FIJI REEF CONSERVATION PROJECT 2002

REEF CHECK REPORT (2001-2002)

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EXECUTIVE SUMMARY

?? Reef Check surveys were carried out by CCC volunteer divers in the Mamanucas region, Fiji at the same locations over a two year period (2001-2002) as part of the *'Fiji Reef Conservation Project' (FRCP)*.

?? Data was collected on anthropogenic impacts, benthic cover and a number of target reef fish and invertebrates at 22 sites.

?? The results for benthic cover have been reported and discussed with reference to two coral bleaching events. The first, in early 2000 was severe and resulted in significant loss of hard coral cover in the Mamanucas region. The second smaller event occurred in April 2002.

?? Data reported here indicates that mean hard coral cover has almost doubled between the two survey periods from 14 % in 2001 to 27 % in 2002. There was a corresponding decrease in the amount of reef rock recorded by divers.

?? Benthic data suggests that the reefs of the Mamanucas region are recovering well after the deleterious effect of coral bleaching in 2000. The smaller bleaching event of 2002 has not significantly altered the amount of live hard coral in the region.

?? Data collected on target reef fish and invertebrates has highlighted the apparent rarity of some species in the Mamanucas although further information is required to confirm their scarcity. Crown-of-thorns sea stars (COTs) were recorded but at low levels.

?? Future CCC Reef Check surveys in the Mamanucas (2003 and beyond) will provide evidence to determine whether the data presented here is part of an ongoing trend in terms of coral recovery.

1. INTRODUCTION

Fiji is one of the wealthiest countries in the South Pacific. The nation's wealth is partly attributed to its extensive marine resources, which generate significant revenue through tourism and fishing. Fiji's marine environments are also an important source of protein for the local population. The country is made up of approximately 844 volcanic islands and is dominated by the Viti Levu and Vanua Levu platforms which account for 87% of the total land area (Vuki *et al*., 2000). Fiji has a moderate tropical climate which, over time has enabled the development of extensive coral reefs around all of the nation's islands.

Although the tropical forests and coral reefs of Fiji are of vital importance both ecologically and economically, they are under threat through rapid economic and population growth. Fiji's natural forests are now seriously threatened from land-use conversion activities such as logging and agricultural development (Spalding *et al*, 2001). Similarly, the countries' coral reef ecosystems are being adversely affected by a range of anthropogenic activities including over-fishing, destructive fishing, sedimentation, eutrophication and pollution. This has resulted in extensive loss of coral reef habitats and the inducement of coral diseases. Recent coral bleaching events and storm damage have synergistically exacerbated these effects to reduce reef health further (South and Skelton, 2000). Such impacts represent substantial threats to the ecological balance and health of reef ecosystems on a variety of temporal scales. If left unchecked these impacts will ultimately lead to reduced financial returns for coastal communities and other stakeholders who rely on fishing and marine-based tourism for their livelihoods.

1.1 Background

The Mamanuca Islands in western Fiji (Fig. 1) have been the focus of tourism development in Fiji for many years (at least since the mid-1960s). The tourism industry in Fiji is very much aware of the value of conserving the coral reefs and fostering sustainable development.

At the invitation of the Fiji Visitors Bureau, the Ministry of Tourism and Transport and other stakeholders, a small delegation from CCC visited Fiji in December 2000 to attend the annual *Fiji Tourism Forum* and enter into discussions with the aforementioned parties. As a result, the Forum passed a resolution enlisting the services of CCC. In March 2001, the FVB and other project partners sponsored a CCC follow up visit to Fiji to continue discussions. One significant outcome of this trip was the signing of a Memorandum of Understanding between the Ministry of Tourism and CCC, which formalised arrangements for the '*Mamanuca Coral Reef Conservation Project – Fiji 2001'* (MCRCP). This pilot project was carried out between June and September 2001. (see Harborne *et al*., 2001) and its success led to the inception of a much more expansive series of activities collectively known as the *Fiji Reef Conservation Project* (FRCP). The current project started in March 2002 and is initially expected to run for three years until March 2005 (as stated in a Memorandum of Agreement between CCC and the Fijian Department for Tourism, Transport and Aviation, with collaboration with the Mamanucas Hoteliers Association signed in December 2001).

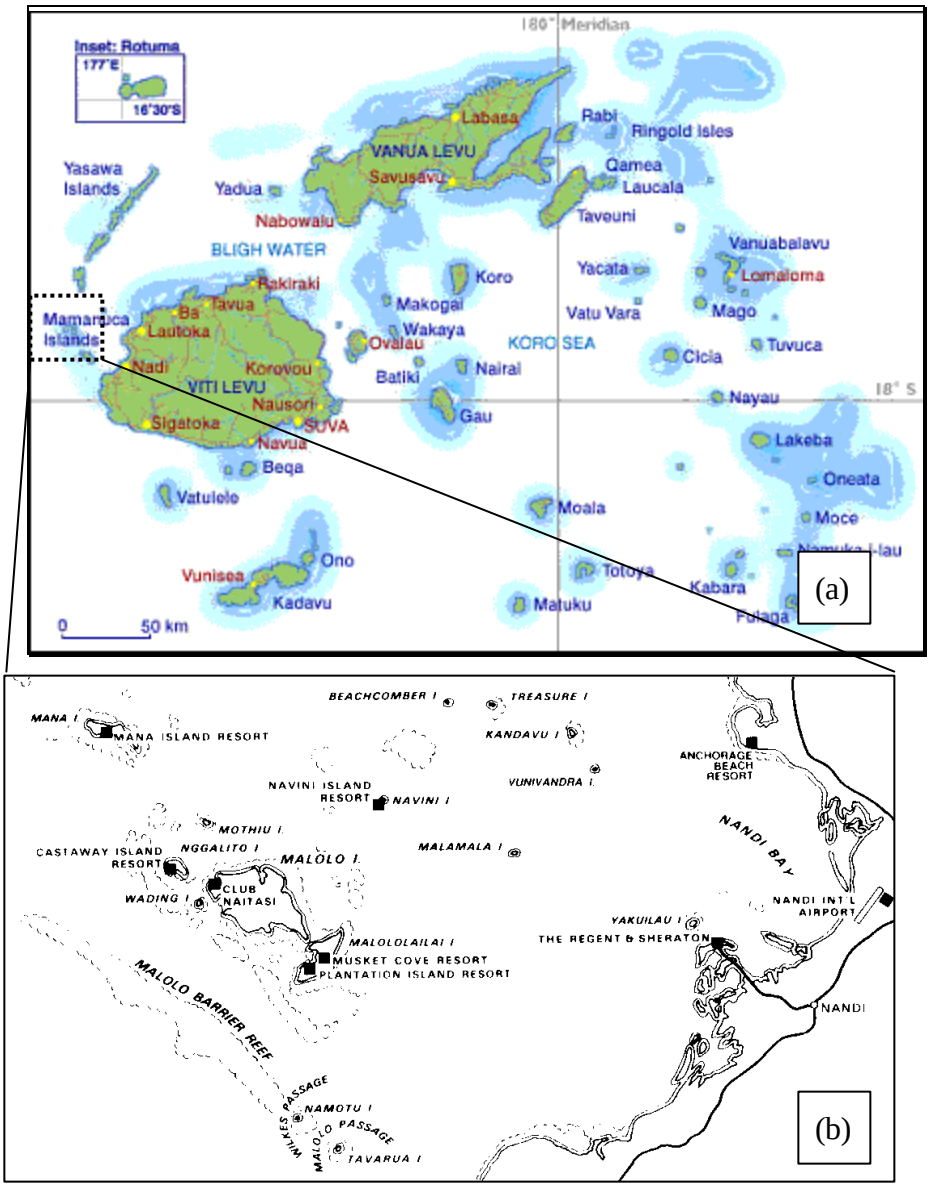


Figure 1. (a) The Fiji islands, showing the project area (dashed line) for the MCRCP. *Source*: Fiji Visitors Bureau. (b) Major islands with the Mamanucas.

1.2 Aim of this report

This report compares Reef Check data gathered from the Mamanucas Coral Reef Conservation Project in 2001with that collected exactly a year later in June/July 2002 during the FRCP. The comparison will highlight any significant differences in fish,

invertebrate and benthic population characteristics between 2001 and 2002, and in so doing offers an insight into potential changes in reef health over this time span.

In February 2000 there was a considerable bleaching event which decimated many of the shallow water corals around the Mamanucas and across the wider Fiji area (South and Skelton, 2000). A minor bleaching event was also observed on many Fijian reefs in May 2002. Water temperatures in the Mamanucas reached 31°C during April 2002, the threshold temperature at which many corals are thought to become most susceptible to bleaching (Brown, 1997). Reef Check data for 2002 was collected just after any effects of elevated water temperatures were noticed in other parts of the archipelago.
The combination of data collected after the 2000 event and directly after the minor event of 2002 will give an indication of the relative health of corals for the Mamanucas in relation to the bleaching effects.

2. REEFCHECK

2.1 Overview

Reef Check[1] is the largest international coral reef monitoring programme designed for non-professional divers to assess reef health. The organisation recently published a five-year report summarising the results of surveys at more than 1500 reefs (Hodgson and Liebeler, 2002). Reef Check surveys generate relatively simple but useful quantitative information. Five types of data are recorded:

- ?? Physical and anthropogenic factors (site description sheet)
- ?? abundance of commercially important fish
- ?? abundance of target invertebrate taxa
- ?? percentage cover of substratum types and components of the benthic community
- ?? obvious anthropogenic impacts.

The FRCP has modified the standard Reef Check protocol to collect more detailed data (giving greater taxonomic resolution) and hence provide a better assessment of reef health. Such modifications are possible because all CCC volunteers on the FRCP receive more intensive training than regular pleasure divers who undertake Reef Check.

2.2 Method

The standard Reef Check survey protocol utilises transects at two depths of approximately 3 and 10 m. During the FRCP all transects were carried out at 2 and 10 m as at most sites, the reef community in the slightly shallower water was more representative of Fijian reef systems. Along each depth contour a 100 m transect was deployed. Four replicate transects, each 20 m in length were surveyed along the 100 m. The replicate transects followed the designated depth contour in sequence but the start and end points are separated by a 5m space (Fig. 2). Therefore the distance between the start of the first transect and end of the last transect was 20 + 5 + 20 + 5 + 20 + 5 + 20 = 95 m. By collecting data from each of the 20 m sections, four replicates were collected per survey, allowing the calculation of a mean value per transect and hence more powerful statistical analysis.

Five types of data were recorded via three surveys along each transect line at each depth. Firstly, a site description sheet was completed which included locations, anecdotal, observational and historical information and other data.
Secondly, four 5 m wide by 20 m long transects (centred on the transect line) were sampled for commercially important fish, for example those typically targeted by fisherfolk and aquarium collectors. Fish were only counted if they were less than 5 m above the transect line, giving a survey area for each transect replicate of 20 x 5 x 5 m = 500 m^3. CCC volunteers in Fiji recorded data for more fish species than specified by the standard Reef Check protocol. Divers on fish surveys remained stationary at the start of each replicate transect for three minutes and recorded target fish in this time. This method ensures minimal disturbance to the fish population allowing reef fish to resume 'normal

[1] Further details at http://www.reefcheck.org

behaviour'. The divers then swam slowly along the transect to the next 5 m mark and repeated the process every 5 m until the line was completed.
Thirdly, four 5m wide by 20 m long transects (centred on the transect line) were sampled for invertebrate taxa typically targeted as food species or collected as curios. Quantitative counts were made of each species. In addition, the invertebrate surveyors noted the presence of coral bleaching or unusual conditions (e.g. diseases) along transects.
Finally, four 20 m long transects were point sampled at 0.5 m intervals to determine the substratum types and benthic community of the reef. The diver noted down the substratum type directly under each point 50 cm apart. The standard Reef Check protocol splits the benthic substratum into 11 categories (hard coral, soft coral, recently killed coral, dead coral, fleshy seaweed, sponge, rock, rubble, sand, silt / clay and 'other'). However, CCC volunteers recorded hard corals to lifeform level (along with target species), soft corals to lifeform level and five categories of algal cover (mixed assemblage, coralline, *Halimeda*, 'macro' and 'turf'). Finally, the substratum surveyors recorded coral damage from anchors, dynamite or 'other' factors and trash from fishing nets or 'other'. Divers rated the damage caused by each factor using a 0-3 scale (0 = none, 1 = low, 2 = medium, 3 = high). All data were transferred to specially designed recording forms (see Appendix 1 for examples).

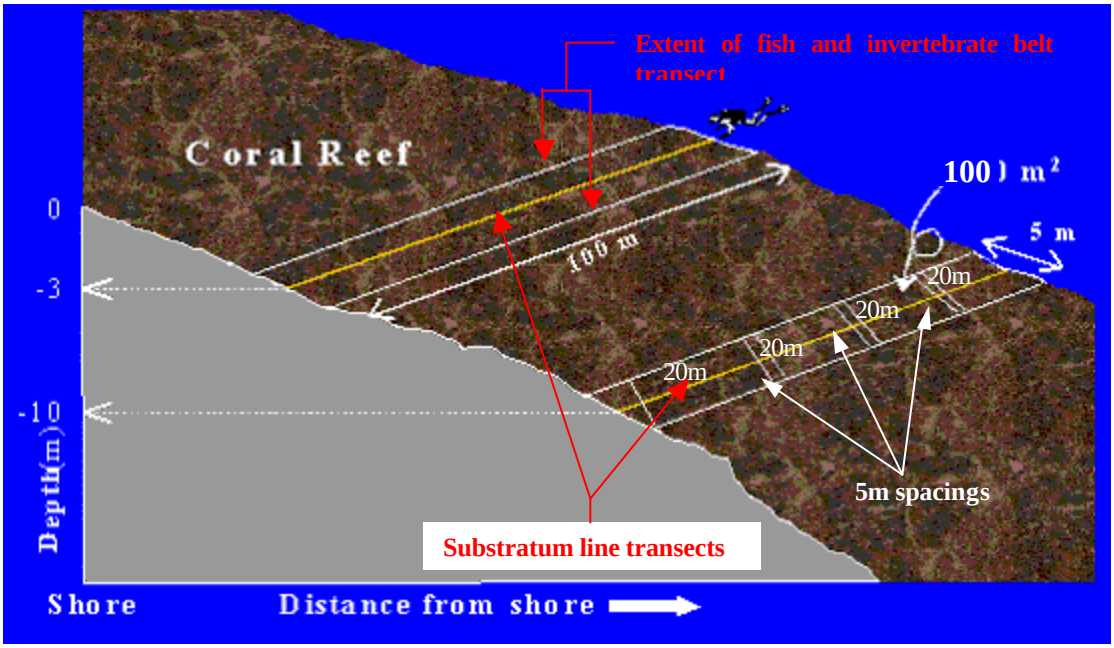


Figure 2. Schematic diagram showing the position of the transect lines during a Reef Check survey. 100 m transect is divided into four 20 m replicates so area of each belt transect is 20 x 5 m = 100 m^2

This report documents the results of reef check surveys, comparing data collected in 2001 and 2002. The particular relevance for the collection of this data was the occurrence of the major bleaching event in 2000. Data presented here gives preliminary information on recovery rates of benthic communities affected by bleaching and the subsequent effects on the community structure. All information will be made available to the global (Reef Check) and national databases, hence increasing the impact of the project.

1.3 Surveys carried out

Between the 18th of June and the 12th of July 2002, the Fiji Coral Reef Conservation Project (FCRCP) completed 23 Reef Check surveys. Of these, 22 surveys were carried out at sites visited by the Pilot Phase of the FCRCP which were resurveyed to check on the change in reef health over the year that has passed since the original surveys were carried out.

The locations of the Reef Check transects carried out are shown in Figure 3 and Table 1. Note that because of limited reef development below 6m, most of the transects were completed in the 'shallow' depth band (3-6m) defined by the standard Reef Check methodology. Deeper transects were generally restricted to platform reefs or the Outer Malolo Barrier Reef where reef development was more extensive.

Table 1. Sites revisited in June and July 2002 of the MCRCP. See Figure 2? for the exact location of each site. Reef complexes: MA = Mana Island; NO = Namotu Group; IM = Inner Malolo Group; OM = Outer Malolo Group; NA = Navini Island.

Site code	Site name / General location	Reef complex	Depth (m)
RCA 1	Cousteau Rock	IM	5
RCA 2	Castaway house reef	IM	5
RCA 3	Runners Beach	IM	3
RCA 4	Castaway wall	IM	4
RHM 1	Mothiu (Honeymoon) Island	IM	5
RIB 1	Inner barrier reef (Castaway Cut)	OM	3
RIB 2	Outside of inner barrier reef close to Waidigi Island	OM	1
RIB 3	Outside of inner barrier reef, south west of Qalito (Castaway) Island	OM	3
RMI 1	Wilkes Passage	NO	20
RMI 3	Outer barrier reef close to Namotu (Magic) Island	NO	6
RMI 4	Outer barrier reef close to Namotu (Magic) Island	NO	13.5
RML 1	Malolo Island	IM	7
RML 2	Malolo Island	IM	4
RML 3	Malololailai	IM	6
RNA 1	Nayauu Levu	OM	3
RNI 1	Navini Island	NA	5
RRA 1	Raviniyake (close to CCC base)	IM	3
RRA 2	Raviniyake (close to CCC base)	IM	4
RSF 1	Sunflower	OM	14
RSF2	Sunflower	OM	4
RSM 1	Supermarket	MA	8
RWI 1	Waidigi Island	IM	6

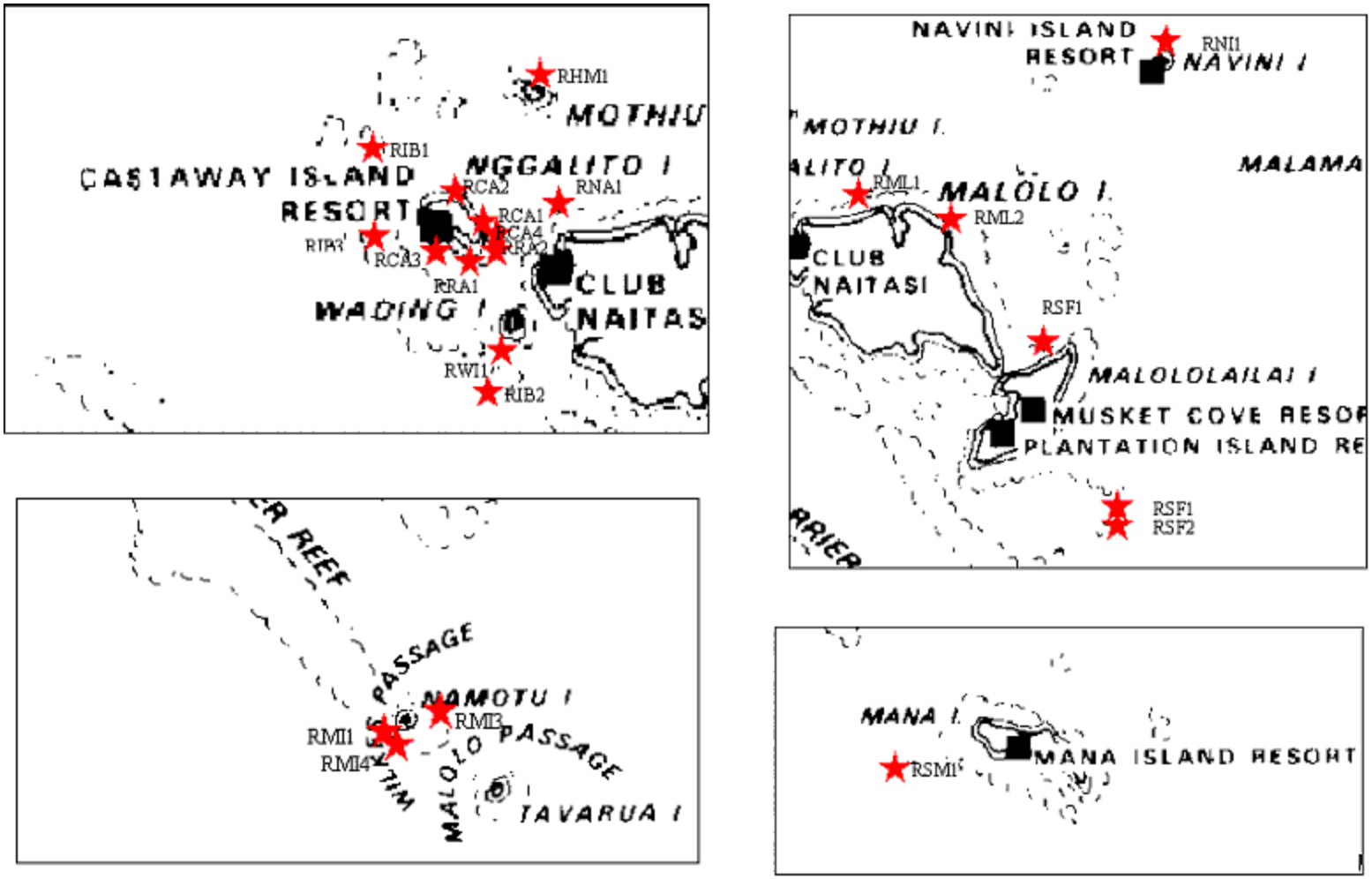


Figure 3. Location of Reef Check sites (red stars) completed during the pilot phase of the MCRCP, and subsequently during the Fiji Reef Conservation Project in June/July 2002. (Key to codes in Table 1).

3. RESULTS

3.1 Quantitative assessment between 2001 & 2002

A summary of the parameters recorded along each transect line during the Reef Check surveys in 2002 are shown in Tables 2, 3 and 4. A graphical summary of all sites combined is shown in Figures 4 - 7. An overall increase in coral cover was recorded, from 14 % in 2001 to 27 % in 2002. Figures 6 and 7 show a comparison of the mean benthic cover recorded during 2001 and 2002 surveys.

All sites surveyed in 2002 had greater percent cover of non-*Acropora* corals than *Acropora* corals (means of 19.86 % and 7.36 % respectively), with the exception of Navini Island. The highest coral cover was recorded on the two Sunflower transects (means of 49.38 % and 51.26 % total cover) which was also found in 2001.

The increase in mean total coral cover (non-*Acropora* and *Acropora* combined) between 2002 and 2001 suggests that the region has recovered slightly from the bleaching event in 2001. An increase in cover was also shown by both non-*Acropora* and *Acropora* corals; non-*Acropora* increased from 10.7 % in 2001 to 19.9 % in 2002, whilst *Acropora* cover more than doubled, from 3.0 % in 2001 to 7.4 % in 2002.

The 2002 surveys showed a similar amount of algal cover to the 2001 surveys (25 % and 27 % respectively) including mixed assemblage, coralline, *Halimeda* and Macroalgae. Sponges and soft corals were rarely seen on the transect lines (both had mean coverage of 2 %) and no zooanthids recorded at all. The habitats surveyed in 2002 were very similar to those surveyed in the previous year. The subject of inter-year differences in the habitats surveyed is discussed in the accuracy section later in this report.

The most abundant fish seen were fusiliers (Caesionidae) and surgeonfish (Acanthuridae) with mean abundances of 16.1 and 9.9 per $500m^3$ respectively. Surgeonfish were generally common on each transect but fusiliers, as schooling fish were patchily distributed. Hence this family was recorded as abundant at some locations (mean abundance of 162.5 on the first Sunflower transect) and absent at others. Butterflyfish (Chaetonitidae), 'other parrotfish' (Scaridae; not Bumphead) and snappers were the only other taxa with a mean abundance greater than 1 individual in $500m^3$. Significantly, no humphead wrasse (*Cheilinus undulatus)*, bumphead parrotfish (*Bolbometopon muricatum*) or barramundi cod (*Cromileptes altivelis*) were seen on any of the surveys. These are targeted by fishers and aquarium trade collectors (barramundi cod only) and are likely to have been 'fished out' in the region.

Most of the invertebrate taxa targeted by the Reef Check surveys were rarely seen in either year. However, the number of *Diadema* urchins decreased significantly between 2001 and 2002 (mean of 9.0 per $100m^2$ in 2002 compared with 24.9 in 2001). Again, in 2002 these were patchily distributed and ranged from 37.2 per $100m^2$ at Castaway House reef to none at Magic Island and Sunflower. All other taxa had a mean abundance that was less than 1 individual per 100 m^2. The commercially important sea cucumbers and

clams rarely seen during 2001 surveys were seen even less frequently during 2002. Lobsters and squid were not seen at all during the 2002 surveys, and only a single reef octopus was recorded at Castaway East. A similarly low number of crown-of-thorns sea stars (*Acanthaster plancii*) were seen during 2002 as compared with 2001 (mean abundance of 0.14 per $100m^2$ as compared with 0.11 in 2001). However, no triton trumpet shells (*Charonia tritonis*), a natural predator of the corallivorous COTs were seen. Also, no corallivorous *Drupella* gastropods were recorded on surveys.

3.2 Accuracy Assessment

As no permanent markers of the transects were used, two sources of error are apparent when comparing the 2002 data with that of 2001. GPS points were taken over the start and end points in 2001, and in 2002 when the sites were revisited using these GPS readings. Dive teams were dropped in as close to the original points as possible. However, due to several factors, including adverse weather conditions and currents, this was only possible to within about 10-15 metres in some cases. It would be very difficult to drop divers in on the same point that was used as the start point from the year before unless the start and end points are permanently marked underwater.

Similarly, it would be difficult to know exactly how the measuring tape was laid in 2001, and that the bearing of the line may be slightly different without submerged markers. As a result, all transects will have probably been taken along a slightly different line in 2002 to that swam in 2001. In light of these factors it is highly likely that the data collected will be valid for a gross temporal comparison in benthic cover and faunal abundance. Data were collected along the same depth contours at all sites in both years, and trends in increased coral cover existed at over 80 % of the sites visited.

Site	Acropora (%)	Non-Acropora (%)	Soft Coral (%)	Sponge (%)	Algae (%)	Recently Killed Coral (%)	Rock (%)	Rubble (%)	Sand (%)	Other (%)
RCA1	0.63	30.63	0.00	0.00	21.25	0.00	2.50	15.63	28.75	0.63
RCA2	0.00	14.38	0.00	0.63	9.38	1.88	10.00	11.25	21.88	30.63
RCA3	0.00	22.50	0.00	0.63	43.75	0.00	9.38	8.13	13.75	1.88
RCA4	5.63	0.63	0.00	0.63	38.13	0.63	11.88	14.38	24.38	3.75
RHM1	18.75	23.13	2.50	0.63	27.50	0.00	11.25	0.00	0.00	16.25
RIB1	11.88	12.50	0.00	1.25	19.38	1.25	20.63	2.50	28.75	1.88
RIB2	13.13	27.50	3.13	1.88	25.63	4.38	20.63	3.13	0.00	0.63
RIB3	6.25	7.50	0.00	0.00	13.75	26.25	3.13	2.50	40.63	0.00
RMI1	0.00	26.25	13.75	0.00	43.75	0.00	6.25	0.00	0.00	10.00
RMI3	3.75	20.63	0.00	8.13	18.75	0.63	22.50	0.00	22.50	3.13
RMI4	0.63	22.50	11.88	5.00	50.63	1.25	4.38	0.00	0.63	3.13
RML1	14.38	25.63	2.50	0.00	10.00	0.00	10.63	3.75	19.38	13.75
RML2	0.63	30.63	0.00	1.88	31.88	1.25	1.25	9.38	14.38	8.75
RML3	0.63	24.38	0.00	2.50	2.50	0.00	29.38	10.00	10.63	20.00
RNA1	19.38	20.63	1.25	3.13	12.50	4.38	26.88	1.88	10.00	0.00
RNI1	21.25	18.75	6.88	1.88	21.25	5.00	8.13	1.25	1.88	13.75
RRA1	0.63	14.38	0.00	1.25	35.00	0.63	10.00	8.75	28.75	0.63
RRA2	4.38	1.88	0.00	0.63	32.50	1.88	10.00	27.50	20.63	0.63
RSF1	13.13	36.25	0.63	0.00	23.75	0.00	0.00	7.50	0.00	18.75
RSF2	24.38	26.88	1.88	0.00	2.50	1.25	15.00	2.50	10.00	15.63
RSM1	0.00	23.13	0.63	1.88	39.38	0.00	21.88	0.00	8.13	5.00
RWI1	2.50	6.25	0.00	1.88	16.25	0.63	8.75	37.50	20.63	5.63
Mean (all sites)	**7.36**	**19.86**	**2.05**	**1.53**	**24.52**	**2.33**	**12.02**	**7.61**	**14.80**	**7.93**

Table 2. Summary of percentage cover for each parameter per 20 metre section of the Reef Check line transect at each site. See Table 1 for the location of each site. (2002 data).

Table 3. Summary of abundance of each fish taxa per 500 m^3 section of the Reef Check belt transect at each site in 2002. (See Table 1 for the location of each site).

Notes: 1. No Barracuda, Bumphead Parrotfish, Humphead Wrasse, Barramundi Cod or Checkered Snapper were recorded, and have been omitted for clarity.

2. Twospot Snapper, Black and White Snapper, Flagtail Grouper, Peacock Grouper, Lyretail Grouper, Tuna/Mackerel and Moray Eels have been omitted due to their mean abundance being lower than 0.1

Fish	RCA 1	RCA 2	RCA 3	RCA 4	RHM 1	RIB 1	RIB 2	RIB 3	RMI 1	RMI 3	RMI 4	RML 1	RML 2	RML 3	RNA 1	RNI 1	RRA 1	RRA 2	RSF 1	RSF 2	RSM 1	RWI 1
Butterflyfish	9	5.75	2.25	8	9.75	2.75	1	3.5	3.75	7	17.5	3.25	1.5	3.75	3.5	6	3.25	1	9	12	8.5	1.75
Sweetlips	0	0.5	0	0.75	0	0	0	0	0	0.75	0.25	0	0.25	0	0	0	0.25	0.5	1	0.75	0.25	0
Snapper	2.5	0	1.75	2.5	0	0.5	0	0.5	0	0.25	0.5	0.75	0	3.25	0.75	0	11.5	0	8.25	0	0.75	0.25
"Bluelined"	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.5	0	0.75	0	0	0
Paddletail	0	0	1.75	0	0	0	0	0	0	0	0.25	0	0	0	0	0	1.25	0	0	0	0	0
Grouper (>30cm)	0.25	0	0.25	0.25	0	1.75	0	0	0	0.5	0.75	0	0.5	0	0	0	1	0	0.75	0.25	0	0
"Honeycomb"	0.25	0	0.25	0	0	1.75	0	0	0	0	0	0	0	0	0	0	0.75	0	0.25	0.25	0	0.25
Parrotfish (>20cm)	5	1.25	0	0	0.5	0.25	0.5	0	1.25	0.25	6.5	1.5	4.25	3.5	2	6.75	0	0	9.5	3.5	2.75	0
Fusiliers	0	23.75	0	0	71.5	0	7.5	0	0	0	0	0	3	0	0	0	18.5	0	162.5	47	8.75	12.5
Surgeonfish	13.25	16	9.75	9.5	8.75	7	8.5	0.25	5.25	8.25	27.25	6.5	10.25	7	7.75	9.25	9.5	7.5	14.75	14.5	10.5	6.75
Rabbitfish	0	0	0	0	0.25	0	0	0	1	0	0.5	0	0	0	0.5	0	0	0	0.5	0	0	0
Jacks / Trevally	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	1.75	0	0.75	0	1.75	0

Table 4. Summary of abundance of each invertebrate taxa per 100 m^2 section of the Reef Check belt transect at each site during 2002 surveys. See table 1 for the location of each site..

Note; No squid, lobster, triton shells or *Drupella* were recorded and have been omitted for clarity.

Invertebrates	RCA 1	RCA 2	RCA 3	RCA 4	RHM 1	RIB 1	RIB 2	RIB 3	RMI 1	RMI 3	RMI 4	RML 1	RML 2	RML 3	RNA 1	RNI 1	RRA 1	RRA 2	RSF 1	RSF 2	RSM 1	RWI 1
Banded coral shrimp (*Stenopus hispidus*)	0	0	0	0	0	0	0	0	0	0.25	0	0	0	0	0	0	0	0	0	0	0	0
Diadema urchins	10.25	37.25	4.25	13.75	0	5	2.5	0.5	0.5	28	0	4	19.5	34.25	20.5	1	0.25	5.75	0	1.75	6.75	2.5
Pencil urchin (*Heterocentrotus mammilatus*)	0	0	0	0	0	1.75	1.25	0	0	0	0	0	0	0	0	4.25	0	0	0	0	0	0
Sea cucumber (edible only)	0.25	0.25	0	0.25	0.75	0.5	0	0	0	15.25	0	0.5	2	1.75	0.25	0.5	0	0	0	0.25	0.5	0
Crown-of-thorns seastar (*Acanthaster plancii*)	0	0	0.25	0.5	0.5	0	0	0	0	0	0	0	0	0	0	0.25	0.75	0	0	0.25	0	0.75
Giant clam (*Tridacna* spp.)	0.25	1.25	0.25	0.5	0	0.75	0	0.25	0	0	0	0	0.25	2	0.25	0	3	0	0	0.5	0	0.25
Octopus	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

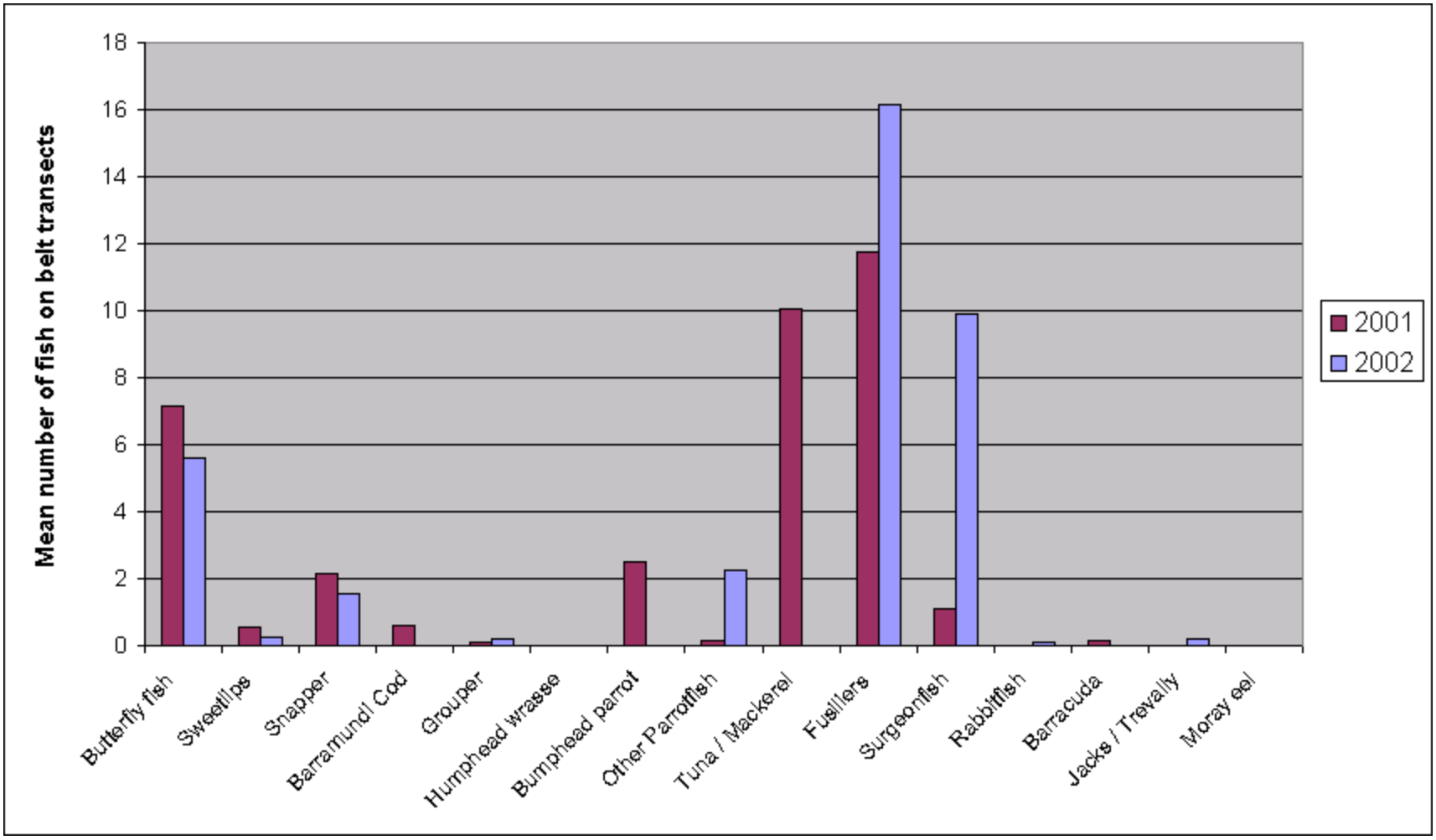


Figure 4. Temporal comparison of reef fish abundance per 500m^3 section of the Reef Check belt transects.

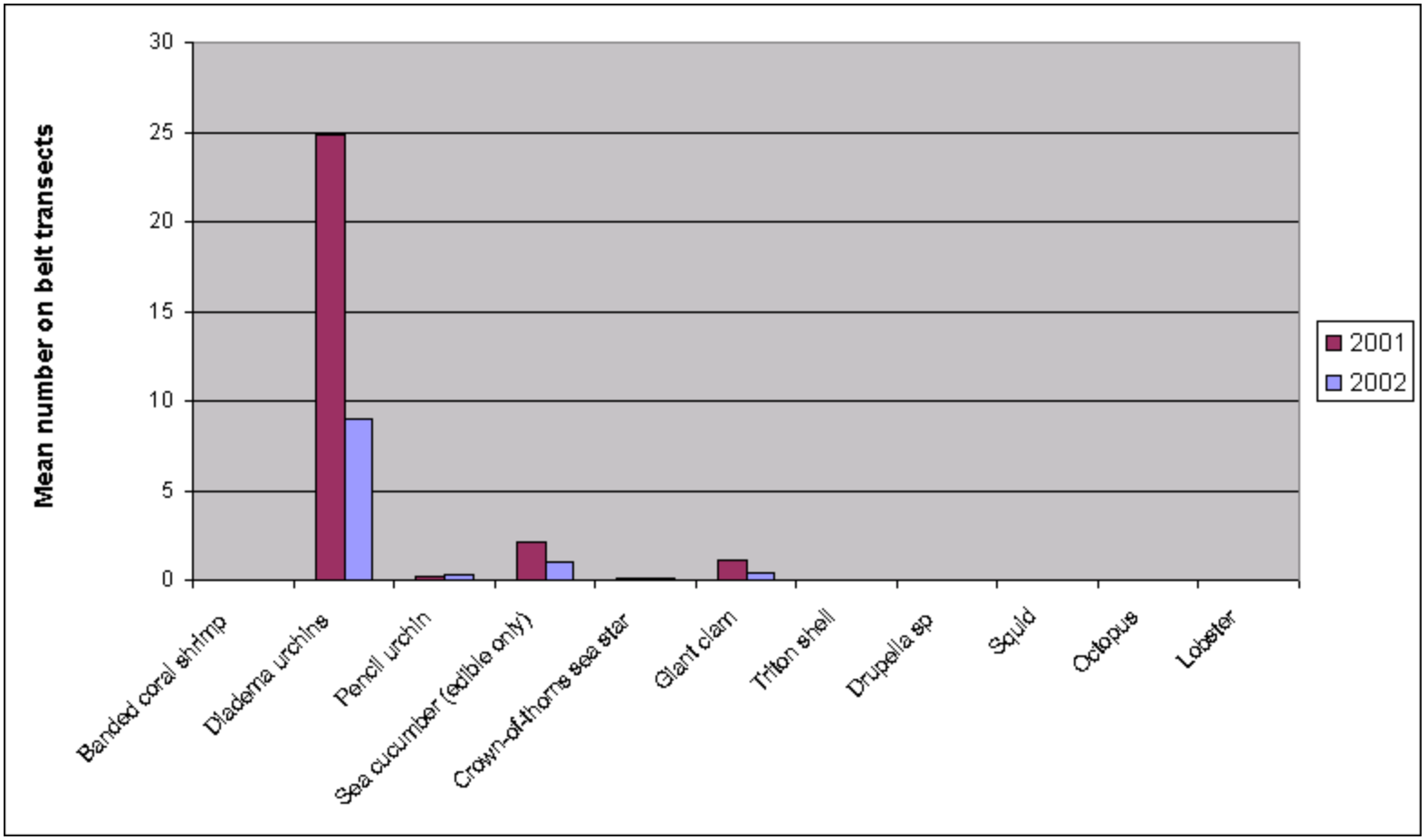
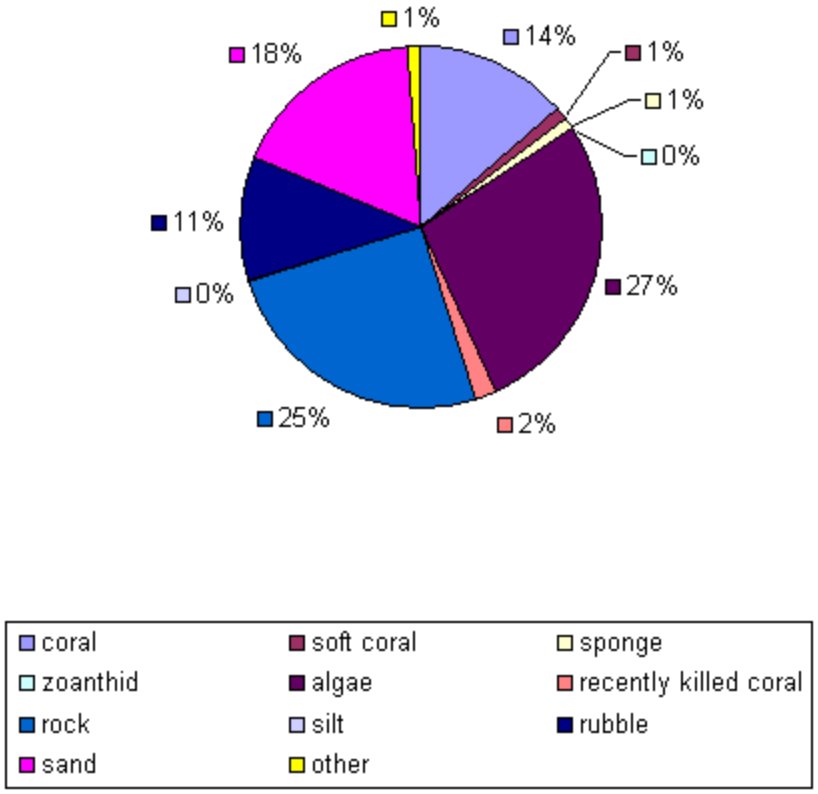


Figure 5. Temporal comparison of invertebrate abundance per $100m^2$ section of the Reef Check belt transect.

2001



2002

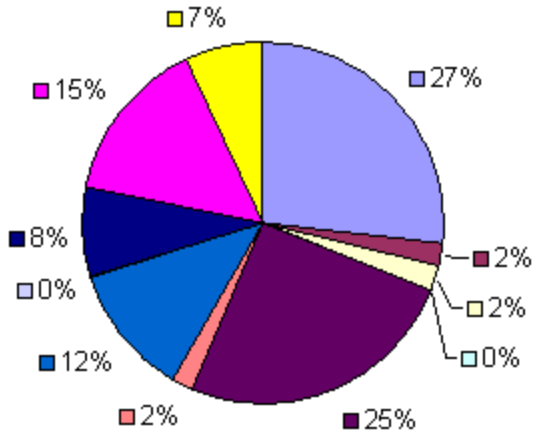


Figure 6. Proportion of different benthic categories from all Reef Check sites for 2001 data (pie chart on top) and 2002 data (lower pie chart).

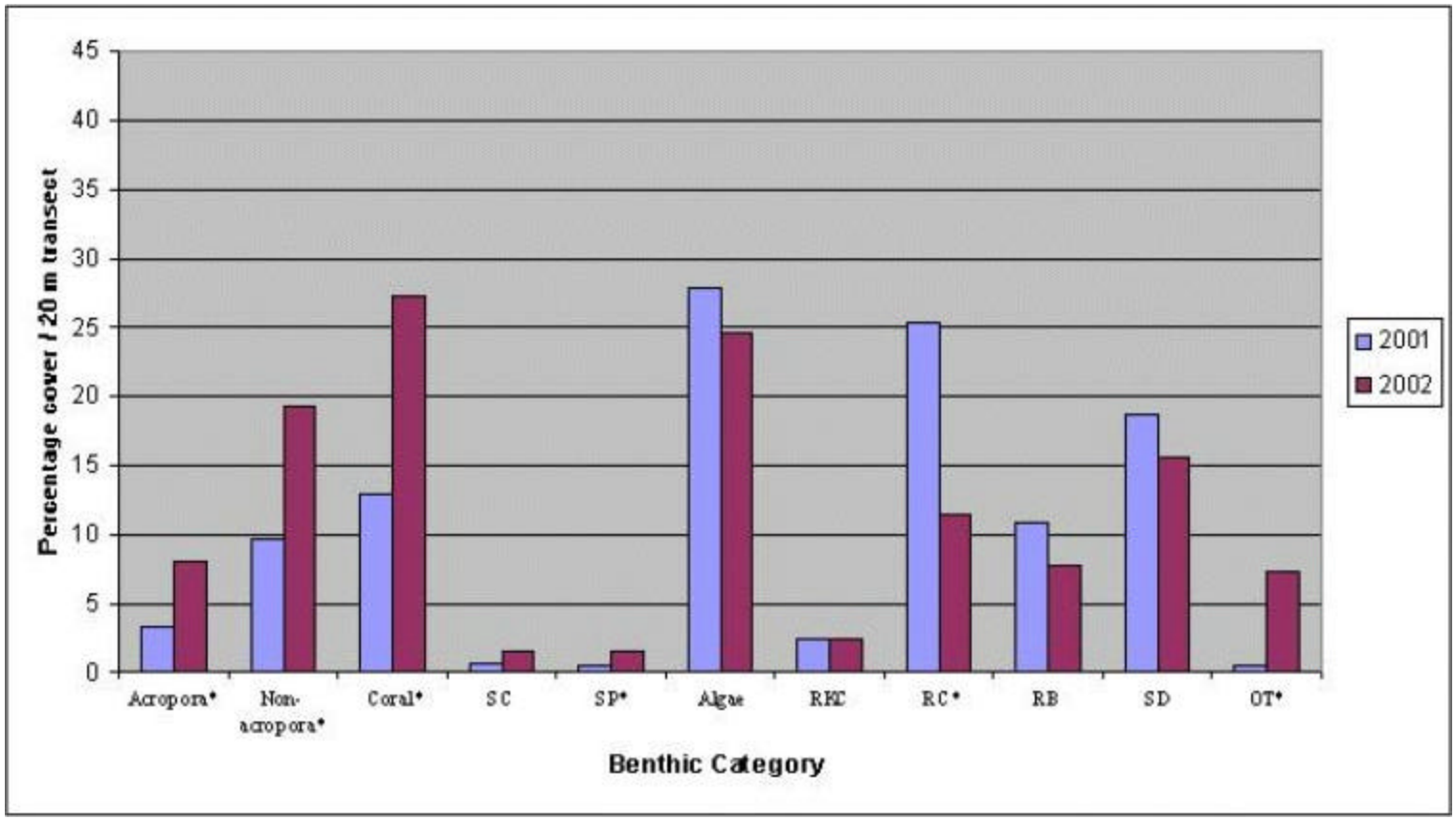


Figure 7. Temporal changes in benthic cover (%) between 2001 and 2002.

Notes: Significant increases occurred in the percent cover of *Acropora*, Non-*Acropora*, total coral and Other (OT) categories. There was a significant decrease in the % cover of rock (RC) between 2001 and 2002.

4. DISCUSSION

The most obvious difference between 2001 and 2002 data sets is the increase in both *Acropora* and Non-*Acropora* and therefore, total coral cover at almost all of the study sites. This increase is extremely encouraging. A small factor in this increase may be due to the difference in exact placement of the 2002 transects in relation to those surveyed in 2001. However, the fact that at over 80% of the sites there was an increase in coral cover makes this unlikely to be significant over the whole study area. Therefore, it can be assumed that there has been a significant increase in coral cover for the Mamanucas area between 2001 and 2002. Survey sites spanned the complete range of geomorphological reef types present in the region at widely dispersed localities. The ASEAN system for describing the health of coral reefs (Chou *et al*., 1984) states that coral reefs with cover less than 25% are described as being in 'poor' health, whilst those of cover in excess of 25% are described as 'fair'. Therefore, the reefs appear to have doubled in live hard coral cover in this area in one year, and increased their ASEAN health rating from poor to fair. *Acropora* coral, normally known for its susceptibility to bleaching has also recovered significantly with volunteers recording branching *Acropora* coral cover in areas such as Namotu Island backreef and Sunflower reef (to the south of Malololailai). *Acropora* corals are designed to recover quickly from breakage, are amongst the fastest growing corals and have high fecundities. This makes them able to recover quickly from population crashes as a result of this life history strategy (*r*-selected traits) over the slower-growing *K*-selected species such as *Porites lobata, Diploastrea heliopora* and some other massive coral species.

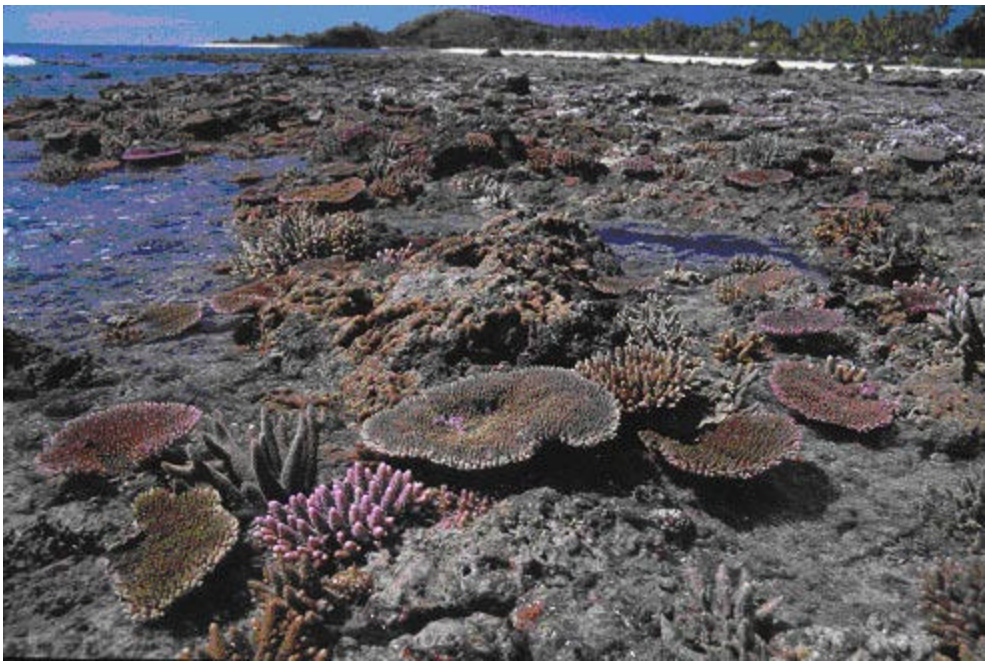


Figure 8. Shallow *Acropora* rich coral reef platforms on the intertidal area of Mana Island. These corals are exposed as a result of an extreme low tide.

The survey period of June-July in which the 2002 Reef Check surveys were carried out coincided with a bleaching event witnessed in other areas of the Fiji archipelago. Sea surface temperatures (SST) of 31°C were reported on the Suva barrier reef approximately 100 km to the east of the study area. Water temperatures in April 2002 recorded in the Mamanucas also reached between 30.5 and 31°C (CCC data, Solandt *et al*., 2002).

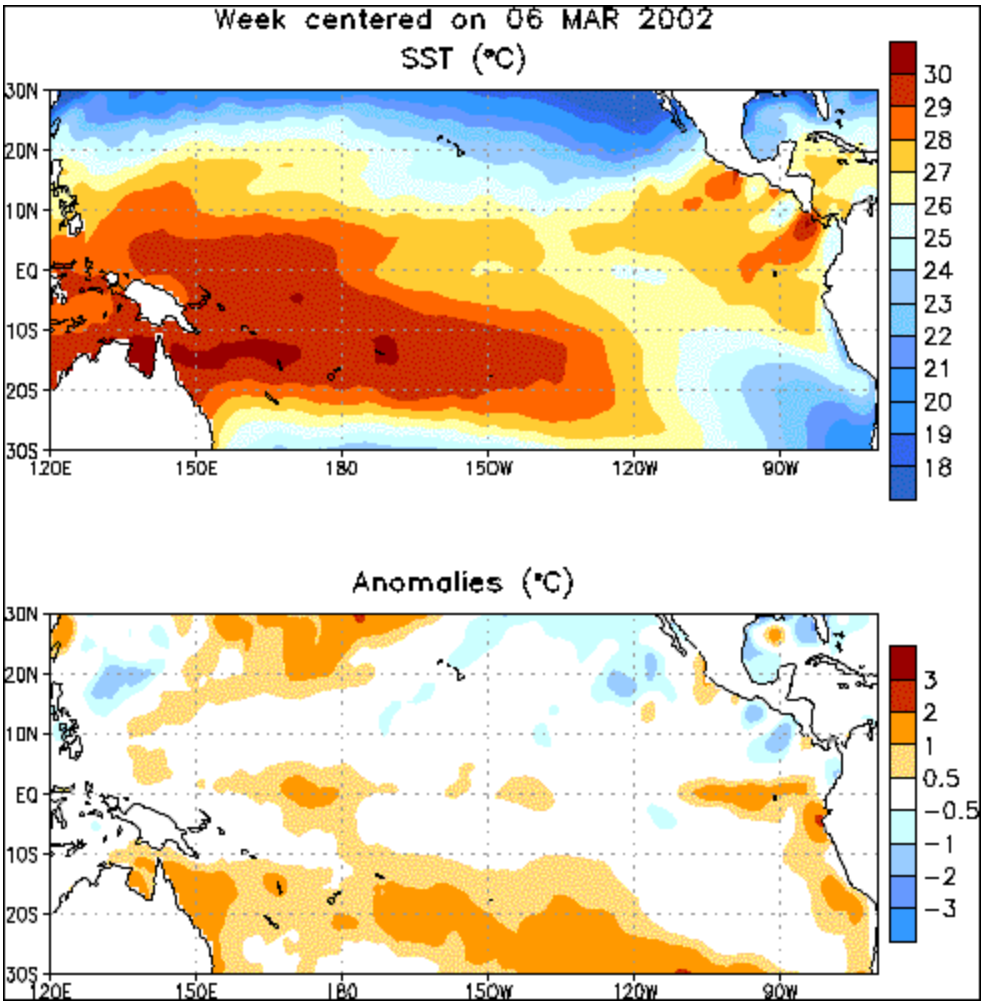


Figure 9. NOAA satellite image of water temperatures over the south Pacific in March 2002. The top figure highlights areas of particular temperatures in different regions. The lower diagram shows the number of 'degree heating weeks' where temperature was in excess of monthly mean values (in Fiji for one week).

30°C is generally regarded as the watershed point at which corals start to bleach (Brown, 1997). In April 2002, water temperatures around the Mamanucas reached approximately 30-31°C for approximately one month. This led to some bleaching at a national scale, principally of the genus *Acropora* corals, but only in shallow waters. Shallow areas (2-4m) in which the CCC Fiji data is derived showed 5 % of coral colonies of the genus *Acropora* having been bleached. There was also one large area of *Acropora* coral at 14 m near Sunflower reef where a 15 m^2 area was bleached, but only the apical portions of the colony's branches. Other than this small percent of bleached coral and the deeper bleaching at Sunflower, there appeared to be little overall impact of the bleaching in the Mamanucas for April-May 2002. Bleaching in 2002 was not nearly as significant as the bleaching event that occurred in 2000.

Comparison of reef fish and invertebrate data between 2001 and 2002 reveal little significant difference in the motile populations of reef associated fish and invertebrate organisms. This is to be expected over such a short time period. There was a significant decrease in the abundance of tuna and mackerel between the years. However, these tend to be non-reef associated species that have large feeding ranges, and would therefore not be likely to be recorded all the time at one individual reef site. The complete lack of some target fish and invertebrate species (e.g. humphead wrasse, triton shell) suggests that these species have been subject to overfishing. However, further work is required to confirm that this suggestion is not just an artefact of the surveying technique in relation to organism distribution patterns.

6. CONCLUSIONS

There was a significant increase in hard coral cover in the Mamanucas over the survey period with values increasing from a mean of 14% to 27% which is more than double the original 2001 cover. This massive increase over such a short time period is reason for optimism, showing recovery of a 'poor' reef rating in 2001 (possibly due to mass bleaching and typhoon damage in 2000 (South and Skelton, 2000)) to a 'fair' reef rating in July 2002.

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Recording forms used for data collected during Reef Check surveys. Note that these are modified from the standard forms available at http://www.ReefCheck.org/

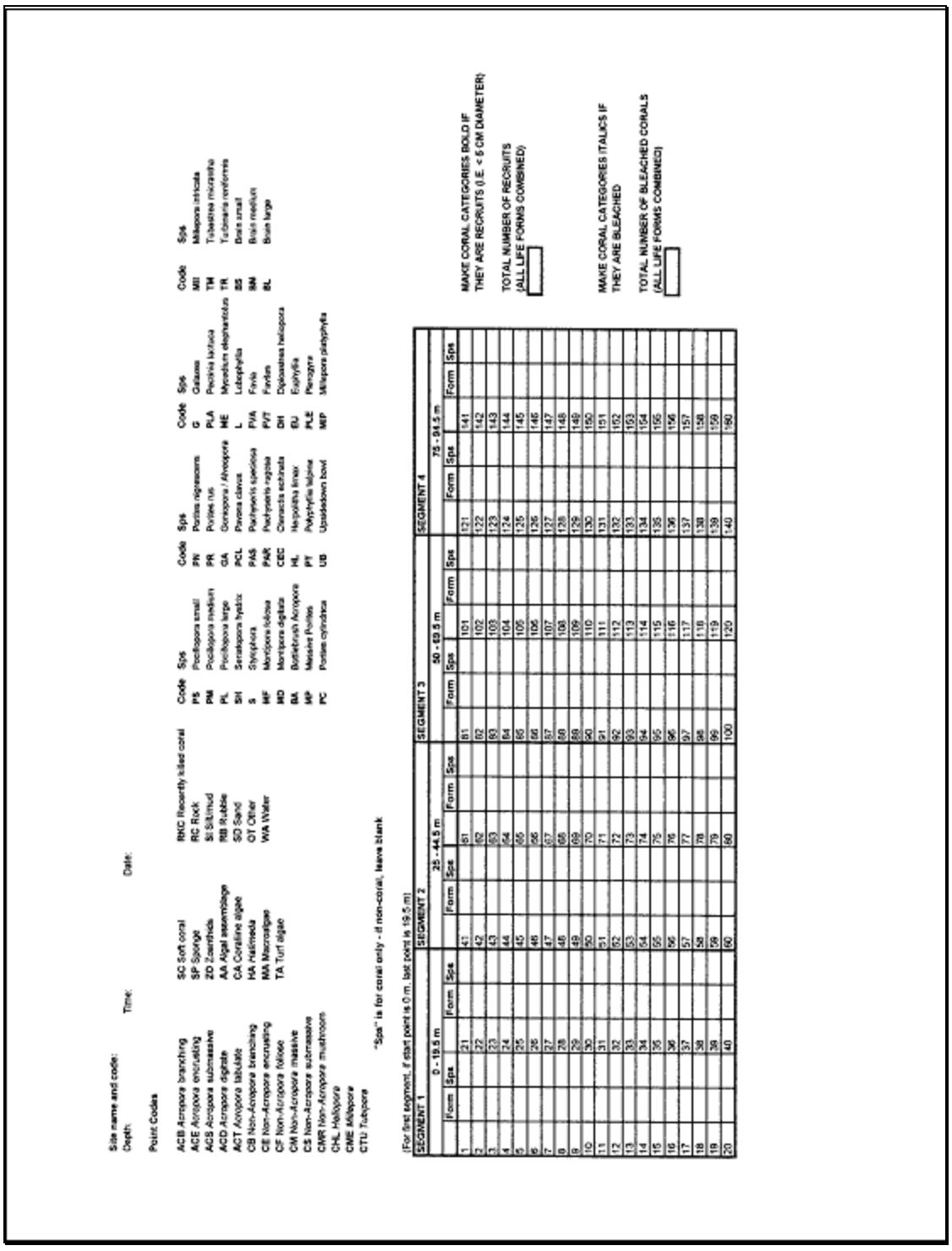
Appendix 1

Physical and Anthropogenic impact data sheet

Site name and code	
Date	
Time of day that work started	
Time of day that work ended	
Longitude of Reef Check transect	
Latitude of Reef Check transect	
Orientation of Reef Check transect	N-S NE-SW E-W SE-NW
Distance of Reef Check transect from shore	_____ m
Distance of site from nearest river	_____ km
River mouth width	<10m 11-50m 51-100m 101-500m
Weather	sunny cloudy raining
Air temperature	___ degrees Celsius
Water temperature at surface	degrees Celsius
Water temperature at 3 m	___ degrees Celsius
Water temperature at 10 m	degrees Celsius
Water temperature at 20 m	___ degrees Celsius
Water temperature at 30 m	___ degrees Celsius
Distance to nearest population centre	km
Approximate population size	x 1000 people
Horizontal visibility in water	m
Vertical visibility in water	m
Why was this site selected?	
Is this site -	sheltered or exposed
Any major coral damaging storms in past years?	yes no unknown
How do you rate this site overall in terms of anthropogenic impact?	none low moderate heavy
What types of impact do you believe occur?	
Number of fishing boats within 500m	
Number of other boats within 500m	
Dynamite fishing	none low moderate heavy
Poison fishing	none low moderate heavy
Aquarium fish collection	none low moderate heavy
Harvest of invertebrates for food	none low moderate heavy
Harvest of invertebrates for curio sales	none low moderate heavy
Tourist diving	none low moderate heavy
Sewage pollution	none low moderate heavy
Industrial pollution	none low moderate heavy
Other forms of fishing? (Specify)	none low moderate heavy
Other impacts? (Specify)	none low moderate heavy
Is there any form of protection (statutory or other) at this site?	yes _____ no _____
If yes, what type of protection?	
Other comments	

APPENDIX 2

Benthic cover data sheet



Site name and code: Time: Date:
Depth:

Point Codes

ACB Acropora branching	SC Soft coral	RKC Recently killed coral	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	Code	Spa	
ACE Acropora encrusting	SP Sponge	RC Rock	PS	Pocillopora small	PN	Porites nigrescens	G	Galaxea	MII	Millepora intricata													
ACS Acropora submassive	ZO Zoanthids	SI Silt/mud	PM	Pocillopora medium	PR	Porites rus	PLA	Pectinia lactuca	TM	Turbinaria mesenterina													
ACD Acropora digitate	AA Algal assemblage	RB Rubble	PL	Pocillopora large	GA	Goniopora / Alveopora	ME	Mycedium elephantotus	TR	Turbinaria reniformis													
ACT Acropora tabulate	CA Coralline algae	SD Sand	SH	Seriatopora hystrix	PCL	Pavona clavus	L	Lobophyllia	BS	Brain small													
CB Non-Acropora branching	HA Halimeda	OT Other	S	Stylophora	PAS	Pachyseris speciosa	FVA	Favia	BM	Brain meilun													
CE Non-Acropora encrusting	MA Macroalgae	WA Water	MF	Montipora foliosa	PAR	Pachyseris rugosa	FVT	Favites	BL	Brain large													
CF Non-Acropora foliose	TA Turf algae		MD	Montipora digitata	CEC	Cleneacis echinata	DH	Diploastrea heliopora															
CM Non-Acropora massive			BA	Butterfruit Acropora	HL	Herpolitha limax	EU	Euphyllia															
CS Non-Acropora submassive			MP	Massive Porites	PT	Polyphyllia talpina	PLE	Pectogyra															
CMR Non-Acropora mushroom			PC	Porites cylindrica	UB	Upsidedown boat	MIP	Millepora platyphylla															
CHL Heliopora																							
CME Millepora																							
CTU Tubipora																							

"Spa" is for coral only - if non-coral, leave blank

(For first segment, if start point is 0 m, last point is 19.5 m)

SEGMENT 1				SEGMENT 2				SEGMENT 3				SEGMENT 4			
	0 - 19.5 m			25 - 44.5 m				50 - 69.5 m				75 - 94.5 m			
	Form	Spa	Form	Spa	Form	Spa	Form	Spa	Form	Spa	Form	Spa	Form	Spa	Form	Spa
1							81		101		121		141			
2		22		42		62		82		102		122		142		
3		23		43		63		83		103		123		143		
4		24		44		64		84		104		124		144		
5		25		45		65		85		105		125		145		
6		26		46		66		86		106		126		146		
7		27		47		67		87		107		127		147		
8		28		48		68		88		108		128		148		
9		29		49		69		89		109		129		149		
10		30		50		70		90		110		130		150		
11		31		51		71		91		111		131		151		
12		32		52		72		92		112		132		152		
13		33		53		73		93		113		133		153		
14		34		54		74		94		114		134		154		
15		35		55		75		95		115		135		155		
16		36		56		76		96		116		136		156		
17		37		57		77		97		117		137		157		
18		38		58		78		98		118		138		158		
19		39		59		79		99		119		139		159		
20		40		60		80		100		120		140		160		

MAKE CORAL CATEGORIES BOLD IF THEY ARE RECRUITS (I.E. < 5 CM DIAMETER)

TOTAL NUMBER OF RECRUITS (ALL LIFE FORMS COMBINED)

MAKE CORAL CATEGORIES ITALICS IF THEY ARE BLEACHED

TOTAL NUMBER OF BLEACHED CORALS (ALL LIFE FORMS COMBINED)

APPENDIX 3

Target Fish and Invertebrate data sheet

REEF CHECK 2001- Please fill in all Black outlined boxes

Site Name:
Depth:
Date: Time:

Indo-Pacific Belt Transect : Fish
Data recorded by:

	0-20m	25-45m	50-70m	75-100m
Butterfly fish (ALL SPS)				
Sweetlips (Haemulidae) (ALL SPS)				
Snapper (Lutjanidae) (ALL SPS)				
Two-spot				
Checkered				
Black-and-white				
"Blueline"				
Paddletail				
Barramundi Cod (*Cromileptes*)				
Grouper >30cm (Give sizes in comments) (ALL SPS)				
Flagtail				
Peacock				
"Honeycomb"				
Lyretail				
Humphead wrasse				
Bumphead parrot				
Other Parrotfish (>20cm)				
Tuna / Mackerel				
Fusiliers				
Surgeonfish				
Rabbitfish				
Barracuda				
Jacks / Trevally				
Moray eel				

"ALL SPS" means that all individuals from that family should be counted in the box and additional target species are counted a second time on subsequent line
e.g. a paddletail snapper is

counted both as a snapper AND as a paddletail snapper

Indo-Pacific Belt Transect : Invertebratee
Data recorded by:

	0-20m	25-45m	50-70m	75-100m
Banded coral shrimp (*Stenopus hispidus*)				
Diadema urchins				
Pencil urchin (*Heterocentrotus mammilatus*)				
Sea cucumber (edible only)				
Crown-of-thorns star (*Acanthaster*)				
Giant clam (*Tridacna*)				
Triton shell (*Charonia tritonis*)				
Drupella sp				
Squid				
Octopus				
Lobster				

For each segment, rate the following as: None=0, Low=1, Medium=2, High=3

Coral damage : Anchor				
Coral damage:Dynamite				
Coral damage : Other				
Trash : Fish nets				
Trash : Other				

Comments:				

Grouper sizes (cm)				
Bleaching (% of coral population)				
Bleach (% of colony)				
Suspected disease (type/%):				
Rare animals sighted (type/#):				
Other:				