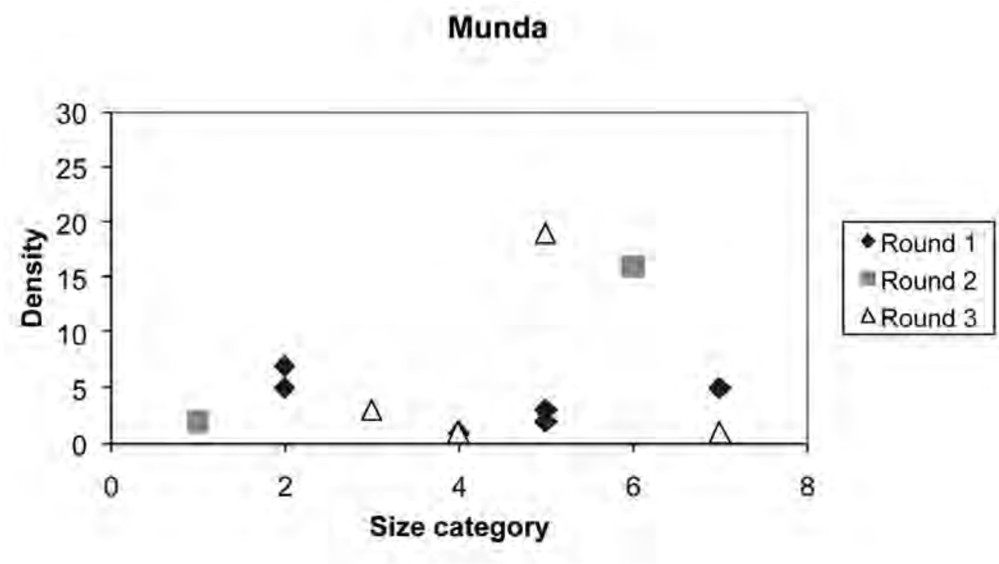


Figure 37. Size distribution vs abundance (density) of Bumphead parrotfish (B. muricatum) around Munda.

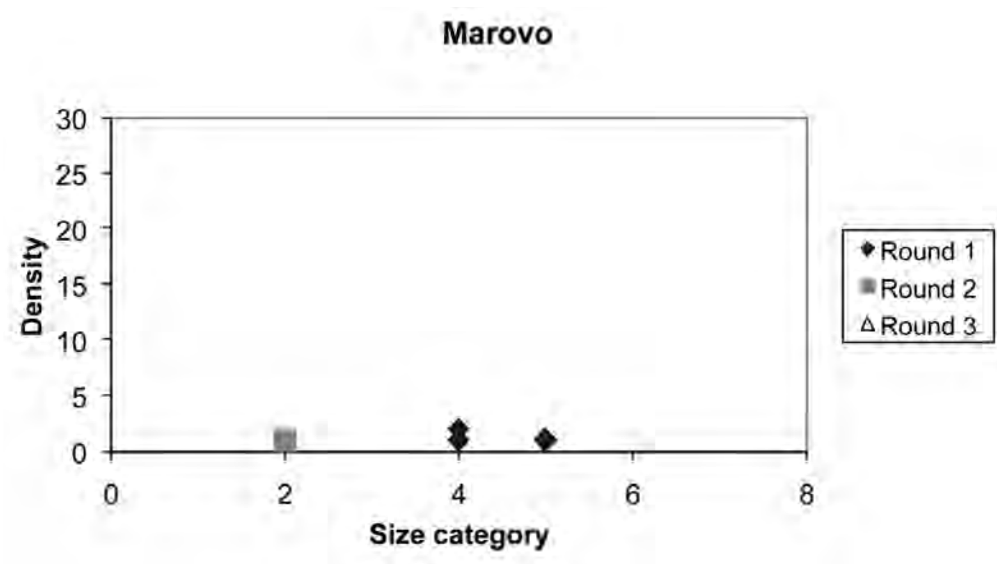


Figure 38. Size distribution vs abundance (density) of Bumphead parrot fish (B. muricatum) around Marovo

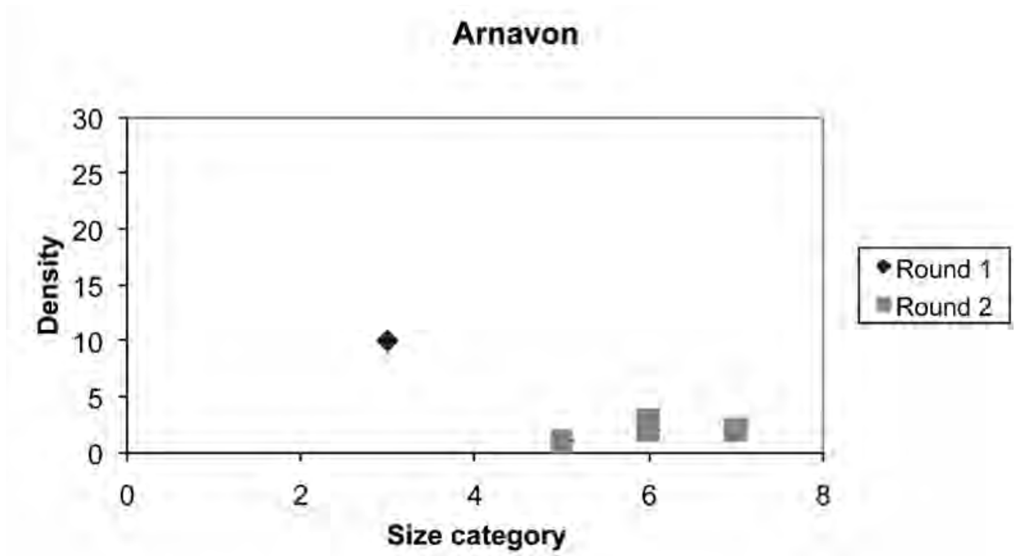


Figure 39. Size distribution vs abundance (density) of Bumphead parrot fish (B. muricatum) around Arnavon Marine Conservation Area

6.4 Water Temperature

The temperature logger at Njari had its housing cracked lengthways and was not working by the time it was collected in November 2007. Only the temperature logger placed at Kennedy remained in working condition

The results shown are after 16 months of deployment from August 2006 to October 2007 (Fig. 40). Water temperature in August 2006 reached a minimum of 27.8 degrees C, whilst only falling to 28.5 degrees C during the same period in August 2007, approximately one degree Celsius higher. A similar observation was reported for these two years in Fiji (Helen Sykes, Fiji GCRMN Coordinator pers comm., November 2007). For both Fiji and Solomon Islands, the water temperature was found to be higher from the months of December to May in 2007 than in 2006.

7
DISCUSSION

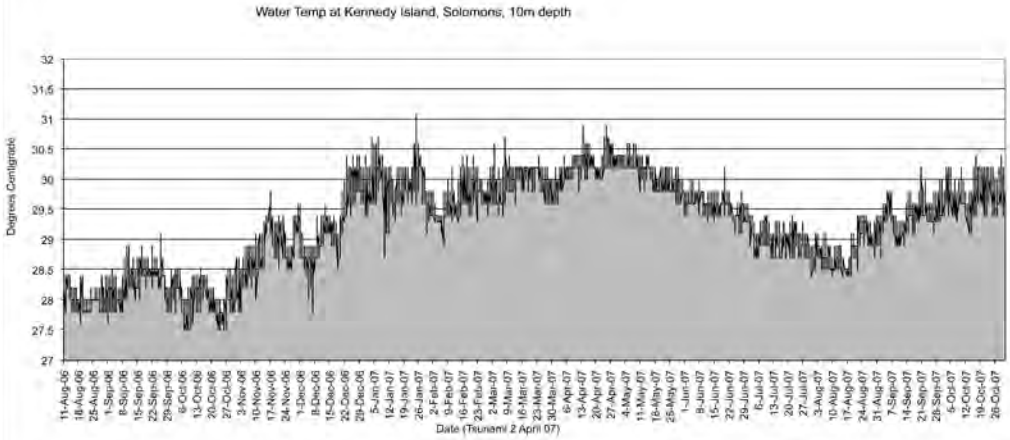


Figure 40. Graph showing the water temperature recorded at Kennedy Island in one week intervals from August 2006 to October 2007

7.1 Gizo

branching corals were shattered and other coral colonies broken and overturned resting next to their bases. Underwater landslides had occurred along the steep reef slopes that launched huge coral boulders to deeper depths. There was also a temporary high turbidity effect from the landslides that created sandy patches.

Gizo has a large fish market that supplies fish daily to cater for locals and also for Honiara customers. Gizo has a high population with approximately 6,000 people with a mixture of multi-ethnic groups that have different fishing practices. The fishing techniques include night diving, trolling, use of nets and reef fishing. Accordingly, Gizo reef fish are exposed to high fishing pressure due to the high demand for cash. Gizo does have the advantage of large areas of mangrove forest that provide breeding ground for fish and seagrass beds as habitats for juvenile fish. It is not known what the longer-term impact of the recent earthquake and tsunami might be on fish stocks as a result of coral-habitat destruction.

7.2 Tetepare

Tetepare Island has a long stretch of fringing reef on the weather coast side of the island with a short fringing reef on the leeward side. Tetepare Island has a marine protected area and is isolated from highly populated areas, therefore the human impact is minimal.

Acropora coral were found be dominant on the shallow transects while hard coral was found at deep transects. Macroalgae cover was found to be more dominant on the weathercoast side of the island due to the high wave energy exposure as compared to the leeward side of the island. New coral growth was found especially for Acropora tabular and Acropora branching corals, particularly on the weathercoast side. Acropora encrusting was one of the dominant Acropora life forms on the weathercoast side that was able to withstand high wave action.

Tetepare was found to have a wide size range of the Bumphead parrotfish (*B. muricatum*) and also recorded the highest abundance especially on the weathercoast side of the island. Acanthuridae and Scaridae were found to be the dominant reef food fish that occurred in medium abundance whilst the other reef food fish such as Lutjanidae, Serranidae, Haemullidae, Lethrinidae and Caragnidae were low.

7.3 Marovo

Marovo Lagoon is the largest double barrier lagoon in the world. Hard coral was the dominant life form. The dominant hard coral within the lagoon was mainly massive corals, most likely due to their ability to withstand the highly turbid water. In contrast, Acropora species were mostly found in clear water on the outer reef. The once pristine lagoon is now affected by logging activities that have spread rapidly around islands surrounding the lagoon. Logging activities and a plantation project in the area are considered to be the main threats in the lagoon (Personal observation, Nelly Kere, September 2007). Macroalgae was also relatively high, considered to be related to elevated land runoff from logging. The lagoon has limited passages for oceanic flushing therefore much runoff remains within the lagoon.

Marovo showed low fish densities across all genera except for the common reef indicators Caesonidae and Pomacentridae. The important reef food fish

Figure 41. a. Some of the damage around the Njari reef area caused by the earthquake.

Figure 41. b. The first picture shows the branching corals at Njari reef area pre-earthquake while the latter shows the impact of the earthquake.

species that were found in low abundance were Lutjanidae, Serranidae, Scaridae, Acanthuridae and Lethrinidae. All these species showed a marked decrease on the third round of surveys (Fig. 29). Marovo had the lowest abundance and smallest size range category for the Bumphead parrotfish (*B. muricatum*).

The impact of logging around the lagoon which causes sedimentation and high water turbidity, resulted in very poor coral cover. This, along with overfishing, are postulated as reasons for the low abundance of the reef indicator species Caesonidae and Pomacentridae.

In addition to this monitoring a three year project was implemented by a team of scientists from the University of Queensland (from 2004 to 2007) to provide a scientific basis to support community initiatives for the sustainable management of marine resources in Marovo Lagoon. The project received financial support from the MacArthur Foundation. The initial focus was a scientific assessment of marine ecosystem along with an assessment of the related socio-political issues. In initial stages, only two communities were involved. Activities later expanded to include more than 60 villages covering an area of more than 70km^2 and 12,000 people.

Apart from the communities, collaboration took place with conservation organisations such as World Wide Fund for Nature, International Waters Programme, Solomon Islands Locally Marine Managed Areas and World Fish Center.

The greatest challenge was to find practical solutions to local problems such as declines in fish catches, poor water quality in lagoons, changes in benthic sediments, deterioration in reef condition, loss of valuable upland forests, uncontrolled logging and clearing.

Achievements of this project included consultation workshops for community regional representatives, establishment of a communication network where regional representatives disseminated information to regional members, environment assessment reports, reference material on formation of legal entities and associations.

Apart from the skills developed by the team, linkages and friendships, pathways and initiatives made lagoon resource sustainability a realistic option. The greatest lesson learnt was that the most effective way of delivering the benefits of advanced understandings of marine ecosystems into local community level resource challenges is through close engagement and cooperation at all levels (Duke et al., 2007).

7.4 Munda

The reefs around Munda area are relatively exposed places and therefore have continuous oceanic flushing. Munda reefs had a good representation of hard coral and Acropora cover across all stations. Macroalgae was also a dominant life form mainly due to a high proportion of coralline algae and dead coral with algae. Coralline algae holds the substrata to withstand the high wave surge. The highest live coral cover, including hard coral and Acropora life form, was found at Haipe (Figs 16 – 18). This is considered to be due to its location, far from direct human impacts and in an area exposed to oceanic current.

Munda area had high densities across all genera in comparison to the other locations. The dominant reef food fish were Lutjanidae, Scaridae, Acanthuridae and Lethrinidae and these were more prevalent at 5m than 10m. Munda supported high densities across most size categories for the Bumphead parrotfish (*B. muricatum*). The high densities may be related to the extensive surrounding mangrove forests, seagrass beds and healthy coral cover. The main threats around Munda are likely to be overfishing from the large populace that resides in Munda town and the surrounding villages.

7.5 Arnavon Marine Conservation Area

AMCA reef area had a high cover of hard coral, macroalgae and abiotic but low cover for Acropora life forms. Arnavon had the highest cover for the 'Others' category due to the high occurrence of giant clams and sea cucumber along the transects, compared to the other locations. The high abiotic cover was a result of the presence of coral rubble, rock and sand due to the high exposure to strong wave surges. Most of the fringing reefs at the AMCA were exposed to high wave action and very strong oceanic currents.

AMCA showed a medium abundance of fish species across some of the genera. Acanthuridae and Scaridae were the most dominant reef food fish especially at shallow transects. There was a low abundance for Lutjanidae, Siganidae and Lethrinidae. The AMCA is a permanent marine protected area and is far from highly populated areas. It also has very low direct human impact.

8
CONCLUSION AND RECOMMENDATIONS

The variability in coral reef fish abundance and distribution around the five locations reflects to some degree the differences in coral reef habitat and the variety of direct and indirect human impacts on marine resources and ecosystem. The natural disaster in April 2007 had its own impact on the marine ecosystem but this must be placed in context of the ongoing destructive human impacts such as logging, overfishing and harvesting of corals for construction and lime production.

The water temperature showed a pattern of increasing water temperature last year 2007 compared to the same period in 2006. There was no major sighting of coral bleaching in the country. However, there were a few sightings of coral bleaching during the 2007 surveys. There are several factors that might affect the water such as water current, tidal movement and the weather patterns.

Recommendations

1. It is important to have continuity of long term monitoring of the locations to gather valuable information on the recovery rate and other factors affecting the reefs. Regular monitoring can measure changes in reef health caused by catastrophic events such as the earthquake and tsunami, or human impact activities affecting the reef. Short term monitoring only produces a snap shot of the status of the coral reefs. It does not give consolidated information on the overall trends occurring over long periods. This information is important for the long term management of marine protected areas and the sustainable use of marine resources.

2. There is a need for the inclusion of socio-economic data so as to have social and economic indicators to observe relationships between the coral reef and its resources. Gathering this information will enable resource users and managers to develop practical management plans to sustainably manage their resources.

3. On the basis of the findings of this report, an integrated threat index has been proposed for the GCRMN locations in Solomon Islands (Table 4). An integrated threat index has been used in the recent Status of Coral Reefs reports whereby reefs are assessed using five criteria; coastal development, pollution, sediment damage, over-fishing and destructive fishing. The overall threat index proposed ranges from medium at Tetepare and Arnavon to high at the other three sites.

Table 4. Integrated threat index for five SICRMN locations in the Western Solomon Islands

INTEGRATED THREAT INDEX						
Reef Area	**Coastal Development**	**Pollution**	**Sediment Damage**	**Over-fishing**	**Destructive Fishing**	**Overall Threat Index Score**
Gizo	Medium	High	Medium	High	High	High
Munda	Medium	High	Low	High	High	High
Tetepare	Low	Medium	Medium	Medium	Low	Medium
Marovo	Medium	High	Medium	High	Medium	High
Arnavon	Low	Low	Medium	Low	Low	Medium

9
ACKNOWLEDGEMENTS

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I wish to sincerely thank my work colleague Mr Tingo Leve for the professionalism displayed in fieldwork, logistics and data entry.

Special thanks to all who have supported this project, the Ministry of Fisheries and Marine Resources, Dive Gizo staff, Tetepare Descendants' Association, GCRMN Southwest Pacific Node, WorldFish Center, The Nature Conservancy, Uepi Resort Staff, Zipolo Habu Resort staff and Arnavon Marine Conservation Area staff.

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STATUS OF CORAL REEFS IN TUVALU 2007

Tupulanga Poulasi

CONTENTS

EXECUTIVE SUMMARY

Tuvalu's shallow marine environment is dominated by fringing and patch reefs that extend over an area of 710km^2. Five of the islands are true coral atolls, with a continuous eroded reef platform surrounding a central lagoon; three islands comprise single islets of sand and coral material and one has the character of both an atoll and a reef island (McLean and Hosking, 1991). These atolls and low coral islands are subject to constant change through continuing growth of living corals, erosion and accretion from wave action. All are low-lying, with an average elevation of about three metres above sea level (Sauni, S. 2000).

Historical and present data suggest changes in abundance of reef-associated organisms in the lagoon of Funafuti since 1996, with a tendency for a decrease in hard coral cover, an increase in turf and blue green algae, and a reduction in the number of some coral-associated fish (Kaly 2001).

Three ecological surveys have been conducted since Tuvalu joined the South West Pacific Global Monitoring Network in 2002. Two were done in 2003 and the third in late 2007. Monitoring is focused mainly on the following factors: fish numbers, invertebrate numbers and substrate cover. The six permanent monitoring sites were determined based on two key considerations: 1) the existence of ecological datasets; and 2) accessibility. Monitoring happens at irregular intervals due to many constraints and is carried out on three reef zones, crest, slope and floor.

Results from 2007 were similar to those obtained in 2003 for all the stations, with the exception of one. At this site, a notable drop in coral cover was observed in all the three habitats with the reduction being greatest on the slope habitat. The other station also showing significant loss of coral was Fuafatu (slope). It was 3% lower in 2007 than it was in 2003. For algae, some very interesting results were obtained particularly for two of the sites. Tepuka crest and Fualopa slope both scored very high percentages of algae in 2003 with figures of 65.5% and 82.3% respectively. In 2007 no algae was reported from these two particular sites.

Tuvalu's estimated fish consumption of 113kg/capita is the highest in this region. Many households rely on the sea for their livelihood and finfish is consumed predominantly by subsistence fishers. Other non finfish resources such as giant clams, spider shells and lobsters are reserved for special occasions such as birthdays, weddings, Christmas parties and so forth. A cone shell species (known as panea in Tuvalu) is of growing importance with both children and adults engaged in collecting it to sell for cash. Sea cucumbers or beche-de-mer are harvested by locals and sold to a locally-based foreign company operating under a partnership arrangement with three island communities. Turtle hunting is becoming more frequent on Funafuti. A number of fishers are hired to capture turtles for events such as weddings and birthdays.

Major threats include eutrophication, overfishing, coastal erosion and rising sea-levels. The government has adopted a new programme similar to that of Samoa whereby assistance is given to communities for integrated coastal management and development of management plans. Four islands have declared part of their reefs 'marine reserves'. These are Funafuti, Nukulaelae, Vaitapu and Nui. Other islands are also keen to set aside part of their reefs as marine protected areas (MPAs).

I
COUNTRY INFORMATION

Tuvalu comprises nine atolls and lies in the central Pacific, north of Fiji. While the total land area is only 26km², this is spread over a large sea area (Kaly et al. 1999). The nation has a population of around 9,561, which is distributed unevenly among the islands. Funafuti is the most densely populated island with 1,610 persons per km^2 (2002 Census).

Tuvalu's shallow marine environment is dominated by fringing and patch reefs. Five of the islands are true coral atolls, with a continuous eroded reef platform surrounding a central lagoon; three islands comprise a single islet of sand and coral material (McLean & Hosking 1991); and one island has the character of both an atoll and a reef island. These atolls and low coral islands are subject to constant change through continuing growth of living corals, erosion and accretion from wave action. All are low-lying, with an average elevation of about three metres above sea level (Sauni 2000).

Historical and present data suggest changes in abundance of reef-associated organisms in the lagoon of Funafuti since 1996, with a tendency for a decrease in hard coral cover, an increase in turf and blue green algae, and a reduction in the number of some coral-associated fish (Kaly 2001).

Table 1

Table Statistics	
Capital	**Funafuti**
Population (2002 census)	95611
Land Area	26 sq km
Marine Area	900,000 sq km
Reef area	100 sq km
MPA	4 islands
Long-term monitoring sites	6

Source: 1 SPC 2005, 2 FAO 2002, 3 Adapted from Mclean 1986, 1987

2

CURRENT PHYSICAL CONDITION OF CORAL REEFS

2.1 Coral reefs

Fringing reefs are found throughout the seas of Tuvalu and are typically narrow with water depths increasing very rapidly from the coast to over 1000m within a few kilometres of the shore or outer reefs (Sauni 2000). On top of exposed reef flats, a few live corals can be seen and various algae species are now becoming prominent. Numerous patch reefs can also be found at different depths but these are restricted to islands with lagoons. Seamounts of varying sizes are scattered throughout the Exclusive Economic Zone (EEZ), some of them rising to within 30m of the surface (Sauni 2000).

Four islands have declared part of their reefs 'marine reserves'. These are Funafuti, Nukulaelae, Vaitapu and Nui. Other islands are keen to set aside part of their reefs as marine protected areas (MPAs).

Scientific marine-oriented studies in Tuvalu are scarce and sporadic. Of the few studies undertaken, most have tended to concentrate on Funafuti, with little work conducted on the other islands.

A coral reef monitoring programme was initiated in 1995 as a component of a pilot project to establish the marine reserve in Funafuti. On that occasion, six permanent sites were chosen for monitoring. Between 1995 and 1999, two surveys were undertaken. No further survey was made for many reasons but funding has been reported as the primary problem. In 2001, Tuvalu became part of the Global Coral Reef Monitoring Network (GCRMN) Southwest Pacific Node and, with Canadian sponsorship, monitoring was extended for another three years.

2.2 Monitoring methods and issues

Three ecological surveys were conducted from when Tuvalu joined the South West Pacific Global Monitoring Network in 2002. Two were done in 2003 and the third in late 2007. However, these sites had existed long before Tuvalu became part of the programme. Datasets from surveys prior to 2002 have been obtained and stored.

Our monitoring is focused mainly on the following factors: fish numbers, invertebrate numbers and substrate cover. The Belt Transect (5mx25m) and the Line Intercept Transect methods were used to collect data for fish and invertebrates, and substrate cover, respectively. Datasets from these surveys were stored and analysed using the excel programme.

Divers used snorkeling gear in shallow waters, and SCUBA in deeper waters or when the current was too strong.

Monitoring has been sporadic and inconsistent for many reasons. Manpower shortage is the main one. Lack of dive equipment is another major issue. Certain monitoring equipment purchased from Fiji was found to be incomplete. It is now idle as the missing parts are too costly to purchase. In addition, the filling of dive tanks is also very difficult since Fisheries does not have a compressor. Often it is impossible to get approval for the use of compressors from elsewhere.

2.2.1 Monitoring sites

Our monitoring sites are confined to Funafuti only (Figure 1). The six sites were determined and finalised based on two key considerations: 1) the existence of ecological datasets; 2) accessibility. Presently, monitoring of reefs is the responsibility of the Fisheries Department, with some assistance from the Funafuti Kaupule (Island Council). Monitoring happens at irregular intervals. Again there are many reasons for this. In view of the numerous constraints, there are no fixed dates for conducting biological monitoring, although dialogue between collaborating partners is continuous, and monitoring takes place whenever an opportunity arises.

All the sites are situated on the western margin of the Funafuti atoll impact. Three are free from fishing pressure (Fualopa, Fuafatu and Tefala), while the other three are not.

Figure 1: Map of survey sites across the country

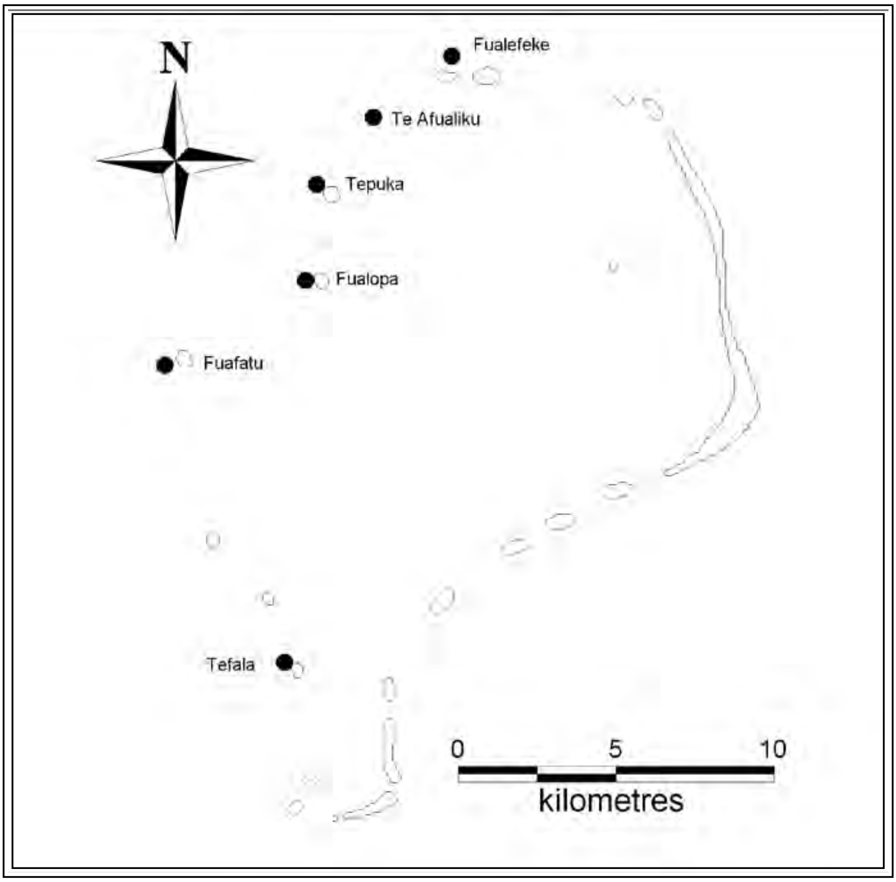


Table 2 Hard Coral cover observed in 2003 and 2007.

Station	Habitat	Hard coral		Algae		Other	
		2003	2007	2003	2007	2003	2007
Fualefeke	crest	36.0	10.0	0.0	8.0	64.3	82.0
	slope	69.0	30.0	0.0	1.7	31.5	68.2
	floor	20.0	7.0	1.0	0.0	79.0	92.7
Teafualiku	crest	24.0	27.0	0.0	0.0	75.6	72.9
	slope	62.0	63.0	0.0	0.0	37.6	36.9
	floor	26.0	27.0	4.1	0.0	69.9	73.0
Tepuka	crest	6.0	23.0	62.5	0.0	31.3	77.0
	slope	89.0	93.0	0.2	0.0	11.2	6.7
	floor	13.0	na	8.0	na	78.9	na
Fualopa	crest	1.0	2.0	5.3	0.0	93.7	97.9
	slope	12.0	12.0	82.3	0.0	5.5	88.3
	floor	9.0	na	46.6	na	4.3	na
Fuafatu	crest	17.0	na	0.0	na	82.7	na
	slope	65.0	62.0	0.0	0.2	35.1	37.8
	floor	53.0	na	1.0	na	47.3	na

2.3 Results

2.3.1 Substrate

Good coral cover is observed on the slopes but is not abundant in the other two habitats. The most dominant coral form, Acropora branching, is found in all the sites and the different habitats monitored. In terms of coral (diversity), the number of different types of corals increases from north to south.

Results from 2007 were similar to those obtained in 2003 for all the stations, with the exception of one. At this site, a notable drop in coral cover was observed in all the three habitats with the reduction being greatest on the slope habitat. The other station also showing significant loss of coral was Fuafatu (slope). It was 3% lower in 2007 than it was in 2003.

For algae, some very interesting results were obtained particularly for two of the sites. Tepuka crest and Fualopa slope both scored very high percentages of algae in 2003 with figures of 65.5% and 82.3% respectively. In 2007 no algae was reported from these two sites.

Table 3: Status of the percentage hard coral cover by habitat in 2003 and 2007 for the five sites.

Stations	Habitat	Live coral		Recently dead		Long dead		Bleached	
		2003	2007	2003	2007	2003	2007	2003	2007
Fualefeke	crest	44.5	22	14.5	0	41	78	0	0
	slope	60.7	54	20.8	6	18.5	40	0	0
	floor	97.1	90	0	0	2.9	10	0	0
Teafualiku	crest	81.6	35	0	0	18.4	64	0	2
	slope	70.5	40	0	0	29.5	60	0	2
	floor	84.6	73	15.4	0	0	26	0	1
Tepuka	crest	68.2	37	0	0	31.8	63	0	0
	slope	83	77	12	1	5	22	0	0
	floor	86.4	na	4.4	na	9.2	na	0	Na
Fualopa	Crest	100	100	0	0	0	0	0	0
	slope	100	96	0	0	0	4	0	0
	floor	52.6	na	10.4	na	37	na	0	Na
Fuafatu	crest	65	na	0	na	35	na	0	Na
	slope	69.6	64	19.7	0	10.7	35	0	1
	floor	80	na	4.1	na	15.9	na	0	Na

Overall there were fewer live corals in 2007 than in 2003. Live corals were significantly lower for Fualefeke, Tefaualiku and Tepuka with coverage ranging between 22% - 90% in 2007 compared to 44.5%-97.1% in 2003. Fualopa crest maintained a 100% live record. Bleaching was observed at Fuafatu slope and at all the three habitats at Teafualiku, though this was not serious.

2.3.2 Fish

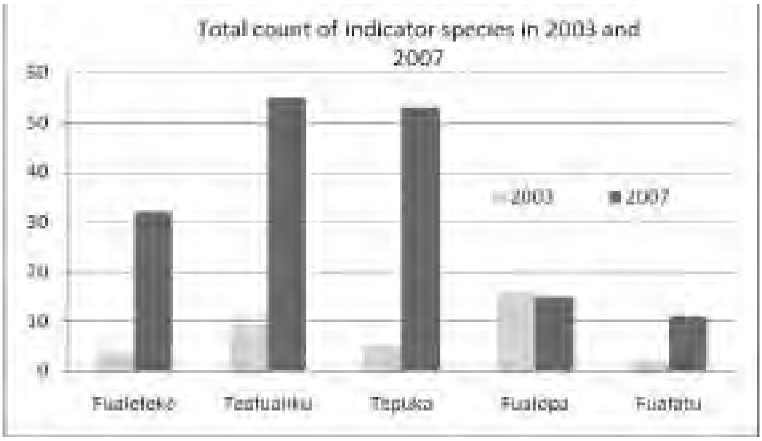
There are two separate categories of fish - one is food fish species and the other is indicator species. Included in the food fish category are fish of social and economic importance. Indicators include species of ecological importance such Chaetodon that are dependent on live corals for food.

A total count of 1,607 fish was made in 2007 for the top eight fish species in the food fish category. In 2003 the total count of the same fish species was 1206 individually. The striped bristletooth, the most common fish, was found throughout the different habitats and stations surveyed. Convict Tang was second in abundance followed by Orangespine Unicorn. The Humpback snapper, one of the most favored fish in Tuvalu for its delicious taste, was observed in only two stations. Numbers, however, were relatively low.

2007 food fish	Fualefeke	Teafualiku	Tepuka	Fualopa	Fuafatu	Total
Orangespine unicorn	50	58	28	55	41	232
Forktail rabbitfish	20	65	82	5	55	227
Humpback snapper	0	0	17	0	59	76
Convict Tang	128	15	22	104	0	269
Striped bristletooth	183	85	35	8	77	388
Bluebanded surgeonfish	8	104	4	39	0	155
Bigeye emperor	63	24	6	0	60	153
Whitecheek surgeonfish	8	32	21	6	40	107
Total	460	383	215	217	332	1607
2003 food fish						
Orangespine unicorn	16	41	28	20	22	127
Forktail rabbitfish	27	4	6	0	0	37
Humpback snapper	0	0	20	0	50	70
Convict Tang	17	18	77	57	0	169
Striped bristletooth	146	81	36	0	41	304
Bluebanded surgeonfish	22	52	4	54	16	148
Whitecheek surgeonfish	28	133	22	0	42	225
Bigeye emperor	39	13	51	0	23	126
Total	235	279	113	54	122	1206

Table 4: Summary of the top eight fish species (in terms of abundance) in the food fish category observed in the two surveys (2007 and 2003) in 125m^2.

Figure 2: Bar graph showing individual fish counted in 2003 and 2007



All the sites have shown a huge increase in fish numbers since the last survey in 2003, except for Fualopa.

2.3.3 Invertebrates

More invertebrates were recorded in 2007 than in 2003, although there is a possibility sampling error may be responsible for this increase.

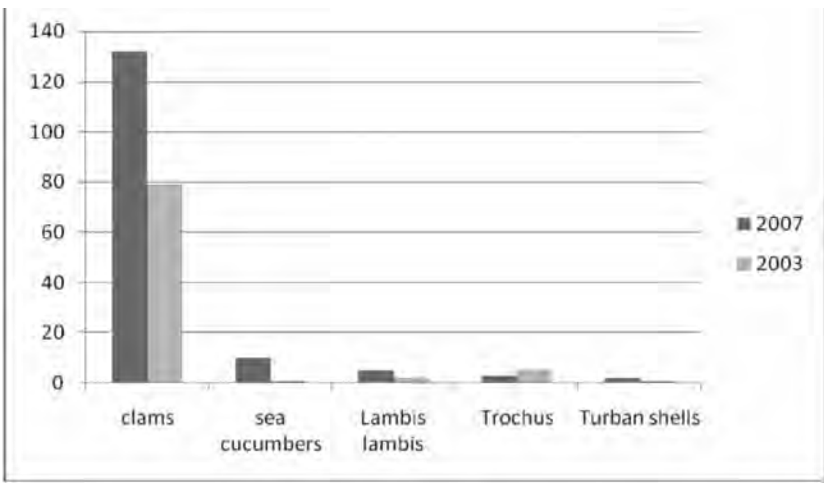


Figure 3: Total number of invertebrates from the two surveys, 2003 and 2007

3

DISCUSSION

3.1 Substrate

3.2 Hard coral

Overall there was very little change observed in coral cover since the last survey in 2003. However some significant changes were noted for Fualefeke where coral cover was reduced substantially throughout the three habitats. The reasons for this change were not determined.

For Tepuka, a change in location of transects on the crest was made because there was rarely anything growing on the surface of the original positions apart from algae. The current is also too strong in the original location making work difficult, especially when the tide falls and rises.

Massive coral death occurred at Fuafatu and Teafualiku before the 2007 survey. For most colonies of branching corals that exist there, the only living parts were the front tips of the branches of about 3cm-10cm in length. The possible cause of the destruction is not clearly understood but could be due to natural phenomenon such as high water temperature and very strong westerlies. At the time of the survey, however, signs of recovery were easily visible with tips of coral branches showing good growth. Some corals were bleached. This could possibly have been caused by predation.

3.3 Algae

The decrease in algae as reported for Fualopa slope and Tepuka crest in 2007 may have been a product of some recording error. There is a suspicion that algae cover at these locations is about the same as previously reported. Nutrient loading into the lagoon is thought to be extremely high but is less likely to cause significant impact in these locations given their distance from sources of nutrients.

3.4 Fish

The fish species surveyed in 2007 were similar to those of 2003. The results (Table 4) indicate that the fish counts in 2007 were greater than fish counts in 2003. This could be due to the fact that different surveyors doing the monitoring had differences in judgment. This change of surveyor was unavoidable because at the time of the 2007 survey the 2003 surveyor was unavailable. Other factors that could have had an effect on the difference in fish counts included moon phase, tide patterns and the survey times.

Reason for the greater number of indicator fish species in 2007 in comparison to 2003, could be due to the fact that fewer fish species were considered in 2003 (only six species) in contrast to the 2007 survey, where the list of the fish species checked has been doubled.

3.5 Invertebrates

The invertebrate numbers were higher in 2007 compared to 2003 (Fig. 2). This increment may be due to the survey in 2007 covering areas with a higher invertebrate diversity than those of 2003. For instance, the Fualopa slope, the site with the highest percentage of clams, is located on a fault line. A high nutrient supply from the fault would increase the microbial activity (producers in a food chain) which could be one reason for a thriving population of clams (Scearce, 2006).

4

CURRENT RESOURCE USE

4.1 Coral Reef Species

Many households rely on the sea for their livelihood. Finfish are consumed predominantly by subsistence fishers. Other non finfish resources such as giant clams, spider shells and lobsters are reserved for special social occasions.

Cornus shell (panea) is now growing in importance. Children and adults are engaged in its collection mainly to sell for cash.

4.2 Turtles

Turtle hunting is becoming more frequent on Funafuti. A number of fishers are hired to capture turtles for events such as weddings and birthdays. During December 2007, a fisher caught 16 green turtles, four of which were tagged by the Department of Environment-SPREP while the other 12 were used as food. Other anecdotal reports suggest that, on average, about 15-20 turtles were killed each month, an alarming figure that needs to be addressed.

4.3 Endangered species

Sea cucumbers or beche-de-mer are collected by locals and sold to a locally-based foreign company operating under a partnership arrangement with three island communities. These three communities include the Funafuti community, Nukulaelae island community and the Nukufetau island community. One shipment weighing over three tons had already been exported. Sea cucumbers in the waters of these islands are now feared to be near extinction.

5

THREATS TO CORAL REEFS/MANGROVES/SEAGRASS

5.1 Eutrophication

Eutrophication is a long standing problem. It is especially pronounced in the waters adjacent to the main island of Fogafale due to waste from numerous pig pens and chicken runs being washed into the lagoon. The result is the absence of live coral and yellowish, brownish, or dark water colour. The lack of action in solving the waste problem will only aggravate the eutrophication problem.

5.2 Fishing

Unregulated and improper fishing practices continue to put pressure on coral reefs. Spear fishing is common in Tuvalu. Some fish, (for example parrot fish, surgeon fish and wrasse), which are a prime target for fishermen, are ecologically important. Over-fishing these species would harm the coral reef as an ecosystem.

5.3 Erosion

This problem is a natural one and is caused by the actions of waves and currents. Sand from eroded beaches moves and ends up on reef platforms preventing reef regrowth.

5.4 Bleaching, coral disease and predators

Bleaching observed in 2007 was basically caused by some coral feeding mollusks. Nonetheless, the impact was minimal and isolated.

6

CURRENT CORAL REEF CONSERVATION EFFORTS

The government has adopted a new programme similar to one in Samoa. It involves a holistic approach to management of coastal fisheries resources. Communities are given assistance and guidance to develop their own management plans. Under these plans communities have the power to make laws and rules to control specific activities, but only within the area under their jurisdiction. The challenge, however, lies in implementation.

7

RECOMMENDATIONS

Conservation efforts remain a challenge in Tuvalu as not all citizens are aware of the importance of coral reefs and thus their activities continue to pose threats to ecosystems. Some of the ways in which coral reefs can be protected or conserved and better managed are:

- Establish some control over fishing; for instance a ban on spear fishing of ecologically important fish;
- Minimise possible problem areas illustrated in this report;
- Source funding to finance necessary tools and equipment for effective monitoring;
- Conduct ecological surveys more regularly, at least once a year;
- Establish some controls for nutrient sources that directly enter the lagoon or the sea;
- Government to commit and support conservation efforts by providing financial assistance for fisheries research and extension work.

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THE STATUS OF CORAL REEFS IN VANUATU 2007

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Ministry of Agriculture,

Quarantine, Forestry & Fisheries

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EXECUTIVE SUMMARY

Vanuatu's inshore (reef and lagoon) areas extend over approximately 4110km^2 (Spalding et al, 2001). It is an important habitat for an array of inshore marine life that supports 80% of the country's rural dwellers who depend largely on fisheries and agriculture for their economic and social sustenance, and food security.

Vanuatu's geographical location makes its corals reefs vulnerable and susceptible to natural phenomena, such as cyclones, the effects of climate change, earthquakes and strong waves. These have influenced, in a fundamental way, development processes of the country's coral reefs over hundreds of years. The Vanuatu Coral Reef Monitoring Network, through its Reef Check Programme, has surveyed 57 sites in 11 regions throughout the islands. These were to identify and confirm current threats to coral reefs so that measures to reduce or prevent the impact of such threats could be developed.

Between 2005 and 2007, monitoring teams conducted a series of mainly one-off surveys. Results revealed that, overall, abiotic components (rock, rubble, and sand) dominated the substrate and comprised an average of 47% while hard coral cover was 26%. Individual regional data showed that the highest coral cover was 49%, with a small amount of recently killed or bleached coral. Butterfly fish and Surgeonfish were the most dominant indicator fish families. However, several other families were absent from a majority of the regions. For example, the Humpback Los was only observed in one of the regions, the Napoleon Wrasse in four, and the Bump head Parrotfish in three regions. Mean invertebrate density was generally low across regions, with the exception of edible sea cucumbers.

There is no information regarding recent subsistence production, but estimated production in 1993 was about 2,400 tonnes (National Statistics Office, 1994). Other reef users are the tourism industry and aquarium trade, both vital contributors to the local economy. Turtle harvest and consumption have a long history and cultural significance, much like in Fiji, with permits issued for traditional use and a moratorium in place. Mangroves and seagrass are both regarded as important ecosystems for food security and biodiversity conservation, as well as for coastal protection.

Overfishing of coral reef resources due to population increase is the major threat to coral reefs. Natural threats include cyclones, earthquakes, bleaching, and crown-of-thorns starfish (COTS) outbreaks. Vanuatu has been under regular influence of cyclones. Pakoa (2007) noted that Cyclone Danny in 2003 affected/damaged 80% of coral on the western coast of Efate.

As with other countries in the region, marine protected areas (MPAs) are regarded as significant for increasing fish biomass. For example, studies of the Nguna-Pele marine protected area in North Efate revealed that both permanent and periodic closures had a higher biomass of indicator fish inside than outside the reserve. This suggests that small-scale,village-based reserves are effective resource management tools, and that opening a reserve temporarily for harvest according to community needs, may be a practice compatible with conservation goals.

One of the core activities of the Fisheries Department is to rehabilitate depleted reef areas by supplying cultured Trochus juveniles to communities. Since 2006, the Department's rehabilitation programme was expanded through a Japan International Cooperation Agency (JICA) project to include other important reef resources such as green snail and giant clams.

I
COUNTRY INFORMATION

Vanuatu is a Y-Shape archipelago comprising more than 80 islands, 67 inhabited and 12 described as major. Land area is about 12,190km^2 and total coastline about 2,528km. The Exclusive Economic Zone (EEZ) covers an estimated 680,000 km^2. Other biologically-important reef-associated habitats, including mangroves, estuaries and lagoons, represent a total area of 25km^2 (Done and Navin, 1990).

The country's geographical location on the western edge of the Pacific tectonic plate, often known as the 'Islands of Fire', means Vanuatu is prone to tectonic activities, including earthquakes, which are catastrophic to coral health (Pakoa, 2007). Vanuatu has 16 volcanoes, nine of which are permanently active, distributed along the North/South island arc from Gaua (in the North) to Tanna (in the South). Of these, six are terrestrial and four are marine (Pers. Comm. Brooks Rakau, Sept. 2007) and remain a threat to coral reefs.

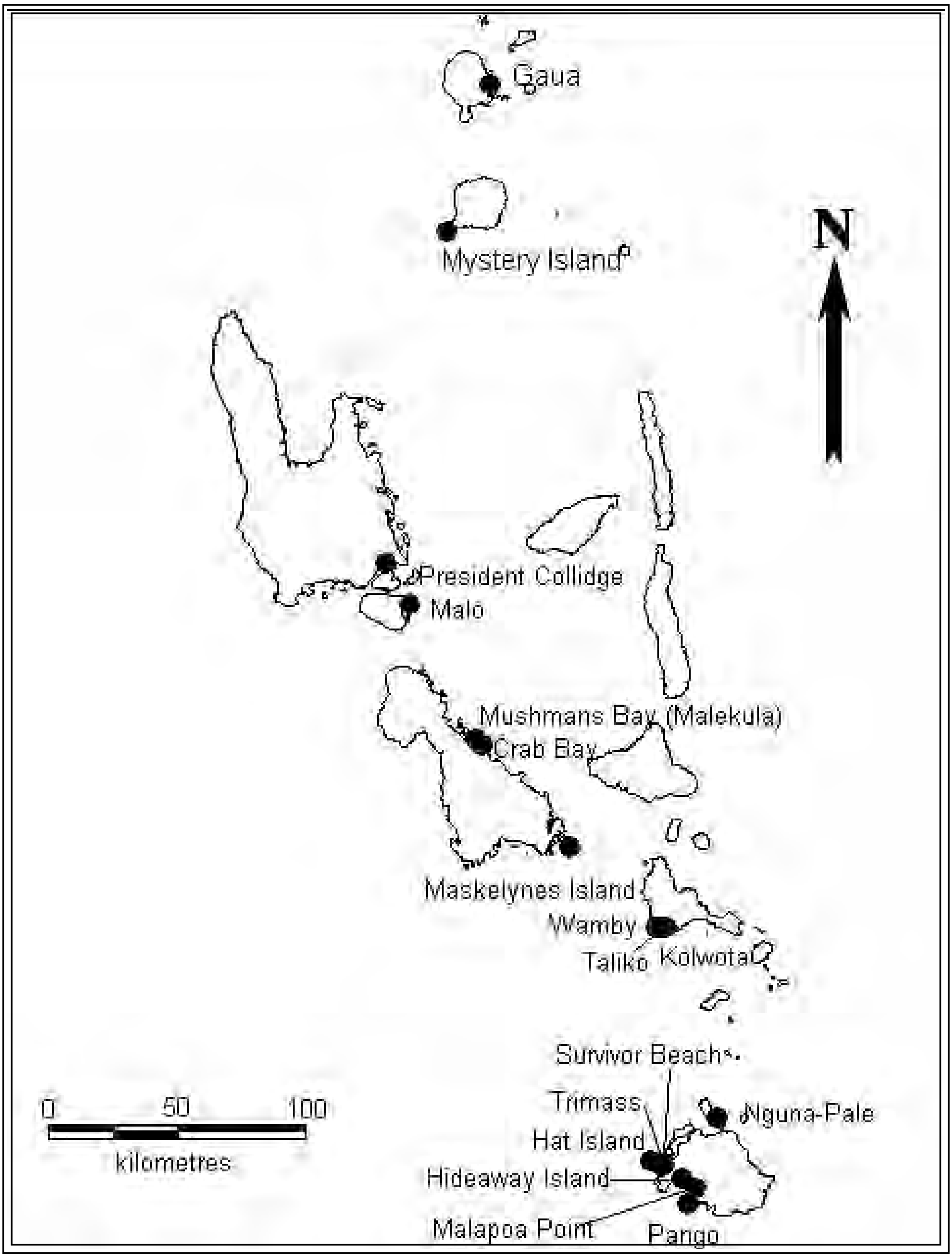
The archipelago also lies within the cyclone belt and experiences on average two cyclones annually. Impacts of cyclones are catastrophic to coral reefs (Don & Navin, 1990). The climate varies from tropical in the north to subtropical in the south. The average annual rainfall ranges from 1,700mm in the South to 3,000mm in the North. The average sea surface temperature in the open ocean ranges from 24°C in the south to 27°C in the north (Pers. Comm. Silas Tigona, Sept. 2007). During El Nino, and La Nina phenomena, there is a sudden rise and fall of sea surface temperature. From 2002 to 2007, occurrences of El Nino and La Nina had drastic bleaching impacts on the coral reefs in many areas that resulted in coral mortality (Personal Observ., Jason Raubani, February and March, 2002; 2004; 2005; 2006).

The country is divided into six provinces namely Torba, Sanma, Penama, Malampa, Shefa and Tafea. (Figure 1) The provinces manage their own affairs, including the adjacent six miles of ocean called the 'provincial waters'. The provinces can pass by-laws relating to the management of fisheries resources within six miles of the provincial waters (Anon, 1997).

The estimated total population of Vanuatu was 221,506 in 2006 according to the Census of the Agriculture Preliminary Report. About 80% of the population lives in rural areas while the remaining 20% dwell in the urban centers. The recent estimated population growth is about 2.7% per annum. About 98.7% of the population is indigenous Melanesian. The remaining 1.3% is comprised of various ethnic groups (National Statistics Office, 1999; 2006a).

There is currently no information on what percentage of the population lives in coastal towns and villages. It appears, though, that the majority of villages are situated along the coastlines of all of Vanuatu's inhabited islands. The coastal dwellers depend largely on agriculture and fisheries for their livelihoods. Inter-island migration is about 9.7%. Urban migration, on the other hand, has shown continuous growth in the period from 1999 to 2006 when the urban population increased ten fold (National Statistics Office, 1999; 2006a).

Figure 1: Map of Vanuatu showing monitoring sites



Three main sectors form the backbone of Vanuatu's economy. These are agriculture, and the service and industry sectors. According to a recent report on the National Accounts of Vanuatu (National Statistics Office, 2006b), the economy grew by 7.2% in real terms in 2006. The primary sector, which includes agriculture, forestry and fisheries, grew by 2.4% and contributed 6% to economic growth in 2006. From 2005-2007, the primary sector made up about 17% of the GDP (National Statistics Office, 2006b). Fisheries, including aquaculture, made a relatively small contribution to the formal economy of an estimated 0.1% of overall GDP, and 5.5% to the primary production sector. However, domestic fishery, in particular reef and coastal fishery, makes an important contribution to the rural economy and food security by providing nutrition and income-earning opportunities to some 60% of rural households. The Vanuatu fisheries sector can be categorized into three broad sectors, namely: i) Offshore fishery or industrial fishery; ii) inshore fishery; and iii) aquaculture.

Table 1: Vanuatu Statistics

Total population, 2006	221,507
Rural population, 1999	80%
Annual growth rate, 2006	2.70%
Urban Population, 2006	50,692
Urban growth rate, 1999	-
Life expectancy, 1999	69 years
Total land area	12,190km^2
Arable land	5,500km^2
Population density, 1999	15.3 person/km^2
GDP per capita, 2006	Vt185,000
Total forest area	447,000ha
Total EEZ area	680,000km^2
Total reef and lagoon area	448km^2
Total mangrove area	3000ha
Total archipelagic area	-
Total provincial waters (3nm)	-

2
MONITORING HISTORY

Vanuatu's systematic coral reef monitoring programme began in 2001 through funding assistance from the Canada South Pacific Ocean Development (CSPOD) Programme. Prior to this, monitoring was conducted on an ad hoc basis. Since the commencement of the programme, two permanent sites have been established on the island of Efate where monitoring was conducted twice a year. In 2004, several other monitoring sites were established on Efate, and the islands of Epi and Espiritu Santo. Since its inception, the Vanuatu Coral Reef Monitoring Programme has been using the Reef Check methodology to monitor reef health. However, in 2003 and 2004, the Fisheries Department modified the Reef Check methodology to include other species important to fisheries that were not in the original indicator species list.

In 2005, due to lack of financial support from the Government to continue the monitoring programme, Reef Check Vanuatu was founded and established (with the assistance of the Peace Corps Office in Port Vila) under the administration and management of Fisheries Department. Financial assistance was provided by the Australian Agency for International Development (AusAID). In future, Reef Check Vanuatu aims to function as a non-profit organization focusing mainly on monitoring, management and conservation of coral reefs in close collaboration with other stakeholders.

Reef Check Vanuatu has worked closely with the Peace Corps Volunteer Services and through their network expanded the monitoring programme to other provinces including Torba and Tafea. Reef Check Vanuatu not only conducts the monitoring programme but also provides training on the Reef Check methodology to interested rural communities and dive tour operators. This enables them to monitor reefs in their locality. In 2007, Reef Check Vanuatu had established monitoring sites in the Torba, Sanma, Malampa, Shefa and Tafea provinces, but had still to establish one in Penama province. The Fisheries Department aims to effectively coordinate reef monitoring and data collection, as it is a challenge to motivate communities and dive tour operators to carry out consistent monitoring and submit data.

Table 2: Reef Check Vanuatu Fish Indicator Species

Common Name	Family/Scientific Name	Indo-Pacific Indicator	Vanuatu Indicator
Butterflyfish, Batfish, & Bannerfish	Chaetodontidae; Ephippididae	X	
Sweetlips	Haemulidae	X	
Grouper	Serranidae	X	
Snapper	Lutjanidae	X	
Parrotfish	Scaridae	X	
Moray Eel	Muraenidae	X	
Barramundi Cod	Cromileptes altivelis	X	
Humphead Wrasse	Cheilinus undulates	X	
Bumphead Parrotfish	Bolbometopon muricatum	X	
Rabbitfish	Siganidae		X

3
CURRENT PHYSICAL CONDITION OF CORAL REEFS

3.1 Monitoring

3.1.1 Methods

Monitors use the basic Reef Check methodology with a modified indicator species list. Additional indicator species include locally and commercially valuable fish such as Rabbit fish and Surgeon-fish and invertebrate species such as Turban shell, Green Snail and Cowrie. Tables 2 and 3 provide a list of indicator species included in Vanuatu's Reef Check surveys. Categories for the substrate survey are listed in Table 4. Rabbit fish, Surgeonfish and Turban shells constitute some of the most targeted species for local consumption. In addition, Green Snail, Trochus and Cowries are harvested for commercial purposes.

Table 3: Reef Check Vanuatu Invertebrate Indicator Species

Common Name	Genus/Scientific Name	Indo-Pacific Indicator	Vanuatu Indicator
Banded Cleaner Shrimp	Stenopus hispidus	X	
Rock and Slipper Lobsters	Panulirus sp. & Scyllaridae	X	
Crown-of-thorns starfish	Acanthaster planci	X	
Diadema Urchin	Diadema sp. & Echinothrix spp.	X	
Pencil Urchin	Heterocentrotus mammillatus	X	
Collector's Urchin	Tripeustes sp.	X	
Edible Sea Cucumbers	Holothurians	X	
Giant Clams	Tridacna sp. & Hippopus sp.	X	
Triton Shell	Charonia tritonis	X	
Trochus	Trochus niloticus		X
Green Snail	Turbo marmoratus		X
Cowrie Shell	Cupraea spp.		X
Turban Shell	Turbo petholatus & Turbo Chrysostoma		X

Table 4: Vanuatu substrate category

Hard Coral (HC)	Sponge (SP)
Hard Coral Bleached (BHC)	Rock (RC)
Soft Coral (SC)	Rubble (RB)
Soft Coral Bleached (BSC)	Sand (SD)
Recently Killed Coral (RKC)	Silt (SI)
Nutrient Indicator Algae (NIA)	Other (OT)

The two main monitoring groups conducting Reef Check surveys are the Vanuatu Department of Fisheries, and village-based Reef Check teams. The Fisheries' team includes staff members of the Division of Management and Policy, and others. Village-based Reef Check teams consist of local divers who have been trained in basic reef ecology, management, and the Reef Check protocol. There have been efforts to include local dive operators and secondary school students in the 2007 monitoring period.

3.1.2 Issues

Although Vanuatu's coral reef monitoring activities are administered by the Department of Fisheries, there is no provision for funding for this in the annual budget. As a result, it is difficult for the monitoring team to effectively carry out its yearly planned activities. Consistency is crucial where both monitoring and supply of data are concerned.

The Department of Fisheries has made efforts to identify permanent monitoring sites around Vanuatu. Challenges include a lack of funding and human resources to ensure consistent monitoring of the sites. Most of the surveys, therefore, are conducted by village-based Reef Check teams. Of the 52 surveys completed in 2007, 45 were carried out by local Reef Check teams, five by the Department of Fisheries' team and two were completed by local dive shop staff. Of the 45 surveys done by village-based Reef Check teams, 38 were conducted on the island of Gaua. Motivating villages to do regular monitoring surveys has been difficult resulting in an inconsistent supply of monitoring data. Strengthening the monitoring programme is a future goal of the Department of Fisheries.

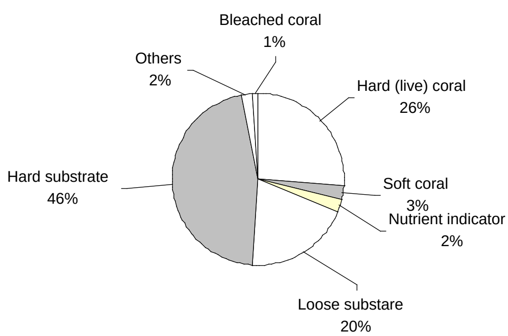
The Department also lacks the capability to develop an appropriate data management system to effectively store all monitoring data collated. Currently, this information is stored either in an excel format or hard copy.

Community-based Reef Check teams have been an asset to Vanuatu's monitoring programme as they have been able to gather data in remote areas that are both difficult and expensive for the Department of Fisheries team to reach. It is through trained local teams that baseline data has been gathered for several of the more remote islands around Vanuatu. Reef Check is also an excellent tool for raising awareness about coral reefs in communities. A goal of the programme over the next few years is to encourage previously-trained communities to monitor their reefs on a regular basis and to use the data to assist in making informed decisions about management of reef resources. Despite some difficulties since 2005, teams have done well, and have managed to expand the number of monitoring sites.

3.1.3 Sites

Between 2002 and 2007, teams conducted surveys at 57 different sites in 11 regions around Vanuatu (Figure 1, Appendix 3). The majority of these were one-off, but in the future regular monitoring in some of these sites will become permanent.

Figure 3: Percentage of each benthic cover over all the regions surveed in Vanuatu.



3.2 Results

A summary of the survey results for the years 2005 to 2007 are presented below.

3.2.1 Substrate

Figure 3 shows the results of the Reef Check substrate survey in all monitoring survey regions. Three of the four most common substrate components were hard substrate (46%), hard (live) coral (26%) and loose substrate (20%). Figure 4 illustrates that the hard substrate which includes Rock (RC) and Recently Killed Coral (RKC) was the dominant category of benthic cover in all regions followed by Hard Corals (HC), Rubble (RB) and Sand (SD). In terms of HC, North Efate has the highest percentage (49%), followed by Epi (40%), Malekula (37%) and Gaua (35%).

3.2.2 Fish

Results of mean fish density (Table 5), showed that Butterfly fish and Surgeonfish were the most dominant families. On the other hand, several families were absent from the majority of the regions. The Humpback Los or Barrramundi cod (*Cromileptes altivelis*) was only recorded in one of the regions, the Napolean or humphead Wrasse (*Cheilinus undulatus*) was recorded in four, and the Bumphead Parrotfish (*Bolbometopon muricatum*) found in three regions.

Table 5: Mean Fish Density per 100m² in each region

Fish species/ category	Aneityum	Mele Bay	N. Efate	Mataso	Epi	Maskelynes	Malekula	Malo	Luganville	Gaua	Mota Lava
Butterfly	7.1	4	4.1	5.6	4.3	0.4	6.9	5.5	1.5	5.9	5.9
Sweetlip	0.1	0.2	0	0	0	0.2	0.5	0.1	0	0.1	0.3
Grouper	0.1	0.2	0.1	0	0.5	0	0.8	0.6	0	0.1	0.1
Snapper	0	0.5	0.4	0.3	0	0	2.9	2.9	3.8	0.7	6.1
Parrot fish	2.5	1.3	0.6	0.4	4.8	0.6	2.8	2.6	0.5	3	1.1
Murray eel	0.1	0.1	0	0	0	0	0.2	0	0	0.1	0
Barramundi cod	0	0	0	0	0	0	0.2	0	0	0	0
Humphead wrasse	0	0	0	0	0.1	0	0	0.8	0	0.4	0.1
Bumphead parrotfish	0	0	0	0	0	0.2	0.8	0	0	0	0.1
Rabbitfish	0.9	0.3	1	0	2.1	0	1.8	3.4	5	2.5	9
Surgeon, Unicorn and Tangs	12.8	12	11.4	10.3	8.4	5.2	*not counted*	26.6	5.5	11.7	6.3

3.2.3 Invertebrates

The mean density of invertebrates in each region ranged from 0 to 38.5 per 100m^2, with edible sea cucumber recording the mean highest density on Aneityum. Results showed that COTS is a concern and a possible threat to coral health in almost all regions. The mean density of diadema urchins in all areas was high and may indicate signs of pollution and other human activity on the reefs. The triton shell and green snail population are very rare with sightings in only one region (Table 6).

Table 6: Mean invertebrates Density per 100m^2 in each region

Invertebrate species	Aneityum	Mele Bay	N. Efate	Mataso	Epi	Maskelynes	Malekula	Malo	Luganville	Gaua	Mota Lava
Banded cleaner shrimp	0	0	0.1	0	0	0	0.1	3.1	0.8	0.2	0.1
Rock and slipper lobster	0	0	0.3	0.4	0	0	0	0.1	0.3	0	0
Crown-of-thorns starfish	0.4	0.6	0.2	0	0	0.2	0	0	0.3	0.3	0
Diadema Urchin	0.6	7	0.7	0.5	0.1	0.5	0.4	16	3.5	1.8	7.9
Pencil Urchin	0.8	1.1	4.9	1.9	0	0.1	0.8	0.1	0	0.7	1.1
Collector's Urchin	0	0.7	0	0	0	0.3	0.1	0	0	0.1	0
Edible Sea Cucumbers	38.5	0.4	1.4	0	0	5.8	0.7	0.3	2.3	2.4	0.4
Giant Clams	1.5	0.2	2.9	0	0.3	6.1	1.2	0	0.3	0.2	0.5
Triton Shell	0	0	0	0	0	0	0.5	0	0	0	0.6
Trochus	0	0.8	0.1	0.1	1.1	0.9	1.2	0.6	0	3	0.8
Green Snail	0	0	0	0	0	0	0	0	0	0	1.5
Cowrie Shell	0	0.1	0	0.1	0	0.5	0.2	0	0.3	0.2	0.4
Turban Shell	0	0.9	0.3	0.3	0	0.4	0.5	0.6	1	0.4	0

3.2.4 Water Temperature

Meteorological Department records show that in the period 2005-2006, the average water temperature ranged from 24°C in the South, to 27°C in the North.

3.3 Discussion

As earlier mentioned, regular monitoring is a major issue, so trends in reef health over a period of time cannot be shown. This is an area in need of improvement.

3.3.1 Substrate

The percentage of hard coral in all the monitoring areas is low, accounting for less than 50% of the substrate composition (Figure 3). The main reason is that most sites were selected for their proximity to the village, rather than for scientific appropriateness. Closeness to urban centres and villages is, therefore, a major influence on the substrate composition, and the coral cover observed at sites is not necessarily reflective of hard coral cover in other parts of the country. On North Efate, however, there has been anecdotal evidence that hard corals are regenerating after a major dieback some five to 10 years ago. The dieback was probably due to changes in sea surface temperatures caused by El Nino in 1998, 2000 and 2001 (Pers. Observ., Jason Raubani, March 2007). From the surveys, there was little evidence of recently killed or bleached corals, and only low percentages of nutrient indicator algae recorded.

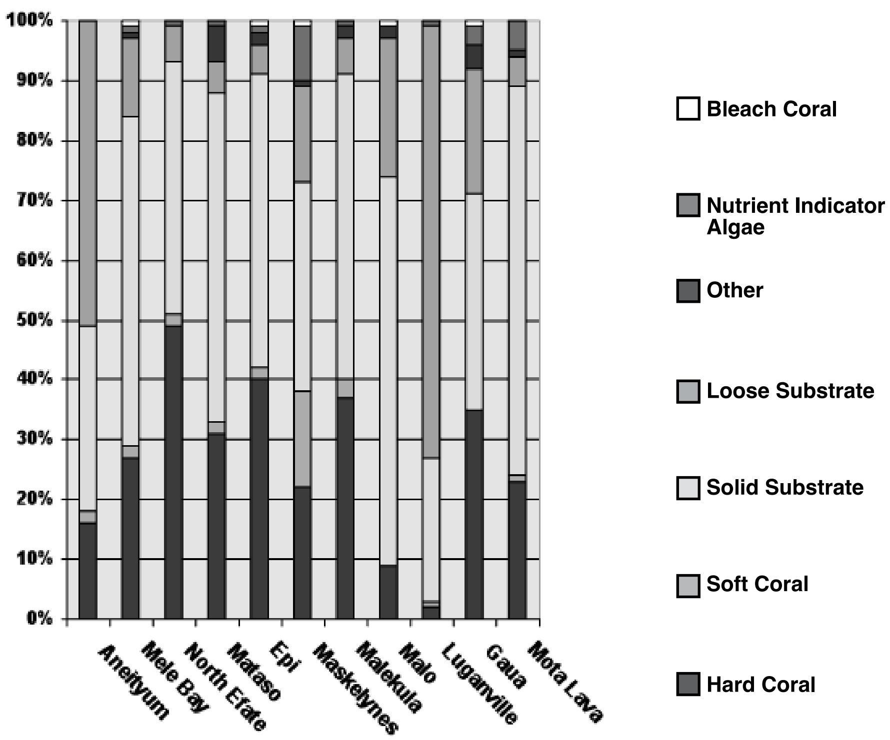


Figure 3: Percentage of each benthic cover in each of the survey regions.

3.3.2 Fish

Three of the main commercially valuable species, *Humpback* Los (Barramundi cod), Napolean Wrasse (*Chelinius Undulatus*), and Bumphead Parrotfish, (*Bolbometopon muricatum*) were absent from a majority of the survey regions. Again, this is likely to be due to closeness to the urban centres and, therefore, high fishing pressure. Rabbitfish and Surgeonfish, which were included in Vanuatu's Reef Check survey, were both present (Table 5). Through continuous monitoring, more information can be determined on the stability of fish populations.

3.3.3 Invertebrates

Sea Cucumbers were the most abundant in three out of the 11 survey regions (Table 6). Many communities were concerned about sustainability of the resource, as they have enjoyed good harvests in the past. There is a Department of Fisheries' ban on the harvest and export of sea cucumbers effective January 1st 2008.

The green snail (*Turbo marmoratus*) was recorded in only one region, while the triton shell (*Charonia tritonis*) was located in two regions. Both species are very valuable for the local curio trade and for export and are therefore actively exploited. Since October 2005, the Department of Fisheries has had in place a moratorium of 15 years on the harvest and export of green snail (Appendix 4). Trochus has also been heavily exploited. A joint venture through JICA and the Department of Fisheries is working on a project to help restore populations of trochus, green snail, and four species of giant clam (*Tridacna squamosa, T. Maxima, T. Gigas and Hippopus hippopus*) in certain target communities in Vanuatu.

Table 7: Export production (Raubani, 2007)

Year	Trochus		Sea cucumber		Aquarium products	
	Mt	Value (USD)	Mt	Value (USD)	Pieces	Value(USD)
2000	90	-	26	-	36,000	84,313
2001	73	500,000	38	127,451	45,517	70,981
2002	67	323,529	8	49,019	49,530	40,392
2003	53	607,843	25	117,647	137,605	595,097
2004	35	343,137	13	127,451	130,421	543,138
2005	36	509,803	9	166,666	153,266	892,158
2006	36	700,000	8	180,000	205,117	218,894
2007	55.2	781,050.80	15.4	135,810	216,446	200,403.42

4
CURRENT RESOURCE USE

4.1 Fisheries

Vanuatu fisheries are utilised on subsistence, artisanal and commercial levels.

4.1.1 Subsistence

Subsistence fishery targets the inter-tidal zone and lagoon resources and, in some cases, includes the near-shore pelagic species associated with fishing aggregating devices (FADs). The gear types and activities employed range from gillnetting, hand line, and reef gleaning, to spearfishing and trapping. In more remote areas traditional fishing practices are still in use. Data from the Preliminary Report of the 2006 Census of Agriculture indicated 72% of households possessed fishing gear and engaged in fishing activities (National Statistics Office, 2006a). Information on recent subsistence production is not known, however, the estimated production in 1993 was about 2,400 tonnes (National Statistics Office, 1994).

4.1.2 Artisanal

Artisanal fisheries exploit resources that fall into two main categories; resources that are marketed and consumed locally, and those primarily for export. The methods employed include gillnet fishing, hand line, reef gleaning, spear-fishing, and trapping. Some of these methods involve vessels powered with diesel outboard motors. Fishing extends from the foreshore to the 12 nautical mile zone. The main fisheries include deep bottom snapper (poulet) and grouper fishery, reef fish fishery, various invertebrates fisheries, such as trochus, sea cucumber, lobster, giant clam and octopus, the game fishery, the aquarium trade fishery and the tuna and tuna-like pelagic species associated with FADs. The export production is shown in Table 7.

Trochus, green snail and beche-de-mer form the bulk of the inshore fishery export product. The total export production from these three fisheries is decreasing (Appendix 2) and in many areas stocks of these resources have been severely depleted. The aquarium trade fishery, which started in the early 1990s, is now the biggest fisheries export product in terms of volume. Products targeted include live ornamental fish, corals (live & dead) and various invertebrate species. Despite some resistance towards the trade, particularly from tour operators, the aquarium trade still offers a huge potential for further future development.

The artisanal fleet consists of canoes and small skiffs. The fleet is becoming dominated by skiffs powered by 20-60 horsepower engines. The skiffs range from about 5-7 meters in length and are made of wood, aluminum or fibre glass. According to Pakoa, (2003), there are more than 70 artisanal fishing boats operating throughout the country. The fishing capacity of these skiffs ranges from 500-1000kg, but the actual average catch ranges from 40-70kg per boat per day (Raubani, 2006). Appendix 5 illustrates the landings of the artisanal fleets.

Aquaculture development is in its early stages with current focus on small-scale freshwater aquaculture, particularly tilapia (*Oreochromis niloticus*) and the local freshwater prawn, *Macrobrachium lar*. Aquaculture is one of the priority development areas of the Department of Fisheries (Ministry of

Agriculture, Quarantine, Forestry & Fisheries Corporate plan 2006- 2008; Priority Action Agenda 2006-2015).

While the Department is concentrating on promoting small-scale community aquaculture pilot farms, it is also collaborating with Vanuatu Investment Permit Authority (VIPA) in encouraging foreign investment in aquaculture. Teouma Prawns Limited is the first established large-scale aquaculture operator which is focusing on penaeid shrimp (*Litopenaeus stylirostris*). The total production in 2007 was 18 mt valued at 34 million vatu.

Expansion of the company saw the formation of a sister operation, Vate Ocean Gardens, which is farming mainly red tilapia. Since its establishment, records show a monthly production of 2 tonnes of fresh red tilapia. From June to November 2007, Vate Ocean Gardens harvested a total of 12.8 metric tones, valued at over 3.2 million vatu.

The principle focus of aquaculture development in Vanuatu is to increase food security. Also important is the desire to reduce pressure on wild stocks, especially the reef resources. By promoting fish farming, it is anticipated that focus will gradually be diverted from exploiting wild stocks, to farming.

4.1.3 Commercial/Industrial fishery

The offshore or industrial fishery covers tuna and other tuna-like pelagic species. Activities are carried out beyond the 12 nautical miles to the 200 nautical mile zone. The major targeted tuna species are albacore (*Thunnus alalunga*), bigeye, (*Thunnus obesus*), yellowfin (*Thunnus albacares*) and skipjack (*Katsuwonus pelamis*). The industrial fishery is dominated by foreign long line fishing vessels. On average, a total of 100 licences are issued annually to foreign vessels. The annual total catch of tuna by foreign vessels within the Vanuatu EEZ is given in Appendix 1. Based on catch data collated by the Secretariat of the Pacific Community (SPC) and the Forum Fisheries Agency (FFA) calculated economic data, the value of tuna caught within the EEZ of Vanuatu has increased from USD 6,101,000m in 1999, to USD 9,230,000m in 2005. Of this, Vanuatu receives an annual average of USD 1million through access fees (Pers. Com. Robert Jimmy Sept. 2007)

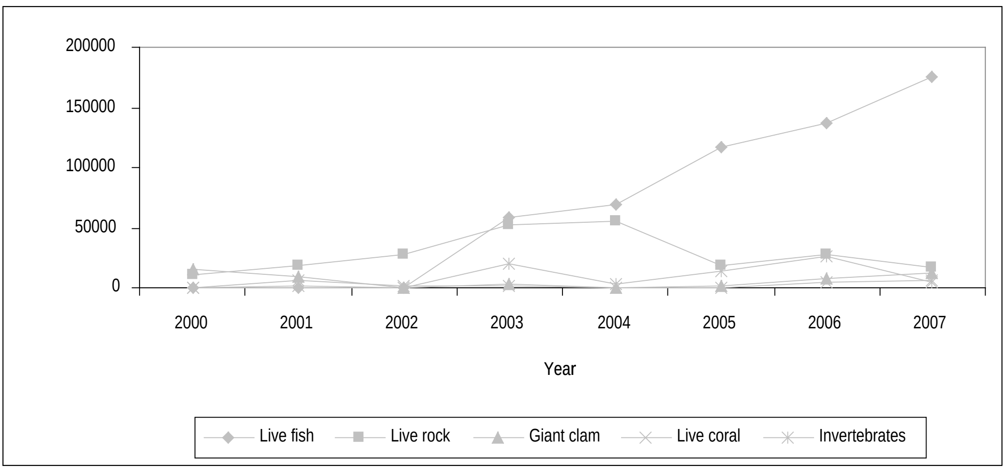
4.2 Tourism

Tourism is one of Vanuatu's vital industries contributing 40% of overall GDP (National Statistics Office, 2006). Pristine waters and the exceptional visual quality and aesthetic appeal of tropical coral reefs are some of the country's major visitor attractions. Tourism activities on coral reefs are concentrated near Port Vila and Luganville. There are limited tourism activities in a few rural areas. The industry continues to grow, leading to increased numbers of divers who may add pressure to coral reefs. In addition, most hotels are built near coastal areas and their waste disposal systems may not be environmentally friendly. These are important factors requiring attention in terms of future management.

4.3 Aquarium trade industry

Aquarium trade export started in the early 1990s with small-scale export quantities. In early 2000 exports began increasing dramatically (Figure 4). Despite concerns of sustainability by the tourism sector, the social and economic benefits are significant, particularly to rural areas. Currently there are three companies involved in the aquarium trade. These are located in Port Vila, with their collection areas concentrated around Efate. In 2006, one of the operators began exporting cultured clams following successful culturing. This was a significant milestone for the industry since export had previously been gathered predominantly from the wild. The initiative to culture clam was a result of a fisheries policy banning the export of clams harvested from the wild.

Figure 4: Aquarium export production (Raubani, 2007)



The aquarium industry is currently generating over US$500,000 annually in export earnings and contributes about US$1 million (net) to the local economy.

Exports are mainly live ornamental fish, coral (live & dead) invertebrates and giant clams. The most common target groups of fish include Angels (Pomacanthidae), Gobies (Gobiidae), Tangs (Acanthuridae), Damsels (Pomacentridae) and Wrasses (Labridae) (Appendix 6). Of the Pomacanthidae, the flame angel (*Centropyge loriculus*) has been the dominant fish species exported, representing 12.5% of the average total annual export of aquarium fish species.

4.4 Turtles

The common species of turtles found in Vanuatu are the green turtle (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*). Leatherback (*Dermochelys coriacea*) and the olive or Pacific Ridley (*Lepidochelys olivaccea*) turtles have also been observed occasionally (Bell and Amos, 1994). Turtles are widely distributed throughout the country, from Torba in the north to Tafea province in the south (Hickey and Pedro, 2005).

Prior to Independence in 1980, there were very few turtle management measures in place. This may have contributed to over-exploitation of the resource. However, reports suggest that after 1985, both turtle numbers and nesting sites have increased. This has been attributed to management measures instituted by the Fisheries Department, and the strong, effective awareness programme and monitoring assessment conducted by the Vanua-Tai resource monitors under the administration of the Wan Smol Bag theatre group (Hickey & Pedro, 2005).

Turtle harvesting has a long history in Vanuatu dating back to the Lapita days (Kirk, 1997 and Bedford, 2000) Cited in Hickey and Pedro (2005). Turtle exploitation is a tradition in some islands that coincides with the yam harvesting ceremony. Bell and Amos (1994) estimated that between 60 and 120 turtles had been harvested by the residents of Maskelynes Islands alone in a year. The commercial use of turtle meat, shells and eggs is illegal. However, according to a recent Fisheries Amendment Regulation Order Number 52 of 2005, an application can be lodged with the Director of Fisheries for permission to harvest turtles for traditional use. In 2007, an application was lodged with the Director of Fisheries from southern Malekula including the Maskelynes islands, to harvest 62 turtles in 2008.

4.5 Mangroves

In 1985, the total area of mangrove coverage throughout the Vanuatu archipelago was estimated at 2,460 hectares (David 1985). Results of surveys by Lal and Esrom (1990) and Esrom and Vanu (1997) confirmed mangroves' important socioeconomic role in the subsistence and semi-subsistence economies of communities adjacent to extensive mangrove areas. This is particularly so for the offshore island of Uliveo in the Maskelynes where mangroves are the primary source of firewood. Lal and Esrom (1990), estimated that annual household consumption of mangrove as fuel to be 3.6-4.8-tonnes. Esrom and Vanu (1997) estimated that the economic benefits derived from mangal-related fuelwood, building materials (house-posts and thatch material), crabs and finfish in the Crab Bay/Port Stanley area totaled some 9.5 million Vatu annually.

4.6 Seagrass

Seagrass beds are occasionally very dense and extensive, and usually limited to shallow waters associated with coral reefs. A report on the survey of coral reefs in Vanuatu, Chambers et al. (1990), found nine species of seagrass. These include *Cymodocea rotundata, C. serrulata, Enchalus acoroides, Halodule pinifolia, H. uninervis, Holopphila ovalis, Syringodium isoetifolium, Thalassia hemprichii* and *Thalassodendron ciliatum.*

According to Chambers et al. (1990), seagrass was widely distributed throughout the country and recommended that these areas be clearly marked to facilitate proper management in the planning process. A preliminary survey is under way as part of a project to map seagrass beds around Efate. The project will be implemented in 2008 (Pers. Com. Francis Hickey, Sept. 2007).

4.7 Deep-sea species

Deep-sea bottom fishery for snapper and grouper is carried out mainly by small-scale ni-Vanuatu fishers or artisanal fishers using outboard motors. Two commercial fishing boats are also involved. The combined landings are given in Appendix 5.

This is fundamentally an open access fishery and the number of new artisanal fishermen increases every year. Brouard and Grandperrin (1985), estimated the national Maximum Sustainable Yield (MSY) to be between 113 and 300 tonnes a year. However, records of landing showed low production, raising uncertainty about the MSY figure. The Department of Fisheries has recognised the need for further surveys to review the MSY so that effective management policies can be developed.

In 2004, the Department granted a licence to a private fishing company for trial fishing on deep-sea snow crabs (*Chionoecetes spp.*) for export. The activity was short-lived as the operation was found to be not profitable enough to sustain operations. However, snow crabs were found to be present around Efate at depths ranging from 1000-1500 metres. A total of 350 kg was exported in 2003.

4.8 Endangered species

The exploitation of marine endangered species in Vanuatu is subject to regulations that apply nationally. A report by the Vanuatu Environment Unit (2007), lists the country's endangered marine species. These include all turtle species (*Cheloniidae*), dugong (*Dugong dugong*), coconut crab (*Birgus latro*), giant clams (*Tridacna spp.*), triton shell (*Charonia tritonis*), and the marine crocodile (*Crocodylis porosus*).

The green snail (*Turbo marmoratus*) is currently considered critically endangered with stocks severely depleted or totally wiped out in most parts of the archipelago where they were once found in abundance. There is a 15-year moratorium, from October 2005, on the harvest and export of this important reef resource to halt further decline and possible extinction (Fisheries (Amendment) Order No. 52 of 2005). Some sea cucumber species are also deemed endangered, especially those of high commercial value.

Further studies are required by the marine sector to confirm the status of some important coral reef species. Indeed, according to Reef Check survey data, some of the largest reef fish species such as the humphead wrasse (*Chelinius Undulatus*), bumphead parrot (*Bolbometopon muricatum*) and humpback grouper (*Cromileptes altivelis*), are very rare and critically endangered (Table 5).

5
THREATS TO CORAL REEFS/MANGROVES/SEAGRASS

5.1 Coral reefs

Previously, the major human impacts on coral reefs in Vanuatu included siltation as a result of logging, and eutrophication caused by sewage disposal (Done & Navin, 1990). Over utilisation of coral reef resources is now, by far, the greatest human threat to coral reef systems. Over utilisation is due to limited economic options in the rural areas, coupled with lower prices for agricultural products. Since fisheries products offer higher prices compared to agricultural products, the reef is an important source of economic and social sustenance in most parts of the archipelago. With continuous population growth, pressure from over harvesting will continue to increase. Illegal gillnet fishing is another threat to coral reef ecosystems despite a fisheries regulation Gazetted in 2005.

Threats by natural phenomena to coral reefs include cyclones, bleaching, and crown-of-thorns starfish (COTS) outbreaks. Vanuatu has been under regular influence of cyclones which have had a detrimental impact on coral reefs. Cyclones contribute to coral breakage, underwater erosion and re-suspension of bottom sediments. A survey by Done & Navin (1990), reported coral damage from cyclones in 50 per cent of the sites surveyed. Naviti and Aston (2000) observed extensive damage to Efate's coral reefs following a major cyclone in 1987. Pakoa (2007) noted that Cyclone Danny in 2003 damaged 80 per cent of corals on the western coast of Efate.

Coral bleaching has had a severe effect on Vanuatu's coral reefs. According to Pakoa (2007), serious coral losses around Efate have been attributed to a bleaching event that resulted in a 60 to 70% loss of live coral. While no major bleaching occurred from 2005-2007, spots of bleaching of coral colonies were observed during monitoring surveys.

Outbreaks of COTS usually resulted in significant loss of corals (Done & Navin, 1990). Pakoa (2007) reported that outbreaks in the vicinity of Luganville, contributed to high loss of coral in the area. Previous outbreaks were also observed around the islands of Efate, Aneityum, Epi and Malekula with major coral mortality seen in 20 percent of the sites (Done & Navin 1990). In the last quarter of 2007, an outbreak of COTS around the Port Vila and Mele Bay areas prompted a clean up campaign by dive tour operators and the Ifira community.

Pakoa (2007) noted other threats to coral reefs in Vanuatu, including sedimentation and nutrification, marine-based pollution and earthquakes.

5.2 Mangroves

Current threats to mangrove forests are limited to subsistence exploitation as a source of wood for fuel and building construction in the rural areas. Although exploitation levels may be on a small scale; the lack of effective monitoring is of concern. A survey by Lal & Esrom (1990), on Maskelyne islands and Port Stanly on Malekula, reported that household consumption of mangrove wood for the two areas was an estimated 3.6 to 4.8 tonnes per year respectively.

Pressure on mangroves from development is moderate as large areas are far from urban centres. There have been reports of deliberate clearing of mangrove around Efate and Litzlitz on Malekula for tourism and infrastructure development (Pakoa, 2007). This is likely to increase with expansion of the industry.

5.3 Seagrass beds

Cyclones are the major threat to seagrass beds (Pakoa, 2007). Coastal development for real estate expansion on Efate is also a potential hazard. There is little baseline information available, however, making it difficult to accurately gauge the likely impact.

5.4 Integrated Threat Index

An Integrated Threat Analysis (Table 8) was carried out using a modification of the "Reefs at Risk" methods (Bryant et al. 1998, Burke et al. 2000). Modifications reflect local conditions in the small Island states of the South West Pacific Node, where detailed technical information is often not available, or where threats that may not apply in other regions may exist. In this analysis, potential threats to reef health in areas where data is gathered are assessed in five categories: coastal development, marine-based pollution, pollution and sedimentation, over fishing, and destructive fishing, (see Appendix 7 i-v) then integrated into a single threat score. Threats were assessed in all 11 survey regions.

5.5 Coastal development

Coastal development is concentrated in the urban areas of Port Vila and Luganville. This is a major danger to reefs in close proximity. Coastal development undertakings in Vanuatu are subject to provisions of the Environmental Management and Conservation Act of 2000. The Act requires any coastal development considered to have a major environmental impact to be subject to an Environmental Impact Assessment (EIA) prior to commencement of the development. The threat index table indicating the impact to coral reefs in each region surveyed is shown in Appendix 7 i).

5.6 Pollution

There is little Information on coral reef pollution. There are concerns though about sand mining in the Mele Bay area, but the extent to which it has affected reef health is not known. Other potential sources of pollution include the run-off from ag-

Table 8: Total Integrated threat index table

Reef Area	Coastal Development	Pollution	Sediment damage	Over-fishing	Destructive Fishing	Overall Threat Index Score
Aneityum	Medium	Medium	High	Medium	Low	Medium
Mele Bay	High	High	High	High	Low	High
N. Efate	Medium	Medium	Medium	High	Medium	Medium
Malekula	Low	Low	Medium	Medium	Low	Medium
Maskelynes	Low	Low	Low	Medium	Low	Low
Matasso	Low	Low	Low	Medium	Low	Low
Epi	Low	Low	Medium	Medium	Low	Medium
Luganville	High	Medium	High	Medium	Low	Medium
Malo	Medium	Low	Low	Medium	Low	Medium
Mota Lava	Low	Low	Low	Medium	Low	Low
Gaua	Low	Low	Medium	Medium	Low	Low

ricultural practices and land use, deforestation and oil spills, and the indiscriminate dumping of plastic bags. Appendix 7ii) demonstrates how pollution is affecting each of the surveyed regions. Plastic bags, and the remnants of fishing gear and tyres have been observed at the Malapoa Point monitoring site (Pers. Observ..Jason Raubani, April 2005, 2007).

5.7 Sedimentation, nutrient enrichment and eutrophication

There were no reports of major occurrences of sedimentation, nutrient enrichment and eutrophication during 2004-2007. Other causes of this form of pollution are detailed in Pakoa (2007). Pollution and sedimentation are assessed in Appendix 7iii).

5.8 Over fishing

Overfishing is the most significant threat to reef fisheries. According to Pakoa (2007) reef fish are under enormous pressure in populated areas. Other commercially-important reef resources (trochus and sea cucumber) are also being over harvested throughout the country. Stocks of green snail are severely depleted in most parts of the archipelago, with over fishing one of the major causes of this decline. Overfishing is assessed in all regions surveyed in Appendix 7iv).

Efforts to revitalize stocks of trochus and green snail are underway through a JICA/Fisheries project. This entails reseeding of depleted reef areas with both artificially-bred trochus and green snail and wild brood/bred stock transferred from healthy well-stocked reefs to depleted or severely depleted reefs. Rural communities are taking the initiative to establish community management areas. However, the lack of clear management and weak enforcement are hampering a positive outcome. Land disputes are a key factor hindering effective community-based reef resource management, and contributing to increased overfishing.

5.9 Destructive fishing and coral harvesting

The Fisheries Act (No. 55 of 2005) prohibits destructive fishing methods (Appendix 8), but no such activities have been reported in recent years. Fisheries amendment regulation order number 52 forbids the use of dynamite and poisons, both chemical and herbal, for fishing purposes. Also, indiscriminate gillnetting has been mitigated by the fisheries amendment regulation with the establishment of legal size limits (Appendix 9).

Coral harvesting in Vanuatu has had very limited negative impact (Pers. Observ., Jason Raubani, May 2007). The export of wild corals is prohibited except for farmed corals. The harvesting of corals in marine protected areas, dive locations and community management areas is also banned.

5.10 Bleaching, coral disease and predators

No major coral bleaching has affected Vanuatu since 2005, although isolated spots of bleaching have been observed in several monitoring sites (Pers. Observ., Jason Raubani, 2005, 2006 and 2007). Bleaching due to global warming is considered a minor threat.

Given that little information is available on coral diseases in Vanuatu, the extent of this threat is not known. What appears to be brown or black ban diseases have been observed in several monitoring sites on Efate but these seem to be of limited threat to corals (Pers. Observ., Jason Raubani, 2005, 2006, 2007). Further skill development is required in the identification of coral diseases.

There have been reports of major outbreaks of

COTS around Mele Bay recently with densities as high as 2-10 animals per square metre. These outbreaks have resulted in coral death in some places (Pers. Comm. Mel Edwards, Sept. 2007). In addition, Drupes snails have been observed feeding on corals. The extent of the threat, however, is not known (Pers. Observ. Jason Raubani, April 2005).

Among natural events threatening coral reefs are cyclones, bleaching, and outbreaks of COTS. Cyclones contribute to coral breakage, underwater erosion and re-suspension of bottom sediments. A survey by Done & Navin (1990), reported coral damage from cyclones in 50 per cent of sites surveyed. Naviti and Aston (2000), observed extensive damage to Efate's coral reefs following a major cyclone in 1987. Pakoa (2007) noted that Cyclone Danny in 2003 damaged 80 per cent of corals on the western coast of Efate.

5.11 Hurricanes/tsunamis

Since 2005, three cyclones have passed through the Vanuatu archipelago (David Gibson, Meteorology Department. Sept. 2007). The immediate extent of damage to corals was not assessed because of financial constraints. Nevertheless, cyclones remain a major coral threat.

5.12 Outbreak of organisms

Apart from the COTS outbreak in 2007, the occurrence of unknown organism on the island of Emau, off the north east coast of Efate caused all reef fish, including crabs, lobster and various shellfish to be contaminated by the ciguatera toxin. This is a rare case of ciguatera poisoning that needs further study (Pers. Comm. Tamata Noah, July 2007).

6
CURRENT CORAL REEF CONSERVATION EFFORTS

Coral reefs form a vital ecosystem that contributes to the social, cultural and economic well-being of Vanuatu's coastal communities. It is a part of national wealth, so efforts to conserve this valuable resource is of paramount importance. Below are some current reef resource and management and conservation measures.

6.1 Marine protected areas (MPAs)

There are numerous efforts at the national, community and non-government organisation (NGO) levels to conserve coral reefs through the establishment of marine protected areas (MPAs). Pakoa (2007), listed several of these. He further stated that the effectiveness of the MPAs varied from site to site. Some of the MPAs were established under the Fisheries Act, a number were registered under the Environmental Management and Conservation Act, while others were community-initiated and managed purely under the chiefly system or the traditional marine tenure system.

The Foundation of the Peoples of the South Pacific International (FSPI), an NGO operating in Vanuatu has committed itself through a project called 'Coral Gardens' to assist with coral reef conservation. The project was implemented in three communities, with Aneityum the first to benefit. Through the project, and with help from the Fisheries Department, a management plan was developed for the Mystery Island marine conservation area.

The Nguna-Pele Marine Protected Area (NPMPA) is a small, community-based and managed organisation or network on the islands of Nguna and Pele in central Vanuatu. The name does not refer to any particular village marine reserve or area. Individual villages on Nguna and Pele have complete control over marine management within their tenured boundaries. Each community is responsible for establishing rules and regulations through the most appropriate channels (chiefs or councils). Today 16 villages on Nguna and Pele have joined the NPMPA. The network and its member villages are moving away from the "pilot project" focus of the MPA's initial years, towards internally-focused, long-term sustainability and independence (Tarip and Bartlett, 2007).

In 2005, the Nguna-Pele MPA network and scientists from James Cook University of Australia embarked on major research to understand how small community conservation areas benefit ni-Vanuatu communities and their marine resources. The study revealed that both permanent and periodic closures had higher fish biomass inside than outside the reserve. This suggests that small-scale, village-based reserves are effective resource management tools. Results also showed that permanent and periodic closures do not have significantly different biomass levels of target fish species. This suggests that opening a reserve temporarily for harvest following community needs may be a practice compatible with conservation goals.

6.2 Legislation

The main legal instruments for the conservation of coastal environment are the Fisheries Act No. 55 of 2005 and the Environmental Management and Conservation Act 2000.

Conservation in the Fisheries Act is addressed under section 43 and empowers the Minister responsible for Fisheries to establish marine protected areas. Currently, there are two marine reserves established under the provisions of the Act. Other provisions that relate to the conservation of coral reefs include the prohibition of fishing for marine mammals in Vanuatu waters, the ban on the use of explosives and poisons for fishing, and the establishment of legal mesh size of gillnets.

Fisheries Regulation Order No. 52 of 2005 also prohibits the collection of live corals in any marine protected areas designated by the Minister responsible for Fisheries. A current fisheries policy bans the export of wild corals from Vanuatu. Coral exports require an export license issued by the Director of Fisheries to ensure only coral certified as cultured is exported.

The Environmental Management and Conservation Act of 2000 is conservation-oriented. It empowers the Director responsible for the Environment Department to protect and register Community Conservation Areas (CCA). There is also provision for conservation of community areas that have national biodiversity significance. Any coastal development likely to have an adverse impact to on coastal dynamics, including corals, must undergo an Environmental Impact Assessment (EIA).

6.3 CITES

Corals are listed under Appendix II of the CITES Convention on International Trade of Endangered Species (CITES). Vanuatu is a party to CITES and is required to implement the Convention's provisions. The export of live corals (farmed) is subject to CITES requirements, which include a permit. The Management and Scientific Authority of CITES in Vanuatu is the Environment Unit.

6.4 COTS clean-up campaign

Tour operators have been organising clean-up campaigns on an ad hoc basis. In 2007, Hideaway Island Resort carried out COTS eradication activities around the reef of Hideaway Island, Mele Bay and Devils Point. An estimated 4,000 - 5,000 COTS were collected over eight months. These were brought ashore and burned (Pers. Com. Mel Edwards, Sept. 2007). The Ifira community also did a clean up around Ifira island. It is becoming a practice that, whenever there is a reported outbreak of COTS, a clean-up campaign is organized to help curb the problem of mass coral destruction.

6.5 Reef rehabilitation

A core activity of the Fisheries Department is to rehabilitate depleted reef areas by supplying cultured trochus juveniles to communities. Management advice is also provided and includes establishment of a closed area where the juvenile seeds are placed. Johannes (1998), reported that, overall, the programme was most successful when communities were actively engaged. Other communities, on their own initiative, soon followed suit but more target species were included such as sea cucumber, green snail, lobsters and even reef fishes.

Since 2006, the Department rehabilitation programme has expanded through a JICA project to include other important reef resources such as green snail and giant clams. Currently, mass production of trochus, green snail and giant clam are progressing well. Through this project the Tridacna gigas species, which was believed to be extinct in Vanuatu, has been re-introduced from Tonga.

A private company dealing with sea cucumber harvesting and export from Vanuatu also introduced a sea cucumber species from Australia called the 'golden sandfish' in 2005 and 2006.

As part of its conservation effort and reef rehabilitation programme, the Department of Fisheries, in close collaboration with other stakeholders, conducted training on coral farming to interested communities and individuals. The aim was twofold: to enable the communities to subsidise their income by selling cultured coral to aquarium operators and, most importantly, to help rehabilitate their reefs. This training was also an opportunity for Fisheries Officers to provide communities with technical advice on conservation and to assist them setup farms.

7
THE FUTURE OF CORAL REEF HEALTH

As earlier stated, cyclones, earthquakes and global warming have influenced the development of Vanuatu's coral reefs over hundreds of years. With such natural events increasing in intensity and frequency, the future health of coral reefs can expect to be affected. Also of major concern is the human impact via overexploitation, sedimentation and the expansion of coastal development for economic activity. These will undoubtedly increase the stress on Vanuatu's coral reefs in the next 10 years or so.

Coral growth is a process whereby after major disturbances causing breakage and death, corals are capable of recovering. Monitoring results have shown that most regions are fringed with hard solid substrate that provides potential and ideal substrate for coral settlement and recruitment, as long as the local threats are controlled. Since Vanuatu's Coral Reef Monitoring Programme began six years ago, it has been observed that the country's coral reefs have demonstrated the ability to recover and regrow after major disasters such as cyclones, predation and bleaching.

8
RECOMMENDATIONS

Although monitoring efforts began in 2002, there have been many gaps. Provided below are some key recommendations central to the management of coral reefs in Vanuatu:

- Monitoring activities need to be more consistent so that significant changes in trends can be detected;
- Government should commit more financial support to the monitoring and management of the country's coral reefs;
- The Vanuatu Coral Reef Monitoring Programme needs assistance for developing a database for data storage;
- There should be a management plan for all commercial near-shore or coral reef fisheries such as trochus and sea cucumber;
- The Fisheries Department, relevant government agencies and NGOs need to assist communities develop management plans for their MPAs;
- Coral reef monitoring should be an annual budgeted activity of the Fisheries Department;
- The main coral reef resource users-tour and aquarium operators, private seafood companies and other individuals - should assist in coral reef monitoring and conservation, along the lines of a user-pay system.

9
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APPENDICES

Appendix 1: Tuna and tuna like species catch in Vanuatu EEZ (Molony, 2007)

Year	Albacore	Yellowfin	Bigeye	Billfish	Skipjack
1996	2,561	455	77	94	3,199
1997	2,342	340	51	51	2,784
1998	1,253	184	62	45	1,613
1999	3,036	290	75	132	3,532
2000	2,480	422	98	122	3,122
2001	1,510	257	58	-	-
2002	2,299	597	162	-	-
2003	2,417	935	248	-	-
2004	3,207	750	179	-	-
2005	6,127	1,450	248	-	-

Appendix 2: Total annual export production for trochus, green snail and sea cucumber (Vanuatu Fisheries Department, 2007)

Year	Trochus (mt)	Green snail (mt)	Sea cucumber (mt)
1990	170	10	50
1991	130	44	50
1992	150	7,35	39
1993	160	51	40
1994	107	1,1	40
1995	100	0,35	50
1996	100	2,7	50
1997	100	3,9	50
1998	100	1,1	50
1999	90	0,6	50
2000	90	0	26
2001	73	0	38
2002	67	0	8
2003	53	0,7	25
2004	35	0	13
2005	36	0	9
2006	36	0	8
2007	55.2	0	15.4

Appendix 3: Survey sites across the country

Site Names	Datum	Type of Reef	Reef Zone	Depth Range	Located in MPA	Years Surveyed	Information Gathered	Methods Used
Mystery Island: Aneityum	Permanent	Inner Barrier Reef	Reef Flat	1.5 - 3m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Mystery Island: Aneityum	Permanent	Inner Barrier Reef	Reef Flat	1.5 – 3m	yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Malapoa Point: Efate	Permanent	Fringing Reef	Reef Flat	1.5 - 3m	No	2001- 2007	Fish, Inverts., Substrate	Reef Check Modified
Malapoa Point: Efate	Permanent	Fringing Reef	Reef Flat	1.5 - 3m	No	2001- 2007	Fish, Inverts., Substrate	Reef Check Modified
Hat Island	Permanent	Fringing Reef	Drop-off	2 - 6m	Yes	2001 - 2005	Fish, Inverts., Substrate	Reef Check Modified
Hat Island	Permanent	Fringing Reef	Drop-off	2 - 6m	Yes	2001 - 2005	Fish, Inverts., Substrate	Reef Check Modified
Hideaway Island: Efate	Opportunistic	Fringing Reef	Reef Flat	1.5 - 3m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Pango Point: Efate	One-Off	Fringing Reef	Reef Flat	1.5 - 3m	No	2005	Fish, Inverts., Substrate	Reef Check Modified
Three Mast: Efate	Permanent	Fringing Reef	Reef Flat	1.5 - 5m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Survivor Beach: Efate	Permanent	Fringing Reef	Reef Flat	1.5 - 3m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Unakap: Nguna	Permanent	Fringing Reef	Reef Flat	1.5 - 3m	Yes/No	2003 - 2007	Fish, Inverts., Substrate	Reef Check Modified
Mataso	One-Off	Fringing Reef	Reef Flat	3 - 4m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Kulwota: Epi	One-Off	Fringing Reef	Reef Flat	1 - 2m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Wamby: Epi	One-Off	Fringing Reef	Reef Flat	1m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Taliko: Epi	One-Off	Fringing Reef	Reef Flat	1.5m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Ringi Tesu: Maskelynes	Permanent	Inner Barrier Reef	Reef Flat	2m	Yes	2005 - 2007	Fish, Inverts., Substrate	Reef Check Modified
Sazal Reef: Maskelynes	Permanent	Inner Barrier Reef	Reef Flat	3m	No	2005 - 2007	Fish, Inverts., Substrate	Reef Check Modified
Amal Tabu Area: Malekula	Permanent	Fringing Reef	Reef Flat	2m	Yes	2005	Fish, Inverts., Substrate	Reef Check Modified
Bushman's Bay: Malekula	One-Off	Fringing Reef	Reef Flat	1.5m	No	2005	Fish, Inverts., Substrate	Reef Check Modified
Crab Bay Access: Malekula	Permanent	Fringing Reef	Reef Flat	1 - 2m	No	2005	Fish, Inverts., Substrate	Reef Check Modified
Crab Bay Tabu: Malekula	Permanent	Fringing Reef	Reef Flat	1 - 2m	Yes	2005	Fish, Inverts., Substrate	Reef Check Modified
Lagoon: Malekula	One-Off	Fringing Reef	Reef Flat	1.5m	No	2005	Fish, Inverts., Substrate	Reef Check Modified
Unua: Malekula	One-Off	Fringing Reef	Reef Flat	2 - 6m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Avanaheo: Malo	One-Off	Fringing Reef	Reef Flat	3m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Avunbaga: Malo	One-Off	Fringing Reef	Reef Flat	2 - 5m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Coolidge: Santo	Opportunistic	Fringing Reef	Reef Flat	6m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified
Aworor: Gaua	Permanent	Fringing Reef	Reef Flat	2m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Navar: Gaua	Permanent	Fringing Reef	Reef Flat	1.5m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Letoltol:Gaua	Permanent	Fringing Reef	Reef Flat	1.5m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Menkoro: Gaua	Permanent	Fringing Reef	Reef Flat	2m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Nwengoro: Gaua	Permanent	Fringing Reef	Reef Flat	1 - 3m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Aru: Gaua	Permanent	Fringing Reef	Reef Flat	2m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Dolap: Gaua	Permanent	Fringing Reef	Reef Flat	3m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Legargir: Gaua	Permanent	Fringing Reef	Reef Flat	2m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Onnel Bay: Gaua	Permanent	Fringing Reef	Reef Flat	4m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Ontar: Gaua	Permanent	Fringing Reef	Reef Flat	4m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Taplon: Gaua	Permanent	Fringing Reef	Reef Flat	2m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Tavalar: Gaua	Permanent	Fringing Reef	Reef Flat	1m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Onlem: Gaua	Permanent	Fringing Reef	Reef Flat	1m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Tequla: Gaua	Permanent	Fringing Reef	Reef Flat	3 - 4m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Lembot 2: Gaua	Permanent	Fringing Reef	Reef Flat	1m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
White Sand: Gaua	Permanent	Fringing Reef	Reef Flat	1m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Metewe: Gaua	Permanent	Fringing Reef	Reef Flat	1- 3m	No	2007	Fish, Inverts., Substrate	Reef Check Modified
Le owo ou: Gaua	Permanent	Fringing Reef	Reef Flat	2m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Lesus: Gaua	Permanent	Fringing Reef	Reef Flat	1m	Yes	2007	Fish, Inverts., Substrate	Reef Check Modified
Rah Island: Mota Lava	One-Off	Fringing Reef	Reef Flat	1.5m	Yes	2005	Fish, Inverts., Substrate	Reef Check Modified
Rah Passis: Mota Lava	One-Off	Fringing Reef	Reef Flat	1.5 - 2m	No	2006	Fish, Inverts., Substrate	Reef Check Modified
Totolong: Mota Lava	One-Off	Fringing Reef	Reef Flat	2m	Yes	2006	Fish, Inverts., Substrate	Reef Check Modified

Appendix 4: Green snail moratorium regulation

1 Regulation 16

Repeal the Regulation, substitute

"16 Green snail

(1) In this Regulation "green snail" means a mollusc of the species Turbo Marmaratus.

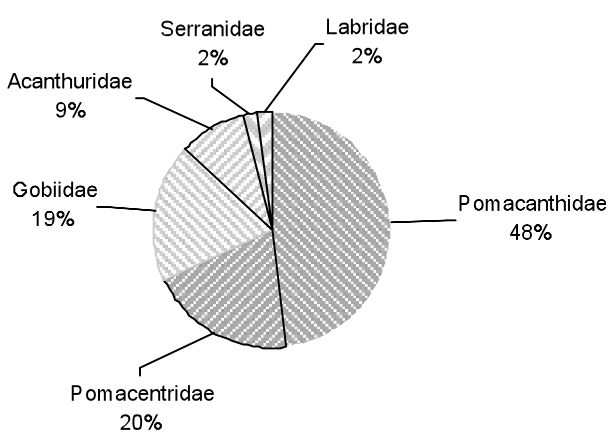
(2) Subject to subregulation (3), a person must not take, harm, have in his or her possession, sell or purchase any green snail during the period starting on 1 October 2005 and ending on 1 October 2020.

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

Appendix 5: Deep-sea bottom fish production (Vanuatu Fisheries Department 2006)

Year	Quantity (t)	Value (millions of vatu)
2000	28	9.3
2001	9	3.1
2002	3	10.4
2003	43	15
2004	34	12
2005	18	6.3
2006	34	12

Appendix 6: Composition of the target groups of aquarium fish species (Pakoa & Raubani, 2008)



Data from registered projects only

Appendix 7: Analysis of potential threats to reef health

i) Threat index for coastal development

Reef Area	Cities	Towns,	Airports	Mines	Tourism	Coastline	Overall Score (highest recorded)
Aneityum	None	None	Medium	Absent	High	Low	Medium
Mele Bay	None	High	Low	High	High	High	High
N. Efate	None	None	Low	None	Very low	Low	Low
Malekula	None	Very low	Low	None	Very low	Low	Low
Maskelynes	None	None	None	None	Very low	None	Very low
Matasso	None	None	None	None	None	None	None
Epi	None	None	Low	None	Medium	Low	Low
Luganville	None	High	Low	None	High	High	High
Malo	None	None	None	None	None	None	None
Mota Lava	None	None	Very low	None	None	None	Very low
Gaua	None	None	Very low	None	None	None	Very low

ii) Threat index for pollution

Reef Area	Ports	Oil Tanks	Shipping Lanes	Overall Score (highest recorded)
Aneityum	Medium	None	High	Medium
Mele Bay	High	High	Very high	High
N. Efate	Medium	None	Medium	Medium
Malekula	Medium	None	High	Medium
Maskelynes	Low	None	High	Medium
Matasso	Very Low	None	Low	Low
Epi	Medium	None	high	Medium
Luganville	High	High	Very high	High
Malo	Medium	None	High	Medium
Mota Lava	Medium	None	Low	Low
Gaua	Medium	None	Low	Low

iii) Threat index for pollution and sedimentation

Reef Area	**Vegetation**	**Steepness**	**Factors**	**Overall Score (highest recorded)**	
	Type	Risk			
Aneityum	Cropland mixed with natural vegetation	Medium	Medium	High	Medium
Mele Bay	Urban and built-up	High	Low	High	High
N. Efate	Mixed Forest	Low	High	Medium	Medium
Malekula	Mixed Forest	Low	Medium	High	Medium
Maskelynes	Mixed Forest	Low	Very Low	Low	Low
Matasso	Mixed Forest	Low	Very high	Very low	Very low
Epi	Cropland mixed with natural vegetation	Medium	High	Medium	Medium
Luganville	Urban and built-up	High	Low	High	High
Malo	Cropland mixed with natural vegetation	Medium	Low	Low	Low
Mota Lava	Cropland mixed with natural vegetation	Medium	Medium	Low	Medium
Gaua	Cropland mixed with natural vegetation	Medium	Medium	Low	Medium

iv) Threat index for over-fishing

Reef Area	**Score**	**Notes on Marine Protection**
Aneityum	Medium	MPA establish with Management plan
Mele Bay	High	Community management areas (seasonal)
N. Efate	High	Nguna-Pele MPA/Submission for World heritage/ Community management areas
Malekula	Medium	Community management areas/IWP Crab Bay conservation area
Maskelynes	Medium	Conservation area for giant clams/community conservation areas
Matasso	Medium	Community management areas
Epi	High	Community management areas
Luganville	High	Marine reserve designated under the Fisheries Act but large area remain open access
Malo	Medium	Community management areas
Mota Lava	Medium	Community management areas
Gaua	Medium	Community management areas

v) Threat index for destructive fishing

Reef Area	Dynamite	Poisons	Herbal Poison	Breakage	Overall Score (highest recorded)
Aneityum	None	None	Very low	Very low	Very low
Mele Bay	None	None	Very low	Very low	Very low
N. Efate	None	None	Very low	Very low	Very low
Malekula	None	None	Very low	Very low	Very low
Maskelynes	None	None	Very low	Very low	Very low
Matasso	None	None	Very low	Very low	Very low
Epi	None	None	Very low	Very low	Very low
Luganville	None	None	Very low	Very low	Very low
Malo	None	None	Very low	Very low	Very low
Mota Lava	None	None	Very low	Very low	Very low
Gaua	None	None	Very low	Very low	Very low

Appendix 8: Prohibited Fishing Methods

42 Prohibited Fishing Methods

A person must not:

(a) permit to be used, use or attempt to use any explosive, poison or other noxious substance for the purpose of killing, stunning, disabling or catching fish, or in any way rendering fish more easily caught; or

(b) carry, or have in his or her possession or control any explosive, poison or other noxious substance in circumstances indicating an intention to use such substance for any purpose referred to in paragraph (a). A person who contravenes subsection (1) is guilty of an offence punishable on conviction by a fine not exceeding VT10,000,000 or by a term of imprisonment not exceeding two months, or both.

Any explosive, poison or other noxious substance found on board any vessel is presumed, unless the contrary is proved, to be intended for the purposes referred to in paragraph (1) (a).

A person must not land, sell, receive or possess any fish taken by any means which contravenes paragraph (1) (a), if the person knows or ought reasonably to have known them to have been so taken.

A person who contravenes subsection (4) is guilty of an offence punishable on conviction by a fine not exceeding VT1,000,000 or by a term of imprisonment not exceeding 2 months or both.

Appendix 9: Fishing net regulation

24 B Fishing nets

(1) A person must not use for fishing:

(a) a drag net or a beach seine net that has a mesh size of less than 50 millimetres when fully stretched; or

(b) any cast net that has a mesh size of less than 20 millimetres when fully stretched, or a radius that exceeds 2 metres in diameter.".

(2) A person may use for the purpose of carrying out a research:

(a) a net referred to in subregulation (1)(a) that has a mesh size of less than 50 millimetres when fully stretched; or

(b) a net mentioned in subregulation 1(b) that has a mesh size of less than 20; millimetres when fully stretched, or a radius of which does not exceed 2 metres in diameter.

Photo: E. CLUA

ABSTRACT

Fiji, New Caledonia, Vanuatu, Solomon Islands, Samoa and Tuvalu report monitoring data for this report, with data from a broad range of observers (scientists, students, dive guides and communities); Nauru has not conducted recent monitoring; Substrate cover changes from 2003 to 2007 were due to effective management (positive), or local disturbances, coral predation and natural disasters (negative).

Average coral cover at monitoring sites was 45% in Fiji; 27% in New Caledonia; 43% in Samoa; 30% in Solomon Islands; 65% in Tuvalu; and 26% in Vanuatu; Monitoring observations over 9–10 years in Fiji and New Caledonia indicate that these reefs have coped reasonably well with natural and human stressors without Catastrophic changes;

Densities of edible fish and invertebrates remained generally low (0–10/100m2) in 4 countries reflecting high subsistence and commercial fishing pressure. Butterflyfish, parrotfish, surgeonfish and damselfish were generally most dominant. High densities of parrotfish were reported from 4 countries;

Socio-economic monitoring is conducted in Fiji, Samoa and Solomon Islands. Greatest activity is by the Locally Marine Managed Area (FLMMA) network at 270 villages across all Fiji provinces. Most households harvest marine resources for subsistence and partially for sale, with few commercial fishers. In Samoa, more people eat canned fish than fresh fish, possibly because of decreased fish stocks in the last 10 years. In the Solomon Islands, some traditional managed systems have collapsed due to poor understanding of fisheries and resource management issues or poor national regulations. Mangrove destruction and greater fishing pressure are reducing family incomes;

A network of temperature loggers has been established within the Node to collect long-term data on temperature relationships with coral bleaching; Reef related ecosystems (mangroves and seagrass) are considered important for food security, biodiversity conservation and coastal protection but less so for tourism.

Seagrasses are important feeding grounds for turtles which have great traditional significance; There are multiple 'natural' stressors, including coral predation, temperature variation, coral bleaching, cyclones, tsunamis and earthquakes. An earthquake and tsunami in April 2007 damaged reefs and other coastal habitats in the Solomon Islands; most dramatic was uplifting of coral reef flats and exposing them to the air. The major human disturbances are over-fishing, pollution, sedimentation, eutrophication and coastal development;

In response, communities, NGOs, researchers and resort owners are managing local marine areas as partnerships such that coral health and fish populations are improving;

There is a need for long-term monitoring to understand the changes in reefs. Most monitoring is coordinated by Fisheries Departments without sufficient resources,capacity or funding. There are no recent data from Nauru as an example.

Photo: E. CLUA