Rarotonga fringing reef survey, 2003 report.

For the Environment Service, Tu'anga Taporoporo, Cook Islands.

Report prepared by

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Marine and Environmental Research Limited.

Contents

Executive Summary

This report has been prepared on behalf of the Environment Service, Cook Islands as part of an ongoing monitoring programme of reef health of the fringing reef of Rarotonga. The initial work was carried out in 2000 and this is the first subsequent sampling and report since that baseline study.

Rarotonga remains an island relative void of polluting industries. The water quality outside the reef is not influenced by activities on the island to any great extent. Factors influencing reef health on the outer reef slope tend to remain natural, or at least environmental on a regional scale, as is the case of warm sea surface temperatures.

- The reef at ten metres exists in a degraded state with regard to coral cover and diversity.
- Coral cover has declined since the last survey in 2000.
- The coral population present is in a steady state, with no evidence of recent mortality.
- Some recovery is evident, however this is a very slow process for such an ecosystem.
- Soft corals are more abundant on the reef.
- Echinoderm numbers are significantly higher, possibly as a result of increased algae cover.
- Algal populations do not indicate nutrification to be affecting the outer reef.

Introduction

Coral reefs provide one of the most diverse ecosystems on the planet. They are also among the most environmentally sensitive and threatened. Many factors influence the state of a reef, some natural, some anthropogenic. In order to understand how a reef is responding to the environment around it, and how best we can manage our part in that environment, monitoring of reef health is an essential tool. Standardised, ongoing monitoring of coral reefs around the world have become a key feature of many governments and NGO's management strategies for the reefs in their care.

This report represents the 2nd survey of the fringing reef of Rarotonga. The base line study on which this survey and report is based was carried out in 2000 with the intention of describing the current state of the reef and setting a base line method and data set that could be added to with future surveys. Although annual surveys are preferred as the best way to assess change and discern key factors influencing reefs, this survey still holds merit when related to the initial study.

Rarotonga is a high island of volcanic origin. The coastline of the island is characterised by a fringing reef which abuts the coast along the NE shore and forms a shallow lagoon around the rest of the island. The reef slope has similar morphology around the entire island. The shallows have a low gradient, sloping gently from the reef crest to the 12 – 15 metre contour. Here the gradient increases slightly, until a depth of around 30 – 40 metres, where the gradient increases again to around 45°. The island is isolated with no other islands or reefs within 100 nautical miles.

Land use on the island is typified by small farm plots on the coastal lowlands. On the foreshore are numerous small developments of both private dwellings and huts built for the tourism market. There is very little bare coastal land present, with most of the foreshore developed.. The majority of the islands mass is mountainous terrain covered in bush. Several small streams flow to the coast from steep sided valleys. On the outer reef the majority of stress from runoff is in the form of fine sediments, with the possibility of a little nutrification.

Methods

In 2000 10 sites were selected for monitoring of reef health on the outer reef slope of Rarotonga. The sites were selected to give a good coverage of the different aspects and conditions affecting the fringing reef of Rarotonga. Although no sites were particularly chosen as impact or control sites, care was taken to ensure the sites represent the range of different reef slope environments of Rarotonga with respect to proximity to outflows, land use and geographical aspect. The names and approximate locations of the ten sites is given in Figure 1.

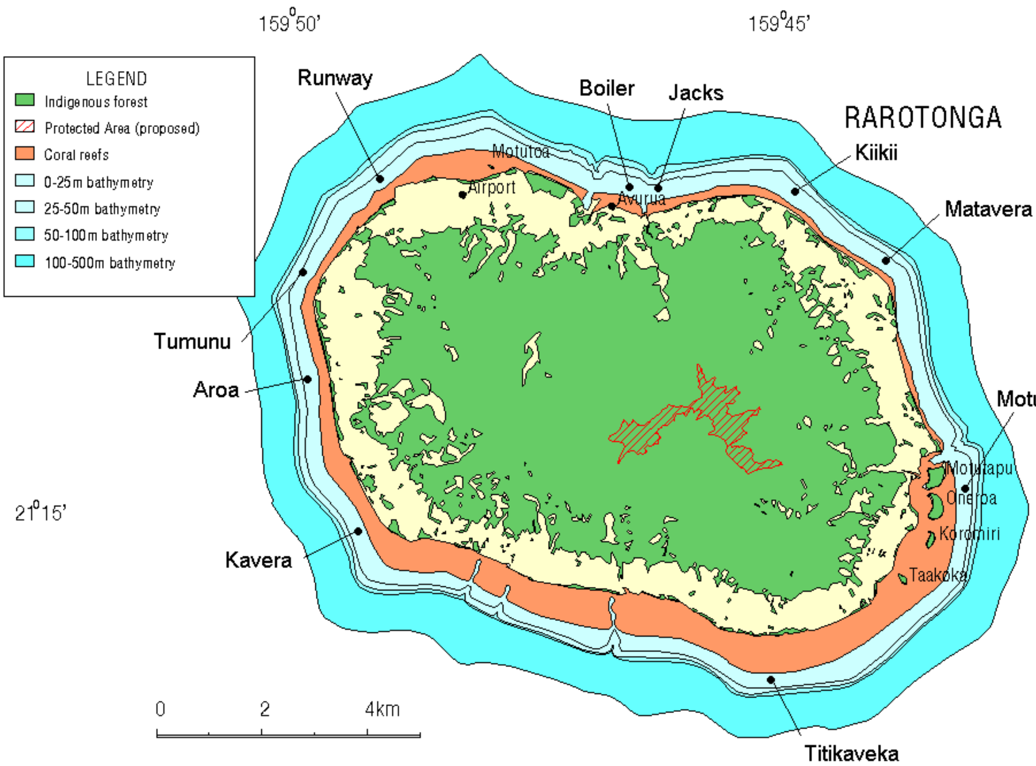


Figure 1. Location map of sites on Rarotonga

Recognizing the importance of the repeatability of the original base line survey, each site was positively marked in the 2000 survey so that they could be located and resurveyed in future studies. This study used the exact site locations as the 2000 survey, as indicated by subsurface markers. The sites are located on the surface by lining up transit marks and moving to the 10 metre depth contour. Subsurface floats and steel rods are used to mark the exact site locations underwater.

The method used in the 2000 base line survey is the Line Intercept Transect (LIT) method as described in the Survey Manual for Tropical Marine Resources, chapter 2. This methodology, devised and standardised by the Australia Marine Science Project, Living Coastal Resources, is in wide spread global use and is considered as a standard form of sampling the reef benthic environment. The same methods that were employed in the 2000 baseline survey have been repeated in this survey.

The field methods are extensively described in *Survey Manual for Tropical Marine Resources, chapter 2.*

The LIT method uses lifeform classifications to establish a ratio of benthic coverage. Categories are based on growth form of coral, algae, abiotic environments and other organisms. A complete list of all classifications used in the survey is given in Appendix 1.

At the survey site 3 replicate transects are sampled using the following method. Parallel to the reef crest, at a depth of 10 metres, a tape measure is run out 20 metres along a transect. The area for the transects was established in the 2000 survey. This survey used the same area for sampling.

Starting at the beginning of the transect, the diver moves along the tape, noting each change in the underlying benthic cover. At the transition the diver notes the current distance along the tape and the benthic category code for the corresponding organism or environment. This is repeated for every transition along the 20 metre transect. The data is recorded onto an underwater data sheet. This is repeated for each of the 3 transects.

Data is collated and analysed using Microsoft Access and Excel applications. For the purpose of this report individual lifeform categories are grouped. The groups are Acropora coral, non Arcopora coral, soft coral, dead coral, algae, coralline algae, abitoic and other organisms. The data is grouped as such to give better individual totals for comparison. These groupings also give good representative data that is easy to understand.

For each group the total length of all included categories is calculated and divided by the length of the transect. This gives a fraction of the benthic environment that this group comprises. This is converted to a percentage for graphing.

Percentage cover = (Total length of group lifeforms / 20) x 100

This is calculated for each transect. The three transects are then averaged and standard deviations of each group calculated.

Results

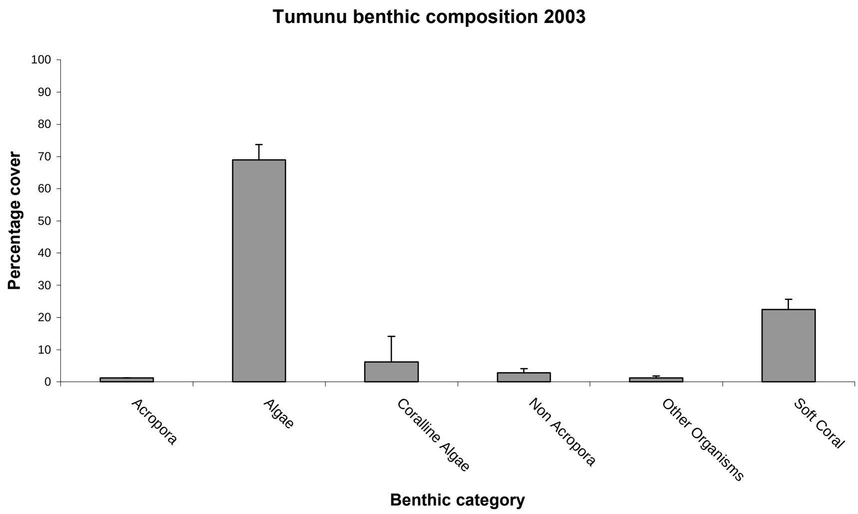
2003 survey results

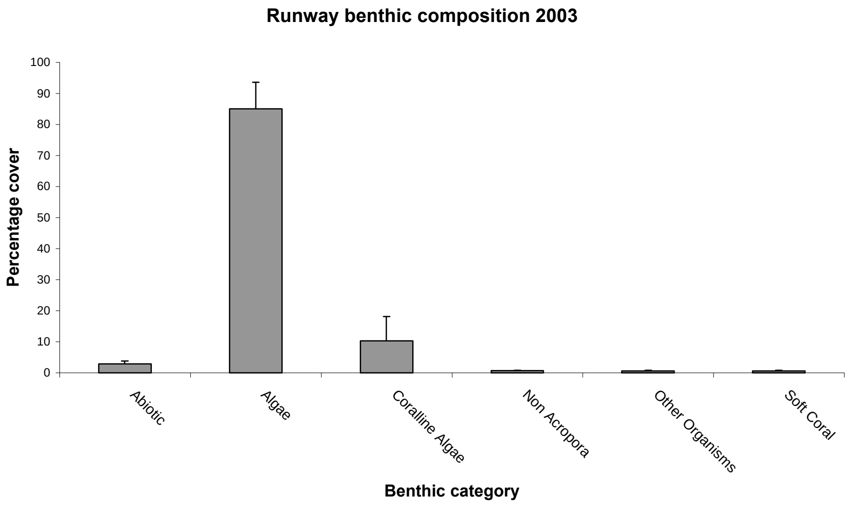
Results are given here in graph form for each site. Appendix 2 contains all figures used in these graphs.

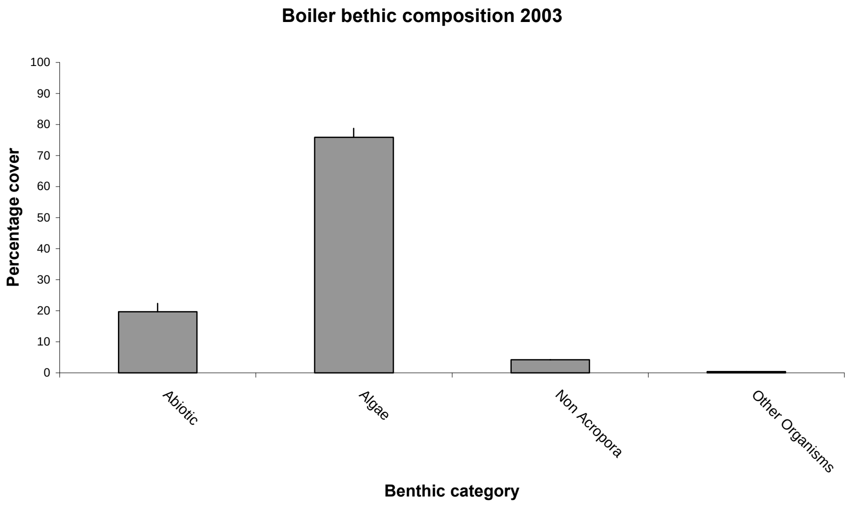
All sites around the entire fringing reef indicate a similar trend. The dominating group of benthic organisms are algae. Most algae are fine, turfing algae or an assemblage of encrusting, turfing and some red algae. Macro algae is not very common, although was noticeable at sites where it had not been previously observed. These sites are Matavera and Motutapu.

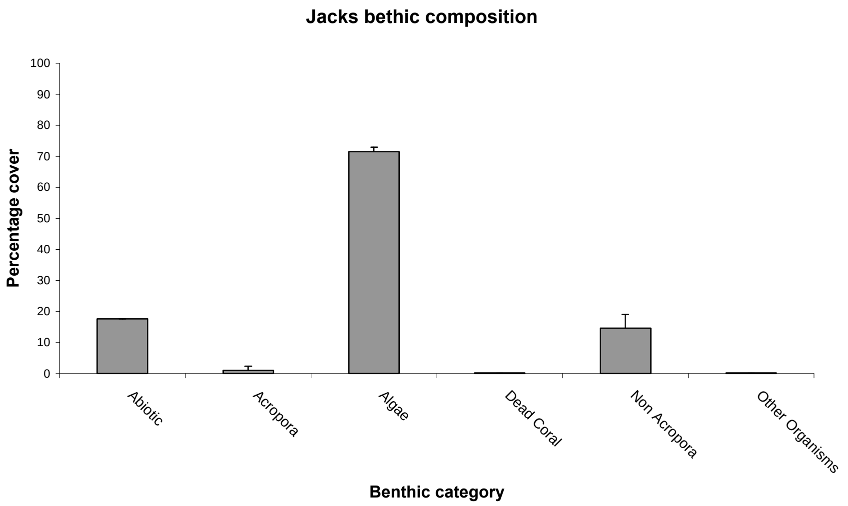
Coral cover is very low with low total coverage, an almost total absence of *Acropora* spp., and low species diversity of what is present. The two most common genus of coral are *Pocillipora* spp. and *Leptoria* spp. Some sites have high numbers of very small colonies, indicating recruitment. However, with regard to total coral cover these juveniles are fairly insignificant. These recruits are most present at Boiler, Jacks and Kiikii sites. Diver observations indicate that coral cover is higher in shallower depths, and possibly also at deeper depths. Possible reasons for this will be discussed later. Other organisms represent an increasing proportion of the benthic cover. This category is represented completely by the black spiney urchin, *Echinothrix diadema*.

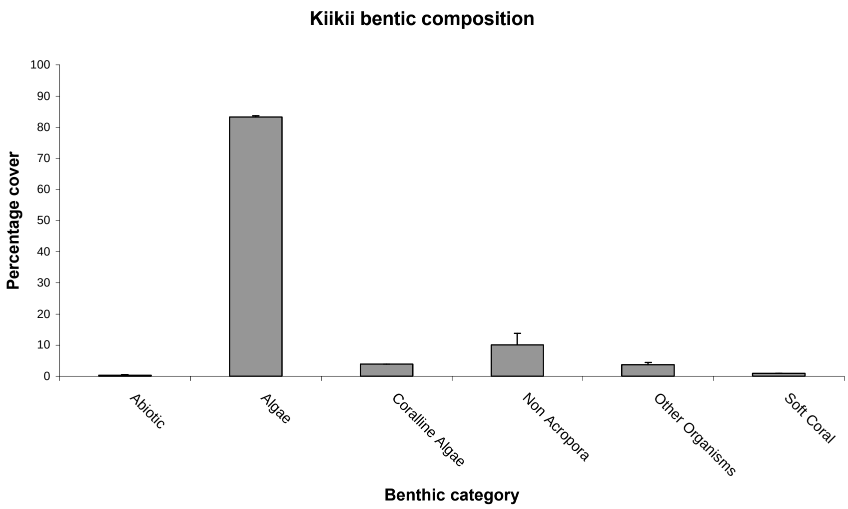
There is a total absence of recently (<1 year) dead coral in the data and this is reflected by broader observations made from the sites during the survey. Soft coral is most abundant on the southern side of the island. Abiotic conditions are expected, and are comprised mostly of sand and rubble held within shallow fissures running perpendicular the reef crest.

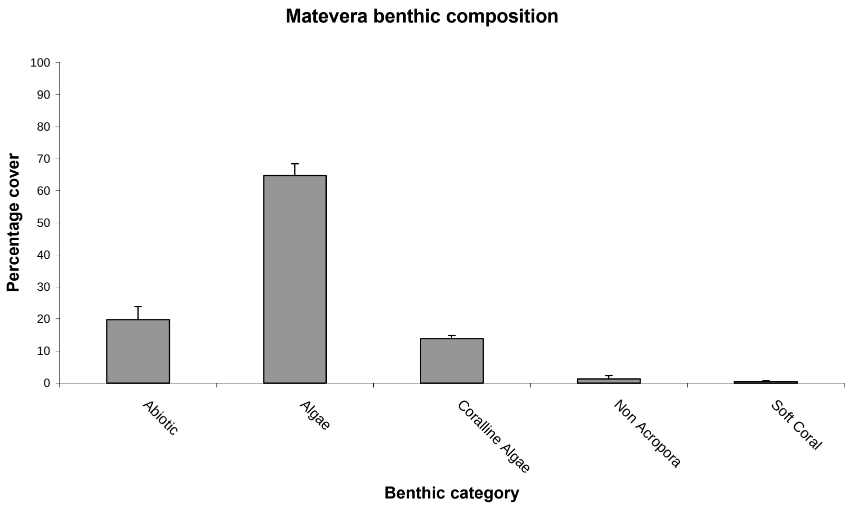


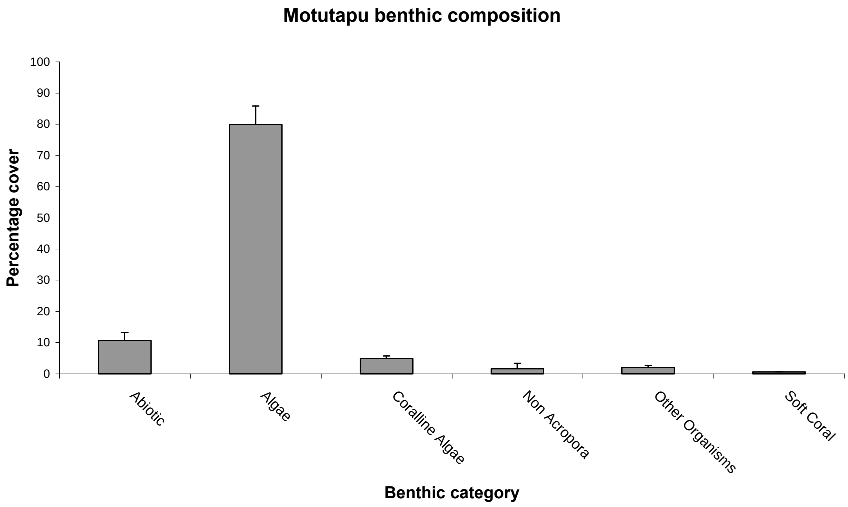


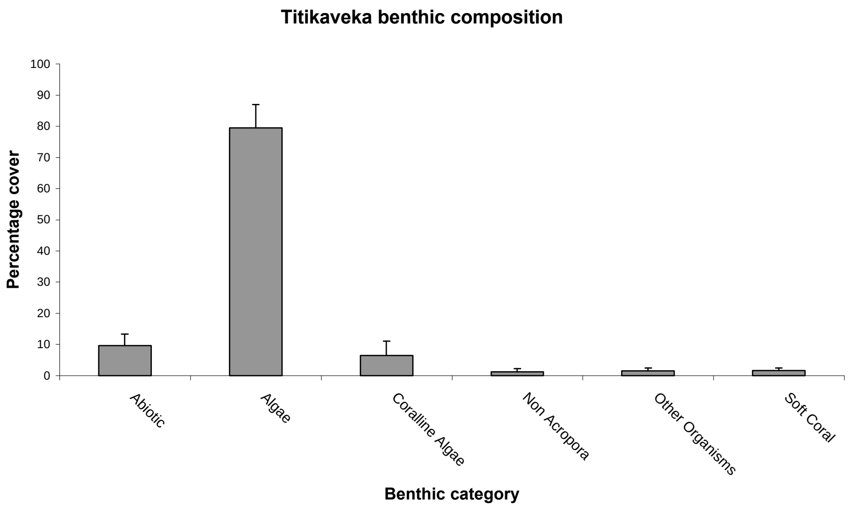

Boiler bethic composition 2003
Percentage cover
100
90
80
70
60
50
40
30
20
10
0
Abiotic
Algae
Non Acropora
Other Organisms
Benthic category

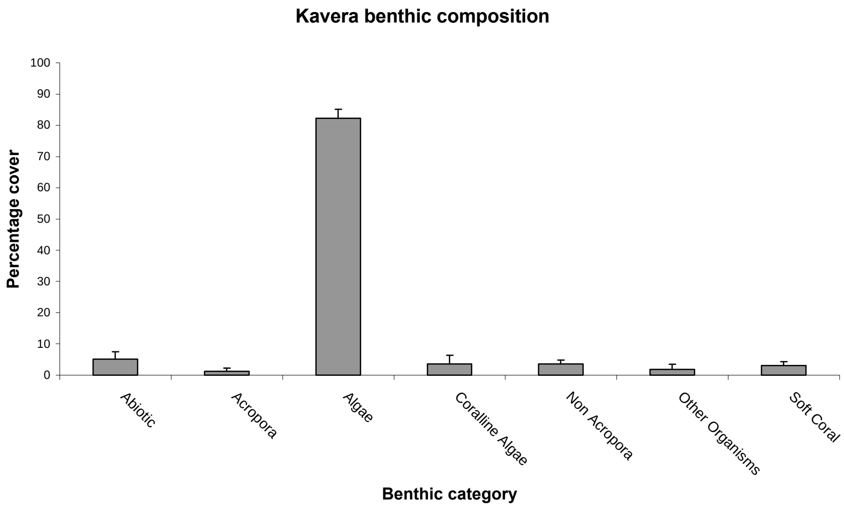

Jacks bethic composition
Percentage cover
100
90
80
70
60
50
40
30
20
10
0
Abiotic
Acropora
Algae
Dead Coral
Non Acropora
Other Organisms
Benthic category

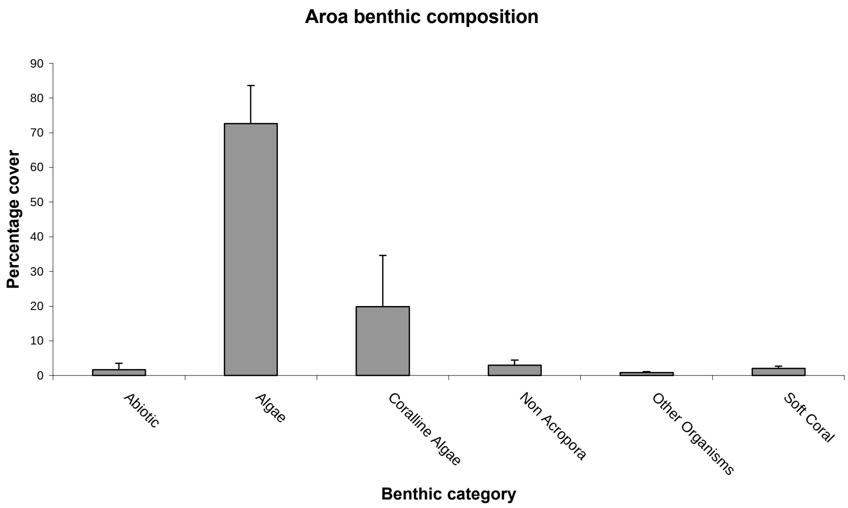

Kiikii bentic composition
Percentage cover
100
90
80
70
60
50
40
30
20
10
0
Abiotic
Algae
Coralline Algae
Non Acropora
Other Organisms
Soft Coral
Benthic category


Matevera benthic composition
100
90
80
70
60
50
40
30
20
10
0
Percentage cover
Abiotic
Algae
Coralline Algae
Non Acropora
Soft Coral
Benthic category


Motutapu benthic composition
100
90
80
70
60
50
40
30
20
10
0
Percentage cover
Abiotic
Algae
Coralline Algae
Non Acropora
Other Organisms
Soft Coral
Benthic category


Titikaveka benthic composition
100
90
80
70
60
50
40
30
20
10
0
Percentage cover
Abiotic
Algae
Coralline Algae
Non Acropora
Other Organisms
Soft Coral
Benthic category



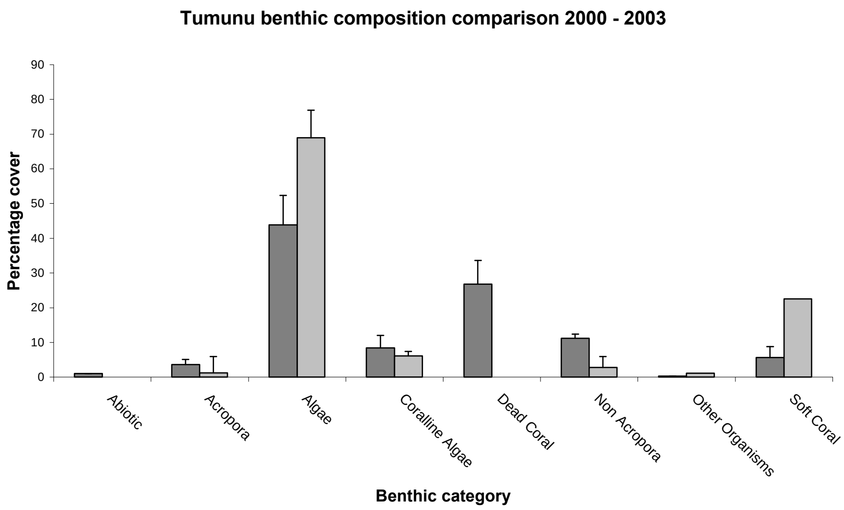


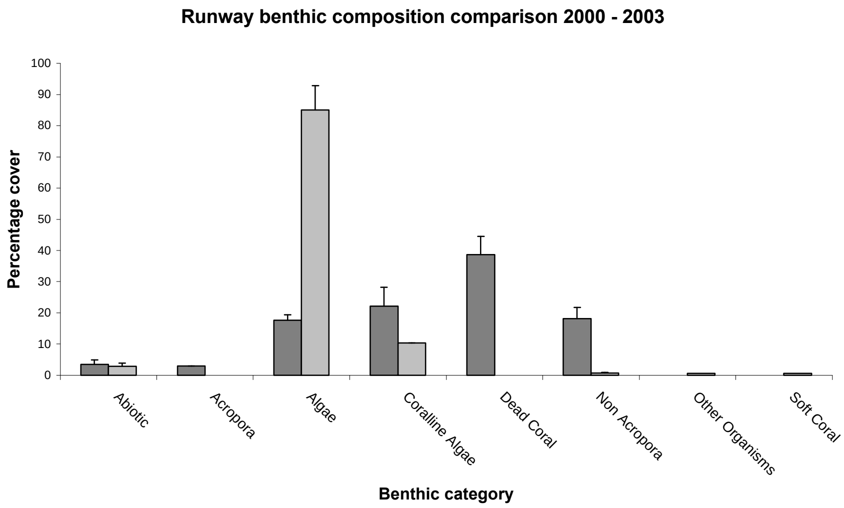
2000 to 2003 comparison results

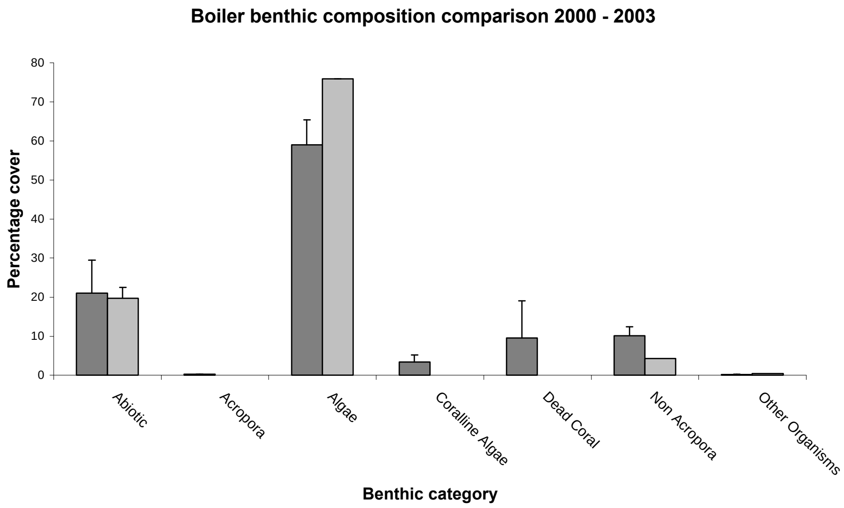
This same survey was conducted as a base line study in 2000. In order to assess change over time the two data sets are compared. Here results from the two surveys are graphed against each other for each site. All the data used in these graphs is given in Appendix 2. 2000 figures are indicated by the dark shading and 2003 results are indicated by the light shading.

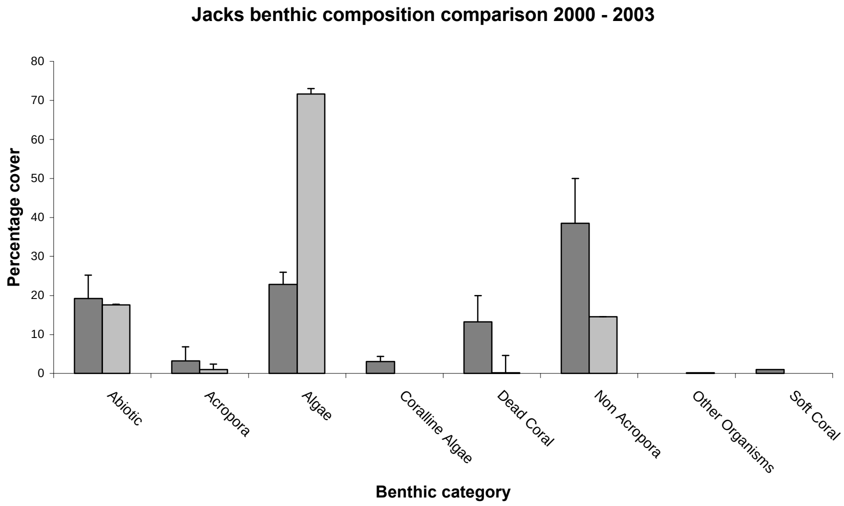
There are some common themes that are evident at all sites. A reduction in total coral cover, including a reduction in *Acropora* spp. which renders most sites completely absent of this important genera. The absence of recently dead coral in the 2003 survey compared to the fairly common occurrence of this category in 2000. An increase in the algae cover, particularly fine filamentous and turfing algae. Other organisms also made an appearance at sites where they were previously absent. This category is comprised solely be the organism, *Echinothrix diadema*, the black spiny sea urchin.

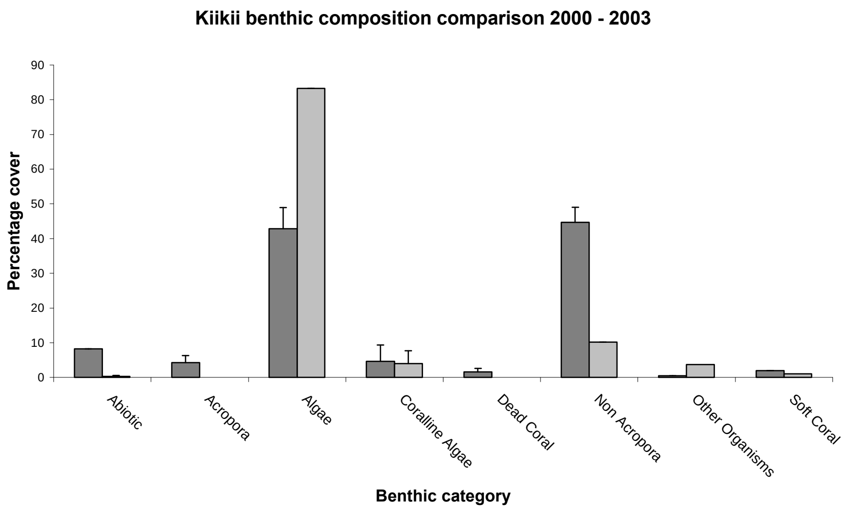
Refer to the graphs below for a comparison of the two sampling periods. The data for these graphs is given in Appendix 2.



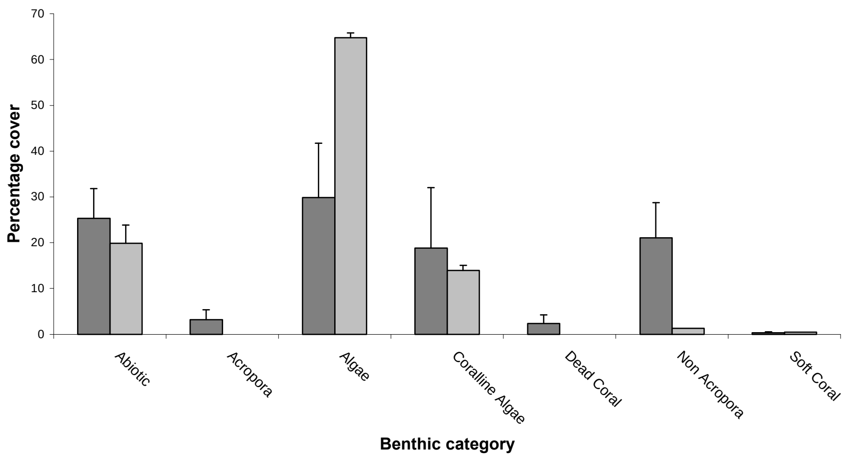



Boiler benthic composition comparison 2000 - 2003
Percentage cover
0
10
20
30
40
50
60
70
80
Abiotic
Acropora
Algae
Coralline Algae
Dead Coral
Non Acropora
Other Organisms
Benthic category

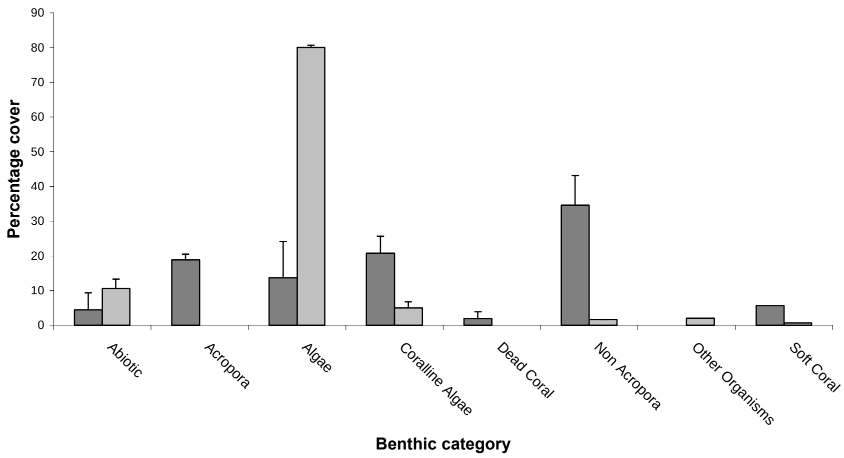

Jacks benthic composition comparison 2000 - 2003
Percentage cover
0
10
20
30
40
50
60
70
80
Abiotic
Acropora
Algae
Coralline Algae
Dead Coral
Non Acropora
Other Organisms
Soft Coral
Benthic category


Kiikii benthic composition comparison 2000 - 2003
Percentage cover
0
10
20
30
40
50
60
70
80
90
Abiotic
Acropora
Algae
Coralline Algae
Dead Coral
Non Acropora
Other Organisms
Soft Coral
Benthic category

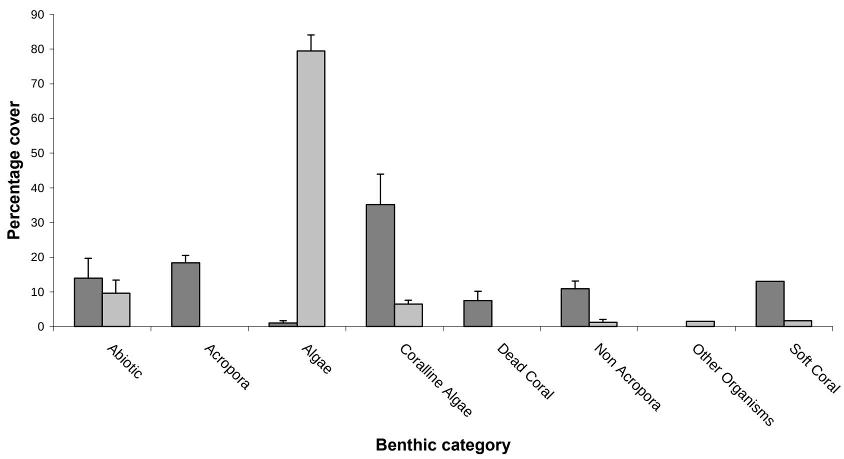
Matavera benthic composition comparison 2000 - 2003

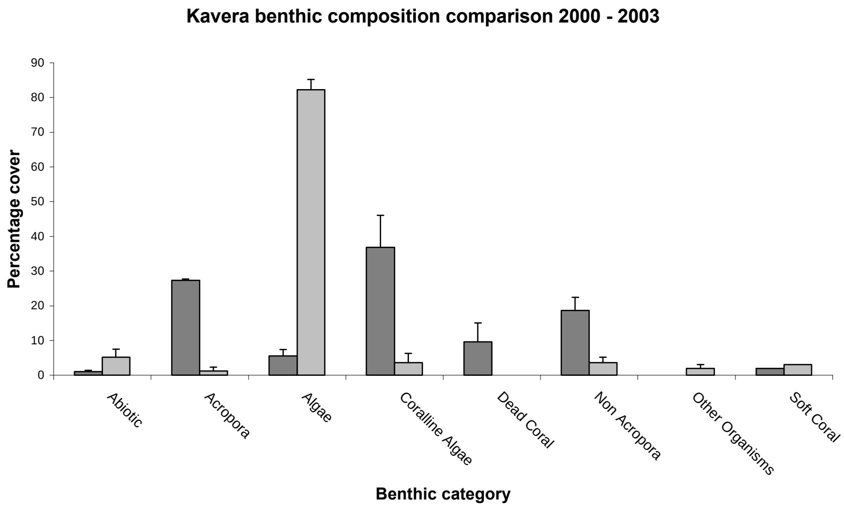


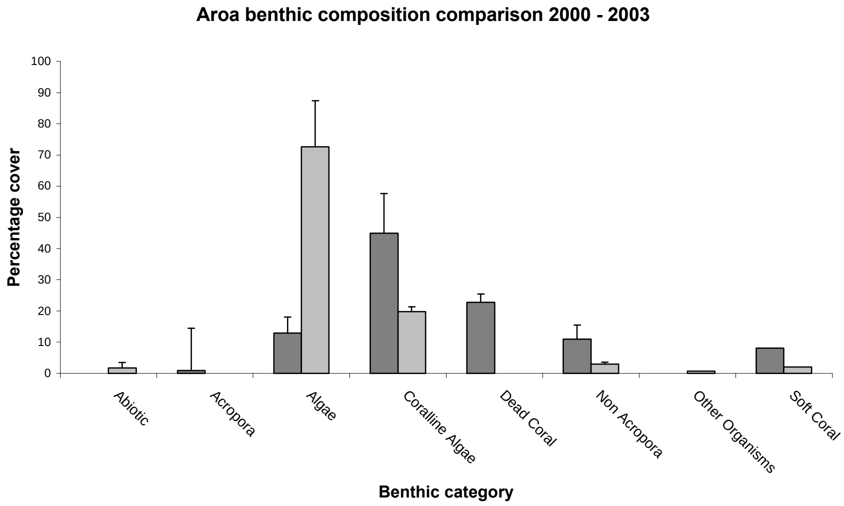
Motutapu benthic composition comparison 2000 - 2003



Titikaveka benthic composition comparison 2000 - 2003







Conclusions

Current state of the reef

Data from this survey indicates the state of the fringing reef of Rarotonga, at a depth of ten metres, is in a degraded state. Some variability around the island exists, with the Jacks site showing the highest coral cover. There is not enough variability to identify any other trends relating to location around the island. Each site is dominated by algae, with urchins present. Soft coral is present at some sites in reasonable abundance. This indicates some early recovery of the reef. Another positive sign is the absence of recently dead coral. Although coral cover is low, some sites do show recruitment, and what live coral is present is does not indicate any mortality. To this regard the reef seems to be in a stable state. Algae cover is high, and as a result, grazing urchins are high in abundance also.

With regard to algal abundance, two mechanisms are considered. Firstly, that algae is establishing where bare rock surfaces allow, being a primary colonist. Secondly, that water quality is such that algae growth is promoted, usually through nutrification. In the case of Rarotonga, it is unlikely that nutrients are having an effect outside the reef at a depth of ten metres for the majority of the island. The algae that is present is no different that in the past, there is simply more of it. If nutrients were having an impact the types of algae would be different, with more fleshy green algae, and other macro algae's dominating. Encrusting Coralline algae still has good representation as part of the algae matrix, and is typical of healthy reef environments.

Changes since 2000

The reef has some noticeable changes in the 3 years since the past survey. In order to better understand how the reef is evolving this study should be more frequent, with annual sampling being optimum. For the most part live coral and recently dead coral has been replaced by algae. An increase in urchins is also worth noting. In contrast, there was a complete absence of Crown of Thorn (COT) Starfish in the 2003 survey. In 2000 the reef was actively being impacted on by heavy grazing by the COT on hard corals, most notably *Acropora* and *Favia* spp. The coral cover in shallower water, and also deeper, where coral species differ, appears considerably higher than at the sampling depth of 10 metres. In shallows COT are affected by wave action. In depths shallower than 6 metres *Poccillopora* spp.and *Leptoria* spp. are still quite abundant. Deeper, large *Porites* spp. colonies and other corals are visible.

Reasons for change

Due to the snap shot nature of this survey the mechanisms for change cannot be conclusively identified. However the most likely cause of the current low levels of coral cover is most probably COT grazing. Previous to and during the 2000 survey COT were impacting significantly on coral populations, in particular *Acropora* and *Favia* spp. The absence of these major groups in 2003 could be attributed to continued grazing pressure by COT. At present there are very few COT starfish on the reef, with none appearing at any of the survey sites. This is a result of a lack of coral to form their diet and is typical of the boom and bust cycles of COT, experienced elsewhere.

Possible trends for the future

Several factors influence the state of any natural environment. Coral reefs are a particularly sensitive ecosystem that respond to environmental stress quickly, but take a long time to recover. Rarotonga is in a relatively fortunate position where high water temperatures and nutrification do not play a significant role. If nutrients on the reef did increase then algae would become a hindrance to coral recovery. Currently algal species present at most survey sites do not indicate this to be an issue.

In the near future soft corals are likely to establish, with a long, slow recovery process for hard corals to follow. Little is understood about coral recruitment on solitary islands, like Rarotonga. In any case, corals are slow growing, and recovery back to pre 1999 state could take as long as 20 years. If COT maintain a continuous presence and predate on emerging corals, then the current state could become the norm.

Management options

Managing for a healthy environment is all encompassing. Although water quality outside the reef is good this will be influenced to some extent by the water quality from the lagoon and from stream runoff around the NE coast of the island. Effective environmental management of these environments, in particular reducing nutrient levels, will benefit the fringing reef.

COT have been identified as having a significant impact on hard coral populations. Managing their density and distribution would invariably assist the survival of hard corals however the methods of control must be such that extra stresses are not created. The historical method of injecting toxins into the COT have been proven to be detrimental to coral in the vicinity, as even a small amount of the toxin n the surrounding water will kill nearby corals. To this end, COT control is labour and time intensive, probably requiring some sort of physical collection and removal of the organism.

Other activities impacting on the reef also need to be addressed. An increase in dive operators will be having an impact on the reef by way of anchoring and diver interaction.

Although scuba is generally non destructive there is still a need on Rarotonga to address the anchoring of boats. Permanent moorings are the excepted norm in most areas around the world, and this practice should be promoted here also.

The practice of fish collection for the aquarium trade also impacts on corals, as *Acropora* and *Pocillopora* branches are broken off to gain access to fish hiding there. Although the local operators are generally very environmentally aware a code of conduct for this industry would assist in reducing the impacts of this activity.

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Appendices

Appendix 1

CATEGORY	SUB CATAGORY	CODE	NOTES / REMARKS
Dead coral		DC	Recently dead, white to dirty white
Dead coral with algae		DCA	This coral is standing but no longer white
Acropora	Branching	ACB	At least 2 deg of branching
	Encrusting	ACE	Usually the base plate of immature acropora forms
	Submassive	ACS	Robust with knob or wedge like form
	Digitate	ACD	No 2 deg branching
	Tabulate	ACT	Horizontally flattened plates
Non Acropora	Branching	CB	At least 2 deg of branching
	Encrusting	CE	Major portion attached to the substrate
	Foliose	CF	Coral attached at one or more points, leaf like appearance
	Massive	CM	Solid boulder or mound
	Submassive	CS	Tends to form small columns knobs or wedges
	Mushroom	CMR	Fungia
	Millepora	CME	
	Heliopora	CHL	Blue coral
Soft coral		SC	Soft bodied corals
Sponges		SP	
Zoanthids		ZO	
Others		OT	Ascidians, anemones, gorgonians, clams
Algae	Algal assemblage	AA	Consists of more than one spp.
	Corolline algae	CA	
	Halimeda	HA	
	Macroalgae	MA	Weedy fleshy browns, reds, etc
	Turf algae	TA	Lush filamentous algae
Sand		S	
Rubble		R	
Silt		SI	
Water		WA	Fissures more than 50cm deep
Rock		RCK	
Other		DDD	Missing data

Appendix 2

Table of results.

Sample ID	Abiotic	Acropora	Algae	Coralline Algae	Dead Coral	Non Acropora	Other Organisms	Soft Coral
Tumunu 2003	22.533	1.250	68.967	6.125		2.800	1.200	
Runway 2003	3.383		85.033	10.350		0.775	0.717	
Boiler 2003	19.700		75.900			4.300	0.450	
Jacks 2003	17.575	1.050	71.625		0.150	14.600	0.150	
Kiikii 2003	0.875		83.275	4.000		10.100	3.750	
Matevera 2003	20.300		64.750	13.917		1.283		
Motutapu 2003	10.575		80.725	5.000		1.650	2.050	
Titikaveka 2003	11.300		79.450	6.500		1.250	1.500	
Kavera 2003	8.300	1.250	82.200	3.583		3.583	1.917	
Aroa 2003	3.783		72.617	19.833		2.967	0.800	
Tumunu 2000	1.000	3.667	43.833	8.417	26.833	11.167	0.250	5.667
Runway 2000	3.500	3.000	17.583	22.217	38.700	18.167		
Boiler 2000	20.983	0.250	59.000	3.367	9.500	10.100	0.200	
Jacks 2000	19.167	3.250	22.833	3.083	13.250	38.500		1.000
Kiikii 2000	8.250	4.283	42.850	4.625	1.583	44.650	0.500	1.900
Matevera 2000	25.333	3.250	29.867	18.883	2.417	21.083		0.375
Motutapu 2000	4.417	18.883	13.667	20.833	1.917	34.617		5.667
Titikaveka 2000	14.000	18.417	1.000	35.167	7.500	10.917		13.000
Kavera 2000	1.000	27.333	5.583	36.833	9.583	18.667		2.000
Aroa 2000		1.000	12.917	44.917	22.833	10.917		8.083