Report on Baseline Surveys for Monitoring the Fringing Reef of Rarotonga, Cook Islands

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INTRODUCTION

On a global basis it is generally recognised that coral reef systems are exhibiting signs of increasing stress and that there is a general lack of understanding of the causes of this stress. In the face of global climate change and potential sea level rise, impacts caused by events such as coral bleaching and tropical storms, coupled with increasing human usage, there is a need for reliable information on the status of coral reefs. There are inadequate baseline data to provide rigorous scientific assessment of the nature and the extent of the problem. Such information is essential for the informed management and sustainable use of this vital resource.

With this in mind, IOC-UNEP-SPREP sponsored a workshop in the Cook Islands, hosted by the Cook Islands Conservation Service at Rarotonga from 23rd February to 11th March 1994. Using sampling methods developed jointly by the ASEAN-Australia Living Coastal Resources Project as a basis for a global monitoring program, the workshop had two main aims. These were:

1. To develop a monitoring program and provide baseline data on the status of the fringing reefs surrounding Rarotonga, Cook Islands.

2. To train participants from the Pacific Islands (Papua New Guinea, Fiji, Solomon Islands and Cook Islands) in the use of standard sampling methods adopted for the global monitoring program.

This report summarises the data collected by the teaching staff during the workshop. It also provides a pilot study which it is hoped will form the basis of a more comprehensive program of monitoring on Rarotonga carried out by staff from the Cook Islands. A series of recommendations have also been included at the end of the document.

METHODS

SITE SELECTION

Eight areas (henceforth described as reefs) on the fringing reef of Rarotonga, Cook Islands, were chosen for monitoring. Reefs were selected to represent potentially impacted areas (i.e. reefs where land use practices may (be expected to) influence growth and recruitment of reef benthos and associated fish fauna) and non-impacted areas, or controls (i.e. reefs which may be considered to be relatively free of terrestrial inputs) (Figure 1).

Two control reefs were chosen to represent sites for the global monitoring program. These are:

1. ***Titikaveka Reef*** - on the southeastern side of the island, has no channels emanating from within the nearby lagoonal area that may act as point sources of terrestrial inputs. During much of the year water circulation is dominated by the oceanic waters of the Southern Pacific (brought on by the SE trade winds).

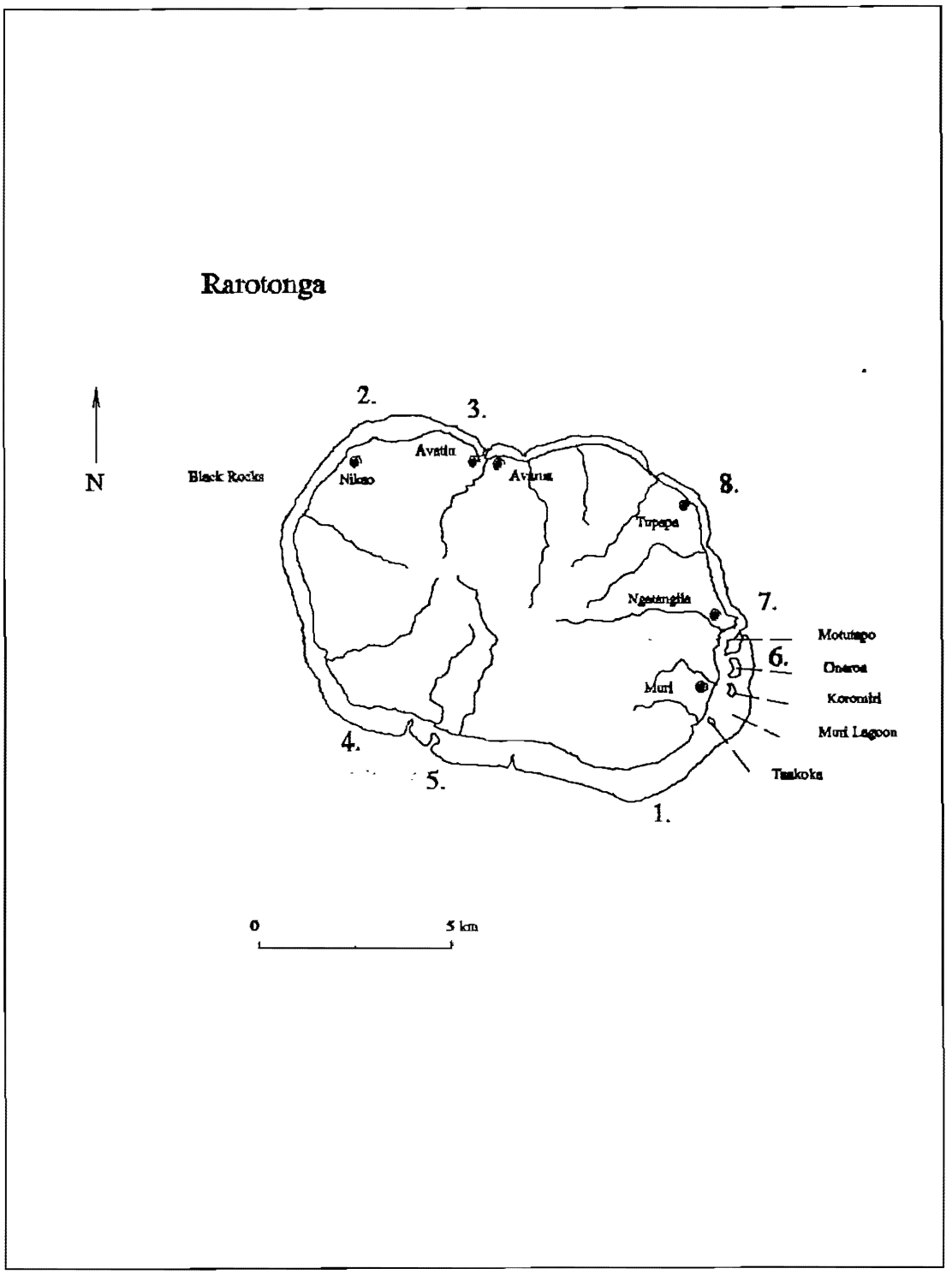
2. ***Nikao Reef*** - on the northeastern side of the island. Despite being near to the airport, terrestrial runoff onto this reef is usually minimal with no nearby channels emanating from within the lagoonal area that may act as point sources for terrestrial input. Much of the year water circulation is dominated by oceanic waters of the Southern Pacific (brought on by summer Northerly winds).

A further six impacted reefs were also chosen as part of the monitoring program for Rarotonga, Cook Islands. These are:

3. ***Avatiu Reef*** - to the north of the main harbour of Rarotonga, was chosen to reflect impacts of current activities in the harbour and to provide baseline data on possible impacts of any future harbour development.

4. ***Rutaki Reef*** - on the southern side of the island west of Rutaki Passage, is opposite an area of the lagoon impacted by sewage seepage. The reef has been chosen to monitor the potential effects of the lagoonal water emitting from Rutaki passage. The lagoon in this area is also presently being monitored by the CICS.

Figure 1. Map of Rarotonga showing approximate locations of reefs chosen for the monitoring program. Numbers correspond to those reefs given in the methods.



5. ***Vaimaanga Reef*** - near to Rutaki Reef, extends eastward from the Papua Passage. Extensive land works (adjacent to the reef) due to a dormant Sheraton Hotel project identified this reef as an important monitoring site. The effects of runoff and the potential for future development and increased tourism in the immediate area highlight the need for adequate baseline data on this reef.

6. ***Muri Reef*** - south of Ngatangiia harbour, the entrance to which is the main channel that drains the lagoon for this side of the island. A popular harbour for small boat operators, the harbour currently has little infrastructure. The need for baseline data on this reef is highlighted by the harbour being earmarked for future development.

7. ***Ngatangiia Reef*** - north of Ngatangiia harbour, is being monitored for the same reasons as Muri Reef.

8. ***Matavera Reef*** - on the eastern side of the island, was chosen to study the effects of runoff from a nearby coastal landfill. This landfill is currently the major repository for the municipal garbage collected on the island.

SURVEY METHODS

Logistical constraints and training commitments reduced the sites surveyed to Titikaveka, Ngatangiia and Avatiu Reefs. At each reef, two sites located approximately 500m apart were chosen. Where possible, the position of these sites was recorded using a hand-held GPS, these positions are recorded in the Sample Table (Appendix 1). Each site consisted of five fifty metre transects laid along the 10m depth contour of the reef. Shallower depth contours were deemed inappropriate for survey due to high wave energy of the system. At each transect, reef benthos was surveyed over a length of 20m using the Line Intercept Transect (LIT) method described in UNEP/AIMS 1993. Only four transects were surveyed on site 1 Ngatangiia Reef.

Fish were surveyed in a five metre wide belt along the entire 50m of each transect. The Visual Census Technique (VCT) as described in English et al. 1994 was used. Absolute counts were made of all species from the families Acanthuridae, Chaetodontidae, Kyphosidae, Scaridae and Zanclidae. Log base 4 abundance categories where recorded for species of the Pomacentridae on all sites except

Ngatangiia site 1. The families Lethrinidae and Lutjanidae were also targeted however none were recorded.

Surveyed reefs were also videoed using the method developed by AIMS (AIMS 1994) to provide a permanent visual record of the reefs surveyed during this study.

RESULTS

REEF BENTHOS SURVEYS

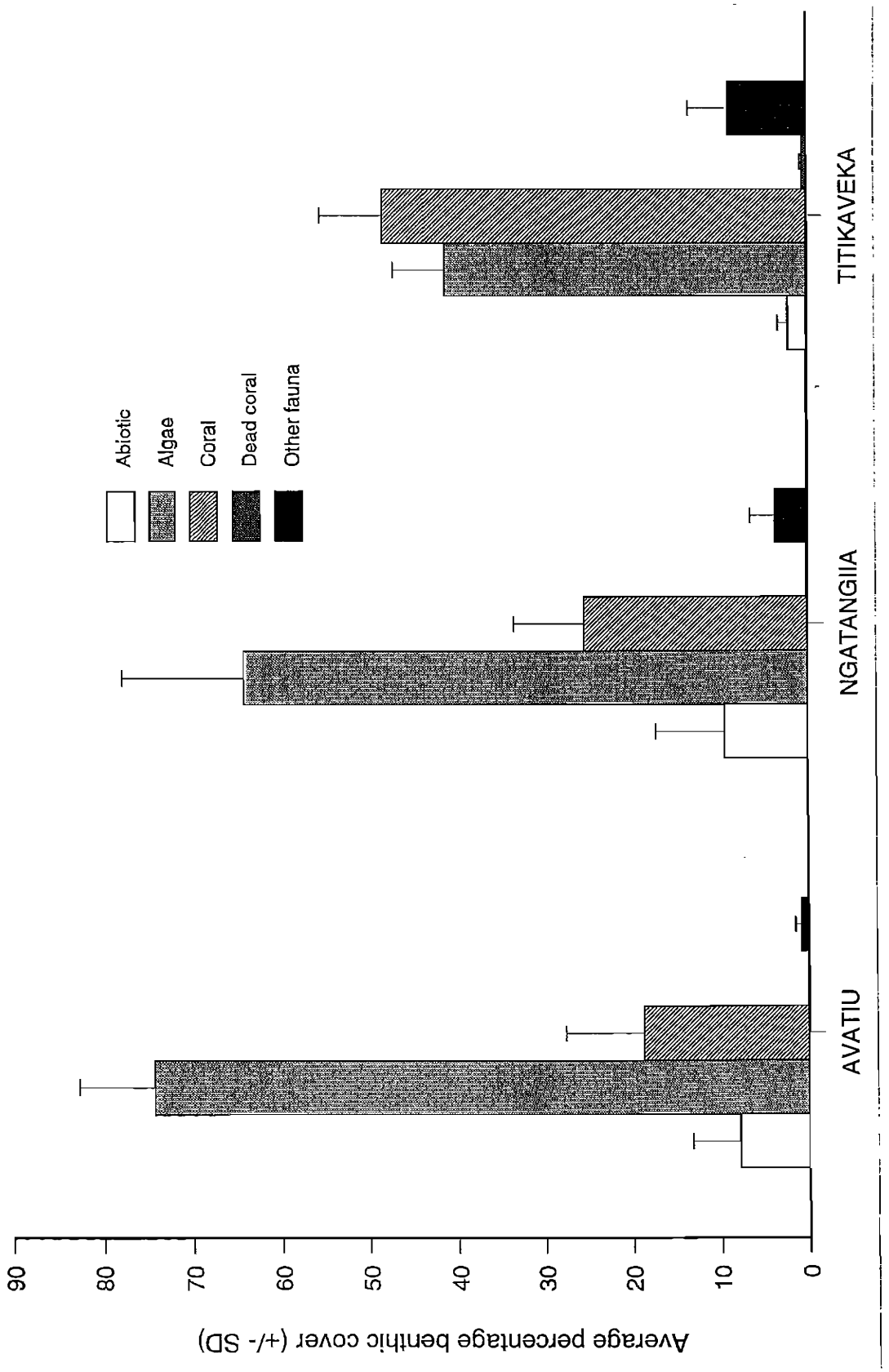
Results for the LIT on the three reefs surveyed have been summarised and presented graphically in Figure 2. A more detailed breakdown of cover estimates for all lifeform categories recorded for each reef is given in Appendix 2.

Algae were the dominant benthic lifeform at Avatiu Reef with a mean percentage cover of approximately 74%. Of this, 72% of the cover was composed of turf algae, the rest (approximately 2%) being composed of coralline algae. Coral cover for this reef was relatively low at approximately 19%. Of this, non-acroporid corals dominated (mean percentage cover approximately 16%) with encrusting corals comprising over 8% of the total coral cover (see Appendix 2).

Ngatangiia Reef like Avatiu Reef was dominated by algae with a mean percentage cover of approximately 64%. Of this approximately 61% was turf algae. While coral cover was relatively low at approximately 25% it was higher than that encountered at Avatiu Reef. Again non-acroporid corals dominated with a mean percentage cover of approximately 19%. Encrusting corals were the best represented coral type with a mean percentage cover of approximately 9%.

Unlike Avatiu Reef and Ngatangiia Reef, live coral was the dominant benthic lifeform at Titikaveka Reef with a mean percentage cover of approximately 48%. Of the corals recorded acroporids dominated with a cover of approximately 26% while non-acroporid corals made up the remaining 22%. While coral cover was relatively high for this reef, algal cover was also quite high at approximately 41%. Again in contrast to Avatiu Reef and Ngatangiia Reef, much of this cover was composed of coralline algae with a mean percentage cover of approximately 26%. Turf algae comprised only approximately 14% of the total benthic cover.

Figure 2. Mean percentage cover estimates of grouped categories for reefs surveyed.



REEF FISH SURVEYS

Figure 3 shows that species richness is higher for the families censused at Titikaveka Reef than the other two reefs except for the Pomacentridae which was represented by eight species at Avatiu Reef compared to 7 species at Titikaveka Reef. The most obvious difference between the reefs is the species richness of the Chaetodontidae being 11 at Titikaveka Reef compared to 7 and 6 at Avatiu Reef and Ngatangiia Reef respectively.

Figure 4 shows the average abundance for species grouped to family for the Chaetodontidae and the Scaridae. The Acanthuridae were grouped to genus due to the dominance of *Acanthurus nigrofuscus* and *Ctenochaetus striatus* in the community (Table 1). There was little difference in the absolute abundance of either the Chaetodontidae or Scaridae between reefs. Acanthuridae numbers were higher on Avatiu Reef (23.5%) than on the other two reefs (18% and 16.5%). The abundance of *Ctenochaetus* was lowest at Avatiu Reef (11%) and highest at Titikaveka Reef (16.1%).

Figure 5 plots the average abundance or the dominant species of Pomacentridae. The values were converted from log abundance categories using the geometric mean of each category to give an estimate of actual abundance on each transect. Avatiu Reef showed a very different distribution of species to the other two reefs with very low counts for all species except *Chromis vanderbilti*. The general species distributions at Ngatangiia and Titikaveka Reefs were very similar, the only difference being slightly higher numbers across all species at Titikaveka Reef.

Table 1: Reef fish species list and total counts per reef.

Species	Avatiu	Ngantangiia	Titikaveka
Acanthurus achilles	0	1	4
Acanthurus nigricans	0	0	3
Acanthurus nigrofuscus	234	173	148
Acanthurus nigroris	0	6	7
Acanthurus triostegus	0	0	6
Calotomus carolinus	0	1	1
Chaetodon bennetti	0	0	2
Chaetodon citrinellus	4	0	0
Chaetodon ephippium	2	0	1
Chaetodon flavirostris	0	0	1
Chaetodon ornatissimus	1	7	8
Chaetodon pelewensis	18	21	3
Chaetodon quadrimaculatus	5	3	6
Chaetodon reticulatus	7	16	18
Chaetodon trifascialis	0	0	2
Chaetodon ulietensis	0	0	1
Chaetodon unimaculatus	5	0	4
Ctenochaetus striatus	110	129	161
Forcipiger flavissimus	0	1	5
Forcipiger longirostris	0	3	0
Gomphosus varius	3	I	9
Kyphosus cinerascens	0	1	2
Naso lituratus	3	8	8
Scarus forsteni	0	0	2
Scarus frenatus	0	0	1
Scarus globiceps	12	19	3
Scarus psitticus	6	13	1
Scarus schlegeli	2	7	
Scarus sordidus	8	11	22
Zanclus cornutus	0	4	2
Zebrasoma scopas	1	1	3
Zebrasoma veliferum	0	0	2
Chromis acares	12	54	142
Chromis vanderbilti	440	112	320
Chromis xanthura	0	0	3
Dascylus trimaculatus	1	0	17
Plectroglyphidodon dickii	1	0	5
Plectroglyphidodon imparipennis	19	1	0
Plectroglyphidodon johnstonianus	7	17	65
Pomacentrus vaiuli	1	9	0
Stegastes fasciolatus	58	80	248

Figure 3. Species richness of dominant reef fish families on reefs surveyed.

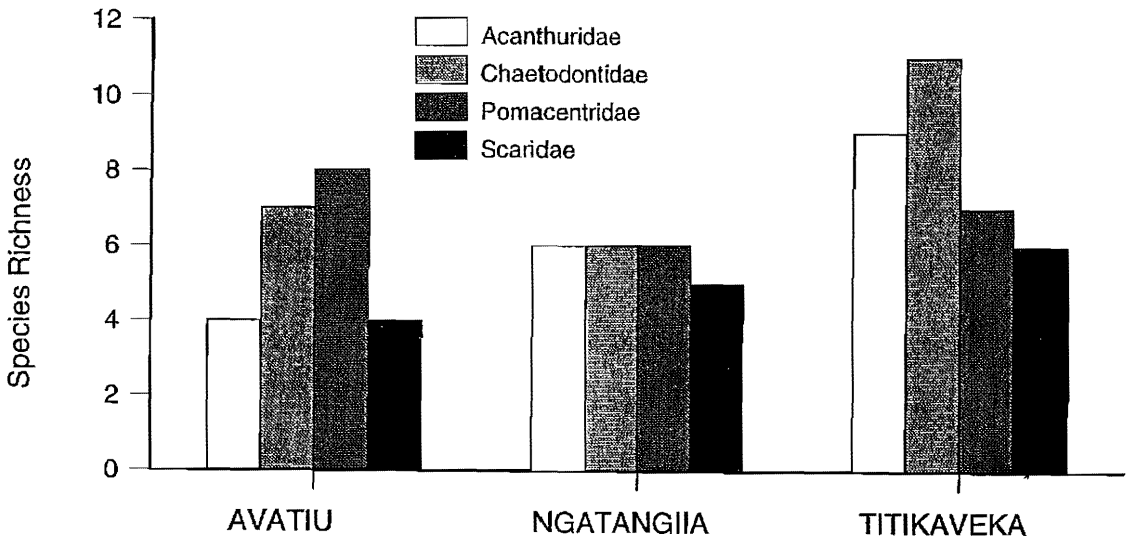


Figure 4. Mean abundance per transect of dominant taxonomic groups of reef fish.

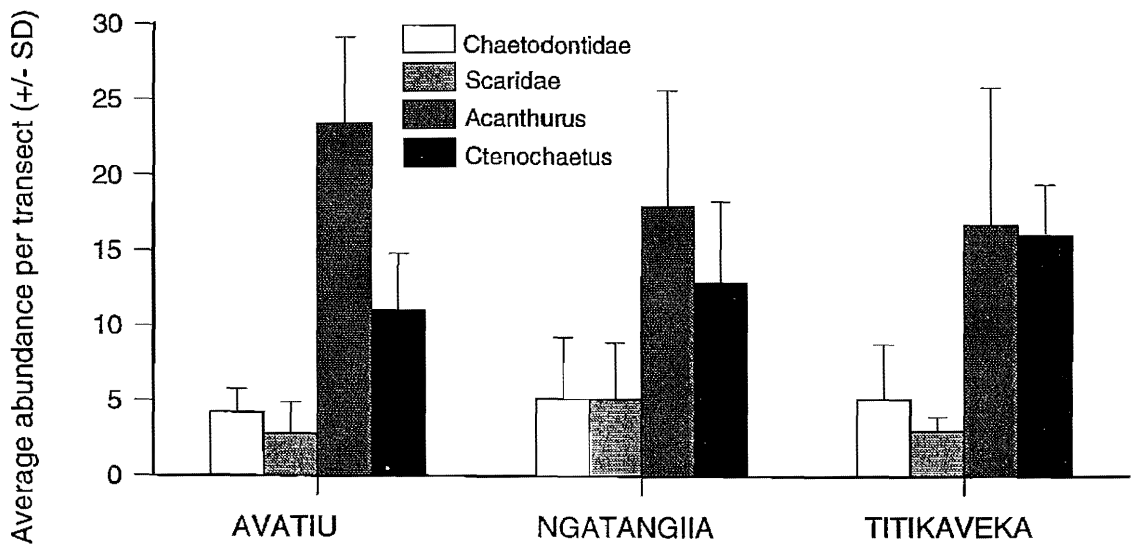
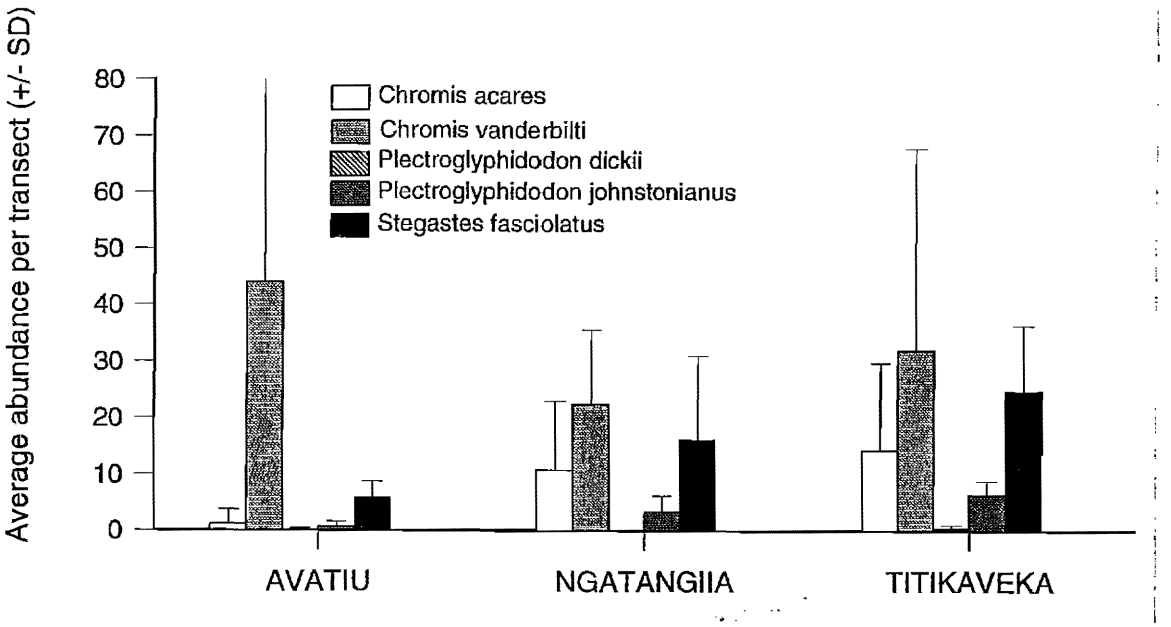


Figure 5. Mean abundance per transect for dominant species of Pomacentridae.



DISCUSSION

This first sample of a monitoring program provides baseline data which enables an initial description of the reefs in question. It is only through continued sampling that changes in the communities can be determined. In the context of this study, the patterns of abundance of reef fish and benthic communities are described and form a baseline description of the surveyed reefs.

The techniques used have revealed differences in the benthic and reef fish communities between reefs. Titikaveka Reef is characterised by a relatively high live coral cover and an algal community dominated by coralline algae. This is in contrast to Avatiu Reef and Ngatangiia Reefs (Figure 1) which have broadly similar benthic communities dominated by turf algae. The higher species richness of reef fish found at Titikaveka Reef is not translated into an over all high abundance of fish. This is due to the fish communities on all reefs being dominated by herbivorous fishes which feed primarily on turf algae. The similarity in numbers of these herbivorous fish between all reefs suggests the food resource of turf algae is not limiting the population on Titikaveka Reef. In contrast, the high species richness of chaetodons on Titikaveka Reef compared to the other two reefs suggests a possible resource limitation (i.e. low live coral cover), which is excluding some species. The very skewed distribution of pomacentrids on Avatiu Reef suggests a low habitat diversity on this reef.

From this limited baseline study the causes of these patterns of distribution and abundance cannot be identified. The results obtained from the deliberate positioning of the sampling program to target impacted (Avatiu and Ngatangiia Reefs) and non-impacted (Titikaveka Reef) areas suggests that impacted reefs are stressed. Whether these stresses are the result of natural environmental conditions or man-induced, cannot be determined. Monitoring will enable the degree of any future impacts on these environments to be assessed.

One striking aspect of the reef fish community noted in all areas dived during the survey, was the very low species richness and abundance of top line predators in the fish fauna. In addition to low numbers the average size of fish seen was quite small. The type of fish which are largely absent are the rock cod (family Serranidae), the Snappers (family Lutjanidae) and the sweetlip (family Lethrinidae), all these fish are readily caught by line fishing and generally sort after as table varieties. This across the

board absence of a whole section of the community is suggestive of over fishing especially considering the small size class of those fish that are present. If the rest of the reef system exhibits similar densities of these species as the area surveyed in this study there is a drastic need for the implementation of a management plan. Such a plan could aim at protecting either spawning areas (if known) or closing sections of the reef to fishing to allow a build up of the population. It would be advisable in determining areas for closure to undertake a broader survey for these species and targeting protection to areas currently showing the highest abundances.

RECOMMENDATIONS

The results presented in this report clearly show that the techniques used are capable of describing differences in reef benthos and fish populations on the fringing reefs of Rarotonga. We, the authors, feel that a monitoring program based on these methods would be appropriate and provide sound information for the future management of the fringing reefs surrounding the island. If such a monitoring program is to be carried out we recommend that:

1. A core group of at least four trained (i.e. workshop participants) staff be selected and dedicated to the project;

2. Tasks be delegated and responsibility given to "task leaders" for the proper collection and management of the data. These tasks should include;

Task Leader: Fish surveys

As a member of a team to conduct VCT for fish populations and ensure the correct entry and checking of data. To assist other team members in all aspects of work both in the field and in the laboratory.

Task Leader: Reef benthos.

As a member of a team to conduct LIT for reef benthos and ensure the correct entry and checking of the data. To assist other team members in all aspects of work both in the field and in the laboratory.

Task Leader: Manta tow and logistics.

As member of a team to be in charge of manta tow surveys including the correct entry and checking of data, as well as maintenance of equipment and supplies. To assist other team members in all aspects of work both in the field and in the laboratory.

Task Leader: Database management.

As a member of a team to oversee the correct entry and checking of data. To maintain and extract information from the database. To ensure correct experimental procedures are carried out at all times. To assist

other team members in all aspects of work both in the field and in the laboratory.

3. The fringing reef be manta towed to gain a broad scale assessment of the benthic cover around the island as a baseline for future monitoring. This will also help determine the efficacy of the reefs selected for LIT and VCT and act as a baseline for determining the effects of any future impacts on the fringing reef;

4. Before LIT and VCT are conducted on the reefs identified in this report Titikaveka Reef, Ngatangiia Reef and Avatiu Reef should be resurveyed immediately and permanent sites established using a "star picket" hammered into the reef with a subsurface buoy attached and position marked using a GPS (Geographical Positioning System). By resurveying these reefs, results can be compared to those obtained in this study. These results should be similar;

5. LIT and VCT be conducted on the reefs identified in this study using identical procedures. This is to establish base line data for the reefs of Rarotonga. If more than one observer is to be used for collecting LIT or VCT data then they should standardise their observations with respect to each other as much as possible. This can be done by direct comparisons of data collected by observers on the same transect. When conducting surveys different observers should take turns doing transects to help prevent bias in the data;

6. Repeat surveys should be conducted at a minimum of an annual basis;

7. Further training and standardisation of observers be a ongoing process to ensure the integrity of any data collected;

8. All observers continue to increase their skills in identifying reef fish and reef benthos (a list of fish recommended for inclusion in future monitoring is given in Appendix 4);

9. A priority be given to continuity through time. If staff changes occur then new team members must be adequately trained.

REFERENCES

AIMS (1994). Standard Operational Procedure for Benthic Video Surveys. AIMS (unpublished.).

English, S., C. Wilkinson and V. Baker (1994). "Survey Manual for Tropical Marine Resources." Australian Institute of Marine Science, Australia. 368pp.

Myers, R.F. (1989). Micronesian Reef Fishes: A Practical Guide to the Identification of the Coral reef Fishes of the Tropical Central and Western Pacific. Coral Graphics 298pp.

Randall, E.J., R.G. Allen and R.C. Steene (1990). Fishes of the Great Barrier Reef and the Coral Sea. Hawaii University Press 507pp.

UNEP/AIMS (1993). Monitoring Coral Reefs for Global Change. Reference Methods for Marine Pollution Studies No.61. UNEP 72pp.

Appendix 1: **Reef description and survey dates**

Country	Reef	Site	Date	Latitude	Longitude	Zone	Depth
Rarotonga	Ngatangiia	1	1/3/94	21°14'45"S	15°943'42"W	Slope	10
Rarotonga	Ngatangiia	2	7/3/94	21°14'18"S	15°943'54"W	Slope	10
Rarotonga	Titikaveka	1	2/3/94			Slope	11
Rarotonga	Titikaveka	2	9/3/94	21°16'57"S	15°944'25"W	Slope	9
Rarotonga	Avatiu	1	5/3/94			Slope	8
Rarotonga	Avatiu	2	6/3/94			Slope	10

Appendix 2: Mean percentage cover by reef

Reef name deviation	Benthic Life form	Mean cover (%)	Standard
Avatiu	ACB	2.36	1.93
Avatiu	ACD	1.14	1.26
Avatiu	ACS	0.35	0.11
Avatiu	ACT	1.44	0.41
Avatiu	CA	1.90	1.40
Avatiu	CB	1.14	
Avatiu	CE	8.37	6.15
Avatiu	CM	3.84	2.42
Avatiu	CS	4.10	3.40
Avatiu	OT	0.53	
Avatiu	R	8.27	3.39
Avatiu	S	2.23	2.08
Avatiu	SC	0.88	0.75
Avatiu	TA	72.43	8.51
Ngatangiia	ACB	4.42	2.07
Ngatangiia	ACD	1.28	1.04
Ngatangiia	ACS	0.19	0.11
Ngatangiia	ACT	2.37	1.38
Ngatangiia	CA	2.80	2.63
Ngatangiia	CB	2.28	1.35
Ngatangiia	CE	9.20	1.61
Ngatangiia	CF	1.13	0.65
Ngatangiia	CM	3.38	3.26
Ngatangiia	CS	4.01	2.07
Ngatangiia	DC	0.16	0.01
Ngatangiia	HA	0.18	0.07
Ngatangiia	MA	1.98	
Ngatangiia	OT	1.27	1.12
Ngatangiia	R	5.12	6.87
Ngatangiia	S	5.08	6.00
Ngatangila	SC	4.20	3.10
Ngatangiia	TA	61.15	15.84
Titikaveka	AA	2.18	0.92
Titikaveka	ACB	15.53	3.43
Titikaveka	ACD	3.60	2.10
Titikaveka	ACE	0.27	
Titikaveka	ACS	0.64	0.16
Titikaveka	ACT	10.45	5.98
Titikaveka	CA	25.89	6.96
Titikaveka	CB	3.30	2.27
Titikaveka	CE	1.73	1.32
Titikaveka	CF	1.28	0.92
Titikaveka	CM	1.78	0.79
Titikaveka	CME	1.00	0.87
Titikaveka	CS	11.59	1.83
Titikaveka	DC	0.16	
Titikaveka	DCA	0.57	0.29
Titikaveka	HA	0.83	0.73
Titikaveka	OT	0.83	0.64
Titikaveka	S	2.10	1.36
Titikaveka	SC	8.07	4.32
Titikaveka	TA	13.68	3.68
Titikaveka	ZO	0.33	0.10

Appendix 3: **Suggested species list for inclussion in future monitoring of reef fish.**

Species indicated by * are those which have been noted in the habitat targeted by the monitoring program. Additional species known to occur in the Cook Islands are included to allow the determination of species richness within the target families. No families representing piscivorous fish have been included due to very low numbers or absence from the sites visited, however, species from the following families should be included if found to occur at any of the other sites to be monitored (Lethrinidae, Lutjanidae and Serranidae). Suggested reference material for reef fish identification include Randall et al. (1990) and Myers (1989).

FAMILY ACANTHURIDAE

**Acanthurus achilles*
Acanthurus blochii
Acanthurus dussumieri
Acanthurus guttatus
**Acanthurus leucopareius*
**Acanthurus lineatus*
Acanthurus mata
**Acanthurus nigricans*
**Acanthurus nigricauda*
**Acanthurus nigrofuscus*
**Acanthurus nigroris*
**Acanthurus olivaceus*
Acanthurus pyroferus
Acanthurus thompsoni
**Acanthurus triostegus*
**Acanthurus xanthopterus*

Ctenochaetus hawaiiensis
**Ctenochaetus striatus*
Ctenochaetus strigosus
**Naso lituratus*
**Naso unicornus*
**Naso vlamingii*
Zebrasoma rostratum
Zebrasoma scopas
Zebrasoma veliferum

FAMILY KYPHOSIDAE

**Kyphosus cinerescens*
**Kyphosus vaigiesis*

FAMILY CHAETODONTIDAE

**Chaetodon auriga*
**Chaetodon citrinellus*
**Chaetodon ephippium*
**Chaetodon flavirostris*
**Chaetodon lunula*
**Chaetodon mertensii*
**Chaetodon ornatissimus*
**Chaetodon pelewensis*
**Chaetodon quadrimaculatus*
**Chaetodon reticulatus*
Chaetodon semeion
**Chaetodon trifascialis*
Chaetodon trifasciatus
**Chaetodon ulietensis*
**Chaetodon unimaculatus*
**Chaetodon vagabundus*
**Hemitaurichthys polylepis*
Hemitaurichthys thompsoni

**Forcipiger flavissimus*
**Forcipiger longirostris*

FAMILY POMACENTRIDAE

**Abudefduf sexfasciatus*
**Chromis acares*
**Chromis agilis*
Chromis atripectoralis
Chromis iomelas
**Chromis margaritifer*
**Chromis vanderbilti*

Family Pomacentridae cont'd

Chromis viridis
**Chromis xanthura*

**Dascyllus aruanus*
Dascyllus flavicaudus
**Dascyllus trimaculatus*
Dascyllus reticulatus

**Plectroglyphidodon dickii*
**Plectroglyphidodon imparipennis*
**Plectroglyphidodon johnstonianus*
**Plectroglyphidodon lacrymatus*

**Pomacentrus pavo*
**Pomacentrus vaiuli*

**Pomachromis fuscodorsalaris*

Stegastes emeryi
**Stegastes fasciolatus*
Stegastes lividis
**Stegastes nigricans*

FAMILY SCARIDAE

**Calotomus carolinus*

Cetoscarus bicolor

Hipposcarus loniceps

**Scarus altipinnis*
Scarus chameleon
Scarus festivus
**Scarus forsteni*
**Scarus frenatus*
Scarus frontalis
Scarus ghobban
**Scarus globiceps*
Scarus japanensis
Scarus longipinnis
**Scarus microrhinos*
**Scarus niger*
**Scarus psittacus*
Scarus pyrrhurus
**Scarus schlegeli*
**Scarus sordidus*