CRISP

Coral Reef Initiative for the South Pacific
Initiative Corail pour le Pacifique Sud

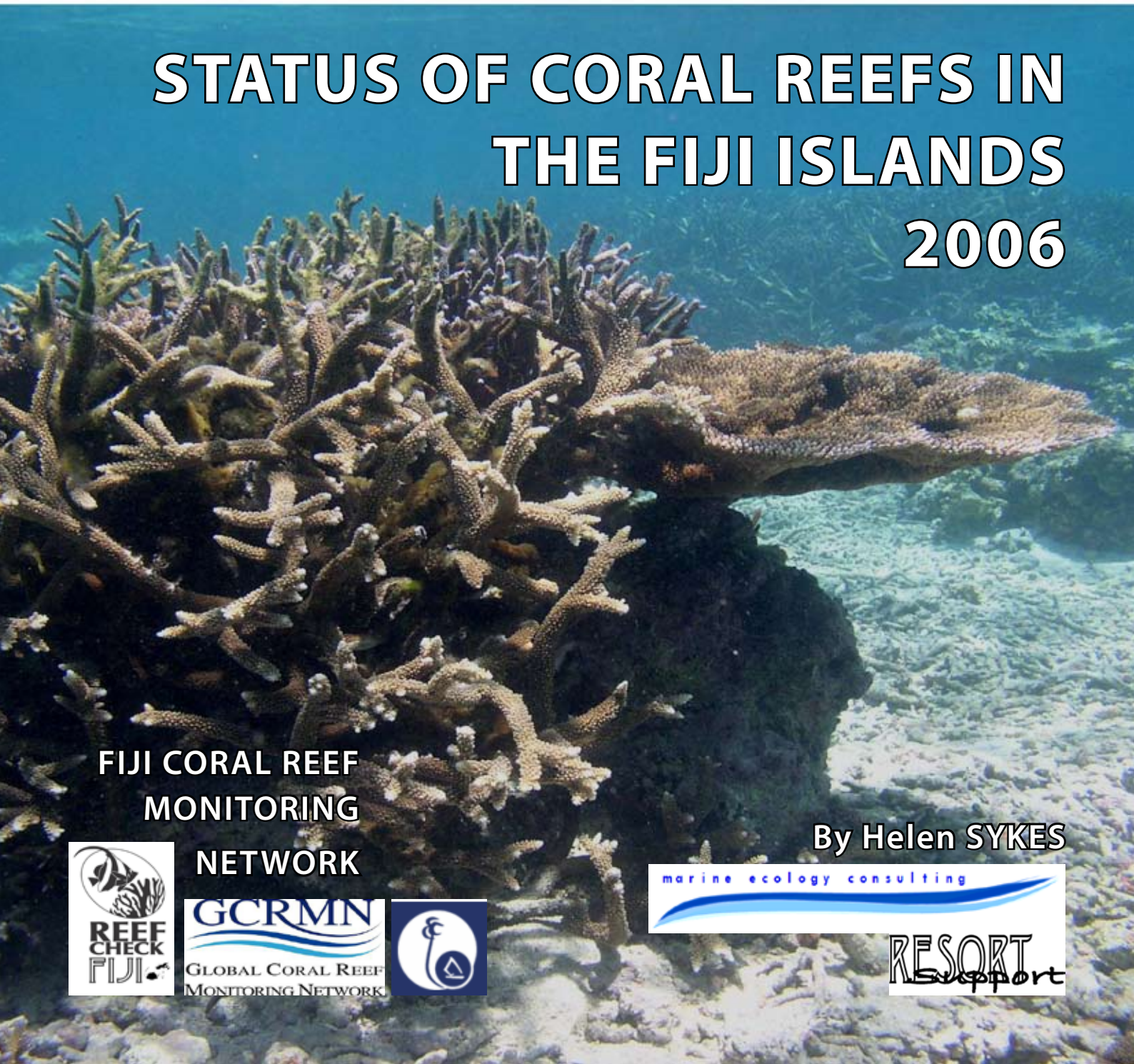
COMPONENT 2A - Project 2A2

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

May 2007

REEF MONITORING

STATUS OF CORAL REEFS IN THE FIJI ISLANDS 2006



FIJI CORAL REEF MONITORING NETWORK

REEF CHECK FIJI

GCRMN
Global Coral Reef Monitoring Network

By Helen SYKES

marine ecology consulting

RESORT Support

CRISP

Coral Reef Initiative for the South Pacific
Initiative Corail pour le Pacifique Sud

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

CRISP Coordinating Unit (CCU)
Programme manager : **Eric CLUA**
SPC - PoBox D5
98848 Noumea Cedex
New Caledonia
Tel : (687) 26 54 71
Email : ericc@spc.int
www.crisponline.net

COMPONENT2A

Knowledge, monitoring and management of coral reef ecosytems

Contact the author:
Helen SYKES
Marine Ecology Consulting
PoBox 2558, Govt. Bldgs
Suva, Fiji
Phone: (679) 336 3625
resortsupport@connect.com.fj

CRISP contact person:
Ken McKAY
School of Marine Studies
Faculty of Islands and Oceans
The University of the South Pacific
Suva, Fiji
Phone: (679) 3232612
Fax: (679) 3231526
Email: mckay_k@usp.ac.fj

- **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

Funded by :

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Section 1) Introduction:

In 2000, the Fiji Islands was at the northern edge of a large pool of unusually warm water, and suffered extensive hard coral death due to coral bleaching. A paper composed of a collection of studies from across the Fiji islands, linking this coral death to elevated sea temperatures at the time, was published (*Cummings et al 2000*). The difficulty of gathering data from very different sources, and which had been recorded using many different methods, established the need for standardised and regular surveys of representative sites across the Fijian archipelago, in order to measure long-term changes affecting the entire country.

With this in mind, a Fiji branch of the Global Coral Reef Monitoring Network (GCRMN), the Fiji Coral Reef Monitoring Network (FCRMN), was formed, as part of the GCRMN South-West Pacific node. The FCRMN established 12 survey sites across Fiji, placed temperature loggers on some of them, and published a report focusing on the recovery of Fiji's reefs between 2000 and 2004. (*Lovell and Sykes, 2004*)

This report follows up those sites which have been surveyed since that report, and presents the results of surveys carried out in 2005 and 2006. Some sites have not been followed up, and others have been established. More temperature loggers have been set out.

Constraints

In the first three years of this project, since 2001, financial support was made available to cover the costs of establishing and monitoring the selected sites, in order to provide the basis of long-term studies of progressive reef health across the country, and to contribute information to the GCRMN network.

Funding has since been made available for placing of temperature loggers, coordination of data, and for the writing of this report, but there has been no direct funding for reef monitoring, and consequently it has not been possible to re-visit all sites first established. Without financial support for the costs of field surveys it has become apparent that the aim of long-term monitoring will fail.

Despite stated willingness to form a data-reporting network, few NGOs or educational organisations have actually been able to submit reef health data when requested. This is an apparent difficulty over data analysis and publication priority.

The majority of the data used in this report has been collected by teams led in person by the FCRMN co-coordinator, Helen Sykes, with the support of tourism dive operators and aquarium collection companies, who have contributed dive support and sometimes personal assistance. The other main long-term contributor has been the marine biologist at Jean-Michel Cousteau Resort in Savusavu, to whom we are very grateful.

In 2006 data was sent in by occasional contributors Coral Cay Conservation, Frontier Fiji, and Laje Rotuma, and it is hoped that some of these organisations will be able to continue to contribute in the future.

Acknowledgements and Contributors 2005 and 2006

Data entering and processing	Simita Singh, **Marine Ecology Consulting** aquastellar1@yahoo.com
Report	Helen Sykes, **Marine Ecology Consulting** Helen@marineecologyfiji.com
Data Contributors	
Kadavu Astrolabe 2006	Simon Harding PhD, Marine Science Co-ordinator **Coral Cay Conservation Ltd.** 1st Floor Block 1, Elizabeth House, 39 York Road, London, SE1 7NJ, UK Tel: +44 (0)870 750 0668 Fax: +44 (0)870 750 0667 sh@coralcay.org www.coralcay.org
Savusavu 2002 - 2006	Mike Greenfelder, Johnny Singh, Marine Biologists; **Jean-Michel Cousteau Resort Fiji Islands**, fiji4fun@connect.com.fj biologist@fijiresort.com gahooley@hotmail.com
Gau Somosomo and Vadravadra 2006	Lesley Brown, Marine Research Coordinator **Frontier-Fiji** The Society for Environmental Exploration / Frontier 50 - 52 Rivington Street, London EC2A 3QP, UK frontierfiji@yahoo.ac.uk www.frontier.ac.uk
Rotuma 2006	Teri Tuxson. Monifa Fiu, Sydney Malo ***Laje*Rotuma Initiative** P.O. Box 10816 Laucala Beach Estate, Suva, Fiji Tel: (679) 922 8422 ttuxson@yahoo.com monifa_fiu@yahoo.com malo_s@usp.ac.fj www.rotuma.net/os/lajerotuma.htm
Suva Harbour Fish Patch 2006	Yashika Nand, **University of the South Pacific** yashika_nand@yahoo.com.au
Weather information 1999 – 2006: cyclones, annual rainfall and sunshine hours.	Simon McGree, Principal Scientific Officer Praveena Patel, Relieving Scientific Officer Climate Services Division **Fiji Meteorological Service** Ph: +679 6724 888 Ext. 5039 Fax: +679 6736 047 Url: www.met.gov.fj
All other data	Helen Sykes, Director Chinnamma Reddy, Field Scientist **Marine Ecology Consulting, Resort Support** PO Box 2558, Government Buildings, Suva, Fiji Islands Tel: (679) 336 3625 Helen@marineecologyfiji.com www.marineecologyfiji.com www.resortsupportfiji.com
Diving support	
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
Financial Support	
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Report Production	**Coral Reef Initiative for the South Pacific (CRISP)**

Survey Sites

The network of survey sites was expanded in 2006, to cover as many different regions of the Fiji Islands as possible.

Figure 1.1: Map showing survey sites and temperature loggers as of Dec 2006

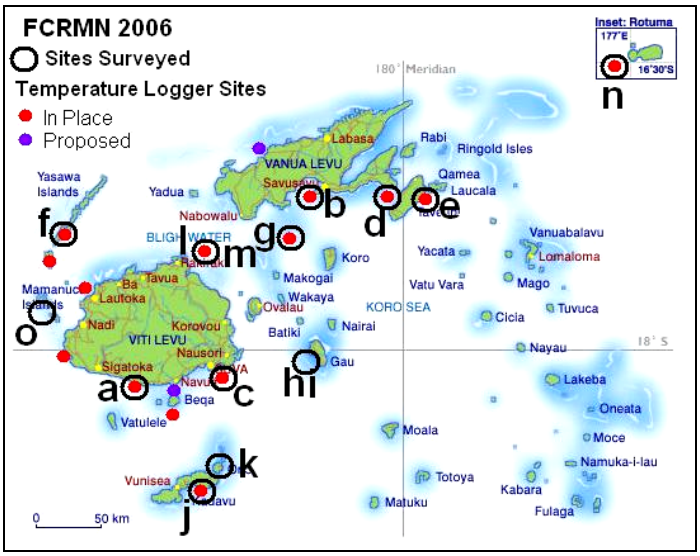


Figure 1.2: Table of regular sites surveyed in 2005 and/or 2006

Site #	Region	Site name	Partners
a	Coral Coast	Cowrie Crawl, Tukituki	Resort Support, Aquasafaris, Diveaway
b	Savusavu	Jetty, Golden Nuggets, Light House, Mystery	J-M Cousteau Fiji Islands Resort
c	Suva	Fish Patch	University of the South Pacific / SMS
d	Somosomo Straits	Great White Wall, Rainbow Reef	Resort Support , Garden Island Resort
e	East Taveuni	Waitabu MPA Cut	Resort Support, Waitabu Marine Park
f	Yasawa Is	Whisky Reef, Wonderland	Resort Support, West Side Watersports, Nanuya Island Resort
g	Namena	Two Thumbs Up Arch	Resort Support, Nai'a Cruises
h	Gau Island	Anthias Avenue	Resort Support, Nai'a Cruises
i	Gau Island	Vadravadra	Frontier Fiji
j	Kadavu	Eagle Rock, Vesi Bay	Resort Support ,Matava Resort
k	Kadavu	Astrolabe Reef	Coral Cay Conservation
l	Vatu-i-Ra Pg	E6, Mount Mutiny	Resort Support, Nai'a Cruises
m	Vatu-i-Ra Pg	Humann Nature	Resort Support, Nai'a Cruises
n	Rotuma		Laje Rotuma
o	Mamanuca Is	Sunflower Reef	Resort Support, Subsurface / Musket Cove

Sites featured in earlier surveys but not surveyed in 2005 or 2006, are not included in this report, but can be found in the 2004 status report. These are listed below.
When surveys are carried out on these sites, they will be included in future reports.

- Lautoka, Coral Farm (Walt Smith International)
- Momi Bay (Biological Consultants)
- Suva – Fish Patch 5m, Dennis Patch 5m, Muiavuso 1m, Nukuboca 1m (USP)
- Beqa – Kavukavu Reef (Aquarium Fish Fiji, Bruce Carlson)

A new survey and temperature logger site in Beqa lagoon, near Storm Island, was added in January 2007. This data will be added in the 2007 report.

Methods

Note: This methodology was used in all surveys conducted by Helen Sykes, and the tourism network. Where other methods have been used by data contributors, the results have been manipulated to provide comparable data.

Point Intercept Transects were used to record coral health and substrate cover, with 40 points being recorded along each of four 20-metre transects at each site.

At all sites, data was collected to a minimum of "Reef Check" standards, a method most suitable where non-specialist recorders may be collecting data, such as at tourism dive operations.

At sites where surveys were carried out by more scientifically qualified personnel, coral and substrate cover was recorded to the "Lifeform" categories suggested in the AIMS Survey Manual (*English at al. 1997)*

Analysis of all data in "Reef Check" categories was used to provide a simple and reliable indictor of live coral and algal cover at each site, compared with different regions of Fiji, and with previous years.

Analysis of data in more complete "Lifeform" categories was used to examine changing dominance of coral types at relevant sites.

Belt transects were used to record numbers of key invertebrates and fish. Again, four 20-metre transects were recorded at each site, 5 metres wide for invertebrates, and 5m wide by 5m high for fish. Species selected were also a minimum of "Reef Check" on all sites, expanded to include other locally relevant species as required.

Site selection was made by choosing a site representative of each reef area as a whole. In most cases, these were tourism dive sites, pre-selected by the dive operative most familiar with the area. This makes it simple to return to the site year after year, as most such sites are marked with permanent moorings, and their location is well known to local boat drivers. Surveys were carried out at two depths where possible, one depth where reef topography was limited. Surveys were separated into *Shallow* (5 metres and above) and *Deep* (below 6 metres).

Figure 1.3: Key to codes used in graphs

General categories	
HC	Live Hard Coral
SC	Live Soft Coral
SP	Sponge
OT	Other Biota
MA	Macro Algae
RB	Rubble
RC	Rock
SD	Sand

Acropora live coral forms	
ACB	Acropora - Branching
ACD	Acropora – Digitate
ACT	Acropora – Table
ACS	Acropora - Submassive
ACE	Acropora - Encrusting
Non-Acropora live coral forms	
CB	Coral Branching
CM	Coral Massive (Boulder)
CF	Coral Foliose
CS	Coral Submassive
CE	Coral Encrusting
CMR	Coral Mushroom
CME	Coral Millipora (Fire)

Algae types	
AA	Algal Assemblage
MA	Macro Algae
HA	Halimedes
TA	Turf Algae
CA	Coralline Algae

Section 2) Reef health in Fiji, 2006

(See following graphs)

Coral health across the Fiji Islands was generally good on reefs deeper than 6 metres, with many areas recovered to or above pre-2000 bleaching levels (see following section on reef health since 1999).

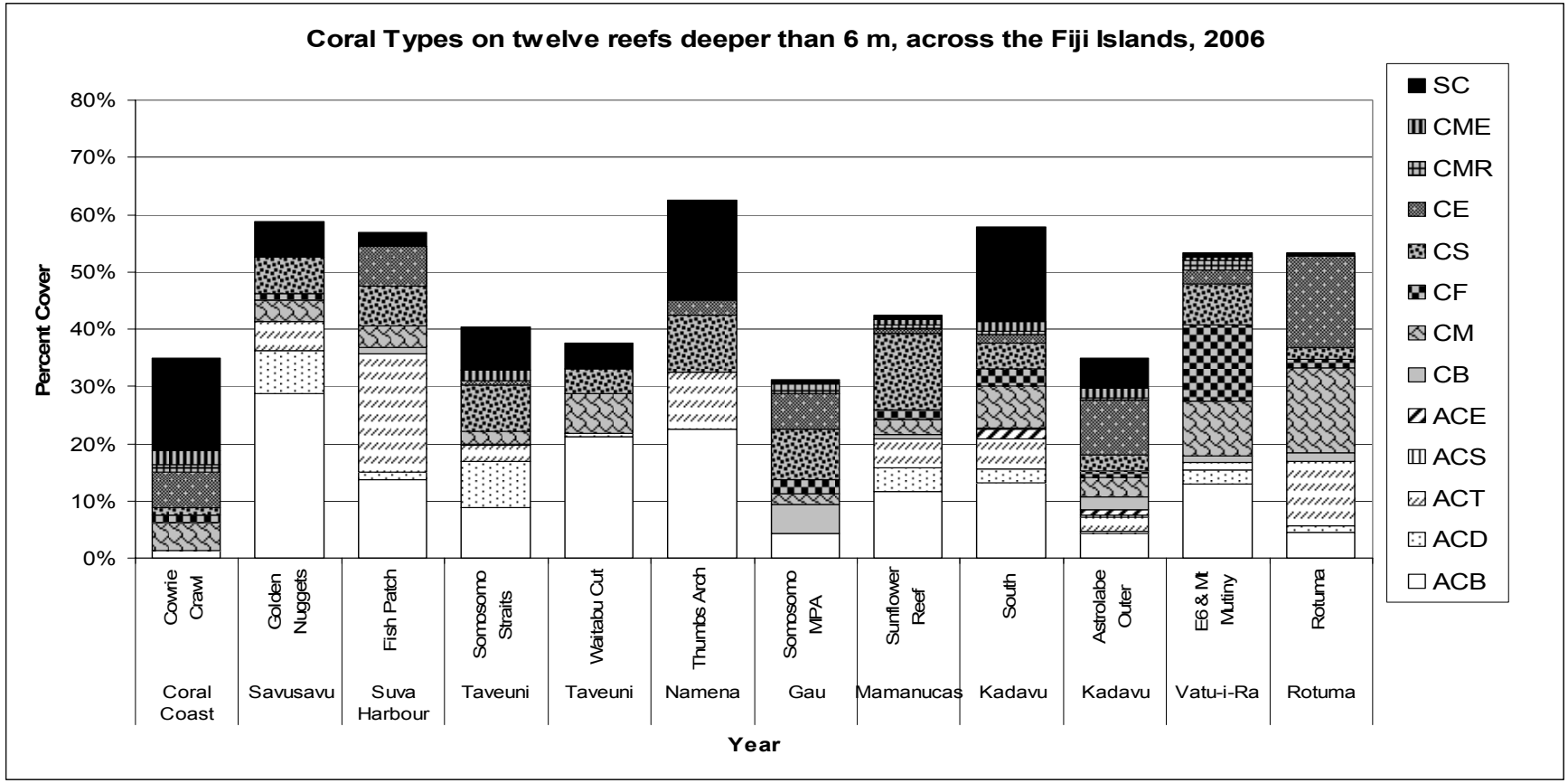
40% coral cover appears to be an average level for many reefs, with those with more than 50% considered to have high coral cover.

In general, the highest coral cover was found in Savusavu, Suva Harbour, Namena, South Kadavu, the Vatu-i-Ra passage, and Rotuma; and the lowest coral cover on the Coral Coast of Viti Levu, and Gau Island in Lomai Viti.

Acropora coral species (primarily branching, finger and table corals, most heavily affected by coral bleaching) have recovered especially well and once again make up a high proportion of many coral populations, particularly in Savusavu, Suva Harbour and Namena. The Coral Coast of Viti Levu, Kadavu Astrolabe Reef, and the nearshore reef in Gau have fewer *Acropora* corals, and are dominated more by submassive, encrusting, and soft corals.

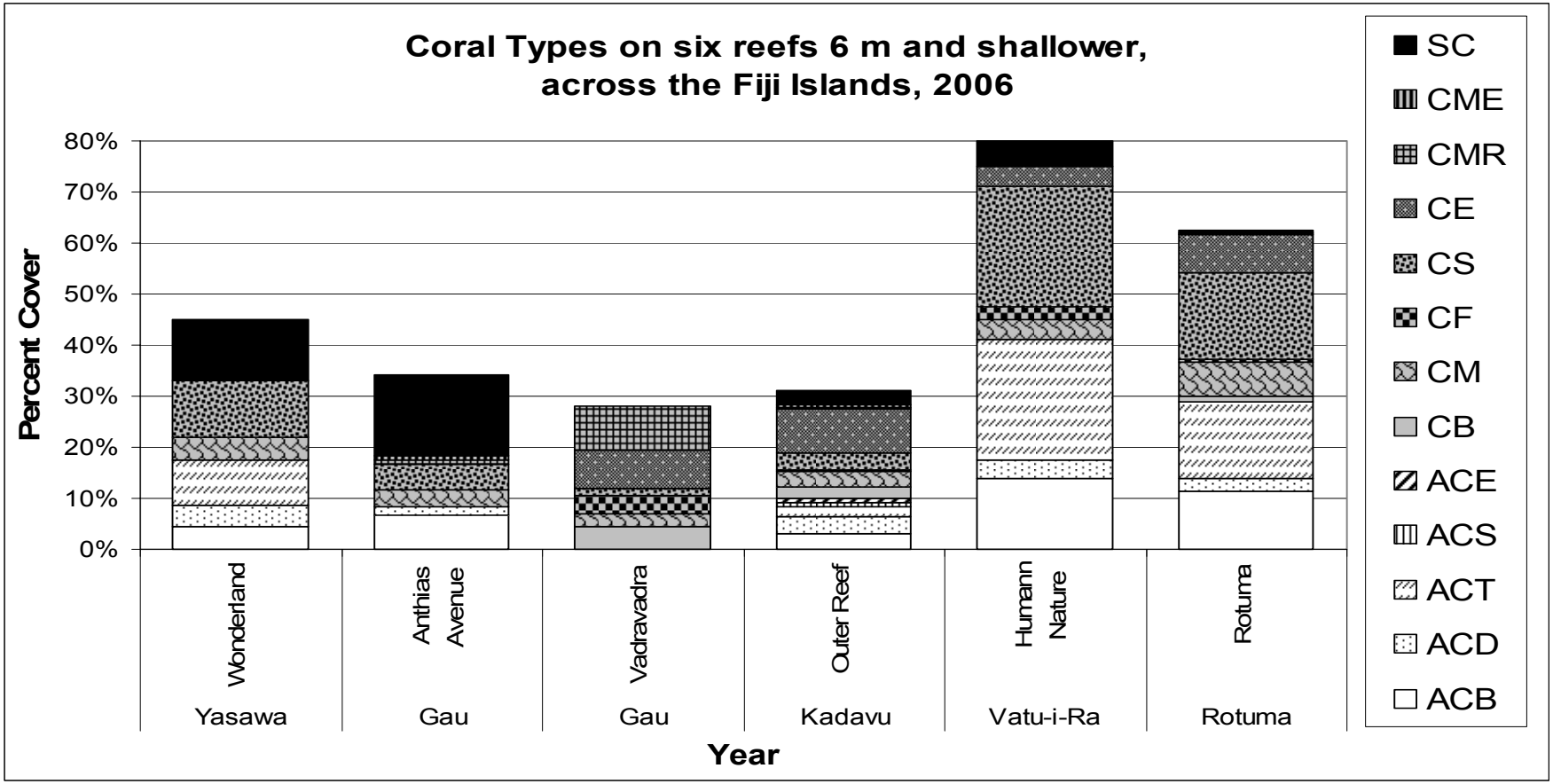
In comparison, coral health on shallower reefs was generally lower, except in Rotuma and the Vatu-i-Ra passage, where very high coral cover (80%) was recorded. The shallower reefs in the Yasawas, Gau and Kadavu had lower levels of *Acropora* corals than the deeper reefs, and more submassive, encrusting and soft corals. Fewer shallow surveys were carried out, as in many areas of Fiji, shallow reefs are subject to too much surge and wave action for safety.

Figure 2.1. Coral Cover: Sites across Fiji in 2006: Reefs deeper than 6m



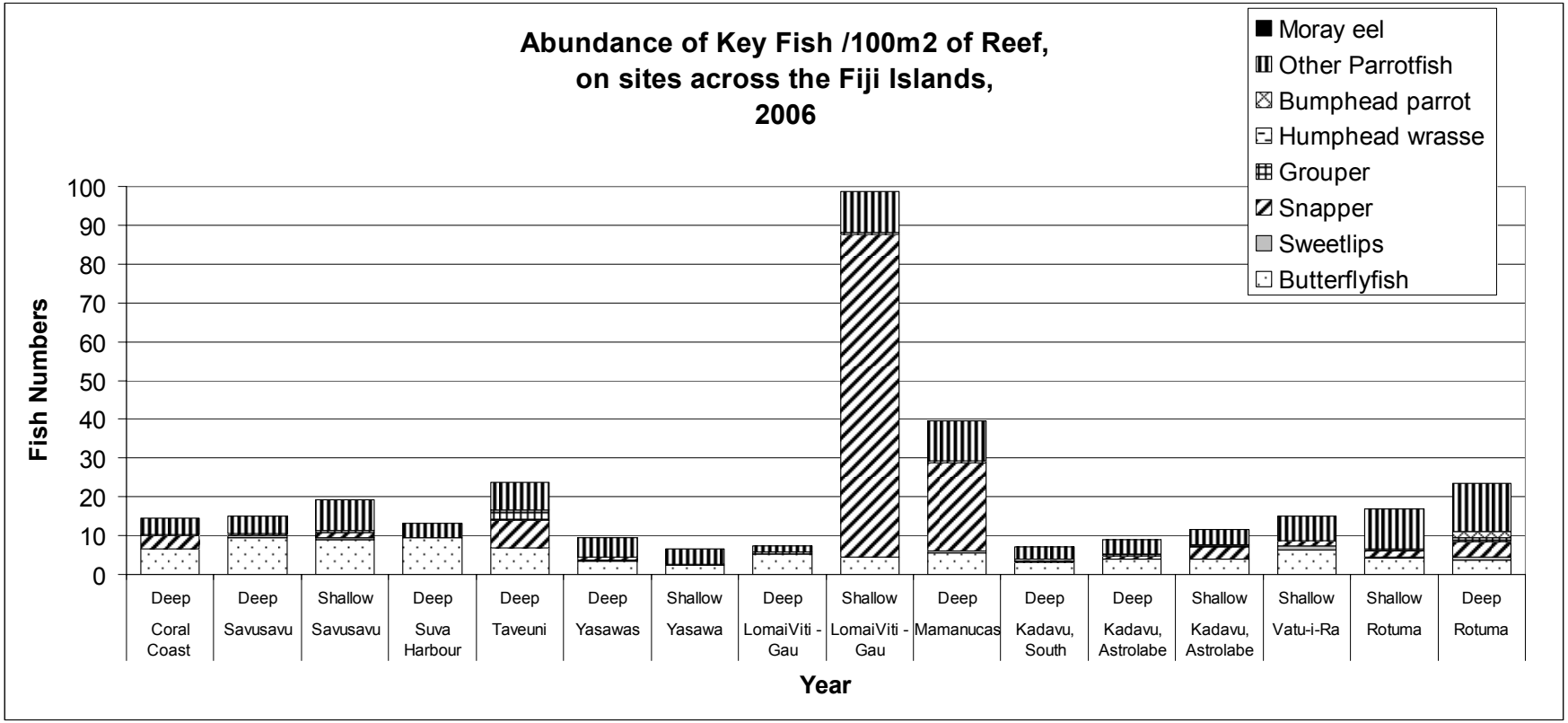
Coral types vary widely across the country. On reefs deeper than 6 metres, *Acropora* species (white background) can be seen to be lowest on the Coral Coast, Gau and the Kadavu Astrolabe reef, and particularly high in Savusavu, Suva Harbour and Namena.
Soft corals (black) representing both the "Leather" corals such as *Sarcophyton* and *Sinularia*, and the "Glass" or "Broccoli" coloured soft corals, such as *Dendronepthea*, are highest on the Coral Coast, Taveuni, Namena and Kadavu.

Figure 2.2. Coral Cover: Sites across Fiji in 2006: Reefs 6m and shallower



Fewer shallow sites were surveyed than deeper ones. On reefs shallower than 6 metres, *Acropora* cover was highest in the Vatu-i-Ra passage, and low to non-existent in Gau. Soft corals were most numerous in the Yasawa Islands and Gau, but these were primarily the "Leather" corals, not the *Dendronepthea* species usually seen on deeper reefs.

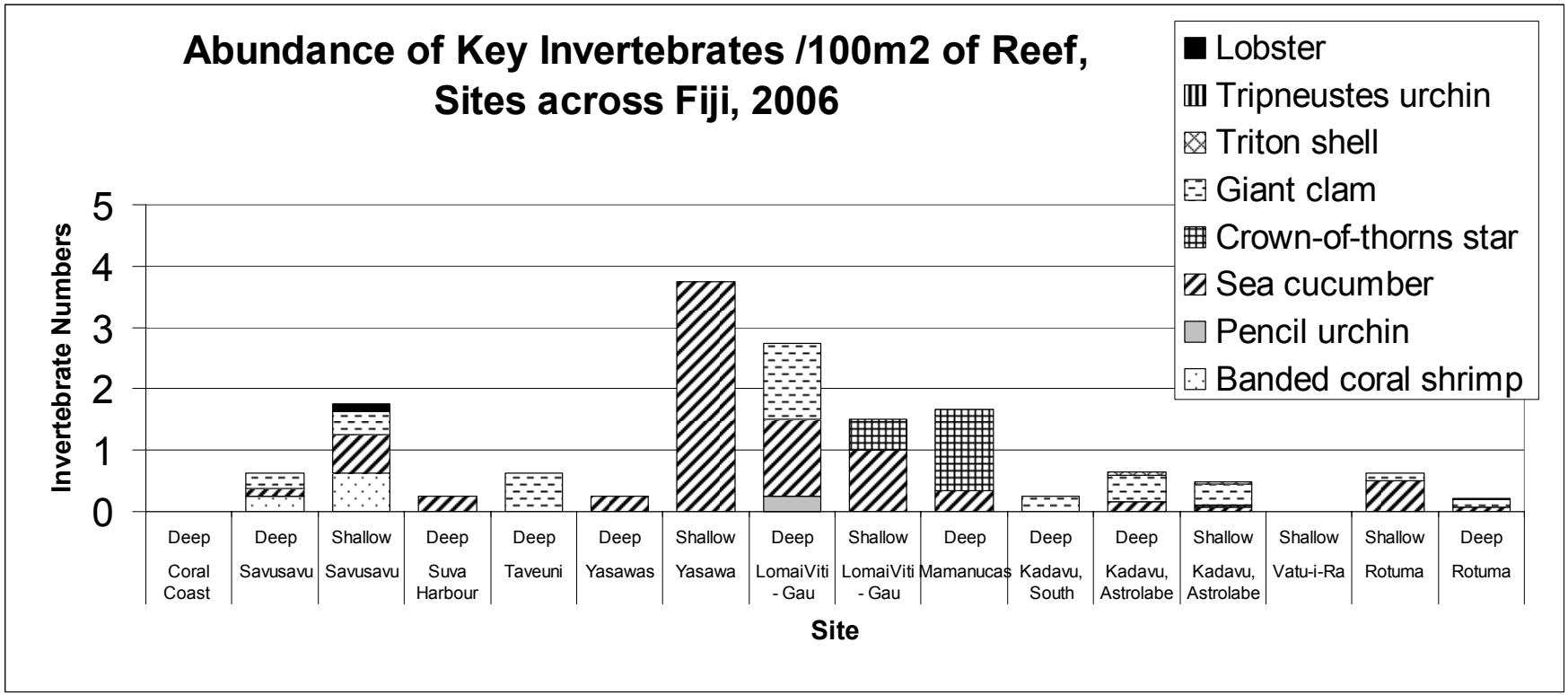
Figure 2.3. Indicator Fish populations: Sites across Fiji in 2006: all depths



Most reefs across Fiji had an average of 10 – 20 indicator fish per 100m^2, with the exception of the shallow reef in a Marine Protected Area in Gau, and one site in the Mamanucas, where schools of Snappers elevated the numbers. For the most part, Butterflyfish were the most numerous of the fish families counted, followed by Parrotfish and Snapper. Overall numbers of larger food fish such as Grouper and Sweetlips were low across the country. Bumphead Parrotfish were only seen during surveys in Rotuma and Kadavu, although they were seen at other times in the Yasawa Islands. Humphead Wrasse were not seen during any surveys, but are commonly seen in large numbers in Taveuni.

Figure 2.4. Indicator Macro-Invertebrate populations: Sites across Fiji in 2006: all depths

Note: *Diadema* urchins are excluded from this graph for reasons of scale. They are represented in their own graph on the following page.



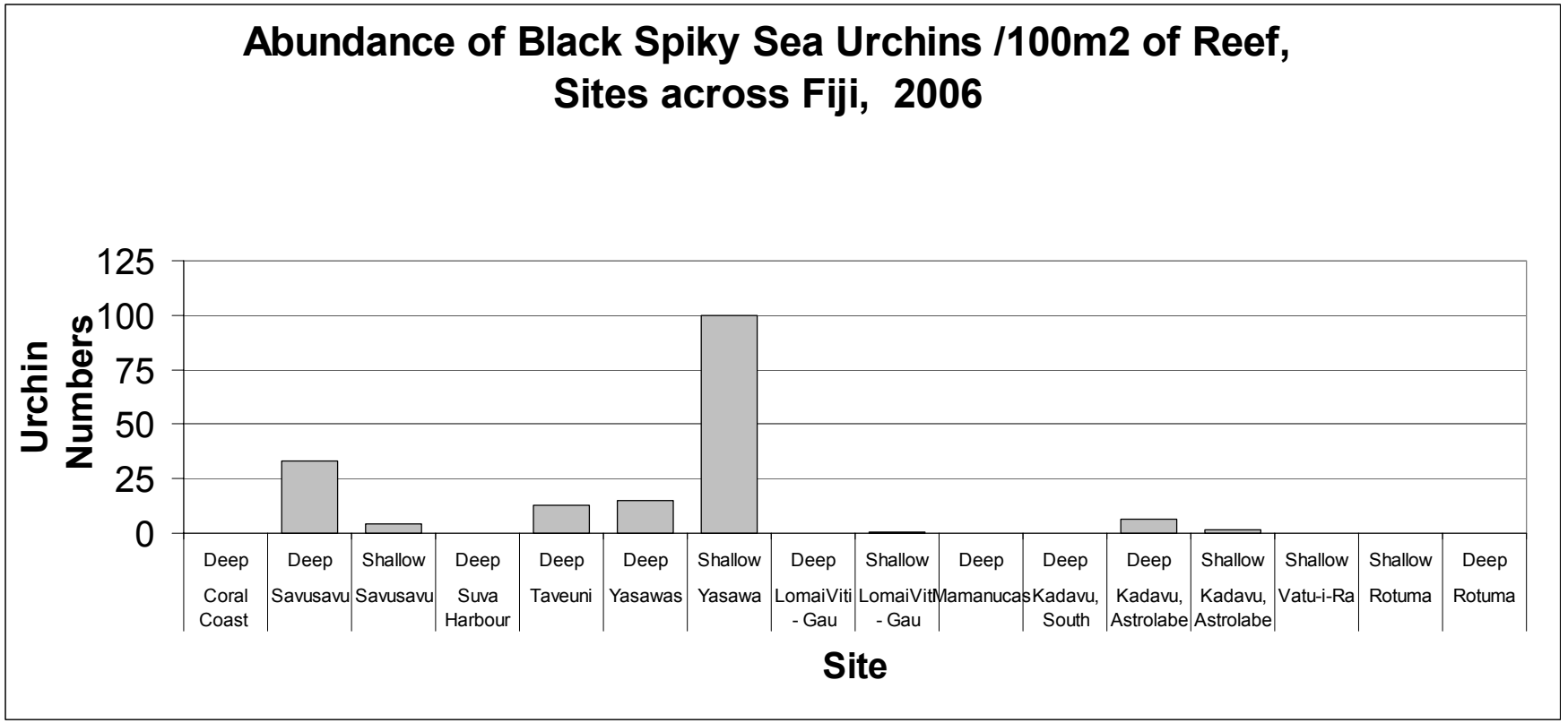
Macro-Invertebrate numbers are generally low across the country.

Large numbers of Sea Cucumbers were recorded in the Yasawa Islands and Gau, and *Tridachna* Giant Clams were found in the highest numbers in Savusavu, Gau and Taveuni.

Acanthaster Crown-of Thorns Stars (COTS) were found on shallow reefs in Gau, and deep reefs in the Mamanuca Islands. Large numbers of COTS have been seen in the Mamanuca Island reefs in both 2005 and 2006.

Figure 2.5. *Diadema* Sea Urchin populations: Sites across Fiji in 2006: all depths

Note: these urchins include all true *Diadema* urchin species, plus the smaller black spiky rock-boring urchin *Echinostrepehlus aciculatus*



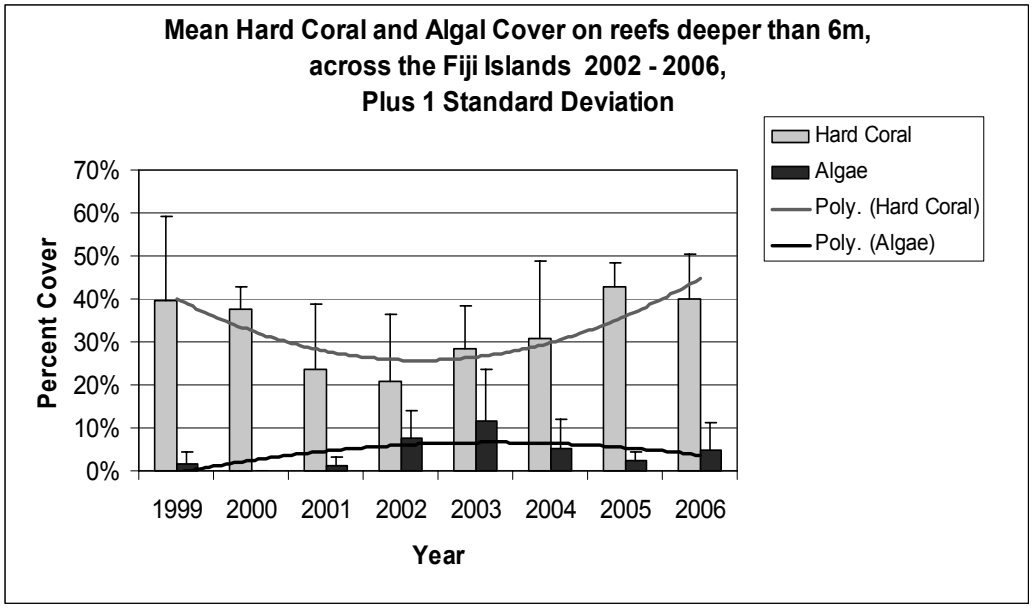
Black Spiky Sea Urchins were by far the commonest macro-Invertebrates counted, especially the smaller rock-boring urchin *Echinostrepehlus aciculatus,* which is often found in large colonies in rocky reef substrate. In particular these urchins were seen in large numbers in the Yasawas and Savusavu. Elevated numbers of these may relate to over-fishing of certain predatory species such as Triggerfish.

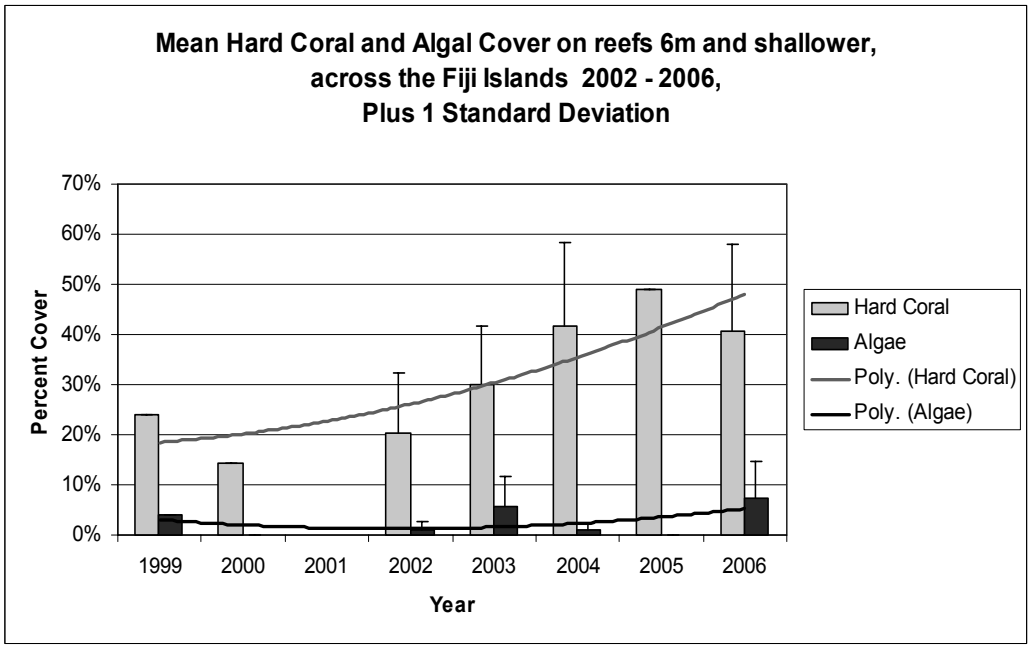
Section 3) Progressive reef health since 1999

Fiji-wide coral and algal cover means were calculated by combining data from all regions. Variation is high, as indicated by the Standard Deviation bars, reflecting the variation between regions of Fiji as seen in the previous section. Details of trends over time in each region are given in Section 6) "Regional details".

Figure 3.1: Bar Charts showing overall Hard Coral and Algal Cover in the Fiji Islands 1999 – 2006

- No shallow surveys were conducted in 2001.
- 2005 figures are represented by only a few sites, as little data was gathered that year due to logistical constraints. Fiji-wide coral cover from that year appears artificially high due to consequent site bias.
- Lines show general trends (Polynomal Trendlines)



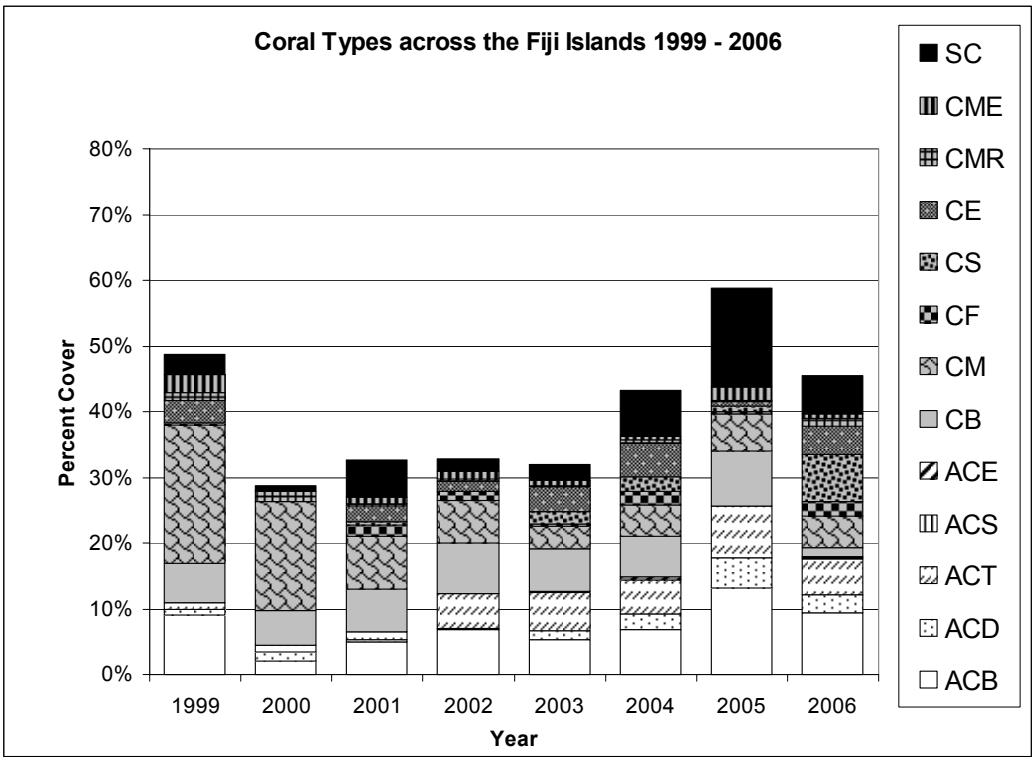


There was a decline in hard coral cover after the mass coral bleaching of 2000, falling to the lowest point in 2001 / 2002. Since that time, coral cover has been gradually increasing, and reached pre-bleaching levels in 2005, plateauing off at an overall Fiji mean of 40% coral cover on both shallow and deep reefs. This is presumed to represent normal coral cover in the region.

Algal Cover, while remaining generally low, rose in the years when live hard coral was in decline, and has fallen again as coral cover increases. This is considered to be due to algal colonisation of dead coral skeletons following bleaching events.

These patterns are most evident on the deeper reefs, but can also be seen on the shallower sites.

Figure 3.2: Bar Chart showing overall coral types in the Fiji Islands 1999 - 2006

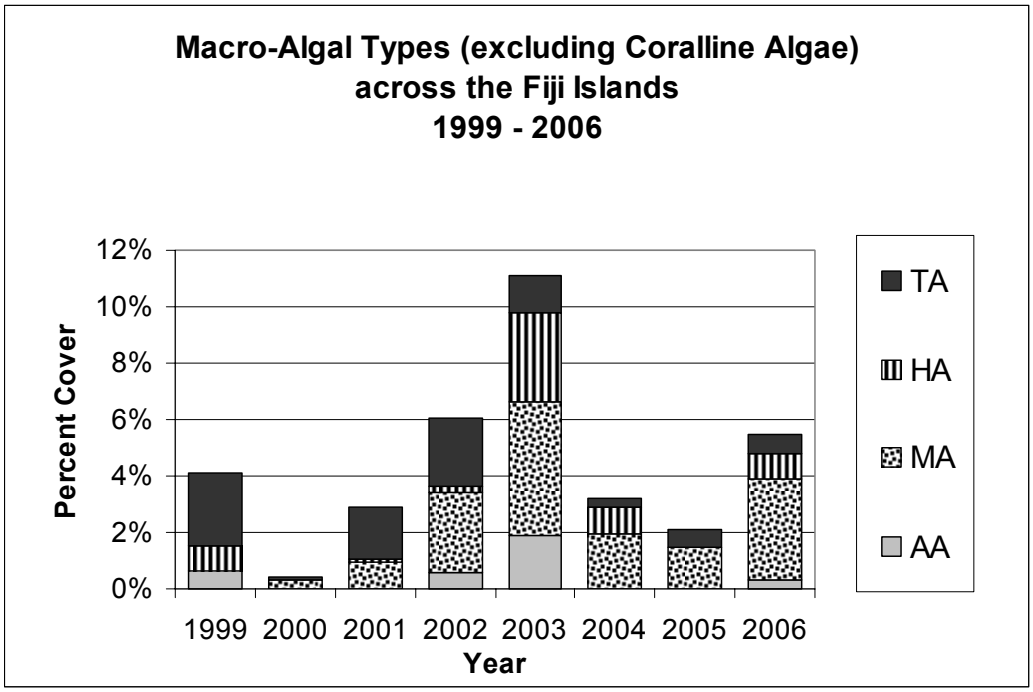


Acropora coral species were most affected by the bleaching of 2000, with less than 6% *Acropora* coral cover surviving by 2001. However, recovery has been remarkably swift, and in many areas *Acropora* corals are now back to or higher than pre-bleaching levels. In particular Finger (Digitate) and Table *Acropora* coral forms appear to be flourishing. In some places, branching *Acropora* corals were seen to grow 15 cm in one year.

In contrast, the non-*Acropora* coral forms were much less affected by the bleaching, with the only change being an apparent drop in Boulder (Massive) coral forms. In-water experience suggests that this is probably due to *Acropora* coral growth above Boulder corals, rather than death of these species.

(Addition of Soft Corals to this graph means that overall percentage cover is higher then that shown in the Hard Coral graphs on the previous page.)

Figure 3.3: Bar Chart showing overall Algal types in the Fiji Islands 1999 - 2006



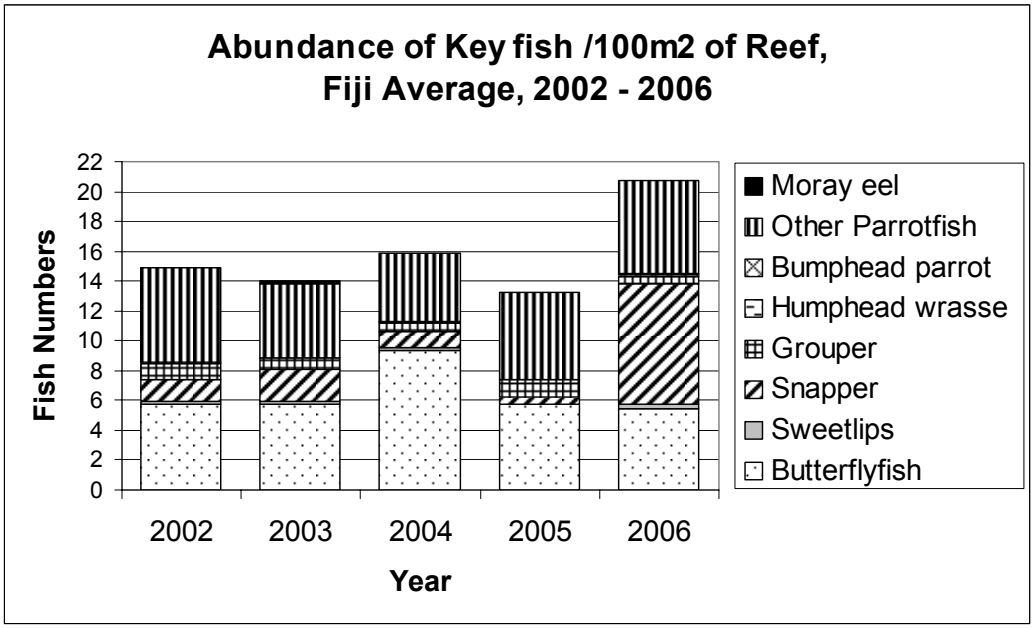
Some alga, such as *Halimedes* (HA), are considered normal inhabitants of the reef and do not reflect adverse changes. Other Macro-Algae (MA and AA) may be the result of over-fishing of grazing fish and invertebrates, or indicators of nutrient enrichment such as from improper sewage treatment or agricultural fertiliser run off.

Turf algae such as Filamentous Blue-green algae, are often associated with nutrient pollution or coral death.

There was an increase in all types of algae observed in 2002 and 2003, which may be due to the coral death from the 2000 and 2002 coral bleachings, providing an increased amount of substrate for algal growth. This is followed by a drop in algal cover as coral health improves in 2004, 2005 and 2006.

No other patterns are seen.

Figure 3.4: Bar Chart showing abundance of key Indictor Fish in the Fiji Islands, 2002 - 2006



Allowing for site variations, indicator fish populations appear to have remained very consistent over the years. Inclusion of new sites with resident schools of Snappers led to elevated Snapper numbers in 2006.

There does not appear to be any wide-spread alteration in fish populations relating to the coral health changes seen over the past 5 years, although it should be noted that pre-bleaching population levels are not available.

Of the fish groups counted, numbers of important food fish such as Groupers *Serranidae*, Sweetlips *Haemulidae*, large Snappers *Lutjanidae*, and the particularly endangered species Humphead Wrasse *Cheilinus undulatus* and Bumphead Parrotfish *Bolbometopon muricatum* are low on Fijian reefs, and have been for at least the past 5 years. Consistently, most indicator fish seen are Butterflyfish *Chaetodontidae* and Parrotfish, and smaller Snapper *Lutjanidae* species.

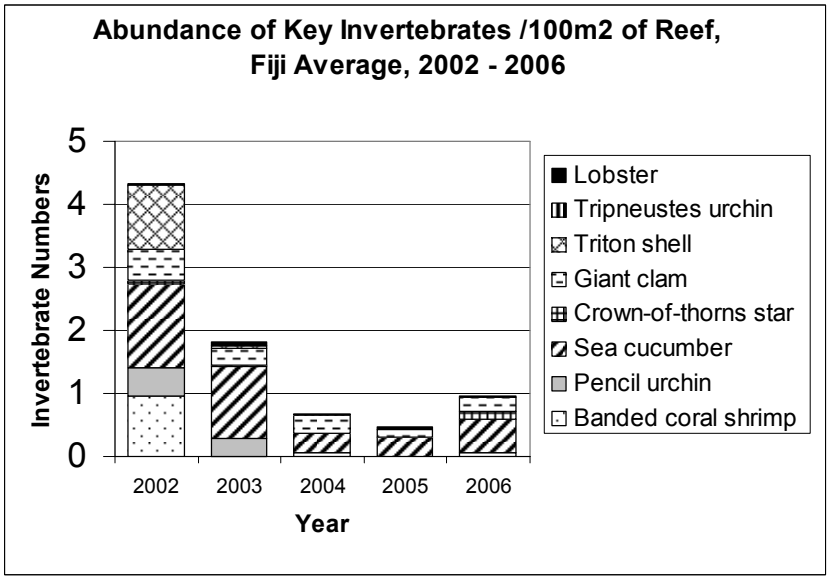
This probably reflects high pressures from subsistence and small-scale commercial fishing affecting most reefs in the Fiji Islands. In particular, coastal fringing reefs near local communities rarely have high populations of the larger food fish species.

Humphead Wrasse *Cheilinus undulatus* is severely endangered, and trade in this species has been forbidden under the Convention on International Trade in Endangered Species (CITES).

Bumphead Parrotfish *Bolbometopon muricatum* are facing a local extinction (extirpation) in the Fiji Islands, and sites where schools of these fish are still seen should be considered prime candidates for protection from fishing, if the Fiji populations are to be saved.

Figure 3.5: Bar Chart showing abundance of key indictor Invertebrates in the Fiji Islands, 2002 - 2006

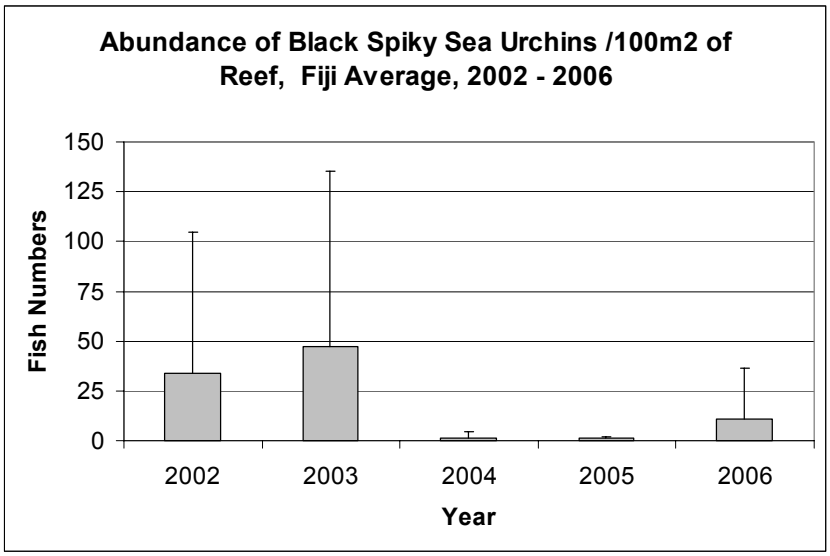
Note: *Diadema* Urchins are excluded from this graph for reason of scale.



There is an apparent drop in invertebrate numbers since 2002, but it should be noted that the 2002 data included banded Coral Shrimp and Tritons Trumpet shell which were seen on a single site.

Overall numbers of the commoner Macro Invertebrates such as Sea Cucumbers and Giant Clams were low, and not seen to alter greatly over time.

Figure 3.6: Bar Chart showing abundance of *Diadema* Sea Urchins in the Fiji Islands, 2002 - 2006



Note: Includes *Diadema* species, plus *Echinostrephus aciculatus.*

Diadema urchins appear to have declined since 2003.

However, the large variation between sites (as shown by the Standard Deviation bars) suggests that this may be due more to site variation than to a definitive population trend. Refer to details of each region (Section 6) for more information.

In general, Macro-Invertebrates are not seen in large enough numbers on Fiji's reefs to provide a reliable indicator of population trends on the broad scale. They may be more important local indicators, and as such, the regional graphs in Section 6) may be more informative.

Section 4) Bleaching and water temperature since 1997

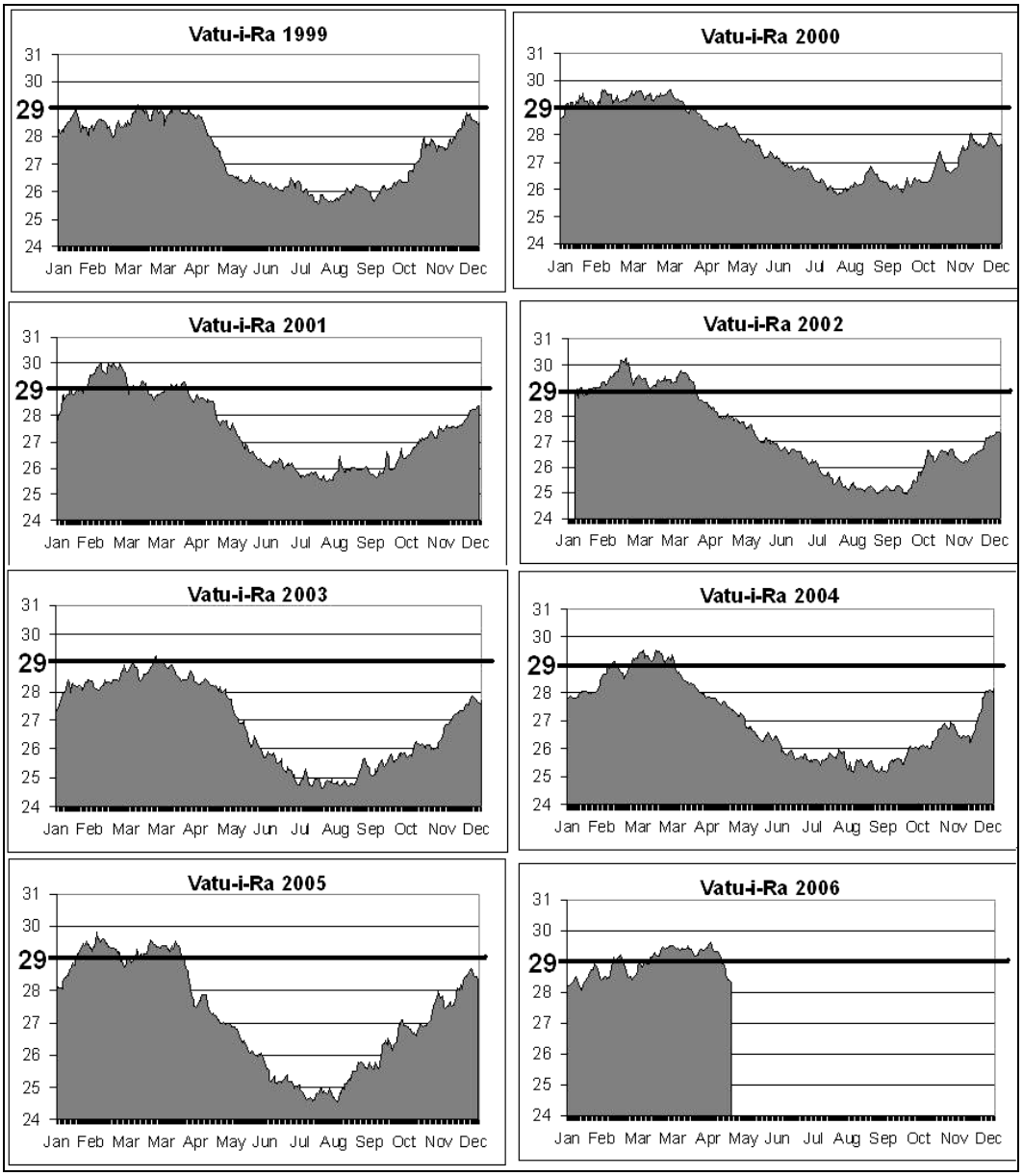
Since 1996, in-water temperature loggers have been in place in some areas of Fiji. Originally placed by Norm Quinn and Peter Newell, with the support of Nai'a Cruises, the logger network has been expanded in past years by the FCRMN.

Long-term data is available from the pinnacle known as Mount Mutiny, in the Vatu-i-Ra passage, which has also been a coral survey site since 1999. Loggers are placed between 5 and 7m depth, on a steep wall facing the deep ocean.

- Data from 1996 – 2004 Norm Quinn / Nai'a Cruises
- Data from 2004 – 2006 FCRMN

Figure 4.1: Graphs of water temperatures, Vatu-i-Ra Passage 1999 – mid 2006

29°C marked with darker line



This Vatu-i-Ra temperature data was subsequently analysed to provide daily means, the number of days in each year where mean water temperature was over 29.0°C and 29.5°C, and times of long periods of consecutive high temperatures.

All data from the Vatu-i-Ra Passage:

Figure 4.2: Graph of number of days with high water temperatures 1997 - 2006

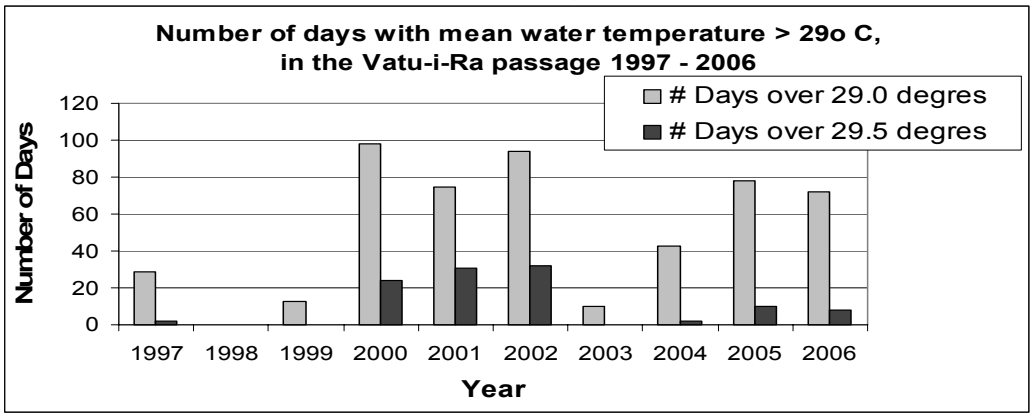


Figure 4.3: Graph of consecutive days between Jan and May with high water temperatures 1997 - 2006

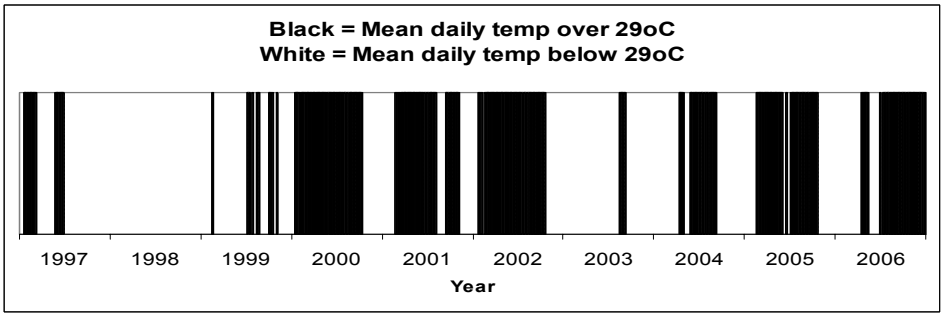
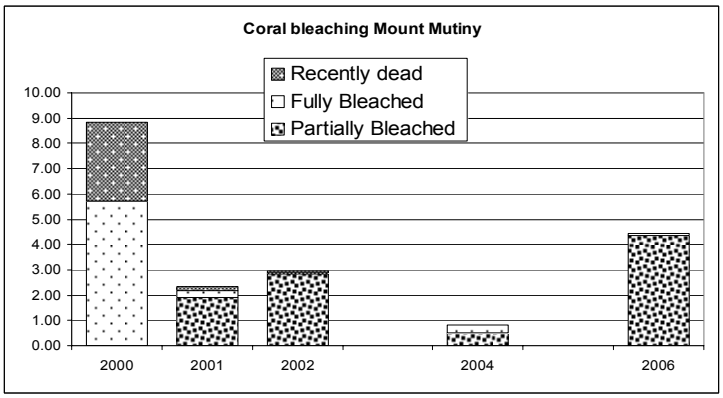


Figure 4.4: Graph of extent of bleaching in the Vatu-i-Ra Passage 2000 - 2006

Note- No surveys were carried out in 2003 or 2005, but no significant bleaching was reported by dive operator in those years.



Mass coral bleaching was reported across Fiji in 2000, and smaller, more localised events in 2002 and 2006.

On this site, partial bleaching was observed in most years, but large-scale full bleaching was only seen in 2000.

Large scale coral death followed the extensive bleaching of 2000, but percent coral cover at this site was back to 1999 levels by 2006.

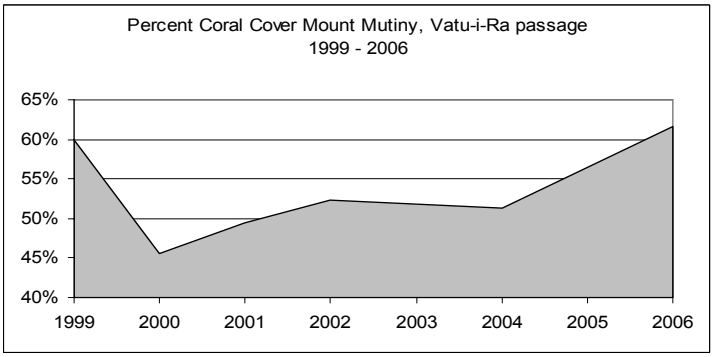
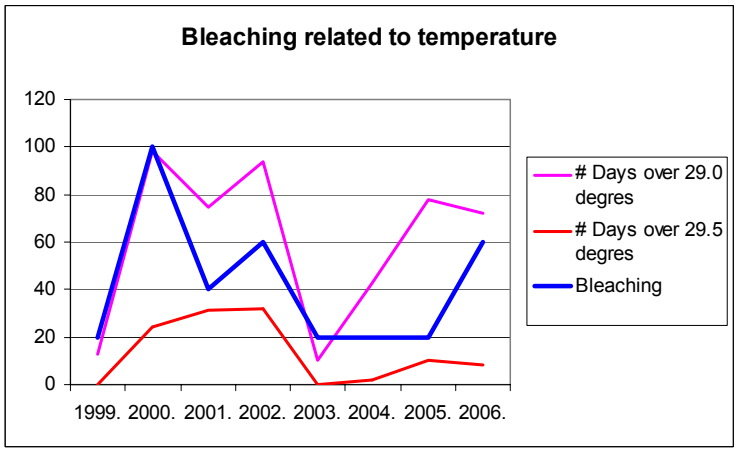
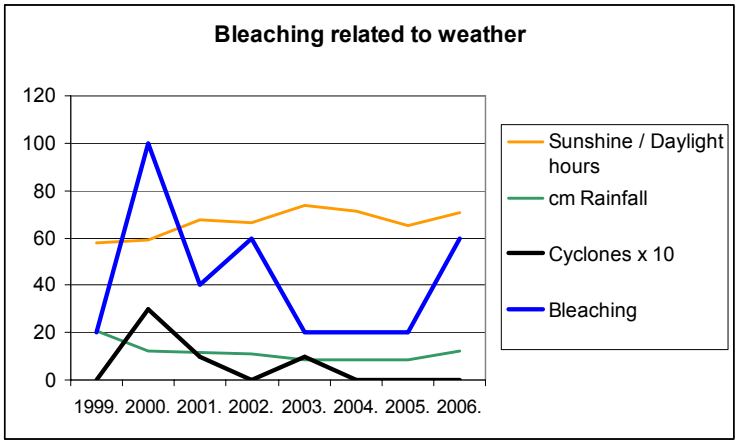


Figure 4.5: Weather conditions 1999 - 2006

Year	1999	2000	2001	2002	2003	2004	2005	2006
Cyclones	None	3	1	None	1	None, but coral damaging storm	None	None
Cyclone focus		Mamanucas, Viti Levu, Kadavu	Viti Levu, Kadavu, Lau		Vanua Levu, Taveuni	Vatu-i-Ra passage		
Mm Rainfall (Lautoka) Jan - April	2061	1229	1160	1124	857	825	881	1198
Hours Sunshine (Lautoka) Jan - April	692	711	815	797	881	858	785	851
Summary	No Cyclones High rainfall Low sunshine Water cool	3 Cyclones Moderate rainfall Moderate sunshine Long consecutive periods hot water	1 Cyclone Moderate rainfall High sunshine	No Cyclones Moderate rainfall Moderate sunshine Long consecutive periods hot water	1 Cyclone Low rainfall High sunshine Water cool	No Cyclones, but coral damaging storms Low rainfall High sunshine	No Cyclones Low rainfall Moderate sunshine	No Cyclones Moderate rainfall High sunshine
Bleaching	UNKNOWN	HIGH (100)	LOW (40)	MODERATE (60)	UNKNOWN	VERY LOW (20)	UNKNOWN	MODERATE (60)

Figure 4.6: Graphs relating environmental conditions to bleaching 1999 - 2006





Note, Extent of Bleaching and some weather factors are represented on manipulated scales, rather than actual values, to enable graphing.

Bleaching appears to coincide with elevated water temperatures over long consecutive periods. It is likely that some partial bleaching occurs most years, but only progresses to a mass event when temperatures remain elevated to 29 – 29.5°C for longer than 8 – 12 weeks.

Weather conditions, including number of cyclones per year, annual rainfall, and sunshine hours, did not appear to relate directly to bleaching intensity.

Section 5) Discussion and References

The present state of Fiji's reefs

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

The bleaching event of 2000 provided an interesting starting point, in that coral health was affected across the country with 40 – 80% loss of hard coral. This provided a basal low point, from which it has been possible to record rates and levels of coral recovery.

Where recovery was slow, reefs were found to be either physically remote from areas of healthy coral, and so from sources of new coral spawn, or badly affected by algal overgrowths which may have prevented coral settlement. Certain areas that escaped major bleaching have been seen to regularly have lower water temperatures than the rest of the country.

Coral bleaching is not the only stressor on Fiji's reefs, which are also regularly affected by cyclones and large storms, as well as more localised factors such as over-fishing, nutrification, algal overgrowth and coral predation from *Acanthaster plancii* Crown of Thorns Star and coral-eating snails such as *Drupella*.

Coral regeneration after damaging storms has usually been rapid, and these are not considered a great threat to long-term reef health. More serious factors threatening long-term coral health are over-fishing, nutrification from farming and increasing populations (both resident and tourist), and algal overgrowths as a result of both of these.

Coral predation appears to occur at regular intervals, but does not usually affect the entire country at the same time. Currently the Mamanuca Islands are suffering an outbreak of Crown-of-Thorns Stars, now in its second year. This last happened in that area in 1996/1997, bearing out the 8-10 year cycle suggested in Australia. *Drupella* snails are also frequently found, but do not appear to have large-scale adverse effects unless they occur in the wake of another coral damaging event when they tend to concentrate on the few surviving corals.

The main finding from these six years of monitoring since the 2000 bleaching is that, on the whole, Fiji's reef system is remarkably resilient, with remarkably rapid coral re-growth in many areas. Over the country, many reefs returned to pre-bleaching coral cover levels in less than 6 years.

This appears to suggest that corals in Fiji can survive quite catastrophic events as long as they do not occur too often, perhaps not more than every 6 years, and this is a cause for optimism.

However, human-generated impacts such as over-fishing and careless development have the potential to seriously harm localised coral health in the long term, and should be controlled.

The future

FCRMN has now placed an extensive network of temperature loggers on many of the regularly surveyed sites, to collect long-term information about temperature variations in the different areas of Fiji. This data, coupled with regular survey information on reef health, will enable the network to identify areas at particular risk from, and areas of likely resilience to, future bleaching events.

Continuing survey work will provide information as to whether the reefs suffer regular setbacks which maintain them at or around the pre-bleaching level of health, or whether they will continue to improve and exceed those levels. Assessing speed of recovery will enable researchers to measure the likelihood of reef survival in the face of future events.

Over-fishing is a major stress on many of Fiji's reefs, and removal of grazing fish and invertebrates is a probable factor in much of the algal issues seen in many areas. Identification of areas with good fish and invertebrate populations is an important step to suggesting sites for protection and conservation. In particular, reefs that house endangered species could be suggested for the formation of no-take Marine Protected Areas.

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 probably take ten to fifteen 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.

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Cumming, R.L., Toscano, M.A., Lovell, E.R., Carlson, B.A., Dulvy, B.A., Hughes, A., Koven, J.F., Quinn, N.J., Sykes, H.R., Taylor, O.J.S., Vaughan, D.
"Mass Coral Bleaching in the Fiji Islands 2000".
Proceedings of the 9th International Coral Reef Symposium, Bali.

English, S., Wilkinson, C., and Baker, V.
"Survey Manual for Tropical Marine Resources" Second Edition
Australian Institute of Marine Resources 1997 ISBN 0 642 25953 4

Lovell, E.R., and Sykes, H.R.
"Status of Coral Reefs in the Fiji Islands, 2004"
In press, Institute of Marine Resources, University of the South Pacific

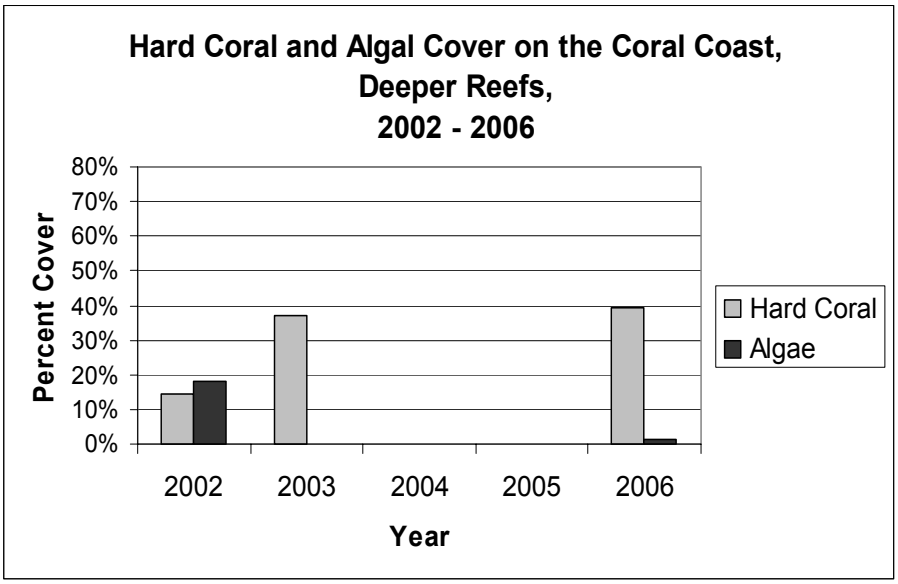
Section 6) - Regional details:

Coral, Fish and Invertebrates over time for each survey region.

a) Coral Coast

Figure a.1: Graph showing Hard Coral and Algal Cover, 2002 - 2006

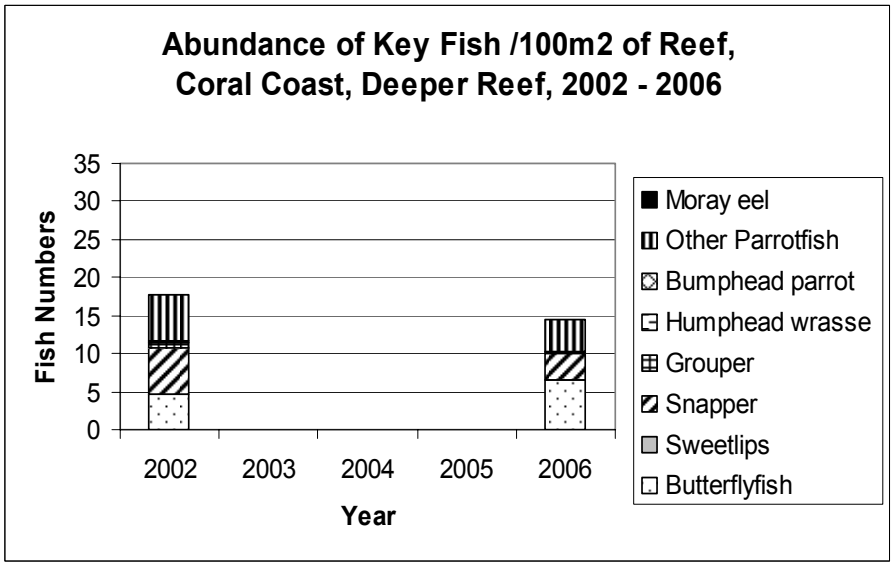
Note: No surveys were carried out in 2004 or 2005



Hard Coral is gradually increasing on the Coral Coast, and algal cover declining. Cover remains average to low for the country at 40% coral cover.

Figure a.2: Graph showing number of Indicator Fish, 2002 - 2006

Note: No surveys were carried out in 2003, 2004, or 2005



Indicator fish numbers are average, and as is typical for outer reef walls and slopes in the country, feature mostly Butterflyfish, Snapper and Parrotfish. No significant numbers of large food fish are seen, suggesting over fishing.

Fish numbers appear to have remained constant since 2002.

a) Coral Coast cont'd

Figure a.3: Graph showing number of Indicator Invertebrates, 2002 - 2006
Note: *Diadema* Urchins excluded from this graph for reason of scale.

No surveys were carried out in 2003, 2004, or 2005.

In 2006, a survey was carried out, but no invertebrates were seen.

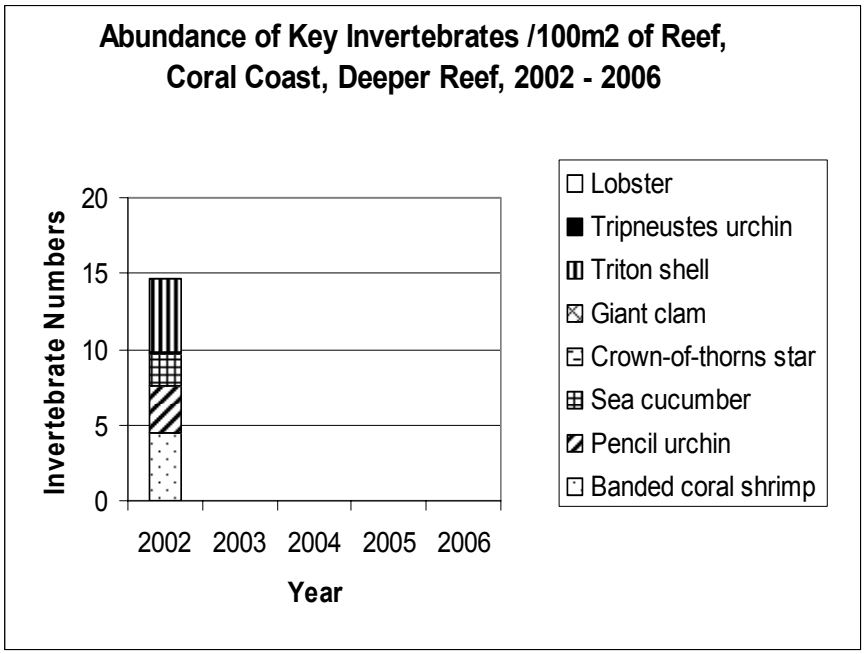
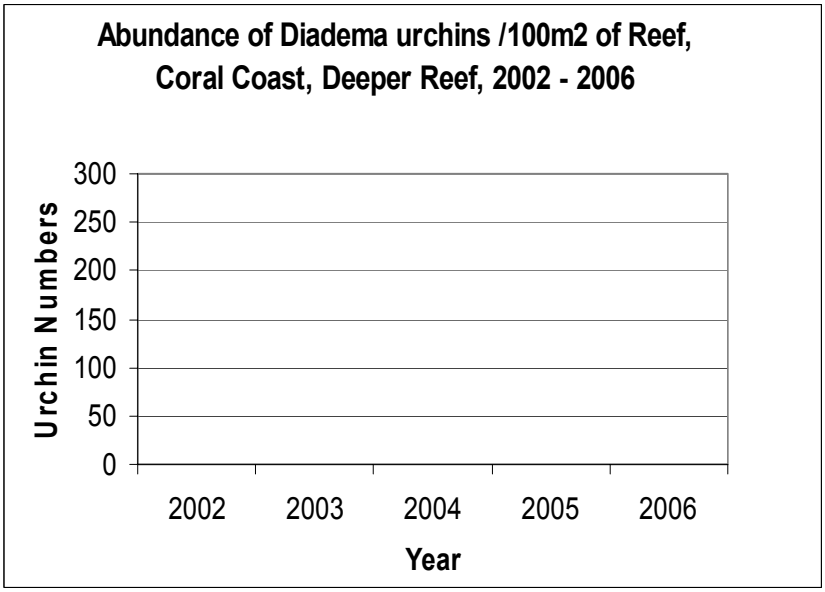


Figure a.4: Graph showing number of Diadema urchins, 2002 - 2006
Note: Includes *Diadema* species, plus *Echinostrephus aciculatus*

No surveys were carried out in 2003, 2004, or 2005.

In 2006, a survey was carried out, but no invertebrates were seen.

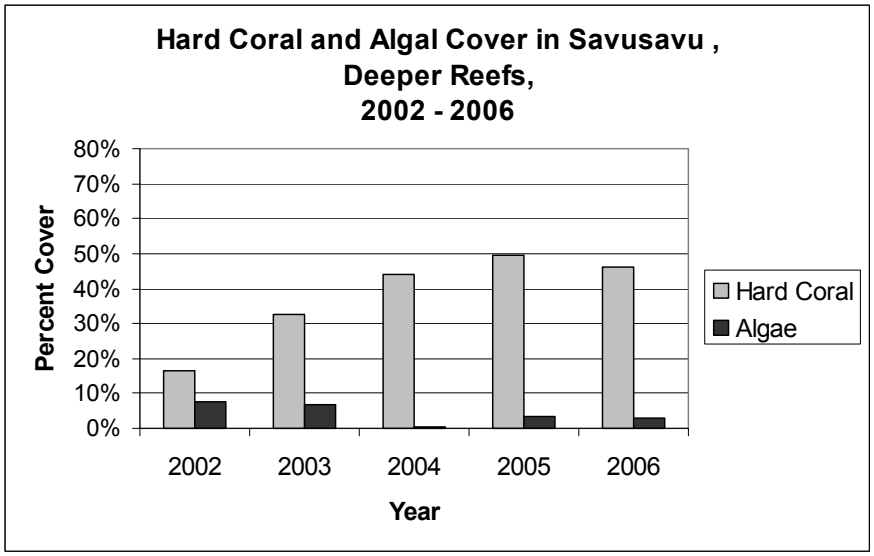


The invertebrates seen in 2002 were mostly the less common ones, Banded Coral Shrimp, Pencil Urchin, and Triton Trumpet Shell.

In general the area is low in the commonest Macro-Invertebrates such as Sea Cucumbers and Giant Clams. No Crown of Thorns were seen.

b) Savusavu

Figure b.1: Graphs showing Hard Coral and Algal Cover, 2002 - 2006



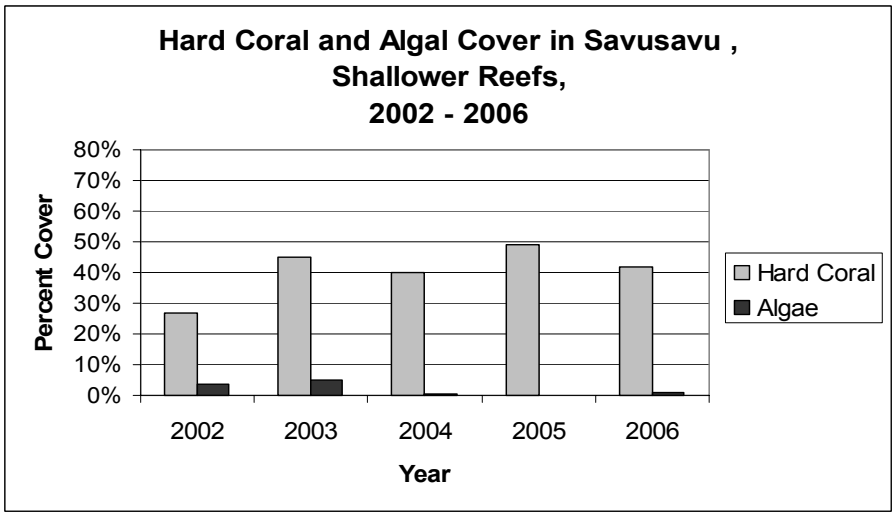
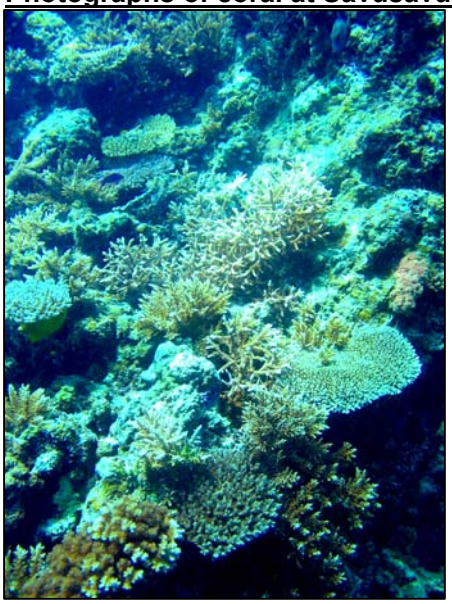
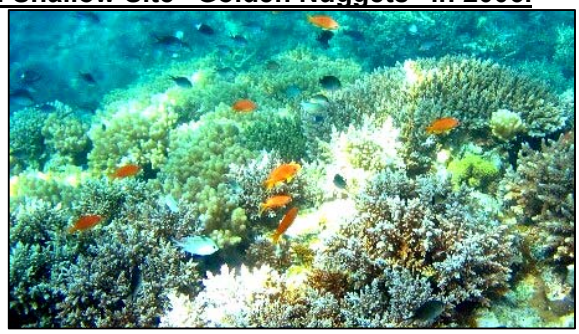


Figure b.2:
Photographs of coral at Savusavu Shallow Site "Golden Nuggets" in 2006.

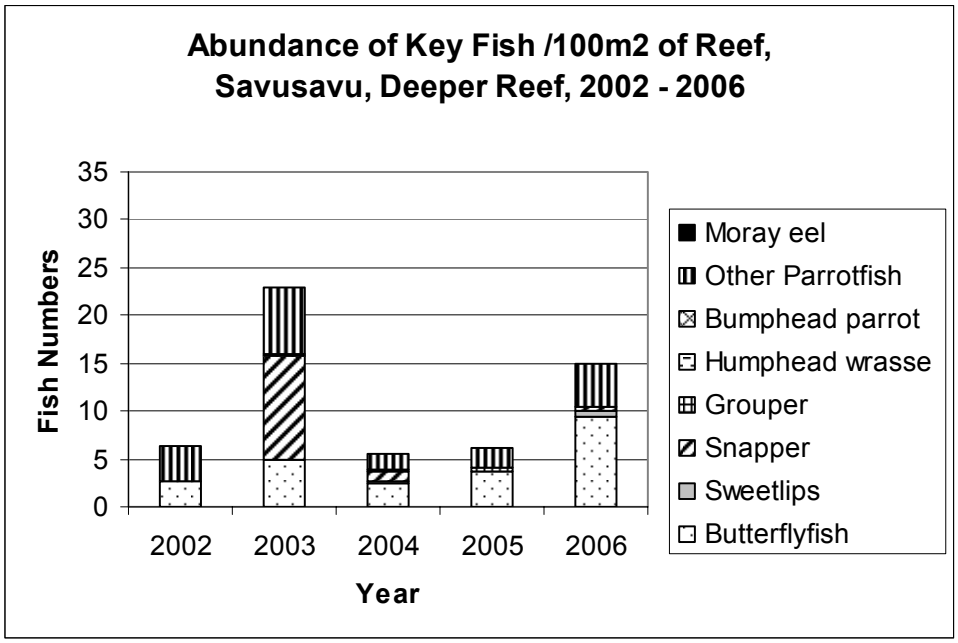


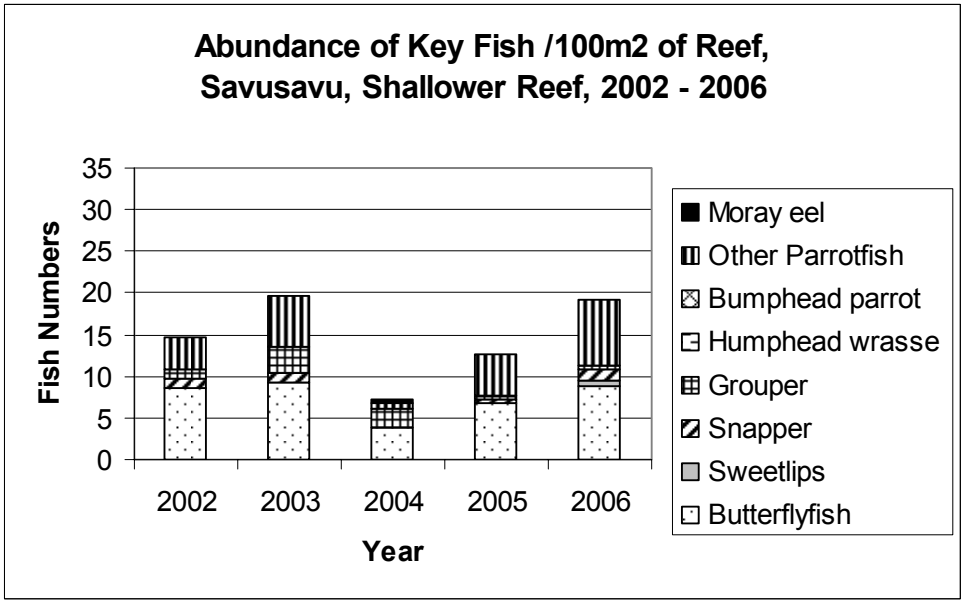


Coral cover at both depths has been steadily increasing since 2002, and is probably now at or higher than pre-bleaching levels. Algal cover has decreased since 2003, and the reef now appears to have a healthy balance of average (40 – 50%) coral and low algal cover.

B) Savusavu cont'd

Figure b.3: Graphs showing number of Indicator Fish, 2002 - 2006





On reefs at both depths, fish numbers appeared to drop in 2004, but are now back to 2002 / 2003 levels.

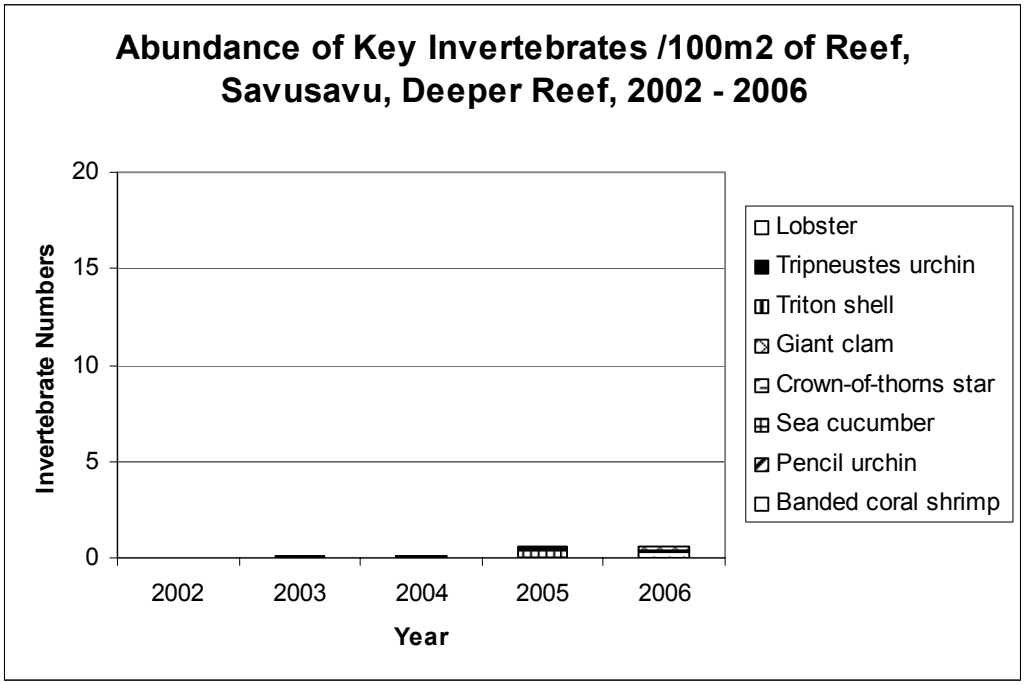
In particular Butterflyfish numbers are steadily rising. This may be due to improving coral cover, as many butterfly fish feed in and on live corals.

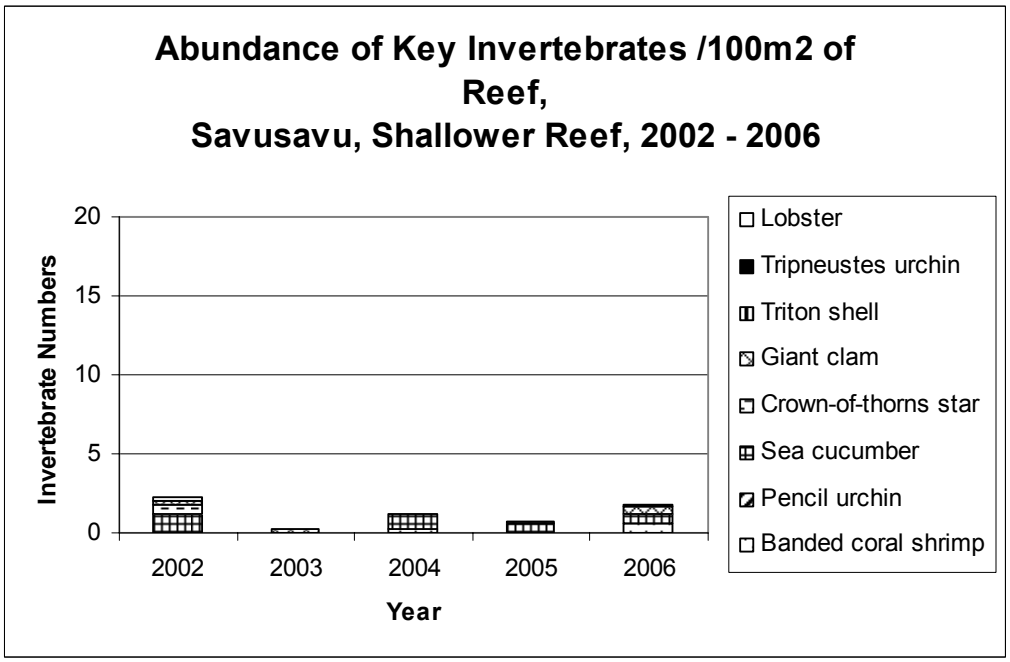
The shallower reef had relatively high Grouper populations in 2003 and 2004, but this is not reflected in 2005 or 2006, so fishing pressures may be increasing.

b) Savusavu cont'd

Figure b.4: Graph showing number of Indicator Invertebrates, 2002 - 2006

Note, *Diadema* Urchins excluded from this graph for reason of scale.





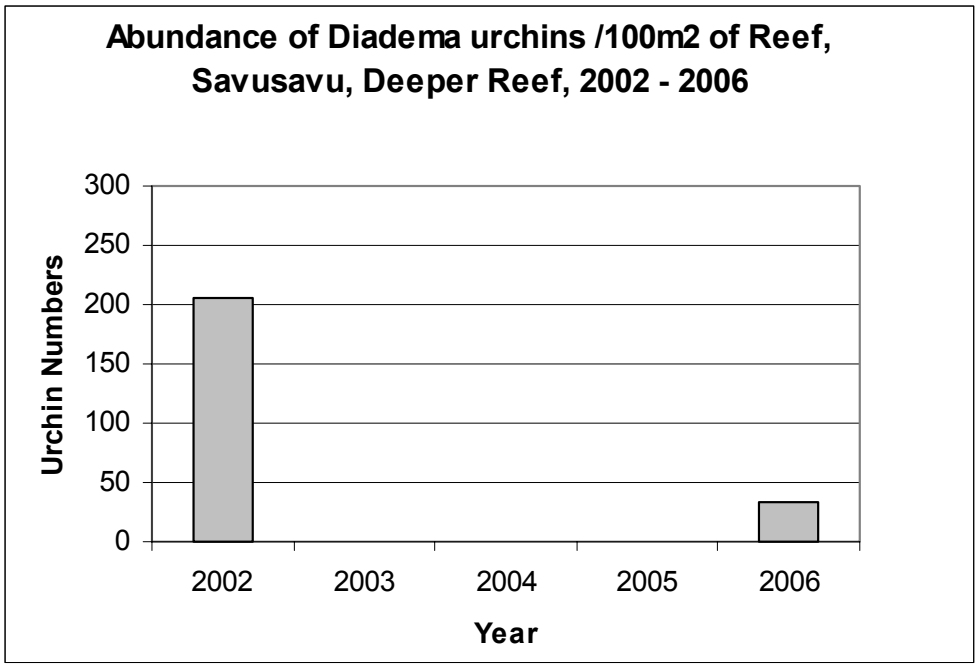
Invertebrate numbers are low on all reefs, although slightly more Sea Cucumbers, Giant Clams and Lobsters are found on the shallow reefs than the deeper ones.

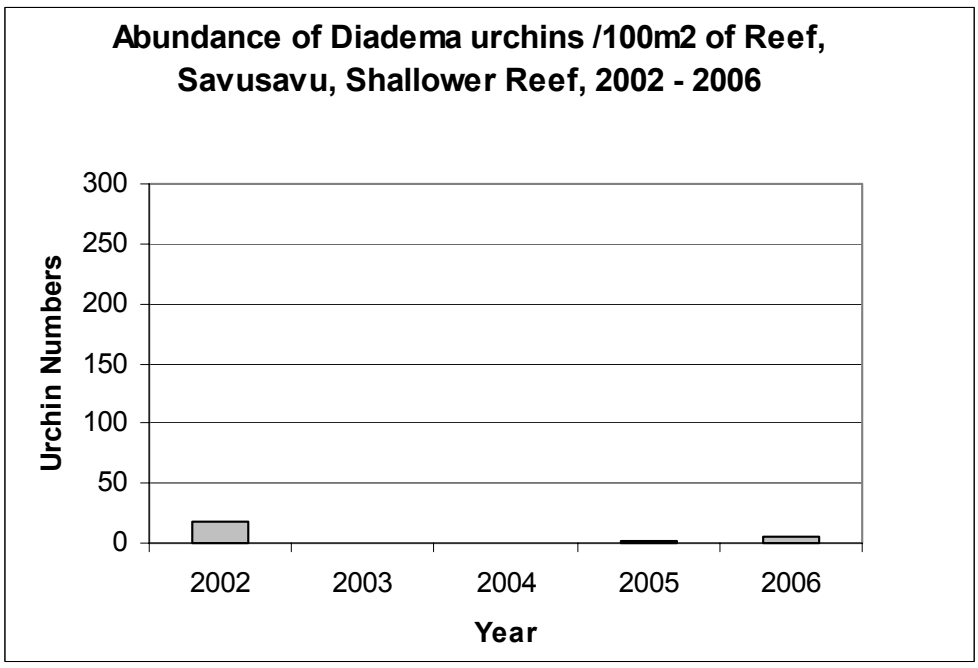
There is no evident pattern of change since 2002.

b) Savusavu cont'd

Figure b.5: Graph showing number of Diadema urchins, 2002 - 2006

Note: Includes *Diadema* species, plus *Echinostrephus aciculatus*





Large numbers of the small rock-boring urchin *Echinostrephus aciculatus* are seen on the deeper reefs, and fewer in the shallows.

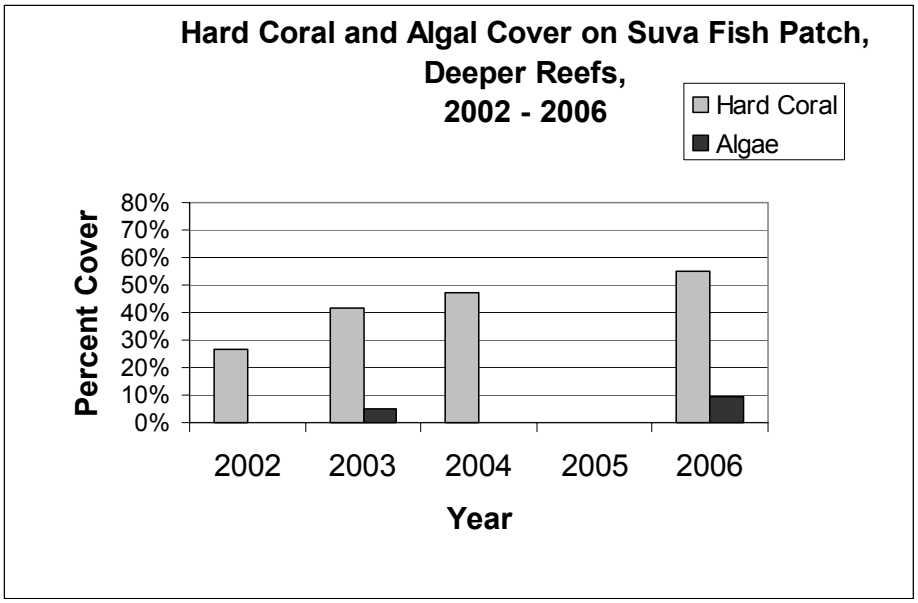
These urchins tend to exist in very dense colonies which are distributed patchily across the reef, and whether they are seen during surveys depends very much on tape placement. There is no evident pattern of increase or decrease of these urchins.

c) Suva Harbour – Fish Patch only

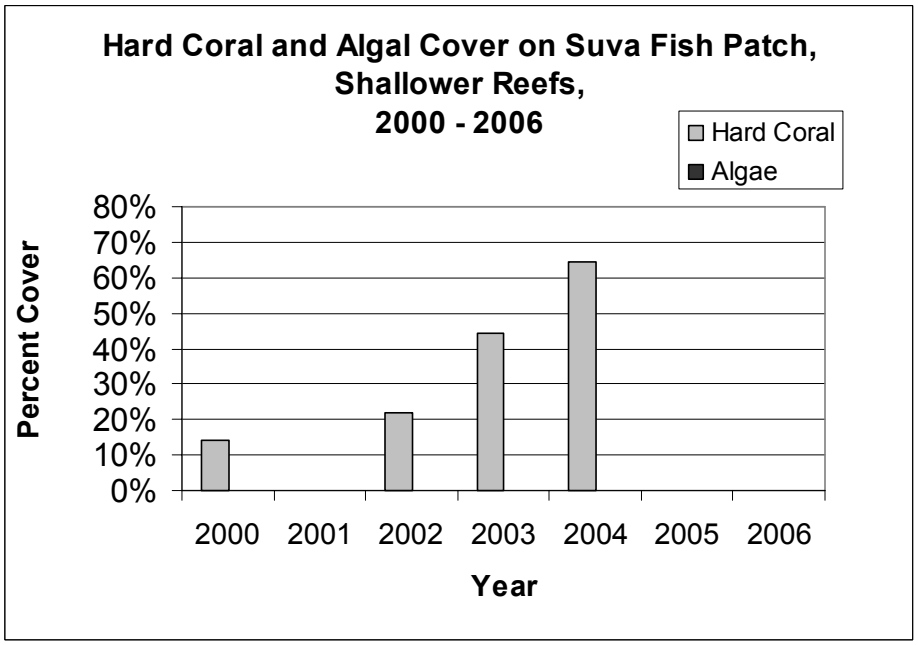
There are several other survey sites within Suva harbour, which were included in the 2004 Status Report, but as they were not surveyed in 2005 or 2006 due to logistical constraints, only Fish Patch is presented here.

Figure c.1: Graph showing Hard Coral and Algal Cover, 2002 - 2006

Note- no surveys were conducted in 2005



Note- no surveys were conducted in 2001, 2005 or 2006



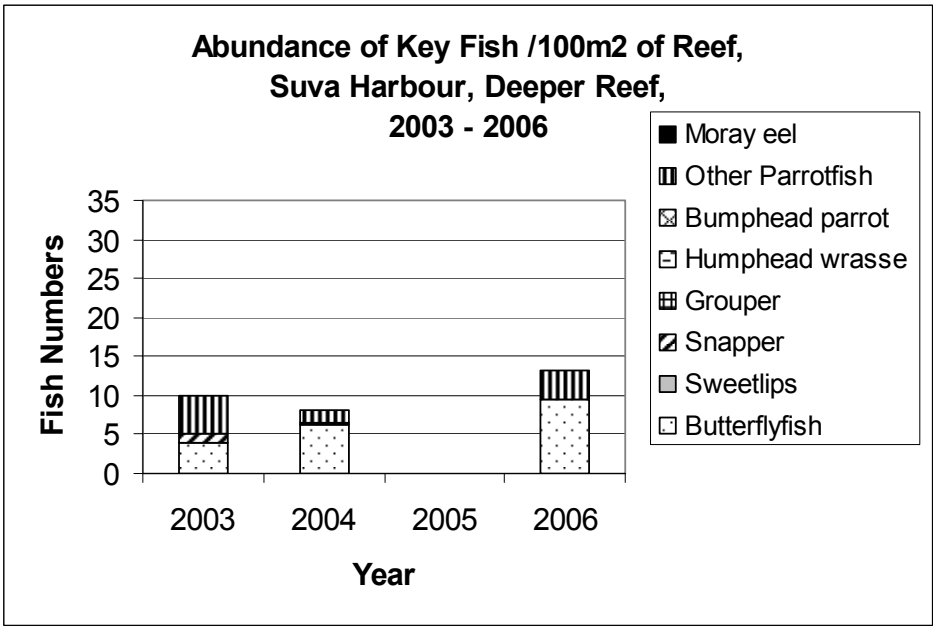
Both depths show a steady increase in coral cover, which is now high (50 – 65%). Considering that the Integrated Threat Index carried out in the 2004 Status report *(Lovell and Sykes 2004)* identified Suva Harbour as a high risk area, the coral health is remarkable.

Very little algae are seen on the shallower reefs, but there was 10% cover on the deeper reef in 2006, which is relatively high for the area.

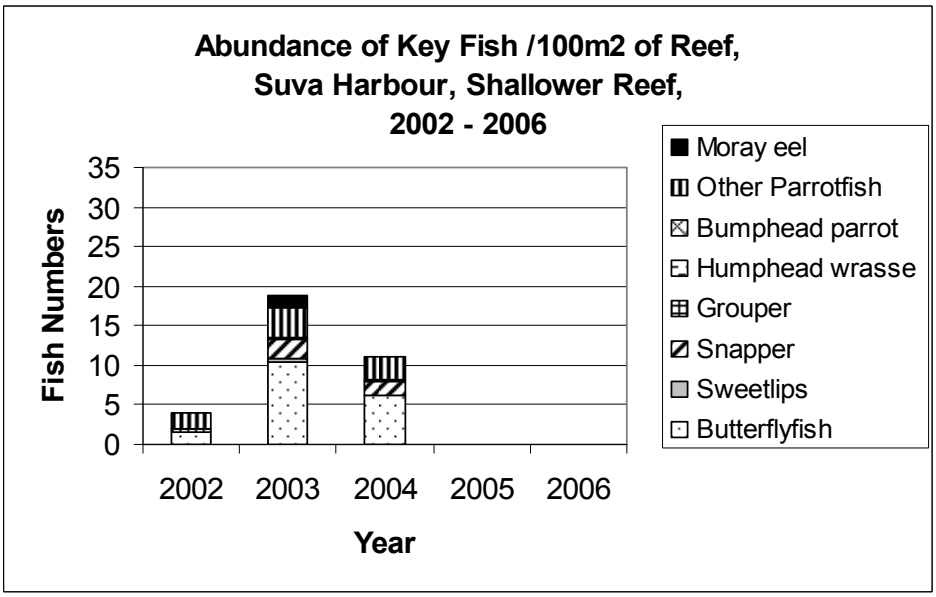
c) Suva Harbour cont'd

Figure c.2: Graph showing number of Indicator Fish, 2002 - 2006

Note- no surveys were conducted in 2005



Note- no surveys were conducted in 2005 or 2006



The reef has average to high populations of indicator fish, with particularly high number of Butterflyfish, reflecting the high coral cover on which they are dependant.

Other indicator species are typical of Fiji, with low numbers of large food fish types, indicative of high fishing pressures.

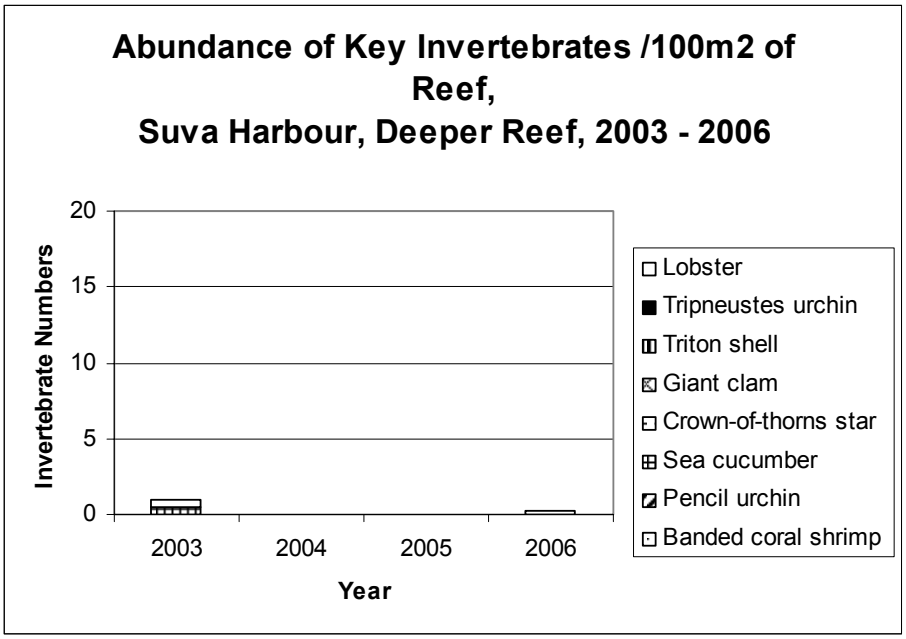
There are no obvious alterations in patterns of fish populations, suggesting that pressures are remaining constant.

C) Suva Harbour cont'd

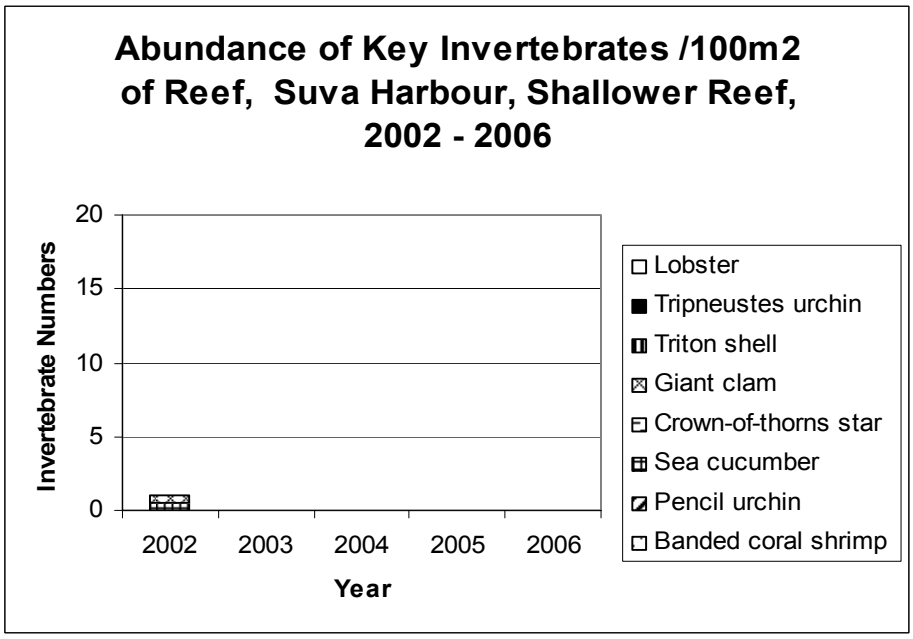
Figure c.3: Graph showing number of Indicator Invertebrates, 2002 - 2006

Note, *Diadema* Urchins excluded from this graph for reason of scale.

Note- no surveys were conducted in 2002 or 2005



Note- no surveys were conducted in 2005 or 2006

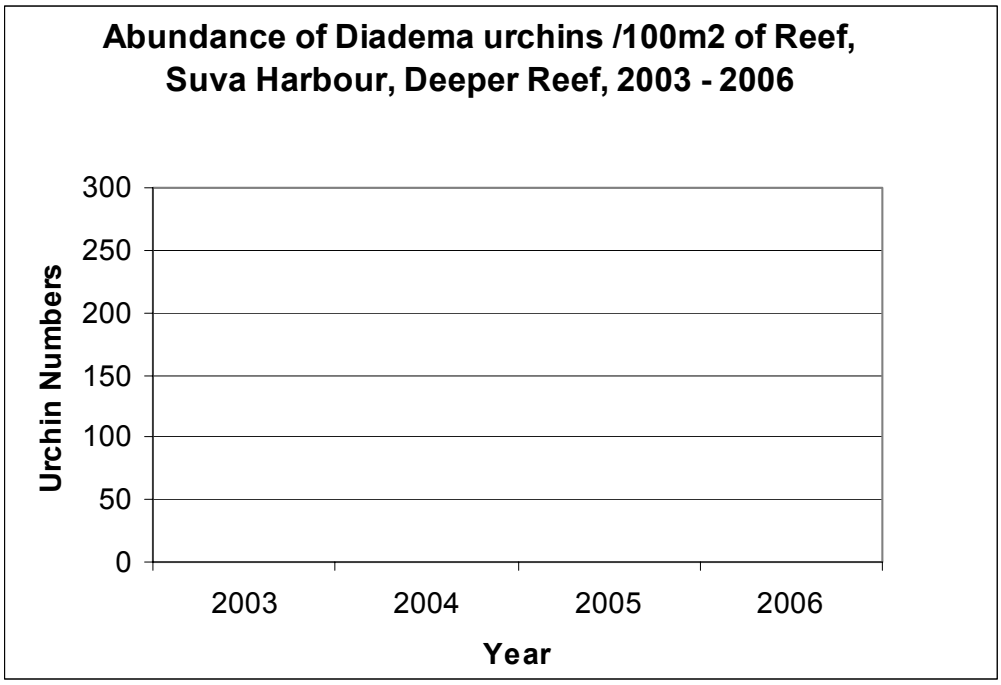


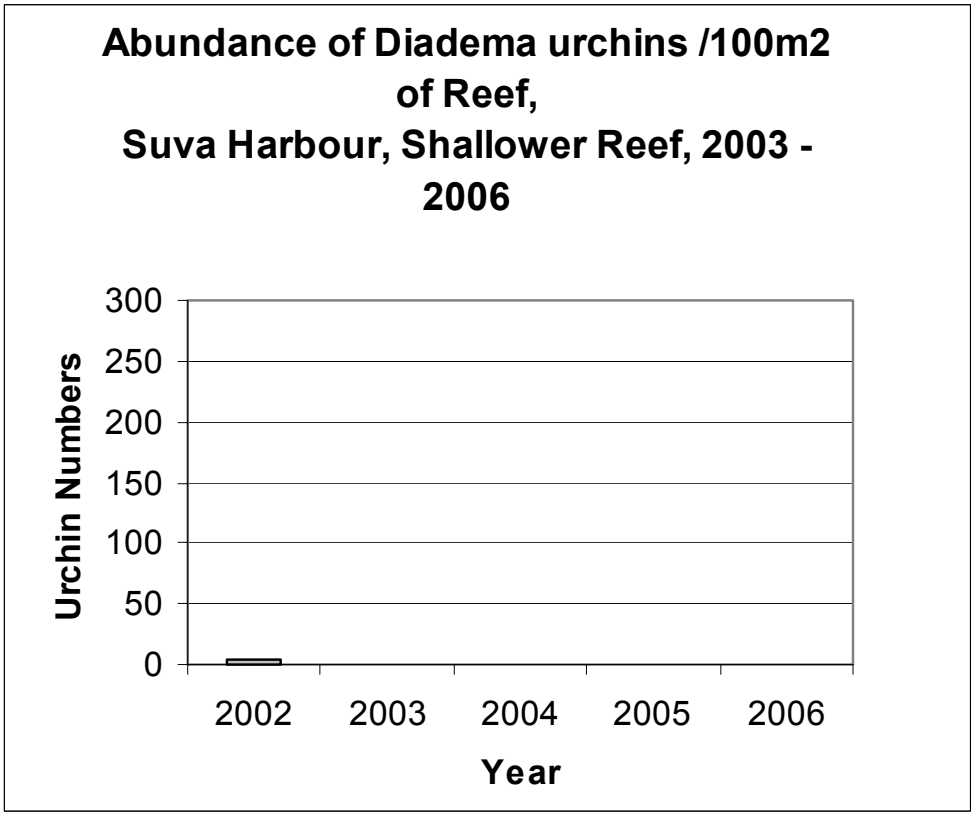
Very few or no invertebrates were seen on this reef, with a solitary Sea Cucumber and Giant Clam seen in 2002 and not since. A single Lobster was seen on the deeper reef in 2002 and in 2006.

c) Suva Harbour cont'd

Figure c.4: Graph showing number of Diadema urchins, 2002 - 2006

Note: Includes *Diadema* species, plus *Echinostrephus aciculatus*

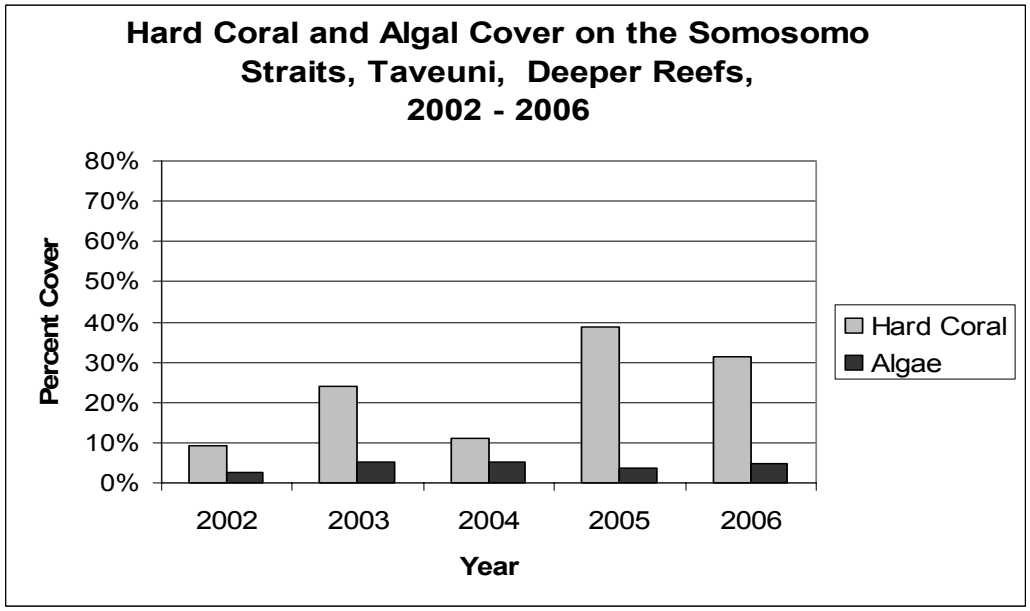


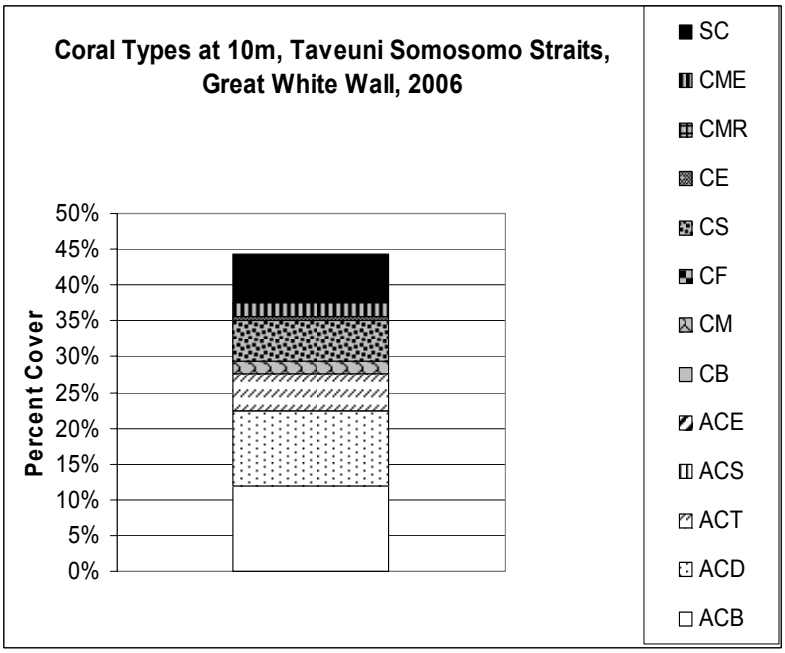


No, or very few, *Diadema* urchins are usually seen, at either depth. This may reflect over-fishing of predatory Triggerfish species.

d) Taveuni, West - Somosomo Straits

Figure d.1: Graphs showing Hard Coral and Algal Cover, 2002 - 2006





Hard coral has been slower to regenerate in Taveuni than in other areas of the Fiji Islands. This may be due to Taveuni's location, as there are no large areas of healthy reef up-current of the area, and therefore no source of new coral polyps. (Similar slow regeneration has been noticed in the Lau Islands, east of Taveuni.)

The hard coral cover has fluctuated quite a lot over the years of surveys, rather than showing the smooth increase found in some other areas of Fiji. This may have been due to cyclone damage in 2003 (Cyclone Ami passed directly over Taveuni). Hard coral cover is currently low (30 – 40%), but increasing, and many of the corals are new *Acropora* Branching and Table forms.

The reef is of a different character to many other Fijian reefs, with its highly coloured *Dendronepthea* soft coral, and low hard coral cover, but is in good and improving condition. *Dendronepthea* soft coral remained unaffected by the bleaching.

Algal cover is low and appears constant, indicating no affects of land-based pollution or over-fishing.

d) Taveuni, West - Somosomo Straits cont'd

Figure d.2: Photographs of coral at Taveuni Somosomo Straits in 2006.

"Great White Wall" at 10 metres

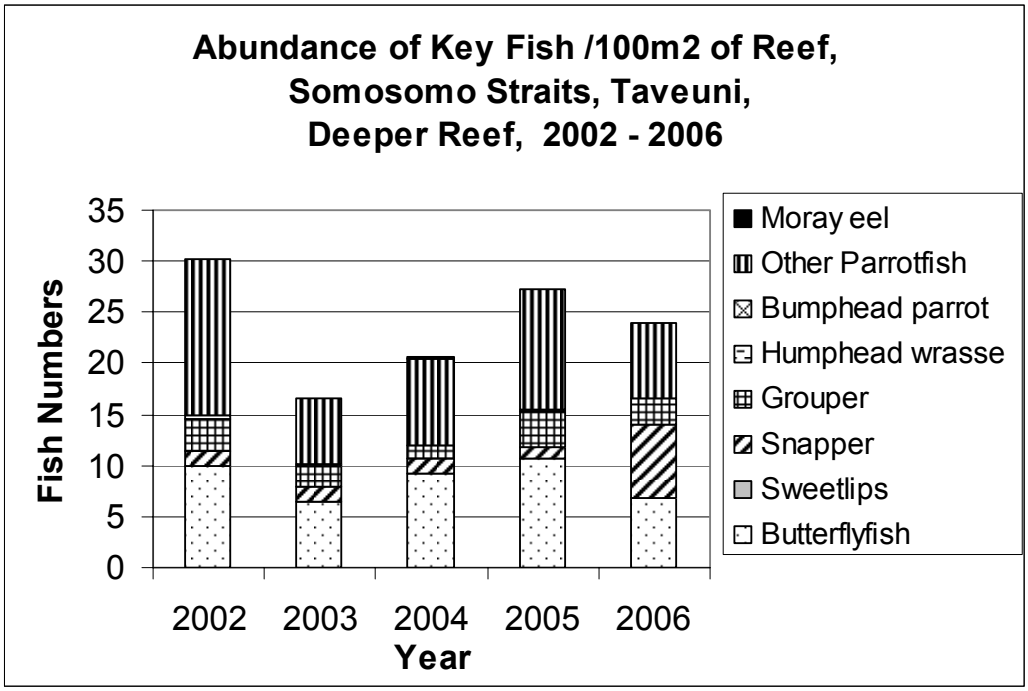
Dendronepthea soft corals are found mostly on the deeper walls at this site, but the reef flats at 10 metres are showing a great deal of new hard corals growth, in particular *Acropora* and *Pocillopora* families.

"Rainbow Reef" at 9 metres

Many of the reef slopes show low hard coral cover, and high sponge and soft *Dendronepthea* coral cover, although hard corals cover is increasing. Large schools of Snappers, Fuseliers, and other fish are found, as well as large Groupers, Emperors and Humphead Wrasse.

d) Taveuni, West - Somosomo Straits cont'd

Figure d.3: Graph showing number of Indicator Fish, 2002 - 2006



Indicator Fish numbers are much higher than found in many areas of Fiji, and larger food fish species are found here as well as the normal Butterflyfish, Snapper and Parrotfish. In particular large Grouper are often seen, and although not recorded during surveys, there are quite large populations of the endangered Humphead Wrasse.

Fish populations appeared to decline in 2003, but have been improving since. This area does not appear to be as badly affected by fishing pressures as many areas of Fiji, and this is probably due to its location far from shore and in rough waters, in an area of quite low local populations.

Although not recorded in these surveys, empirical observations have been made of gradually falling numbers of large pelagic fish in these waters, such as shark, mackerel and barracuda. This may be related to an increasing number of Long-line fishing boats seen in the region.

The area would be a strong candidate for protection against such fishing while populations of such large fish still exist.

d) Taveuni, West - Somosomo Straits cont'd

Figure d.4: Graph showing number of Indicator Invertebrates, 2002 - 2006

Note, *Diadema* Urchins excluded from this graph for reason of scale.

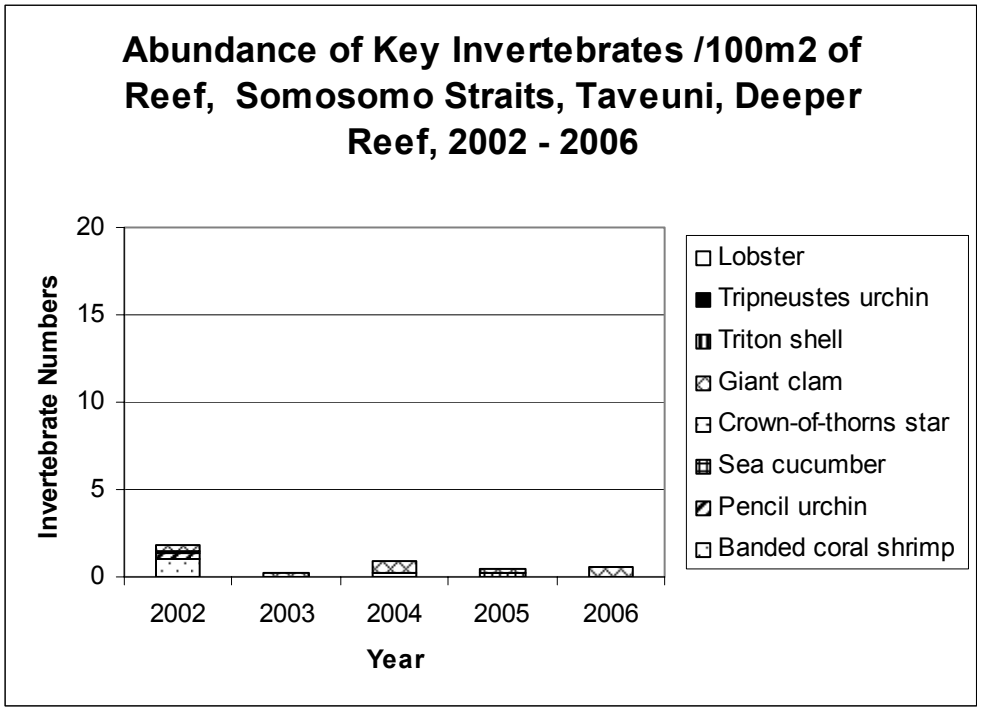
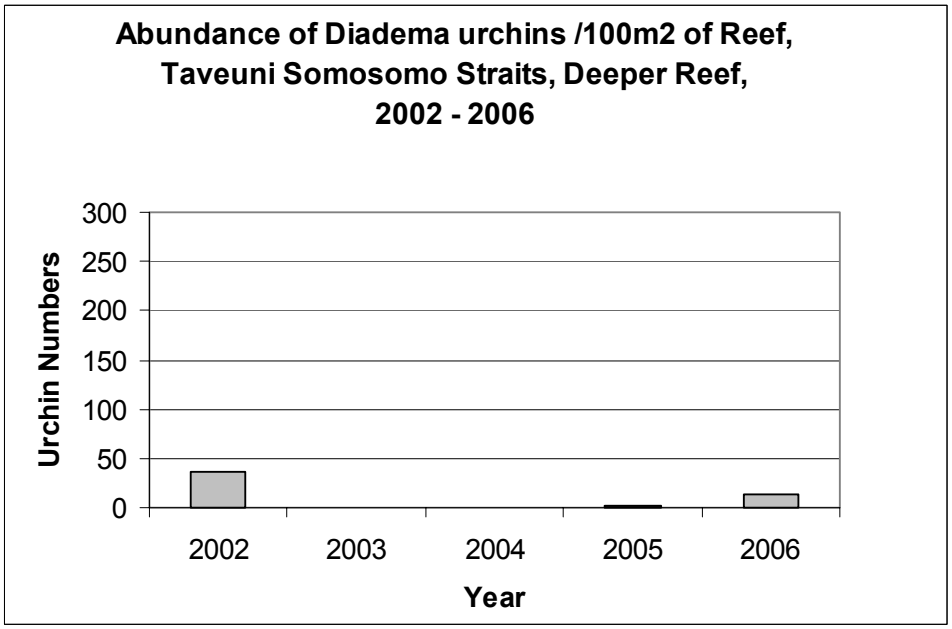


Figure d.5: Graph showing number of Diadema urchins, 2002 - 2006

Note: Includes *Diadema* species, plus *Echinostrephus aciculatus*



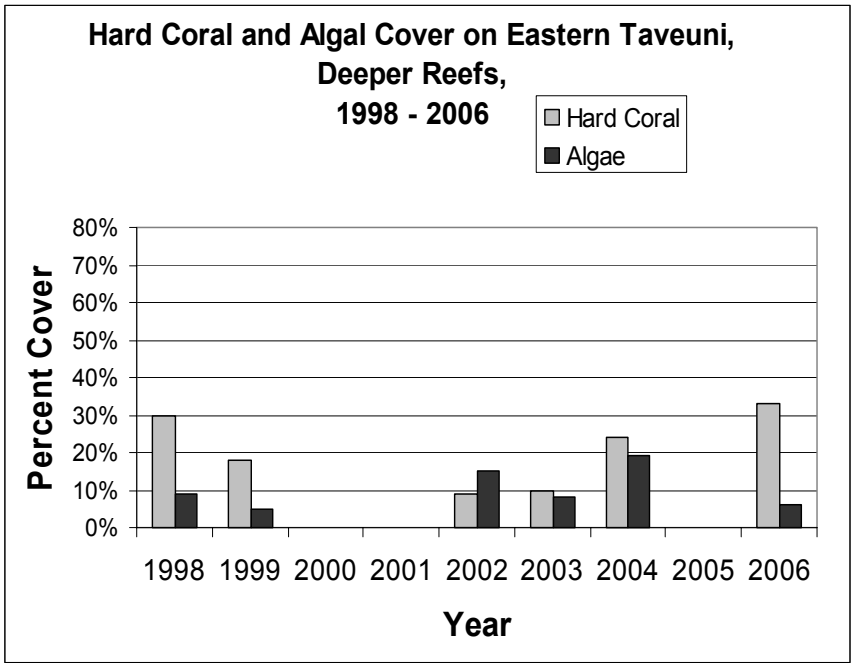
As most places in Fiji, Macro-Invertebrate numbers are low, although small Giant Clams are regularly seen on the surveys. As it is very unlikely that invertebrate fishing by humans takes place on this reef, it is supposed that the low invertebrate numbers are the result of natural predation by the high fish population.

e) Taveuni, East – Waitabu

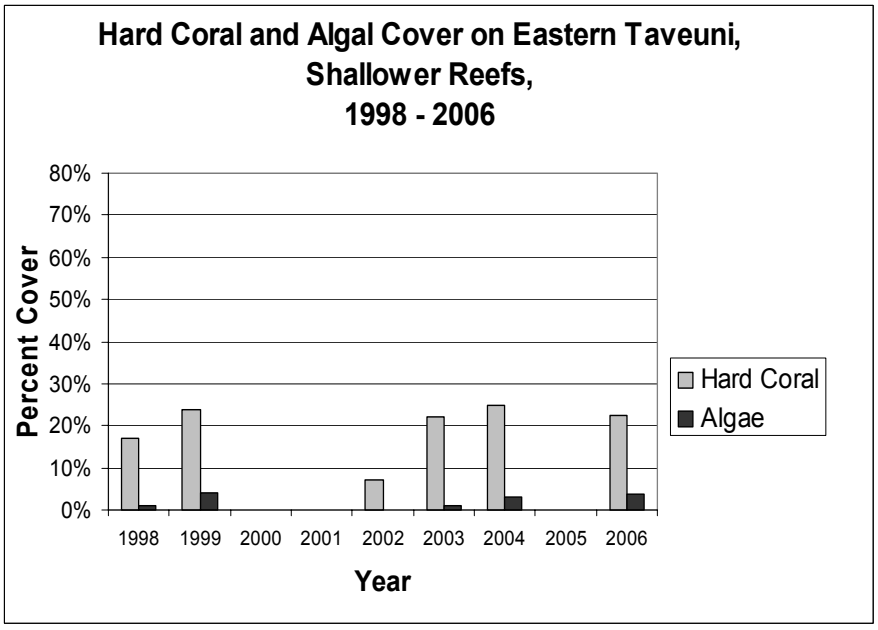
Figure e.1: Graph showing Hard Coral and Algal Cover, 1998 - 2006

Note, no surveys were conducted in 2000 or 2001.

In 2005 a single line survey gave unrepresent-ative data and is excluded.



Note, no surveys were conducted in 2000, 2001, or 2005



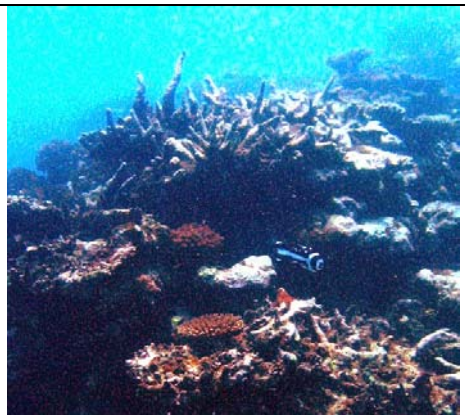
As in the Somosomo Straits, hard coral cover in Taveuni was slow to regenerate after the 2000 bleaching, presumably due to a lack of healthy reef up-current of the area, and therefore no source of new coral polyps. For several years the reef had very low coral cover and very high algal cover.

By 2006 coral cover had started to regenerate in earnest, especially a large area of branching *Acropora* which had been completely dead and covered in algae since 2000, but showed many patches of new coral growth in 2006.

On the deeper reef, algal cover had dropped by 2006.
No Fish or Invertebrate data is available

e) Taveuni, East – Waitabu cont'd

Figure e.2: Photographs of corals at Waitabu 2005 and 2006.

2005	2006
	
	
	
	

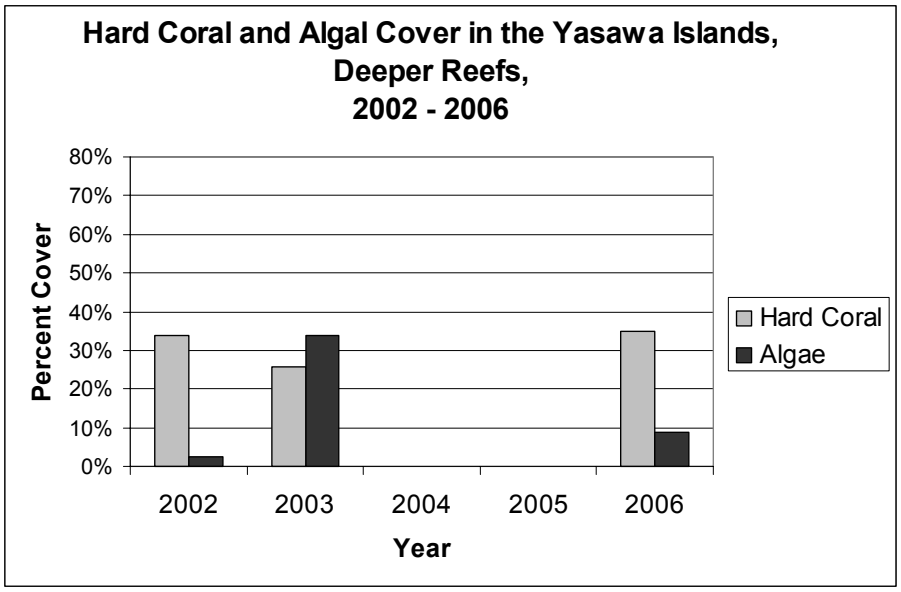
f) Yasawa Islands

Figure f.1: Graph showing Hard Coral and Algal Cover, 2002 - 2006

No surveys were conducted in 2004 or 2005

Coral cover appears to be fairly constant on the deeper reefs, but improving on the shallower ones.

Overall the situation in the Yasawas over the past few years has been one of low coral cover (30-35%), and high algal cover.



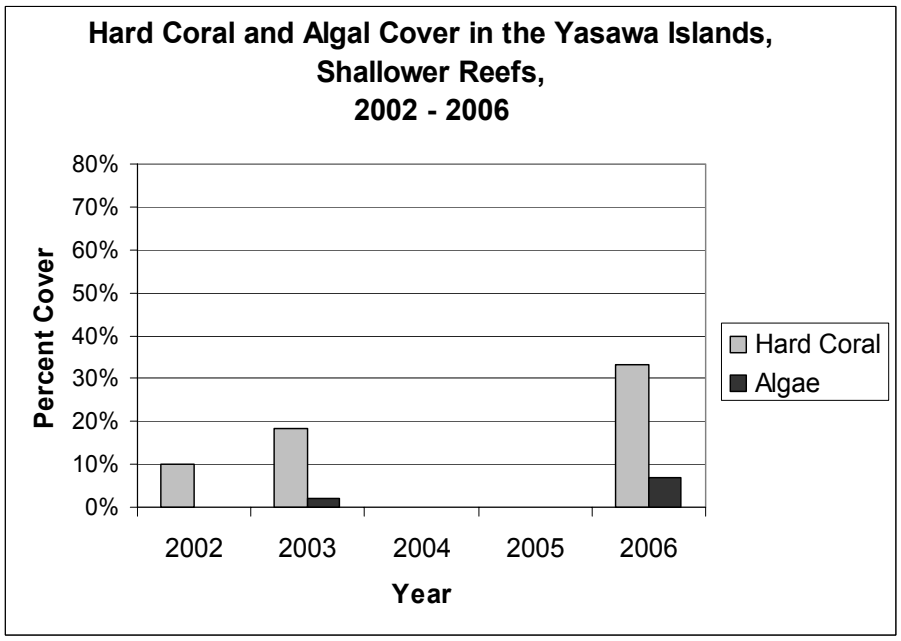


Figure f.2: Photographs showing Corals at 10m and 5m in 2006

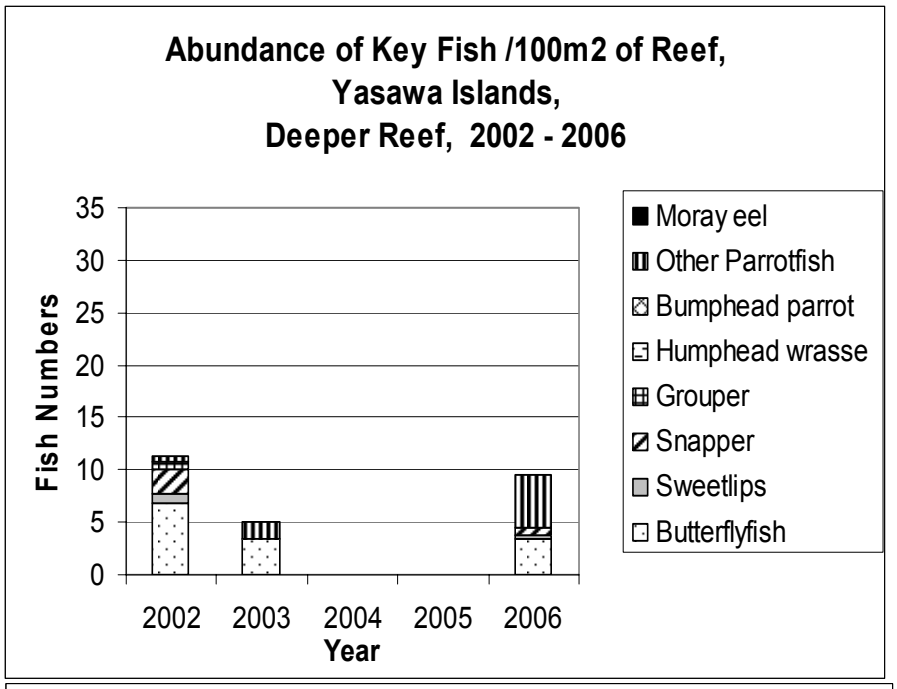
10m 

5m 

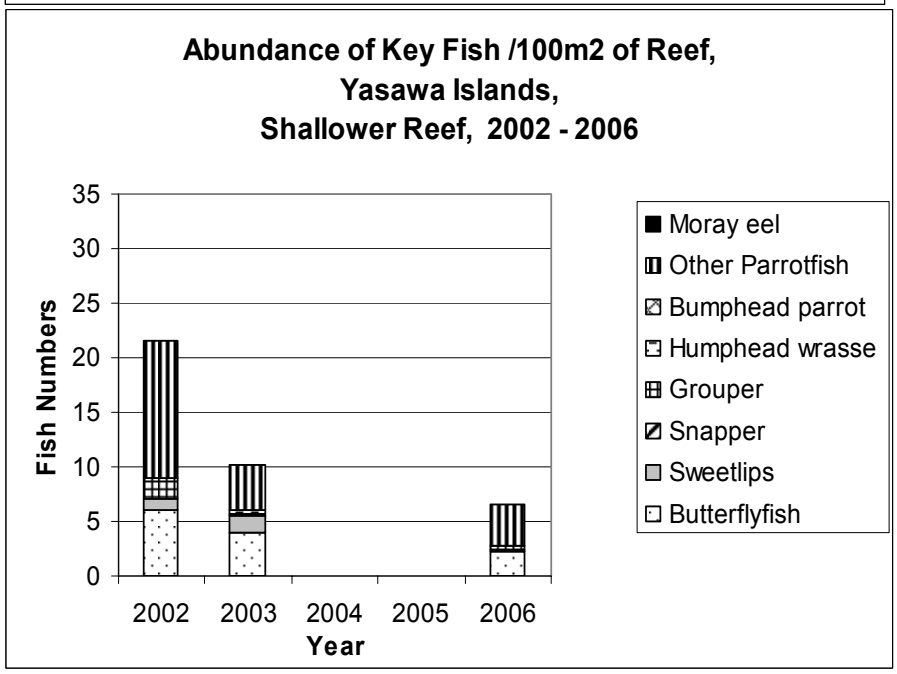
f) Yasawa Islands cont'd

Figure f.3: Graph showing number of Indicator Fish, 2002 - 2006

No surveys were conducted in 2004 or 2005



No surveys were conducted in 2004 or 2005



In the past, Indicator fish numbers have been higher on the shallower reef than the deeper ones, due to the occasional presence of schools of small Snappers on the shallower reef top. In 2006 populations were similar on both deep and shallow reefs.

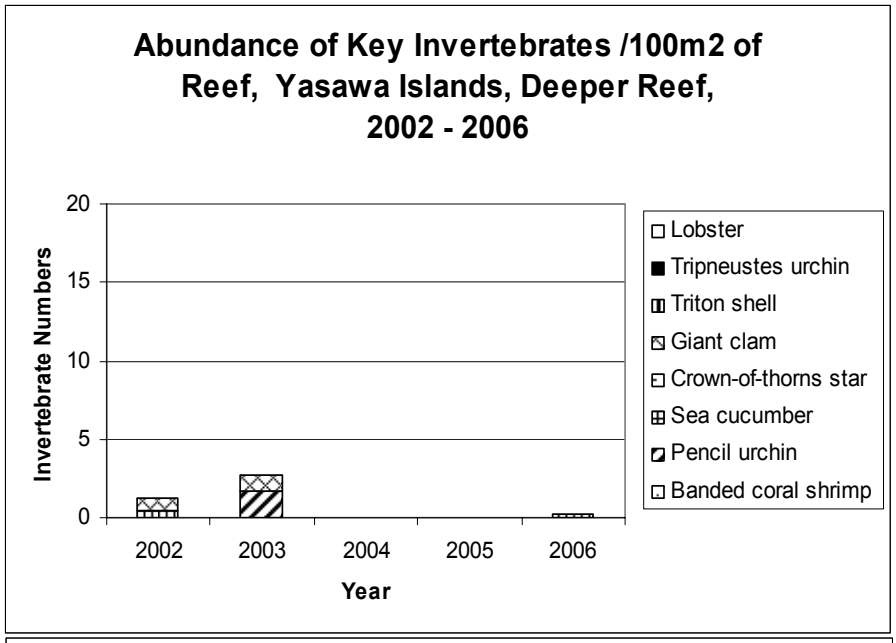
Very few or no Groupers are seen, but Sweetlips have been seen in some areas. As these are one of the most targeted fish during spearfishing activities, this suggests that spearfishing is not the largest pressure on some Yasawa reefs.

f) Yasawa Islands cont'd

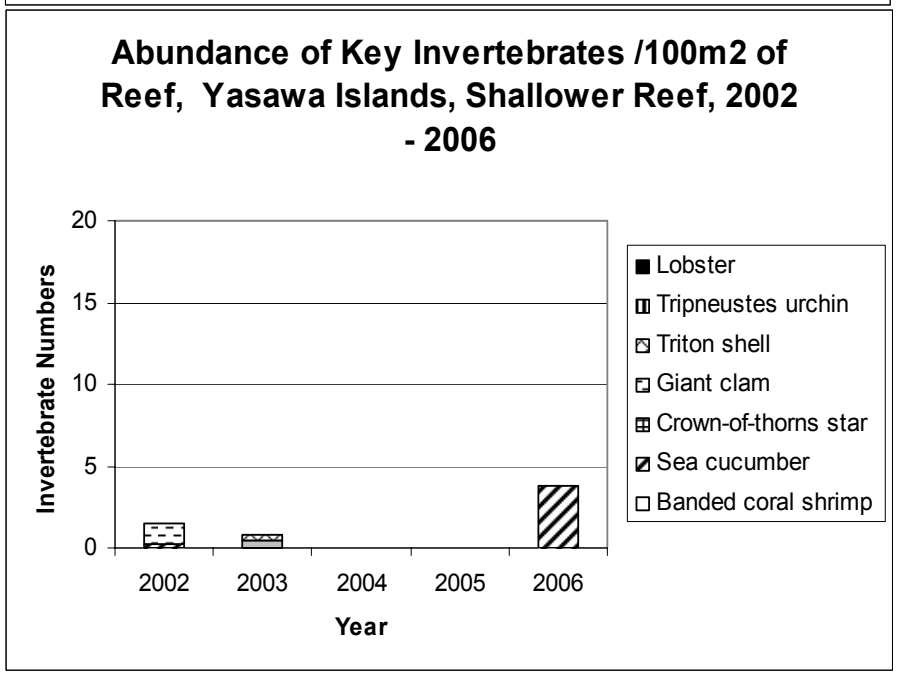
Figure f.4: Graph showing number of Indicator Invertebrates, 2002 - 2006

Note, *Diadema* Urchins excluded from this graph for reason of scale.

No surveys were conducted in 2004 or 2005



No surveys were conducted in 2004 or 2005



Several Sea Cucumbers have been seen during the Yasawa surveys, as well as a few small Giant Clams. Large numbers of the commercially important "Greenfish" Sea Cucumber *Stichopus chloronotus* were seen on the shallow reef in 2006.

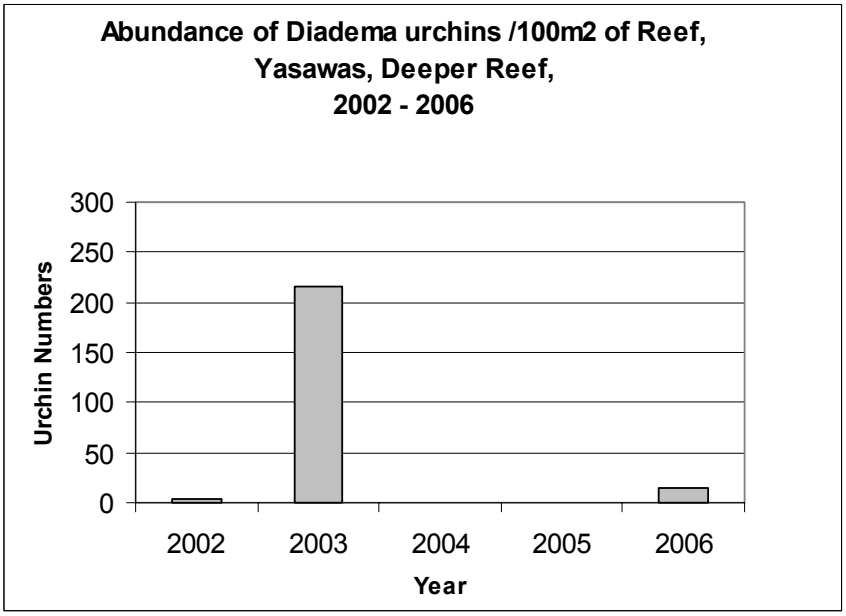
There is no apparent pattern of invertebrate populations relating to coral health.

f) Yasawa Islands cont'd

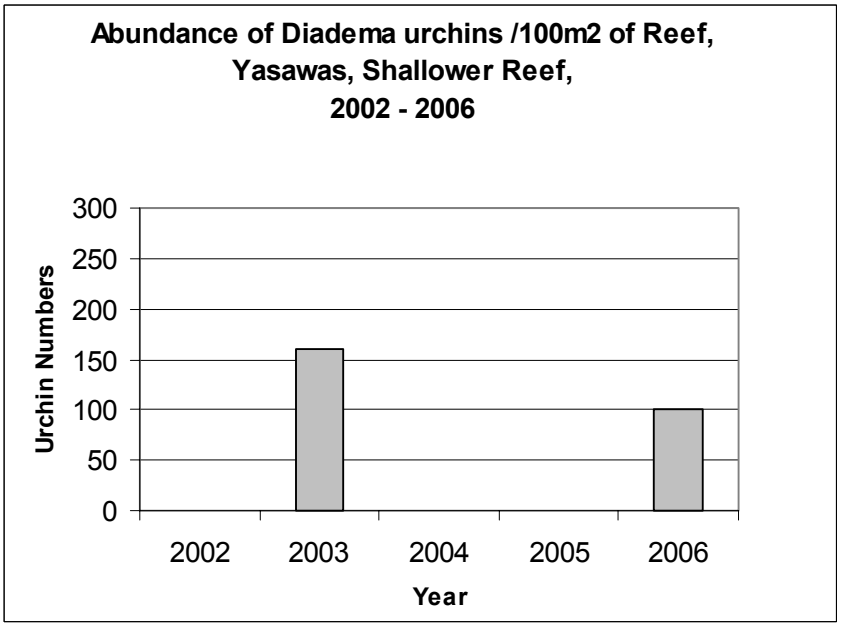
Figure f.5: Graph showing number of Diadema urchins, 2002 - 2006

Note: Includes *Diadema* species, plus *Echinostrephus aciculatus*

No surveys were conducted in 2004 or 2005



No surveys were conducted in 2004 or 2005



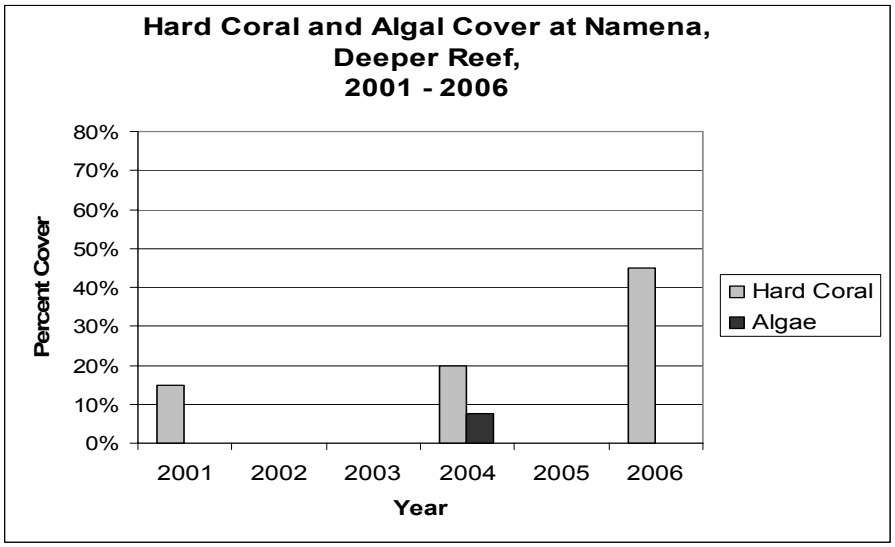
Large numbers of the small rock-boring urchin *Echinostrephus aciculatus* were found in 2003 and 2006. There is no suggestion of a change in the numbers of these urchins, as they are found in patches, and differences in numbers are probably due to survey site variation.

These large numbers of urchins may be related to over-fishing of predators such as Triggerfish.

g) Namena

Figure g.1: Graph showing Hard Coral and Algal Cover, 2002 - 2006

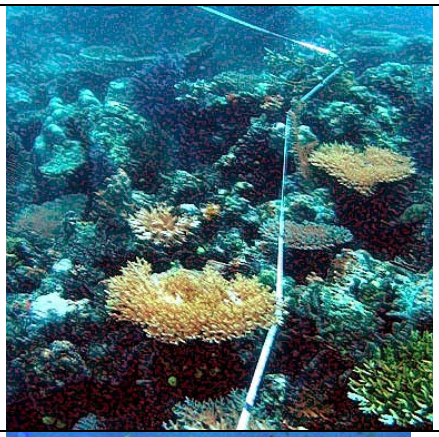
No surveys were conducted in 2002, 2003 or 2005



Although surveys have been intermittent at this site, hard coral cover can be seen to be steadily rising over time, so that by 2006 the cover was average to good (45%), compared to the 15% coral that survived the bleaching of 2000.

Algal cover is generally low,
No Fish or Invertebrate data is available.

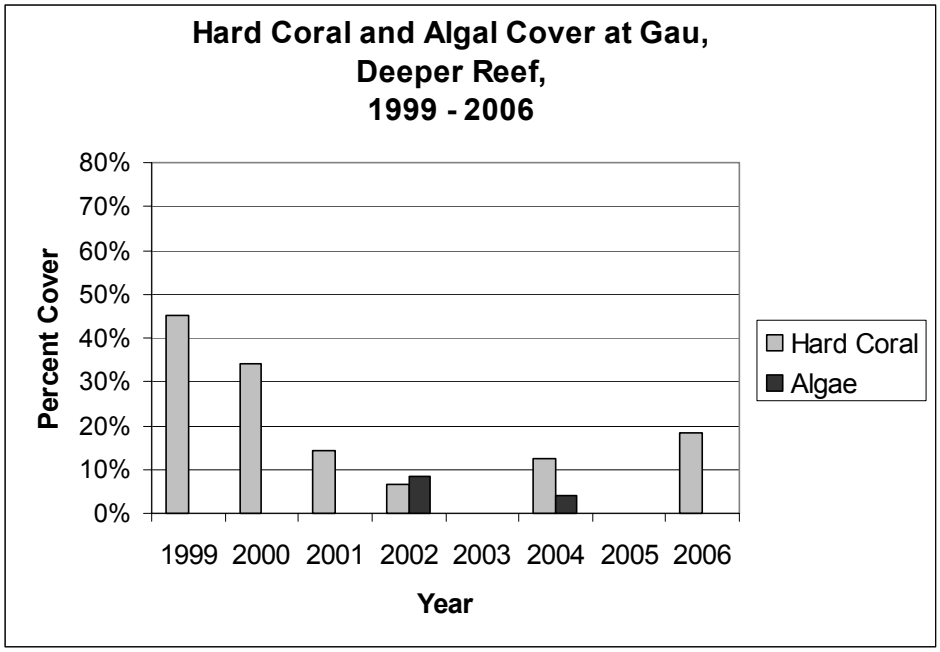
Figure g.2: Photographs of corals at Namena 2004 and 2006

2004	2006
	
	

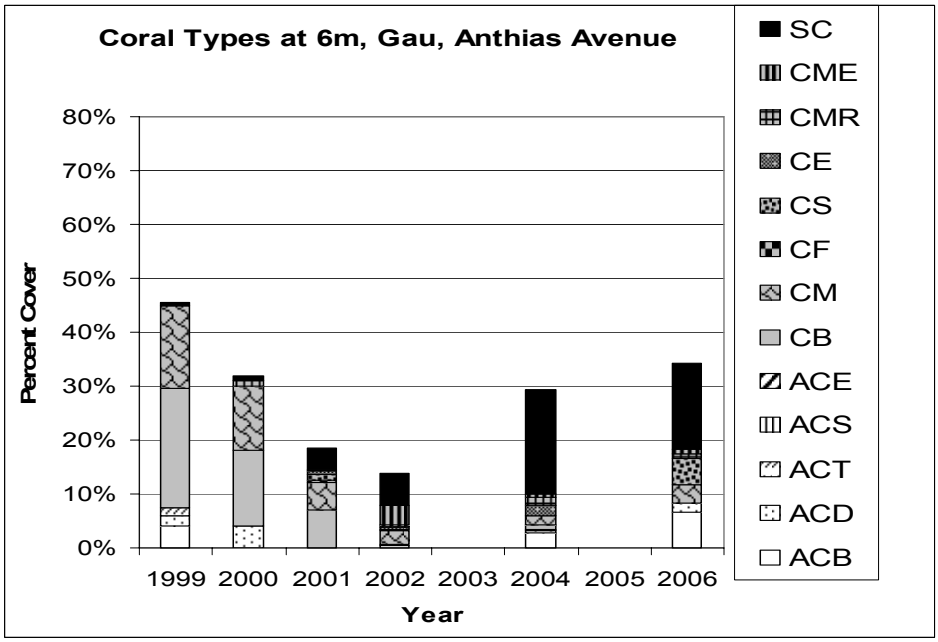
h) Gau, Passage - Anthias Avenue

Figure h.1: Graphs showing Hard Coral and Algal Cover, 2002 - 2006

No surveys were conducted in 2003 or 2005



No surveys were conducted in 2003 or 2005



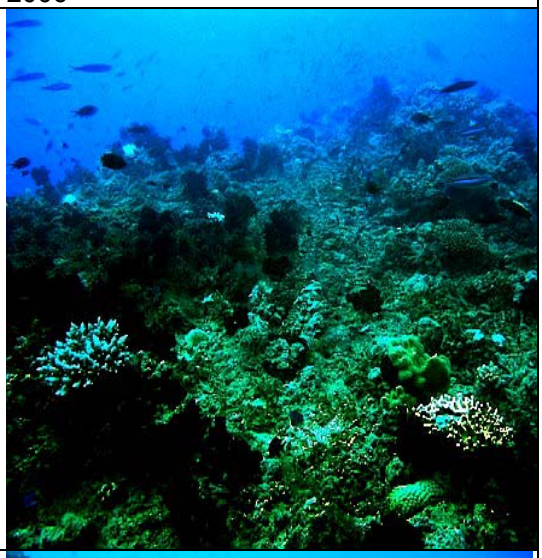
This site was very badly affected by the bleaching event of 2000, followed by a large outbreak of Crown of Thorns Stars in 2001 / 2002, resulting in a decimation of all *Acropora* and many non-*Acropora* corals.

This area is recovering extremely slowly, and in 2006 still had very little hard coral cover (less than 20%), although *Dendronepthea* soft corals appeared to be colonising some of the substrate. In 2006, much of the new *Acropora* coral seen was bleaching.

No Fish or Invertebrate data is available.

h) Gau, Passage - Anthias Avenue cont'd

Figure h.2: Photographs of coral in Gau, 2004 and 2006

2004	2006
	
	
Coral cover was higher in 2006, than in 2004, but bleaching of small *Acropora* corals was occurring.	

i) Gau, Fringing Reef (Frontier Fiji)

This data was submitted for the first time in 2006, so no progression over time is available.

Figure i.2: Graph showing Hard Coral and Algal Cover, 2006

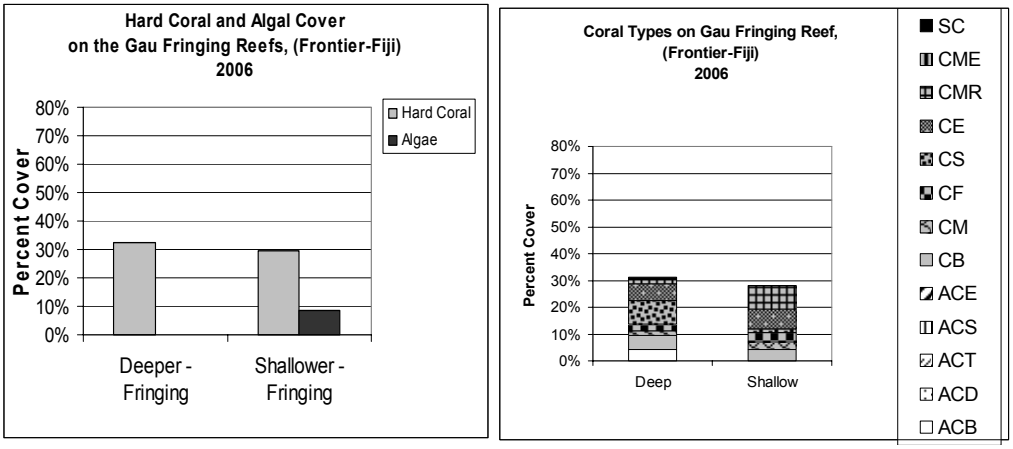
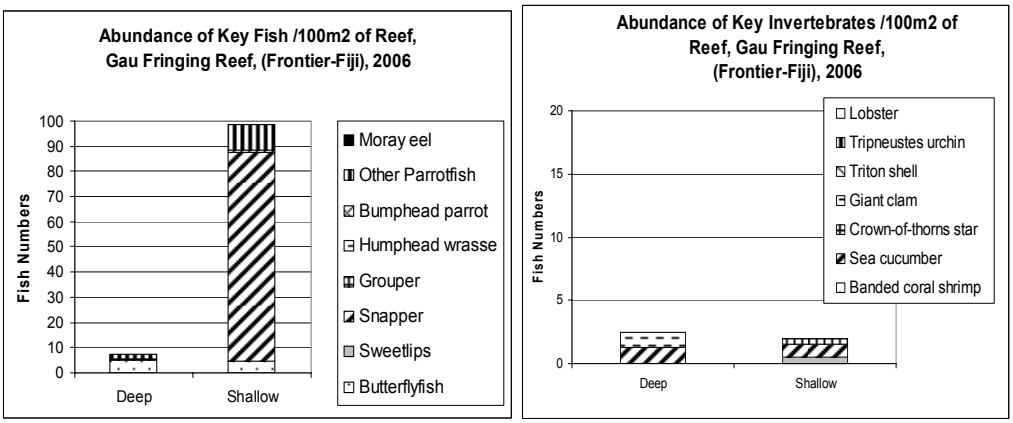


Figure i.3: Graph showing number of Indicator Fish and Invertebrates, 2006
Note - scale increased as fish too numerous for standard graphs used elsewhere



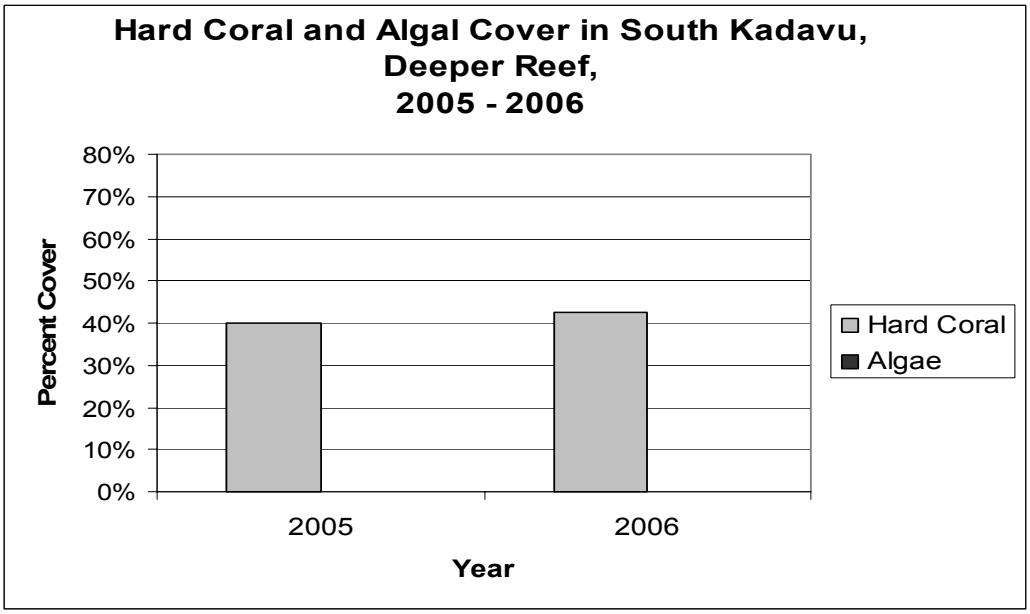
Gau fringing reefs have generally low coral cover (30%), with very little *Acropora* coral, as also seen on the deeper passage reefs discussed earlier, and presumed to have been similarly affected by bleaching and COTS outbreaks.

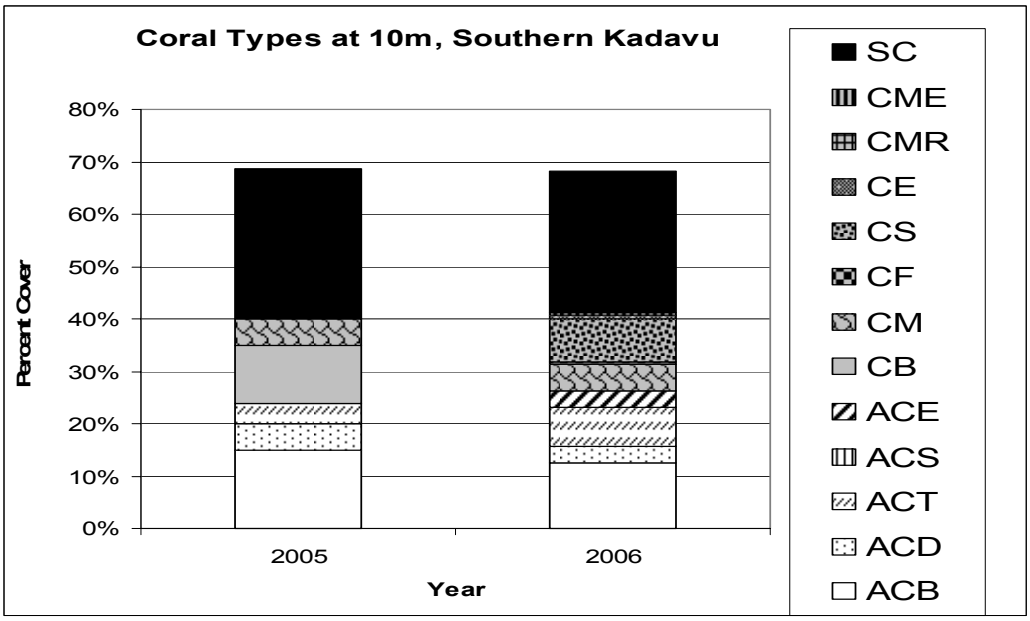
Fish numbers were extremely high in the shallow reef area, which is a designated Marine Protected Area, including what appears to be a very large school of Snappers, and otherwise typical of Fijian reefs.

Invertebrate numbers were low, mostly Sea Cucumbers and Giant Clams, also typical of many Fijian fringing reefs.

j) Kadavu, South

Figure j.1: Graph showing Hard Coral and Algal Cover, 2002 - 2006





Hard coral cover was average to good (40-45%) on the outer barrier reef slope, with some encrusting *Acropora* species not often seen on Fiji's reefs. Soft coral species were very common, bringing coral cover up to a high total of almost 70%.

Hard coral colonies tended to be large, suggesting older, than seen in many other parts of Fiji. There was little change in coral cover from 2005 to 2006, also suggesting that this is a mature, stable reef, rather than one in rapid recovery, as has been seen in other areas of Fiji.

Temperature logger data in 2006 showed this area to be regularly almost a full degree lower than most of the rest of the Fiji Islands, and this may mean that the corals here are less subjected to temperature-related bleaching pressures.

It is likely that this area did not bleach in 2000, although there is no supporting data.

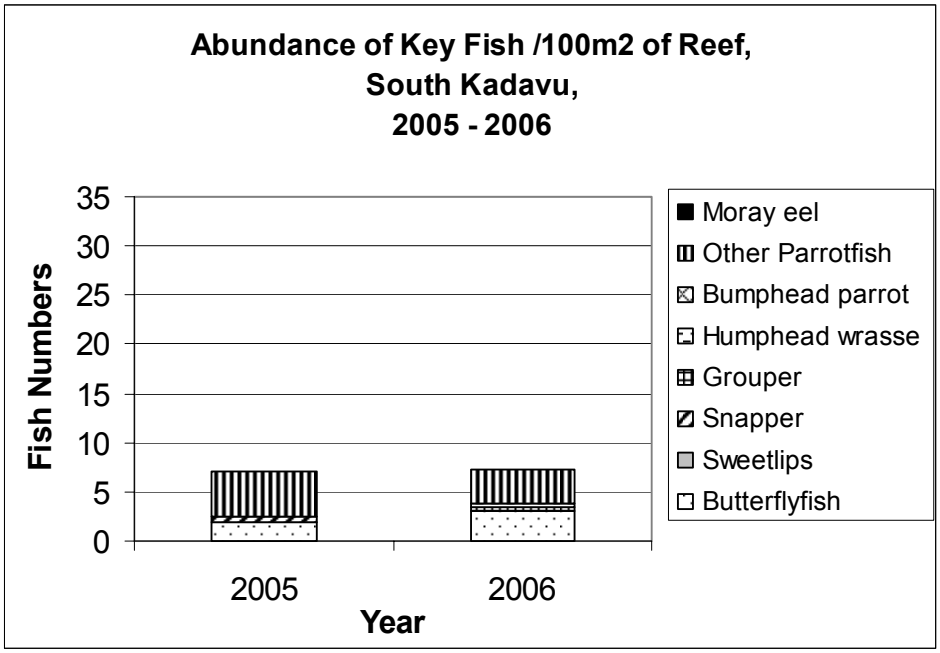
j) Kadavu, South cont'd

Figure j.2: Photographs of reef at Kadavu South 2005 and 2006

2005	2006
	
	
	
There was a notably large overgrowth of purple *Didemnum* species of *Ascidian* (Tunicate) in 2006	

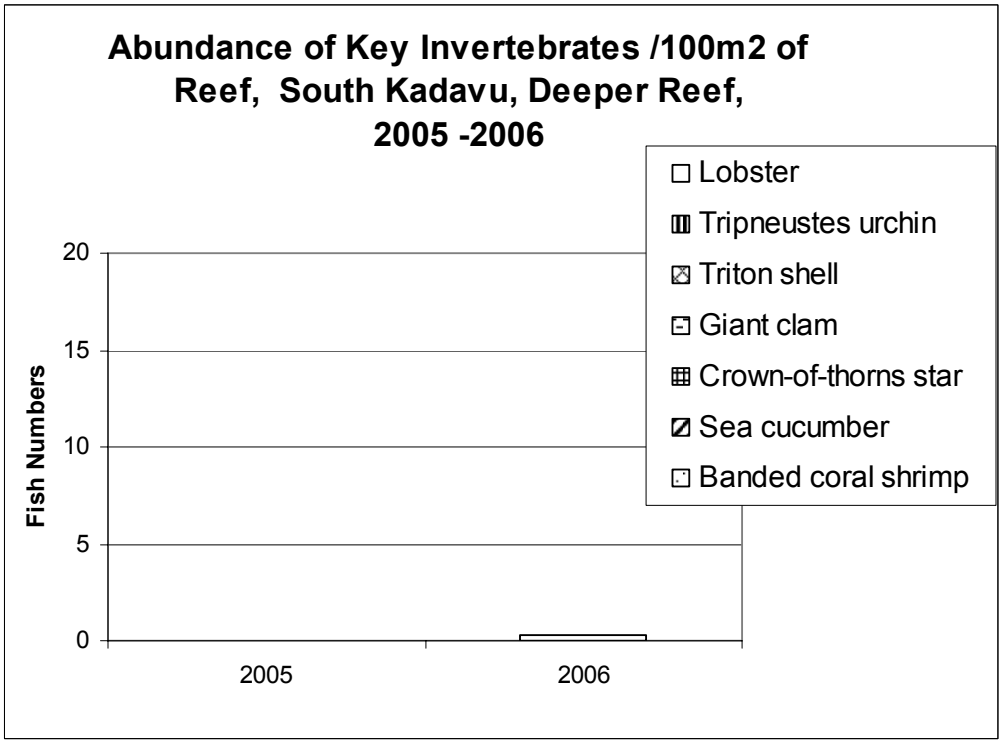
j) Kadavu, South cont'd

Figure j.3: Graph showing number of Indicator Fish, 2002 - 2006



Indicator Fish numbers were average for Fiji Waters, mostly made up of the typical mixture of Butterfly and Parrotfish. No large food fish species were seen.

Figure j.4: Graph showing number of Indicator Invertebrates, 2002 - 2006
Note, No *Diadema* Urchins were seen

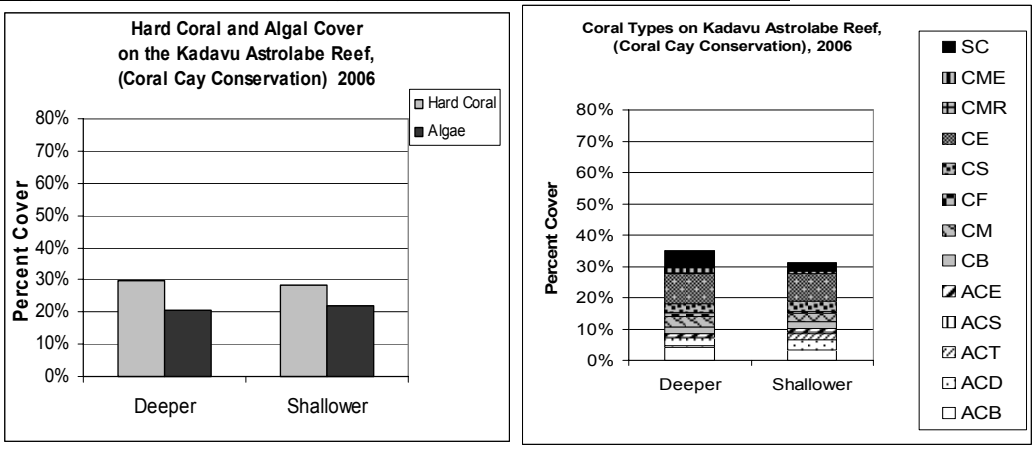


One small lobster was the only Indicator Macro-Invertebrate seen on this reef.

k) Kadavu – Astrolabe Reef (Coral Cay Conservation)

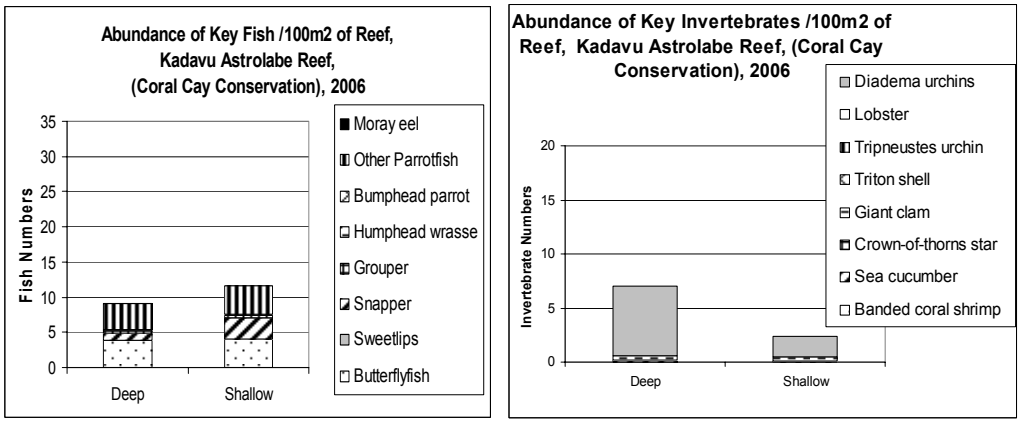
This data was submitted for the first time in 2006, so no progression over time is available.

Figure k.1: Graph showing Hard Coral and Algal Cover, 2006



The coral cover on the Astrolabe Reef is low (30% Hard Coral), and Algal Cover high (20%) at both depths. The coral is dominated by non-*Acropora* forms, mostly low-relief encrusting forms, typical of wave-battered barrier reefs.

Figure k.2: Graph showing number of Indicator Fish and Invertebrates, 2006



Indicator fish numbers were low to average, and featured the usual balance of Butterfly and Parrot fish with a few Snappers and occasional Groupers. Humphead Wrasse and Bumphead Parrotfish were seen on some sites.

Invertebrate numbers were low, expect for *Diadema* Black Spiky Sea Urchins, which were found in higher numbers on the deeper reefs than the shallower ones.

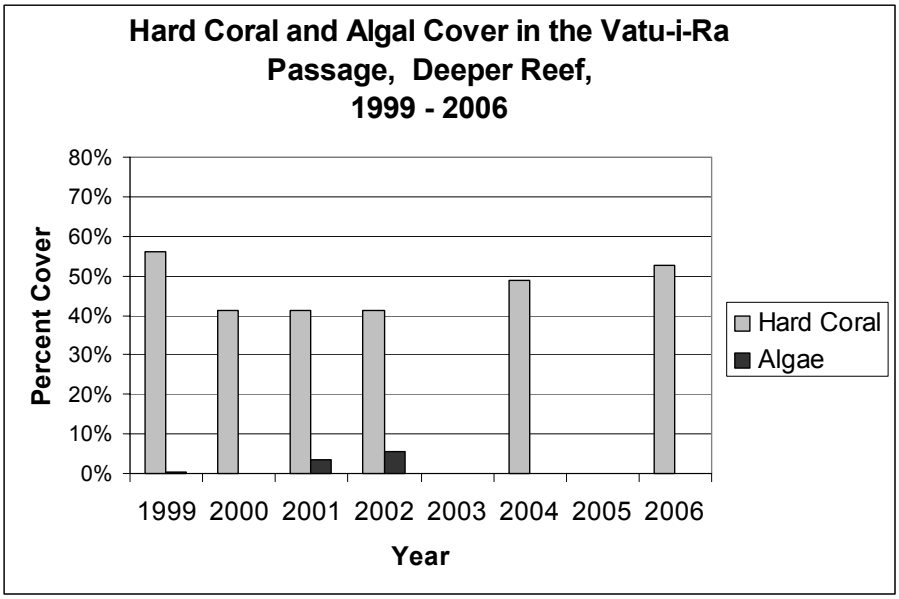
I) Vatu-i-Ra Passage – deeper sites

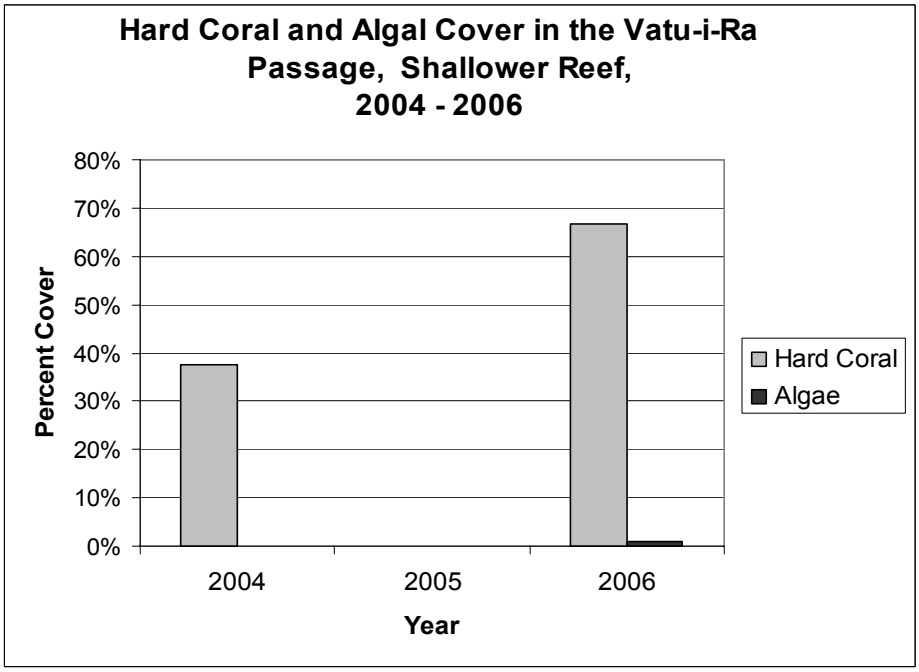
Figure I.1: Graph showing Hard Coral and Algal Cover, 1999 – 2006

No Surveys were conducted in 2003 or 2005

The deeper reefs of the Vatu-i-Ra passage are the sites that have been longest followed during these surveys, and for which pre-bleaching figures are available. The shallower site was added in 2004.

No surveys were carried out on the shallower site before 2004, or in 2005





Coral cover on the deeper reef dropped from 55% to 40% after the bleaching of 2000, and was further reduced during a subsequent smaller bleaching event in 2002. By 2006, coral cover was back to over 50%.

Algal cover rose in 2001 and 2002 when there was recently dead coral skeleton around, but has now dropped again to the normal low levels.

The shallow reef has the highest coral cover of any reef surveyed in these studies.

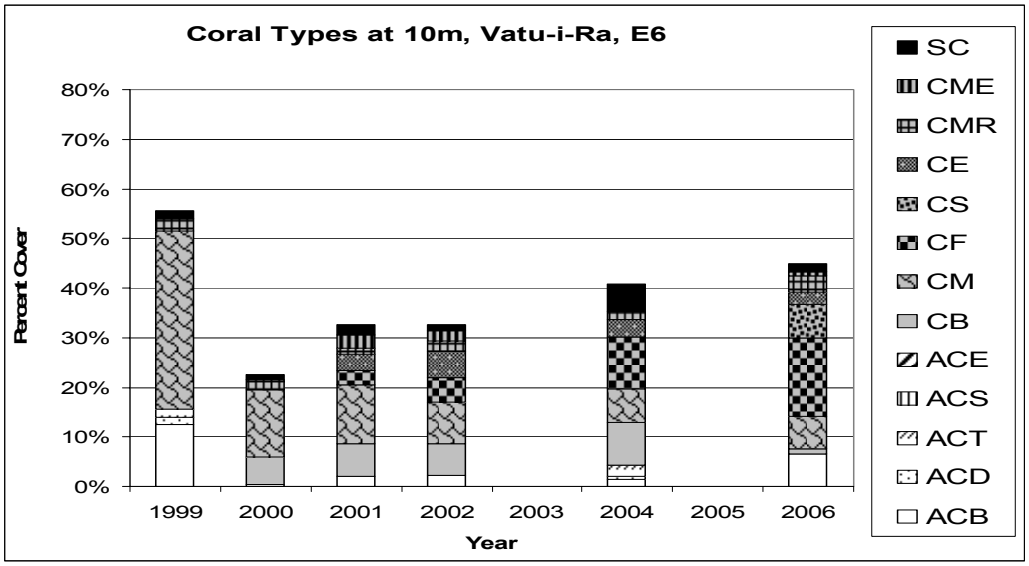
These reefs are considered in more detail in the following graphs.

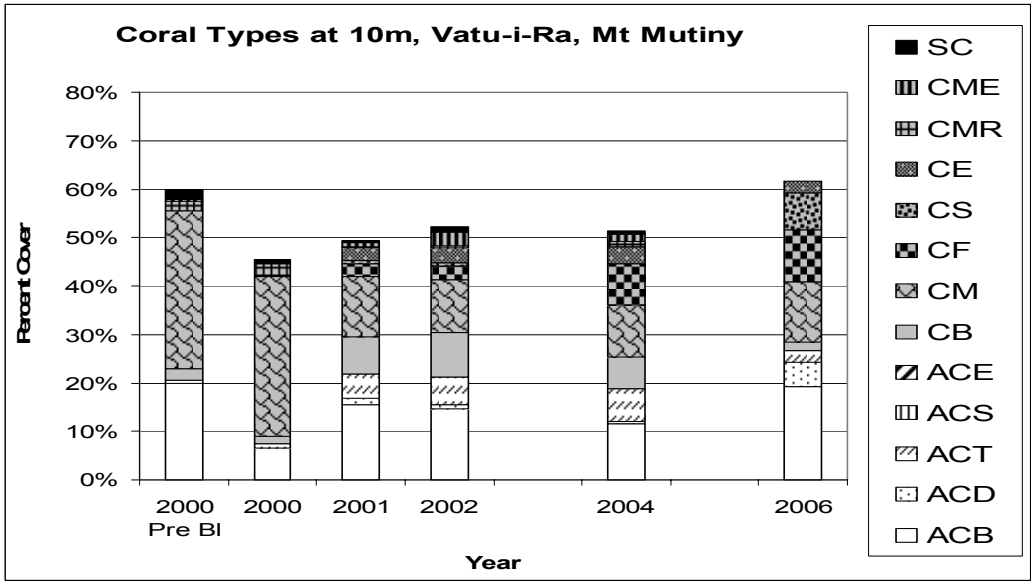
I) Vatu-i-Ra Passage – deeper sites cont'd

Figure I.2: Graphs showing Coral types, 1999 – 2006

The deeper reef figures are derived as an average of two physically similar sites within a few kilometres from each other in the Vatu-i-Ra passage. Pre-bleaching these two sites had similar coral cover (55 – 60%), but one has recovered much faster than the other. They are referred to by their tourist dive site names, "E6" and "Mount Mutiny".

No surveys were carried out in 2003 or 2005



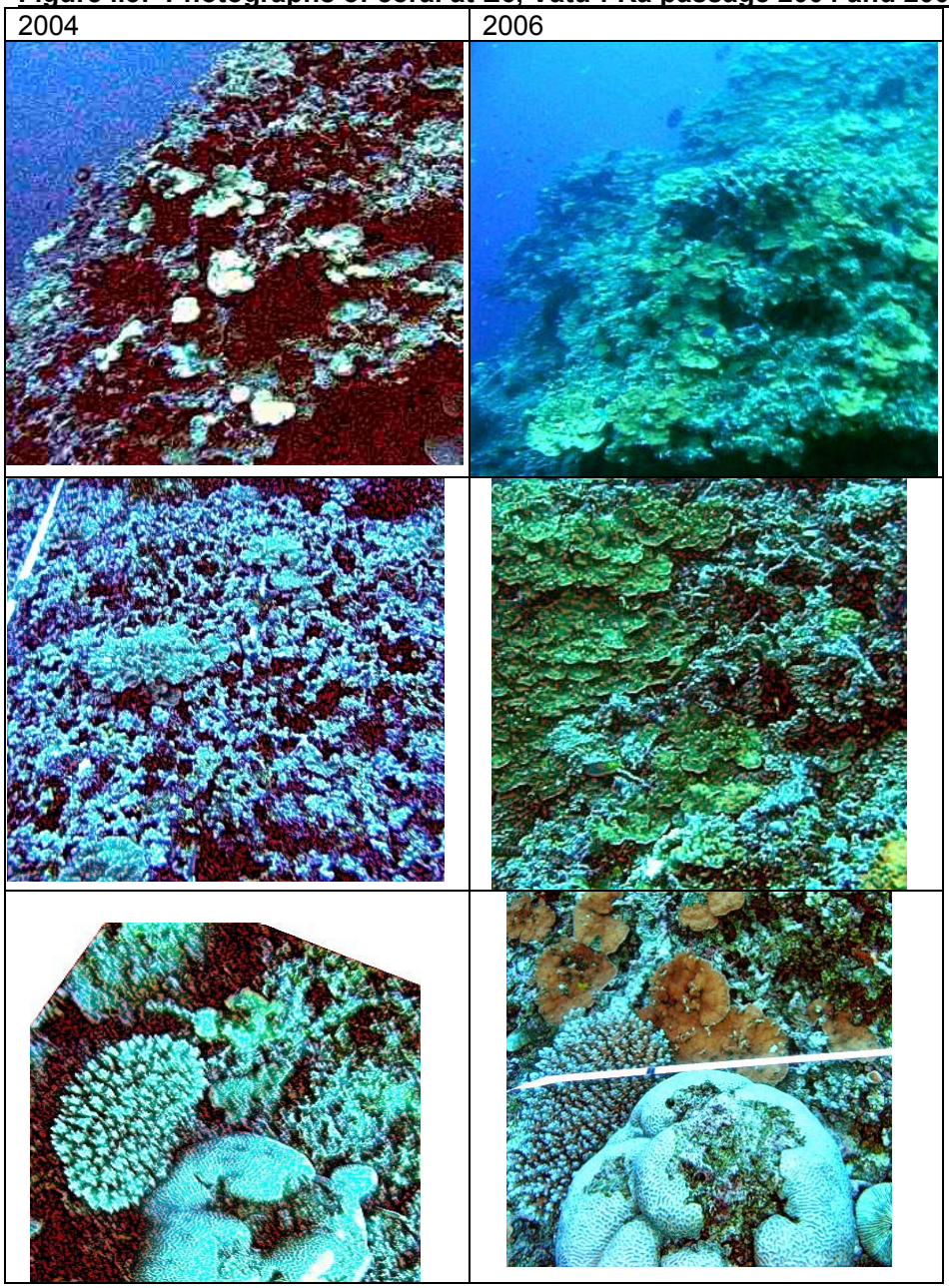


E6 lost more coral than Mount Mutiny during the 2000 bleaching event, and although coral recovery is taking place on both sites, E6 still lags behind its pre-bleaching state, whereas Mount Mutiny is back to 60% cover.

The corals on E6 are now dominated by non-*Acropora* species, in particular leafy or plate (Foliose) coral forms, and have been very slow to regain branching and table corals, whereas *Acropora* new growth on Mount Mutiny was rapid and is now providing more reef cover than before the bleaching.

I) Vatu-i-Ra Passage – deeper sites cont'd

Figure I.3: Photographs of coral at E6, Vatu-i-Ra passage 2004 and 2006

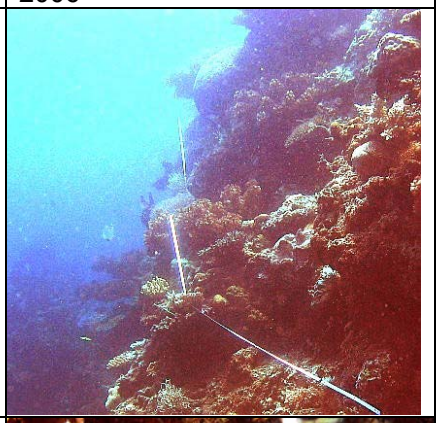
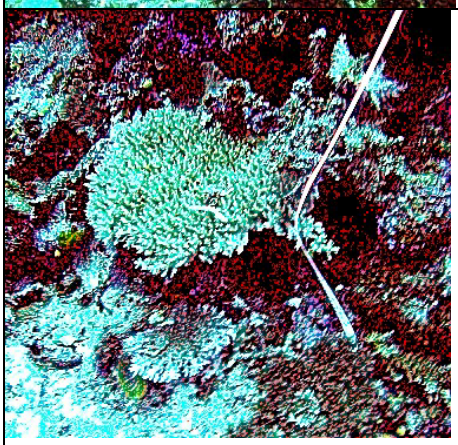
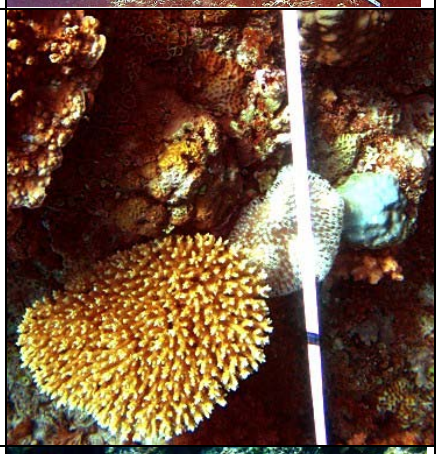
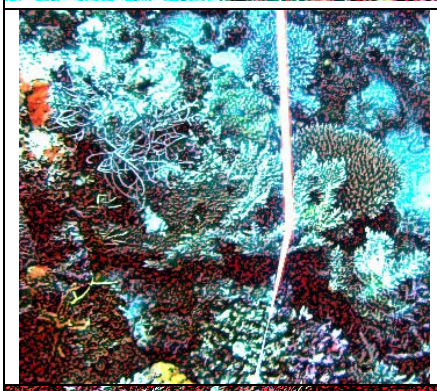
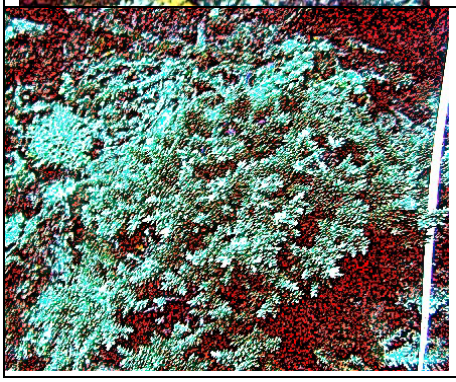
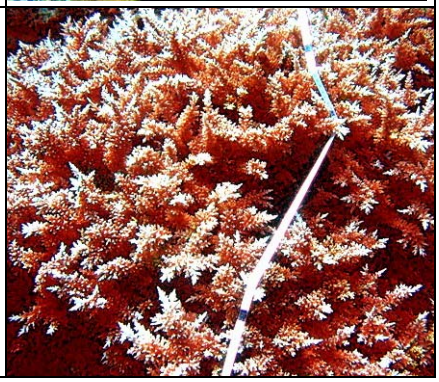


Coral recovery on E6 has been slow, in particular that of *Acropora* species, which do not seem to be returning. However, a large colony of a plate coral with contorted upgrowths, possibly *Merulina spp*, has been an interesting study. This coral was apparently completely killed in the 2000 bleaching, after which coralline and turf algae overgrew the substrate for at least three years. No settlement of other corals occurred on this algae-covered dead coral.

In 2004 very small amounts of live coral started to appear in scattered patches across the dead substrate. By 2006 these patches had grown and expanded to cover about 30% of the original colony surface. In all cases, this was the same species of coral as the original colony, strongly suggesting that some live cells had been retained through the bleaching and three-year "dead" period.

I) Vatu-i-Ra Passage – deeper sites cont'd

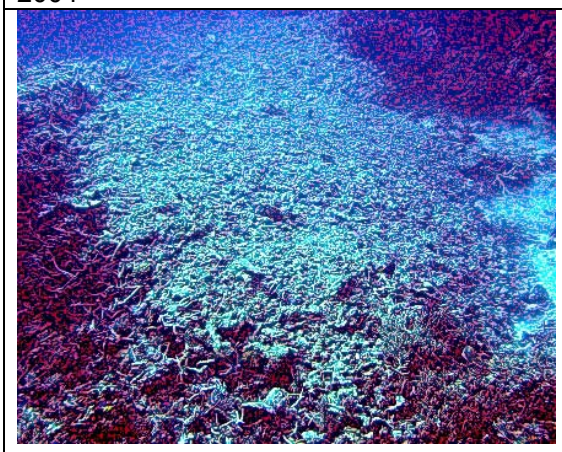
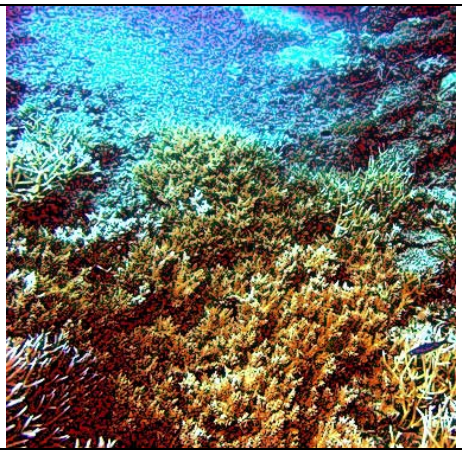
Figure I.4: Photographs of coral at Mount Mutiny, one site in the Vatu-i-Ra passage 2004 and 2006

2004	2006
	
	
	
	

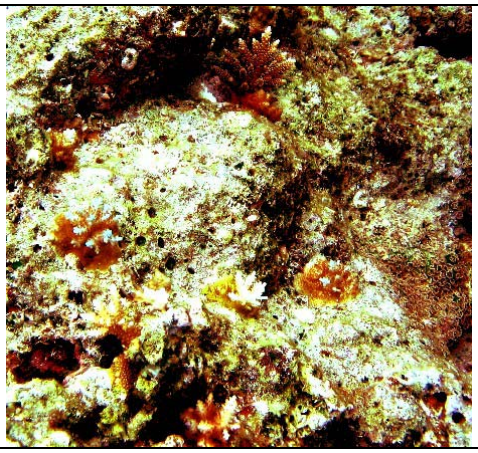
I) Vatu-i-Ra Passage – deeper sites cont'd

Figure I.4: continued: Mount Mutiny, one site in the Vatu passage

Branching Acropora garden destroyed by storm in 2004, regenerating in 2006

2004	2006
	

New coral growth in 2006

At Mount Mutiny, coral recovery was rapid, and *Acropora* species of many types are now settling and growing all over the reef. This reef is now back to, or better than, pre-bleaching levels.

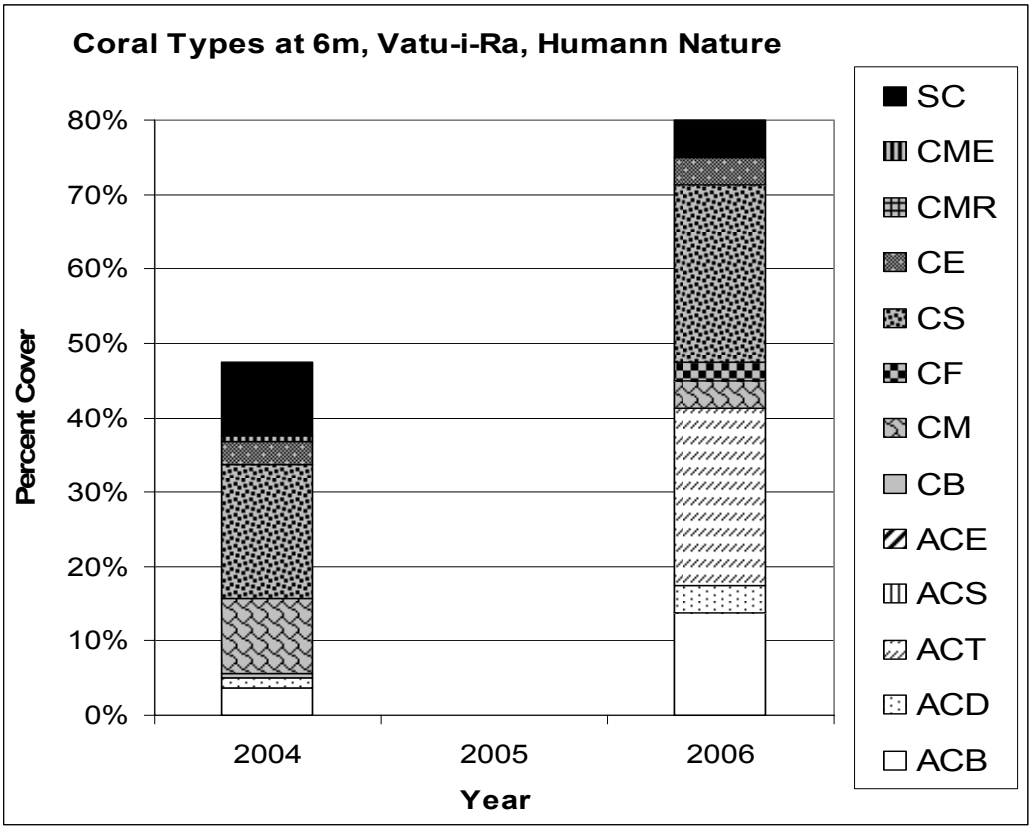
A shallow coral garden at the top of the reef has suffered two severe coral-damaging events in the period surveys have been carried out: the bleaching of 2000, and a severe storm in 2004. In each case coral re-growth has been exceptionally rapid.

15 cm growth of a particular branching *Acropora* species was recorded in a single year after the bleaching.

m) Vatu-i-Ra Passage – shallow site

Figure m.1: Graphs showing Coral types, 1999 – 2006

Note - no surveys were carried out in 2005. A strong storm had passed about 2 weeks before the survey in 2004, leaving a great deal of broken coral.

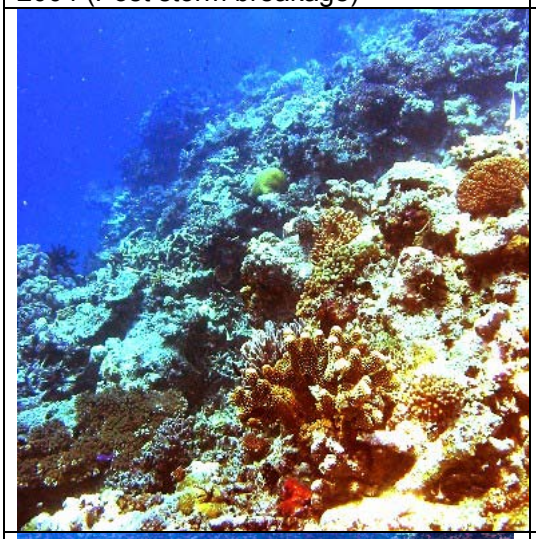
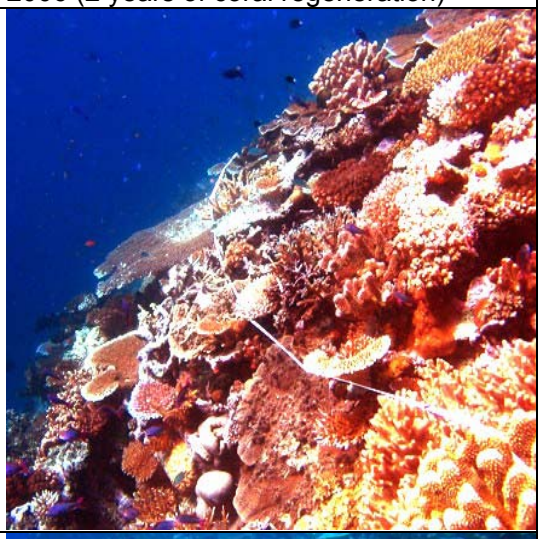


This shallow reef showed a rapid increase in *Acropora* cover between 2004 and 2006, representing very rapid recovery after a great deal of breakage after the 2004 storm. This reef is now a spectacular array of hard corals, with more than 80% coral cover, of which 40% is *Acropora*, the highest seen during the Fiji surveys.

No Fish or Invertebrate data is available.

This site is several kilometres away from Mount Mutiny, but is also in the area of the Vatu-i-Ra passage, and shows a similar pattern of rapid coral growth and high coral cover.

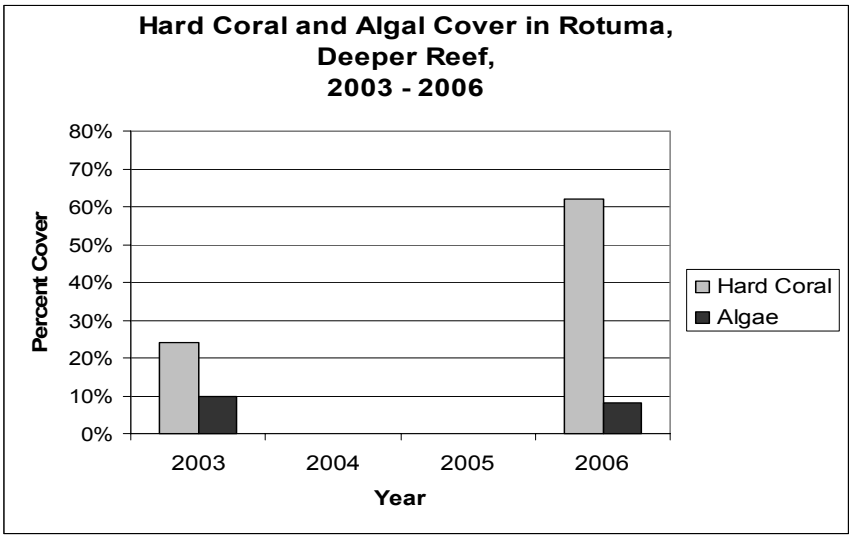
Figure m.2: Photographs of coral on Humann Nature 2004 and 2006

2004 (Post storm breakage)	2006 (2 years of coral regeneration)
	
	
	

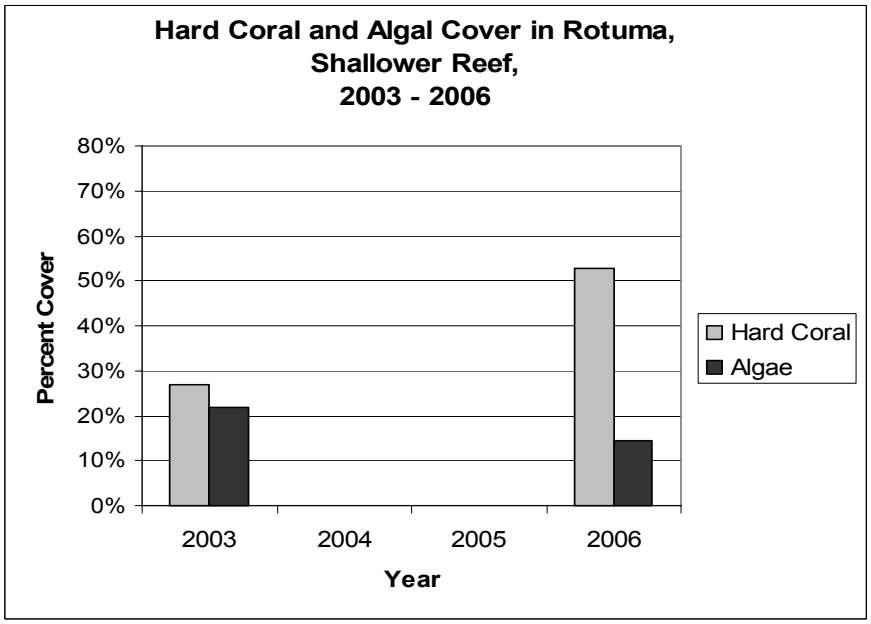
n) Rotuma (Laje Rotuma)

Figure n.1: Graph showing Hard Coral and Algal Cover, 2003 - 2006

No surveys were conducted in 2004 or 2005



No surveys were conducted in 2004 or 2005



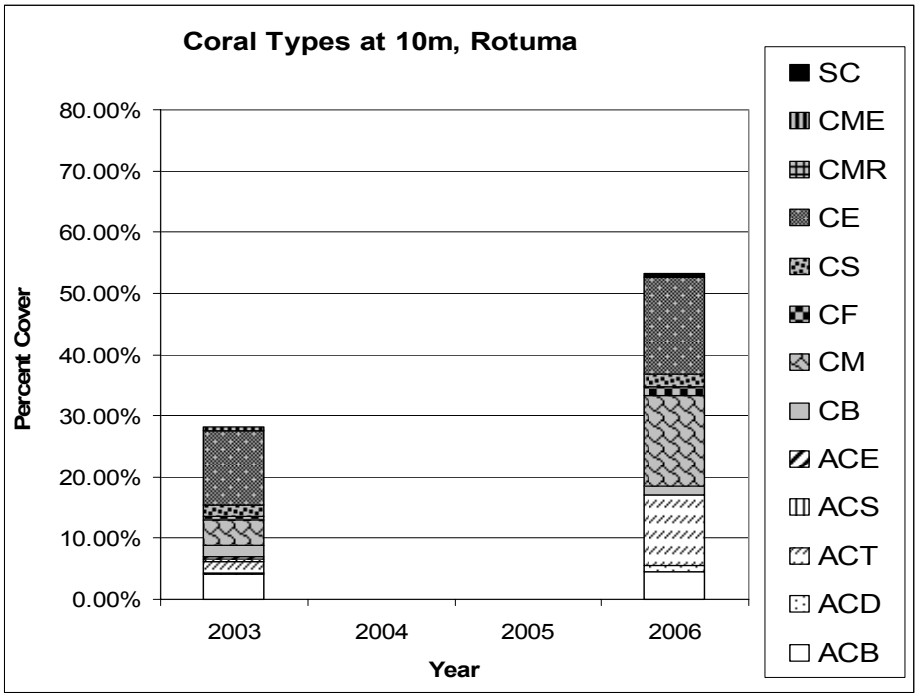
Hard coral cover has increased on both shallow and deep reefs since 2003, from around 25% to very good cover levels of 50 - 60%.

Algal cover is quite high on the shallow reefs, and average to high on the deeper reefs, but appears to have declined slightly since 2004.

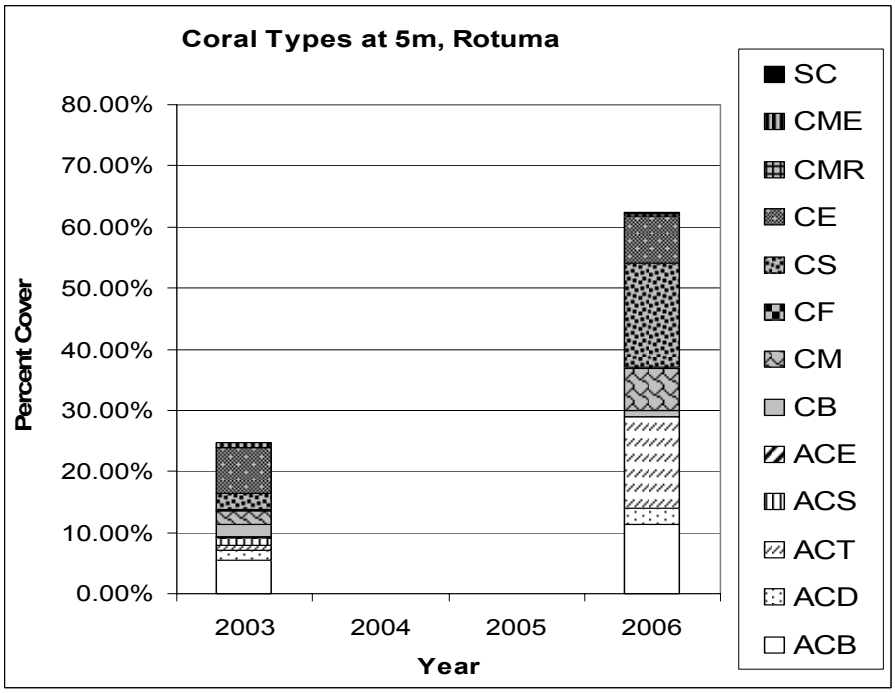
n) Rotuma (Laje Rotuma) cont'd

Figure n.2: Graphs showing Coral types, 2003 – 2006

Note – no surveys were conducted in 2004 or 2005



Note – no surveys were conducted in 2004 or 2005



Both *Acropora* and non-*Acropora* species have increased since 2003, at both depths. In particular Sub-massive forms of non-*Acropora* corals and Table forms of *Acropora* species are now present in large quantities.

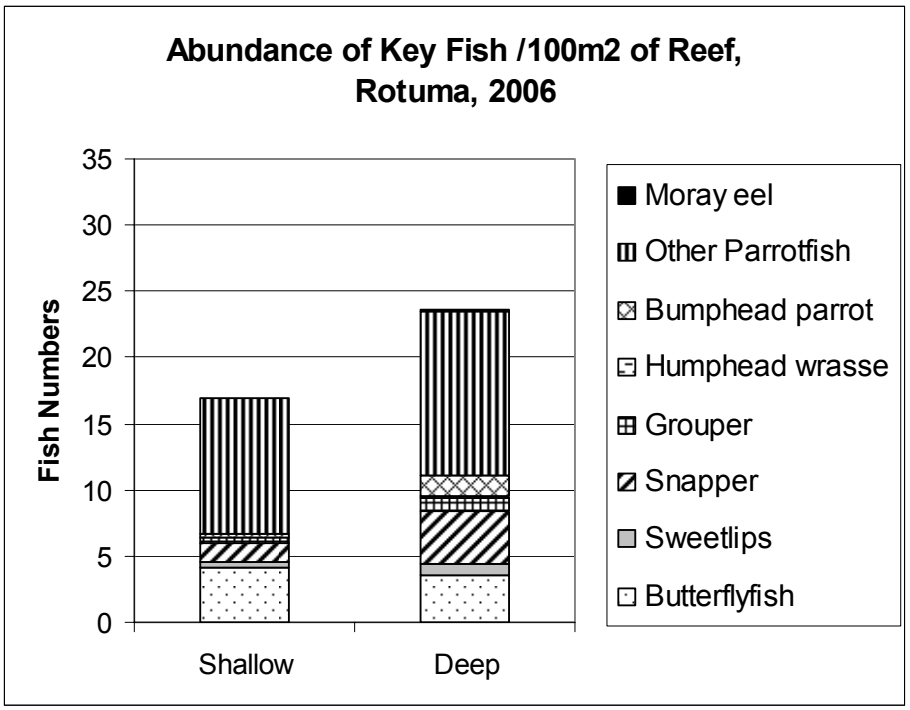
Rotuma is also known to have high amounts of Blue Coral (*Heliopora*) which is rare in the rest of the Fiji Islands, although this does not show on the survey.

n) Rotuma (Laje Rotuma) cont'd

Figure n.3: Graph showing number of Indicator Fish, 2006

No surveys were conducted in 2004 or 2005.

No fish data was available from 2003.



Indicator fish were seen in large numbers, more on the deeper reefs than in the shallows, notably more Parrotfish and Snappers, as well as a few Sweetlips and Groupers, and the only Bumphead Parrotfish seen during surveys. This reef appears to have much lower fishing pressures on it than most of the other Fiji Islands.

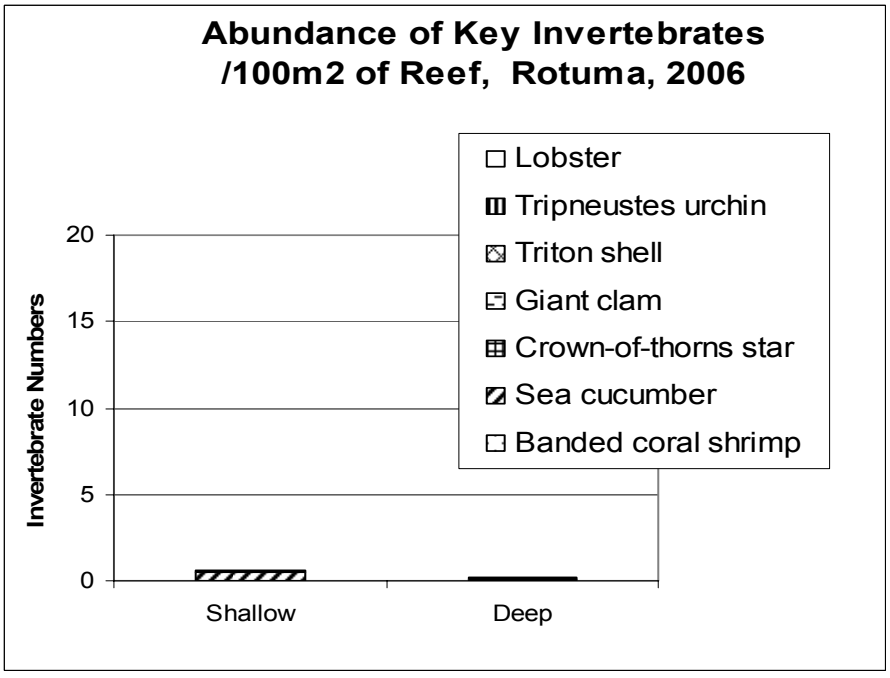
Figure n.4: Graph showing number of Indicator Invertebrates, 2006

No surveys were conducted in 2004 or 2005.

No invertebrate data was available from 2003.

No *Diadema* urchins were seen

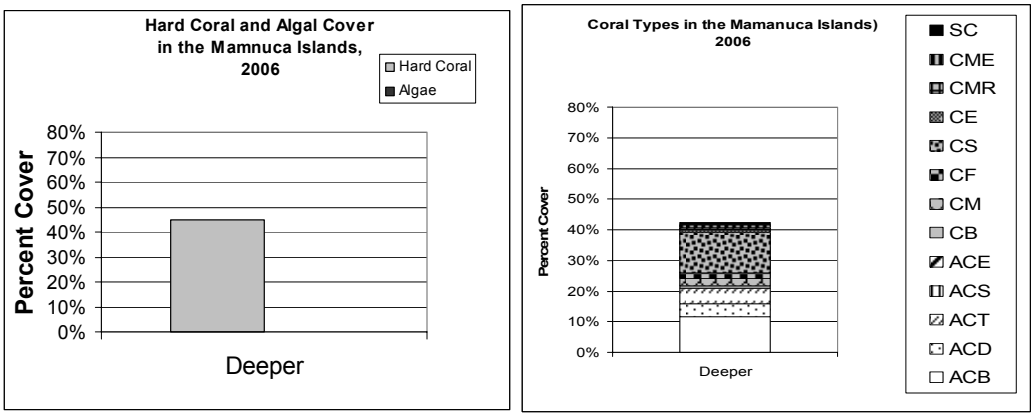
Invertebrate numbers were low at both depths, with only a very few Sea Cucumbers present.



o) Mamanuca Islands

This data was submitted for the first time in 2006, so no progression over time is available.

Figure o.1: Graph showing Hard Coral and Algal Cover, 2006



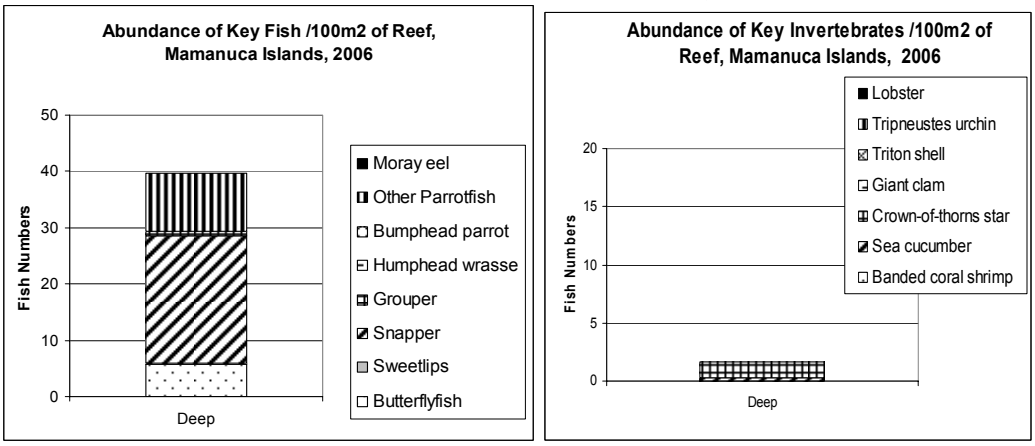
Coral cover was average for the Fiji Islands, with a wide spread of *Acropora* and non-*Acropora* species.

Many Crown of Thorns scars were seen, indicative of quite long-term feeding by these predatory sea-stars, leading to considerable damage to *Acropora* corals.

Some *Drupella* corallivorous snails were also seen causing coral damage.

Figure o.2: Graph showing number of Indicator Fish and Invertebrates, 2006

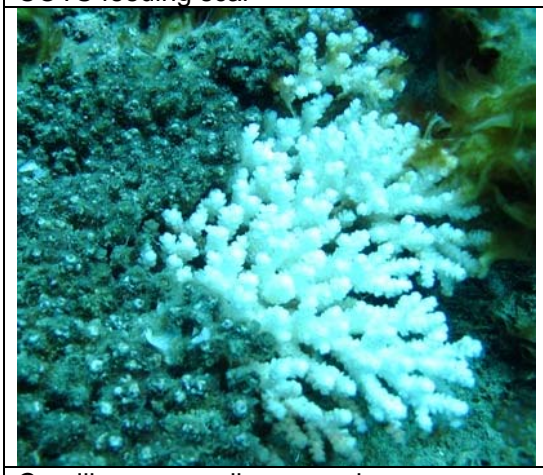
Note - scale increased as fish too numerous for standard graphs used elsewhere



Fish numbers were unusually high for the Fiji Islands, with particularly large numbers of Snappers, as well as high Butterfly and Parrotfish numbers, and a few large foodfish, Sweetlips and Grouper. This site is a recognised dive site, where fishing is discouraged.

Invertebrate numbers were low, except for an outbreak of Crown of Thorns Stars, which has been ongoing in the Mamanuca Islands since 2005, and which is causing considerable coral damage. A similar outbreak was seen in this area in 1996 / 1997, followed by a die back of COTS and re-growth of corals.

Figure o.3: Photographs of coral and predation in Mamanucas in 2006

Reef Views side and top of Sunflower Reef	
	
COTS feeding scar	Crown of Thorns Star (COTS)
	
Corallivorous snails on coral	Corallivorous snails (*Drupella spp*)