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Executive Summary

- Much of Fiji's wealth is generated by its extensive marine resources, which provide an important source of protein-based food in the form of fishing and income from tourism. A range of factors currently threatens the ecological balance and health of Fiji's reef systems.
- Biological surveys have been carried out in the fishing grounds of the Vanua ko Nasigatoka. This lies within the region referred to as the Coral Coast on the southern coast of Viti Levu, Fiji. These surveys were carried out to assess the current status of inshore marine resources on the back reef area fringing the district.
- Through use of point intercept and belt transects, the assessment provides valuable information on the benthic, fish and invertebrate community of the *i qoliqoli*. Traditional fishing right owners, Government and non-government agencies can draw this upon this as a resource in decisions relating to the management of the fishing area.
- Using GIS derived images and other forms of analyses; results have served to highlight the specific concerns over nutrient enrichment and reversion of the system to algal dominated reef platform. Algal dominance over coral generally reduces the abundance of fish and invertebrate communities. Areas of high coral cover tend to contain high levels of important fish and invertebrate species. As such they are of high management concern.
- Future management will require a dedicated and long-term approach in order to boost fish numbers. Possible management concerns and options are discussed.
- Recommendations towards the reduction of detrimental impacts, the employment of more sustainable management practices, and relevant information still required are presented.

1. Introduction

Coral Reefs and their associated habitats are recognised as an extremely important resource throughout the South Pacific region. Fiji is one of the wealthiest countries in the region. This is in part attributable to its biodiverse and productive reef ecosystems, which provide valuable fishery resources, important tourism attractions, as well as protection from storms and coastal erosion. Over recent decades there has been a growing realisation of the degradation caused to coral reef environments as a result of increased coastal development and resource over-utilisation (Hodgeson, 1999). These threats often manifest themselves as increased nutrient enrichment, erosion, siltation, over fishing, destructive fishing, marine pollution, and well as harvest for the aquarium trade. Such impacts, often acting synergistically with natural impacts, can result in a decline in ecosystem productivity and stability. Left unchecked, this will ultimately lead to a reduction in income and resources for coastal communities and other stakeholders that rely on fishing and the marine environment.

1.1 *The Coral Coast*

Fiji comprises approximately 844 islands, of which two, Viti Levu and Vanua Levu, comprise 87% of total area (Vuki *et al.*, 2000). The Coral Coast region is found in the Nadroga Navosa Province on the southern coast Viti Levu and stretches from Natadola bay in the west to Namatakula village in the east. For the purposes of this study a number of reef areas of the neighbouring Serua Province east of Namatakula were also included. The Coral Coast region has been the focus of tourism development in Fiji for a number of years and a large proportion of the indigenous population is employed in the industry. The majority of the population on the coast live in villages of between 100 and 300 people or in the market town Sigatoka, which is central to the region and houses approximately 8000 people. The Queens highway that provides good transport links to Nadi Airport and the capital city Suva services the Coral Coast.

Fringing reef extends along the Coral Coast for approximately 63 kilometres up to 1000 metres offshore. Behind the break zone, back reef habitat extends in towards shore. The continuity of the reef is periodically broken by channels cut through the reef as a result of fresh water influx from rivers and streams. These channels provide suitable habitat for corals, other sessile forms and their associated communities below the spring low tide. These channels are characterised by strong outward currents. The channels draw water off the reef platform creating strong currents parallel to shore.

2. Aims and Objectives

The aims and objectives of this study are outlined in table 1 below.

Table 1. Aims and objectives

Aims	Assess the resources and health of the coral reefs of the coral coast
Objectives	Detailed baseline reef health assessments at various locations in the study area.
Anticipated Outputs	Establishment of a GIS database for the project area Make recommendations towards marine management strategies in the Coral Coast region.

3. Background

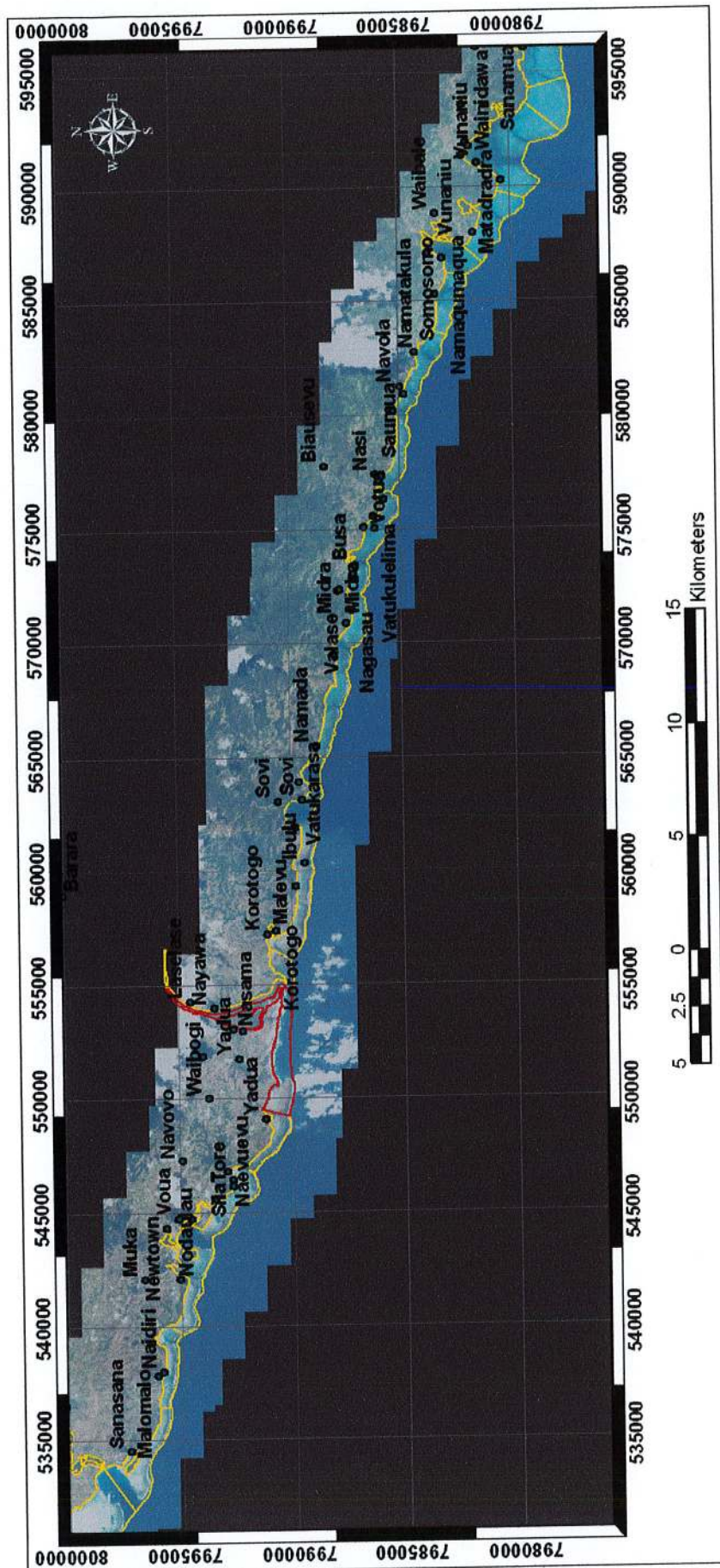
The fishing grounds of the The Vanua ko Nasigatoka comprising Nasigatoka, Yavulo, Volivoli Vunavutu & Nasama villages in the District of Nasigatoka, hereafter referred to for simplicity as 'The *I qoliqoli*', stretches from the Sigatoka river mouth in the east to the Cuvu boundry close to the village of Yadua (See formal definition below). The *i qoliqoli* services Nasigatoka town aswell as many village communities as listed above along the coast and inland. The fishing grounds of the *i qoliqoli* provide for a

large proportion of the local diet. Tourism forms an integral part of the local economy as a number of local people work in hotels in both directions along the coast. Much of the the *i qoliqoli* fronts the Sigatoka sand dunes, a local attraction run and maintained by the National Trust. The fringing reef which forms the focus of this study is absent from most of the *i qoliqoli*, and is restricted to the most westerly edge bordering Cuvu province.

4. Description of Fishing Rights Boundary

A graphical representation of the *i qoliqoli* boundaries can be seen in figures 1 and 2 below. The *i qoliqoli* boundary is described in Native Fisheries Commission records as:

The mouth of Yalasuna creek thence along a line 211° (M) to the centre of Yadua Passage thence on a easterly direction following the outer edge of reef to the centre of Nasigatoka Passage thence along the centre of Sigatoka River upstream to a place opposite on the right bank is Tautaurisila creek thence towards its mouth, thence following the right bank of Sigatoka River downstream to the mouth of Vatueta River, thence along its right bank downstream to its confluence with Sigatoka River, thence along the right bank of Sigatoka River to its mouth, thence along a westerly direction following the high water mark to the mouth of Yalasuna creek to the point of commencement.



5. Research Team

Baseline biological surveys were carried out in the Coral Coast region between July 2004 and May 2005. The research team involved individuals from Coral Cay Conservation (a UK based Non Governmental Organisation working in Fiji), the Institute of Applied Sciences (University of the South Pacific) and associated Peace Corps volunteers represented as follows:

Coral Cay Conservation: Gwilym Rowlands, Louise McNamee, Lucy Ward, Mark Roberts, Matthew Crabbe, Chiara Bertelli, Lene Tuveng, James Couper.

Institute of Applied Sciences: Jolame Sikolia, Marika Tubuna, Napolioni Napote, Alefereti Qauqau, Saki Fong, Jim Reynolds (Peace Corps), Alyson Venti (Peace Corps), Laura Mattison (Peace Corps).

6. Survey Methodology

Survey effort was concentrated on the back reef area, using snorkellers. The back reef relates to the area where the majority of fishing effort and activity is concentrated. Information was collected using a point intercept transect to assess benthic coverage; belt transects to assess the fish and mobile invertebrate populations and a kayak marshal to collect positional data and provide safety cover. Information on target species, substrate variables and lifeforms as well as supplementary data on anthropogenic and oceanographic activities was recorded. Example data sheets used in the data collection phase are shown in Appendix 2. Data was transferred to these recording forms before being entered into a Geographic Information System (GIS) compatible database. The following specific methods were used for data collection on each of the biological and environment data variables:

6.1 Distribution of Transects and survey effort

Four transects were run out from shore towards the reef crest (figure 2). Initial scoping studies indicated the presence of three distinct habitats from shore to crest.

- 1) Near shore zone: relatively sheltered typified by sandy substrate, seagrass, and algae.
- 2) A mid zone: sheltered habitat comprises channels offering greater topographic complexity and a higher abundance of coral.
- 3) Break zone: habitat influenced by the effects of breaking waves and characterised by rubble and algae.

Three 100 metre sections were spaced along these transects to ensure coverage of these habitats, termed zone A, B, and C from shore to reef crest respectively.

6.2 Benthic habitat: Point intercept transect

Point intercept transects derive quantitative data on both biological and abiotic (substrate) cover. The precise percentage area cover allows direct comparison to be made between different geographical areas of the reef.

Using a 100 metre tape, four 25 metre transects were point sampled every 0.5 metres (substrate or biota directly under the point) to determine the substrate and benthic coverage of the reef. This provides a total of 200 data points per 100 metre section. The categories recorded under each point were: soft corals (life form), sponges (life form), algae and seagrass (target genus), hard coral (life form and target species), dead coral, dead coral with algae, bed rock, sand, rubble, and mud.

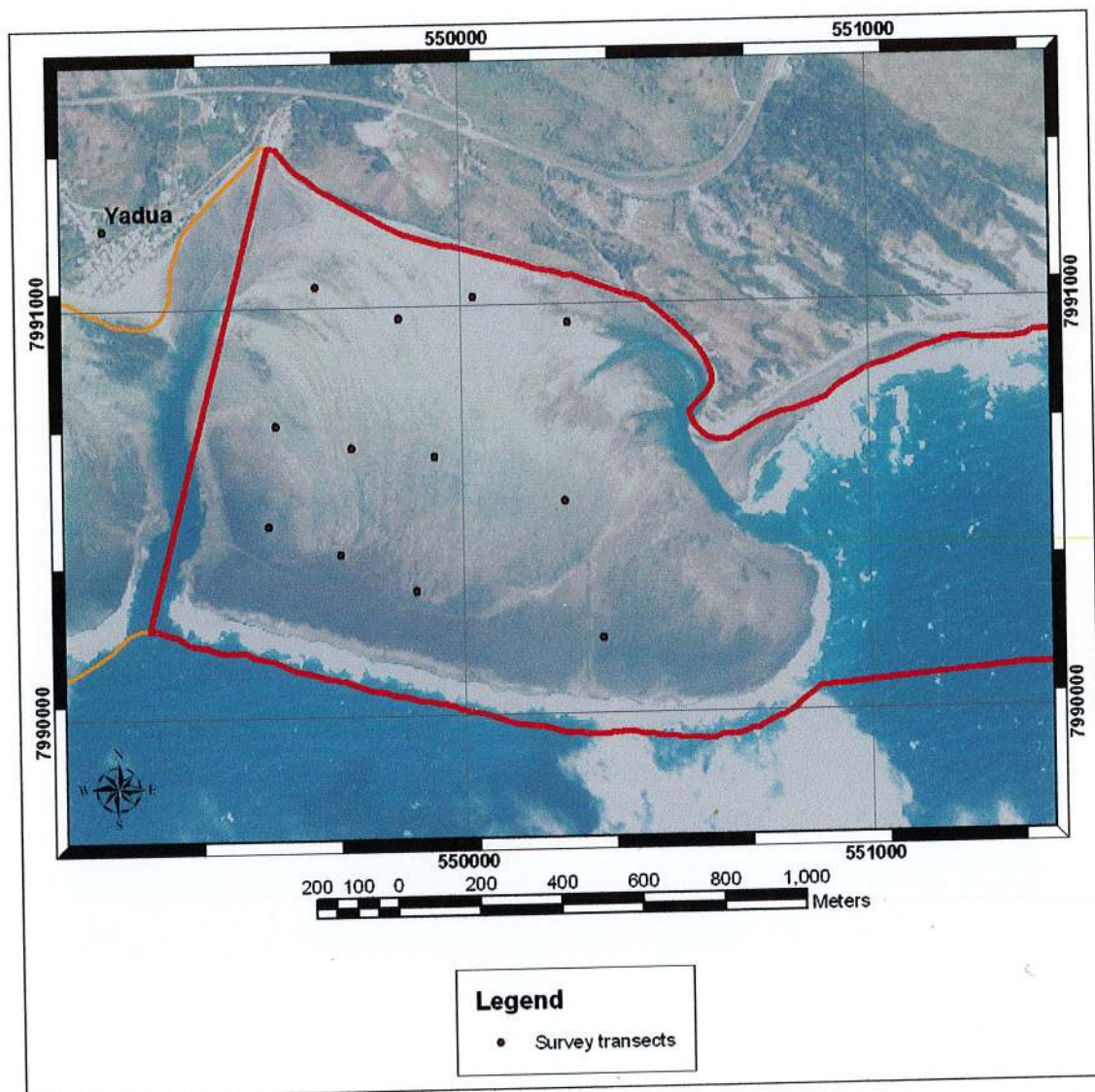


Figure 2 Map showing position of transects within the iqoligloi. Each red dot describes the start coordinates of a section of the transect.

6.3 Fish: Belt transect

The belt transect methodology allows comparison of relative abundances across the region. The method is non extractive and as such has no detrimental impact to fishery populations in the area.

Using the same 100 metre tape, four 5 metre wide by 20 metre long sections were surveyed (centred on the transect line). A 5-meter gap was left un-surveyed between sections to make each section a distinct statistical unit. Absolute numbers of fish, target species and families were recorded.

6.4 Invertebrates: Belt transect

A similar method was utilised for sampling invertebrate taxa. Four 2 metre wide by 20 metre sections were surveyed (centred on the transect line). Again a 5 metre gap was left unsurveyed between sections. The smaller survey area was a compromise to the increased time required to complete accurate invertebrate census per unit area.

6.5 Background data: Kayak Marshal

Background physical information was collected. This included position (GPS reading), temperature, salinity, underwater visibility, time of day, current (strength and direction), and wind (strength and direction). In addition the kayak marshal noted any surface and in-water impacts as well as information of underwater damage or impacts relayed from the snorkel surveyors.

6.6 Geographic Information System (GIS)

This report made use of an Ikonos high-resolution image of the Coral Coast (Image courtesy of Coastal Zone Management team, Institute of Applied Sciences, University of South Pacific, Fiji. Material © 2001, Space Imaging LLC, all rights reserved. All subsequent map images in this document are referenced to Universal Transverse Mercator Spheroid (Zone 60 South) and WGS84 datum).

By using the Inverse Distance Weighted function within *ArcView* GIS software, it was then possible to extrapolate the indicator values into areas of the image adjacent to the survey sites, thus producing a continuum of indices to highlight trends. The survey sites locations were chosen with sufficiently high spatial resolution to allow for accurate representation of the true levels in areas to which this extrapolation technique was applied.

These techniques were applied to produce GIS based data-contour 'maps' of the survey region, to facilitate visual interpretation of the large quantity of data gathered (figures 4 to 18).

7. Results

Though a large number of variables were assessed, the analysis contained within this report concentrates on benthic class, as well as important food and economic species. Data is presented as a series of summary statistics and GIS derived images.

7.1 Summary Statistics

Though only a small area of reef was surveyed in this *i qoliqoli*, there are noticeable differences in the benthic community compared to the wider Coral Coast region (table 2). Algae in the *i qoliqoli* is less abundant on average when compared to the coral coast. At a coverage of 27.21% this is comparable to the westward *i qoliqoli*, which forms part of the same stretch of offshore fringing reef. Rubble contributes heavily to benthic cover, covering 24.13% of the surface area, which is directly comparable to average for the coast and to the westward *i qoliqoli*. Covering 8.92% of reef area, bedrock forms a lesser proportion of reef area on average than the 12.6% coral coast average though is still of less importance in determining benthic cover that the fishing area to the west. *Sargassum* makes up the vast proportion of total algal cover in the *i qoliqoli*, while Coralline red algae forms a very low proportion of cover. At 0.73%, live hard coral cover is significantly less abundant than the Coral Coast average of 2.72%. Over half the coral cover is non-Acropora massive life form (figure 3). The only Acropora lifeform seen was submassive.

Table 2. Percentage benthic cover for The *Iqoliqoli*, neighbouring *i qoliqolis* and for the whole Coral Coast.

	Live Hard Coral	Sand	Bedrock	Sargassum	Algae	Rubble	Coralline red algae
<i>Iqoliqoli</i>	<i>Lahe cola</i>	<i>Nuku</i>	<i>Mahara</i>	<i>Lecau</i>	<i>Alaqi</i>	<i>Lase kamusu</i>	
The <i>i qoliqoli</i>	0.71	17.75	8.92	19.17	27.21	24.13	1.21
Neighbouring <i>i qoliqoli</i> east	0.33	5.63	13.21	40.13	57.92	14.38	1
Neighbouring <i>i qoliqoli</i> west	5.93	11.51	17.57	12.25	28.82	24.79	2.72
Overall average	2.72	16.58	12.62	17.19	33.56	24.22	2.20

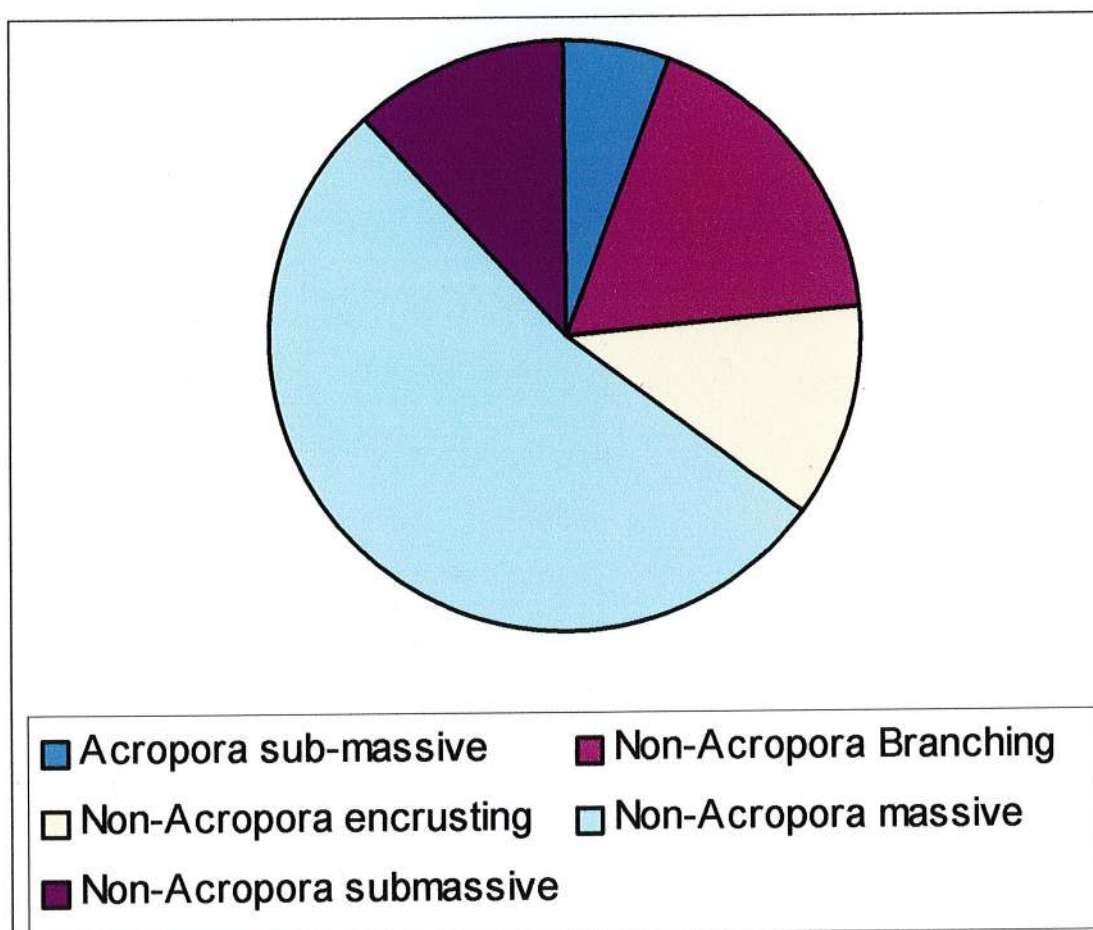


Figure 3. Coral lifeform abundance in the *i qoliqoli*

Fish density in the *i qoliqoli* is generally low. Surgeonfish (Acanthuridae), Goatfish (Mullidae), Grouper (Serranidae) and Snapper (Lutjanidae) are more abundant than average, while Parrotfish (Scaridae), Wrasse (Labridae), Emperor (Lethrinidae) and Rabbitfish (Siganidae) all show marked decline (table 3). The density of Surgeonfish at 20.3 fish per 1000m² reef area does not represent a substantial increase over the coral coast average of 17. Similar to the Coral Coast as a whole, Wrasse contributes a large proportion to total fish numbers. Wrasse density in this *i qoliqoli* is almost a third of the Coral Coast average of 165.4 per 1000m². The most significant change in fish density is the decline in Parrotfish numbers. Parrotfish density has dropped from an average of 34.4 fish per 1000m² to 2.8 fish per 1000m². Not only does this represent a significant decline from the Coral Coast average, but also it is significantly lower than the neighbouring *i qoliqolis*.

Table 3. Estimated density of popular families of food fish per 1000m² for the *i qoliqoli*, the neighbouring fishing areas, and for the whole Coral Coast.

	Parrotfish	Surgeonfish	Goatfish	Wrasse	Groupers	Emperors	Snapper	Rabbitfish
Iqoliqoli	<i>Ulavi</i>	<i>Sivisivi</i>	<i>Daunau</i>	<i>Dradra</i>	<i>Kawakawa</i>	<i>Kabatia</i>	<i>Kabatia</i>	<i>Nuqa</i>
The <i>i qoliqoli</i>	2.8	20.3	2.7	59.3	3.5	0	2.2	1.2
Neighbouring <i>i qoliqoli</i> east	4	2.3	0.7	149	0.3	0.5	2.2	0
Neighbouring <i>i qoliqoli</i> west	74.2	33.4	2.3	260.9	4.2	0.2	0.5	6.9
Overall average	34.4	17	2.2	165.4	3	0.7	1.5	7.4

Density of most invertebrates is low across the *I qoliqoli* (table 4). No *Octopus* or giant Clam are seen in the *i qoliqoli*. Edible sea cucumber density appears about average with 1.1 sea cucumbers per 1000m² reef area. Density of sea urchins is significantly higher with an average of 207.9 urchins per 1000m² compared to 69.3 urchins per 1000m² for the coast as a whole.

Table 4. Estimated density of commonly fished invertebrates per 1000m² for the *i qoliqoli*, the neighbouring *i qoliqolis* and for the whole Coral Coast.

	Octopus <i>Hulua</i>	Giant clams (<i>Tridacna</i>) <i>Coko</i>	Edible seacucumbers <i>Dri</i>	Urchins <i>Cawaki</i>
Iqoliqoli				
The <i>i qoliqoli</i>	0	0	1.1	207.9
Neighbouring <i>i qoliqoli</i> east	0.4	0.4	0.1	73.3
Neighbouring <i>i qoliqoli</i> west	0.3	0.5	2.3	34.4
Overall average	0.5	0.5	1	69.3

7.2 GIS Contour Mapping

Presentation of data as a series of contour maps allows comparison in the distribution of different variables.

7.2.2 Benthic cover

Coral cover is incredibly patchy across the *i qoliqoli* (figure 4). The highest levels of live coral cover are seen in the middle zone and towards the eastern edge of the reef area, where coral covered up to 8.6% of the available substrate. Elsewhere Coral cover is largely absent.

Areas of exposed bedrock comprise a greater proportion of the *i qoliqoli* reef area (figure 5). Bedrock cover increases in the mid and outer reef zones, comprising up to 32.2% of reef area. Bedrock cover does appear to drop off slightly towards the river channels on either side of the reef area studied

Rubble distribution follows a similarly patchy pattern (figure 6). High percentage cover of up to 54.8% is seen, particularly in the middle reef zone towards the western side of the reef.

As discussed above, algae dominates total benthic cover in the *i qoliqoli* however it is not distributed evenly across the *i qoliqoli* (figure 7). Algae tends to be more abundant towards the outer reef zone, as well as on the margins of river channels and bays. Percentage cover may reach as high as 75.6% of available in these areas. In this reef section *Sargassum* comprises as much as 61.9% of benthic cover and dominates the algal flora (figure 8). The distribution of *Sargassum* broadly follows that of algae across the *i qoliqoli*. Though red coralline algae accounts for a very small proportion of total algal cover, it is of interest for its filtering role, as a base of food chains, as well as its economic value as 'live rock' for the international aquarium trade. Red coralline algae comprise a very low percentage of benthic cover and rarely exceed 6.7% cover (figure 9). There is a strong trend towards high abundance in the outer zone towards the western edge, and cline of decreasing abundance away from this region.

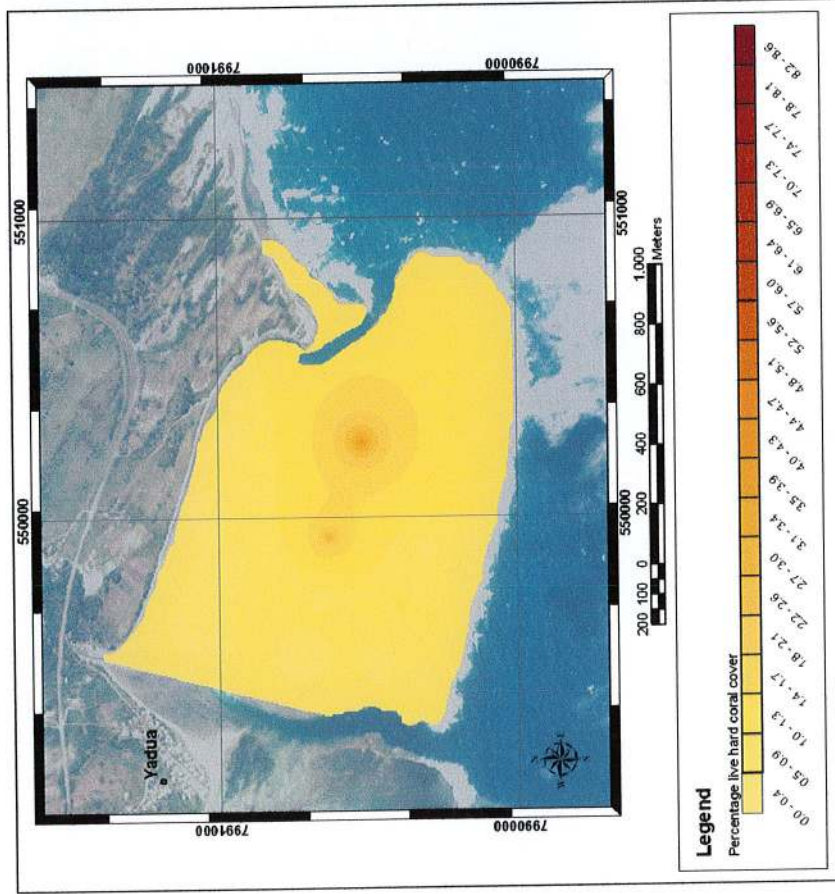


Figure 4. Percentage live hard coral cover for the *i qoliqoli*

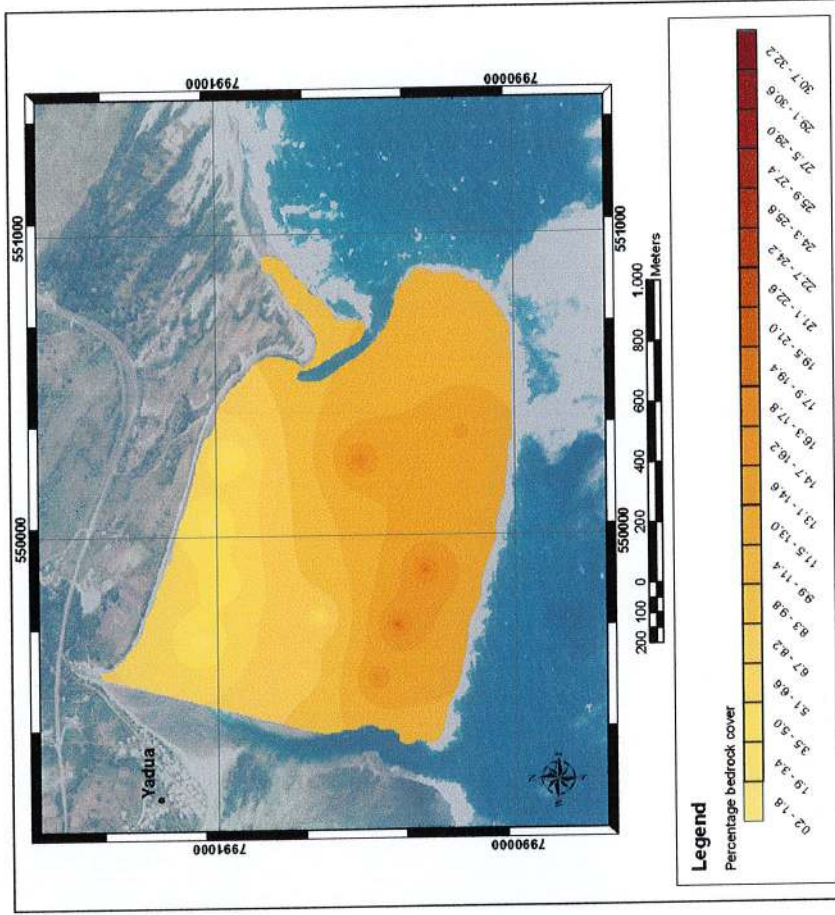


Figure 5. Percentage bedrock cover for the *i qoliqoli*

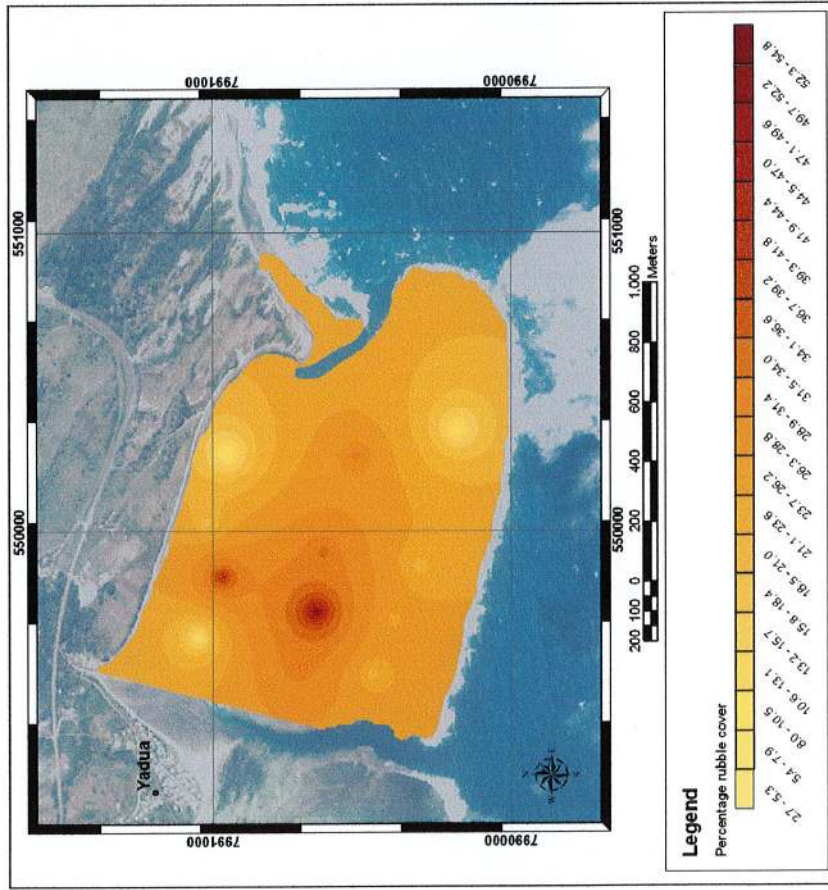


Figure 6. Percentage rubble cover for the *i qoliqoli*

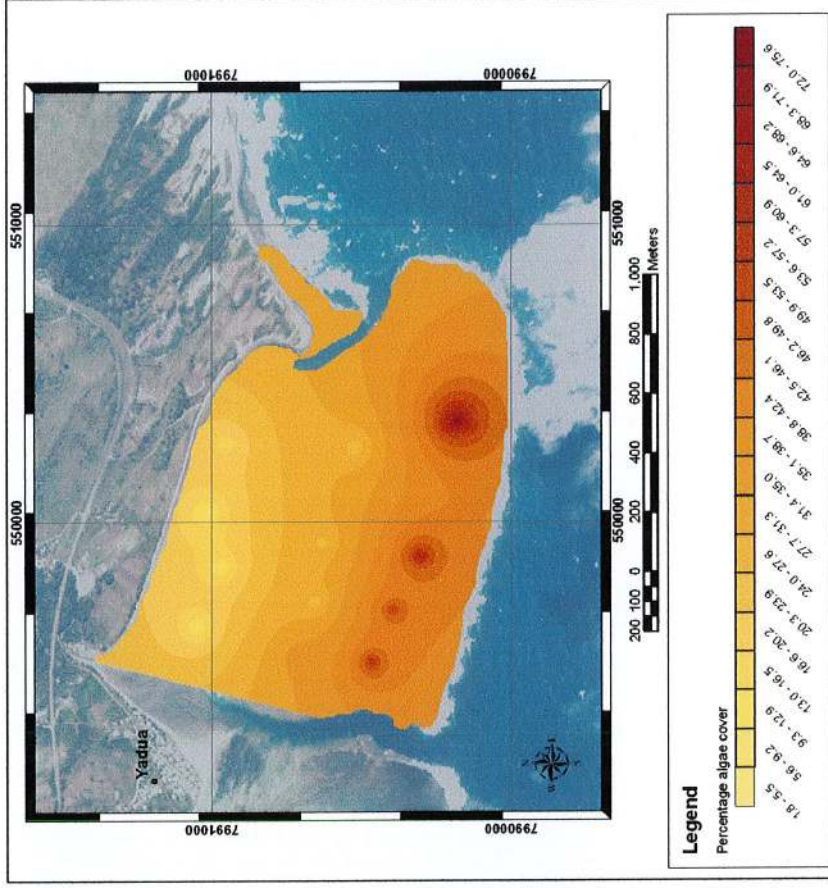


Figure 7. Percentage algae cover for the *i qoliqoli*

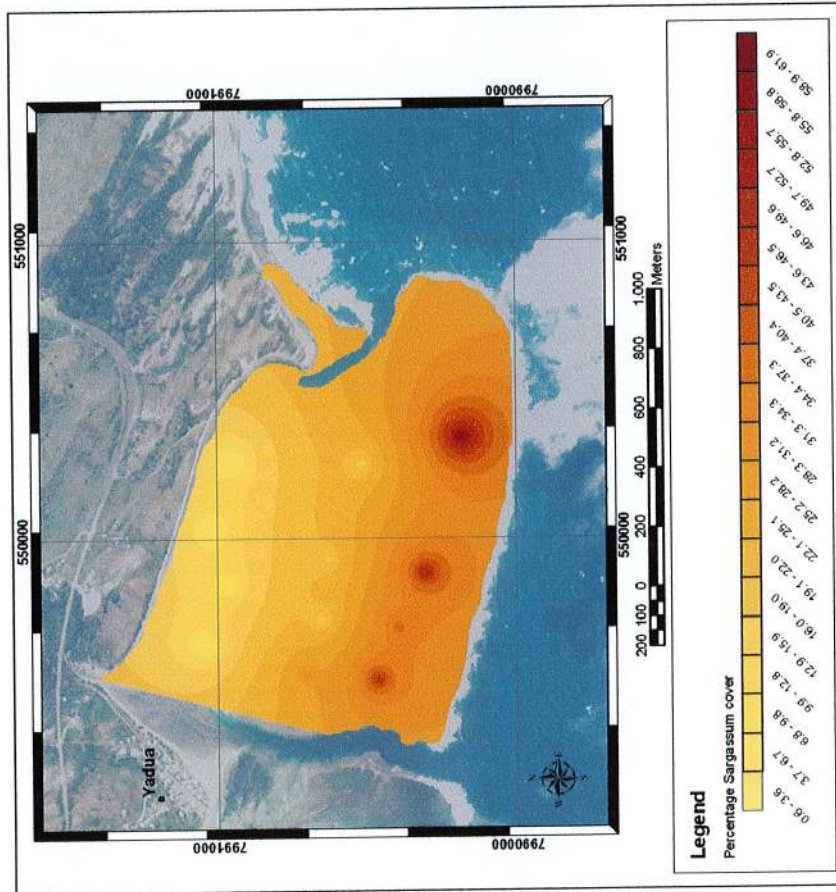


Figure 8. Percentage *Sargassum* sp cover for the *i qoliqoli*..

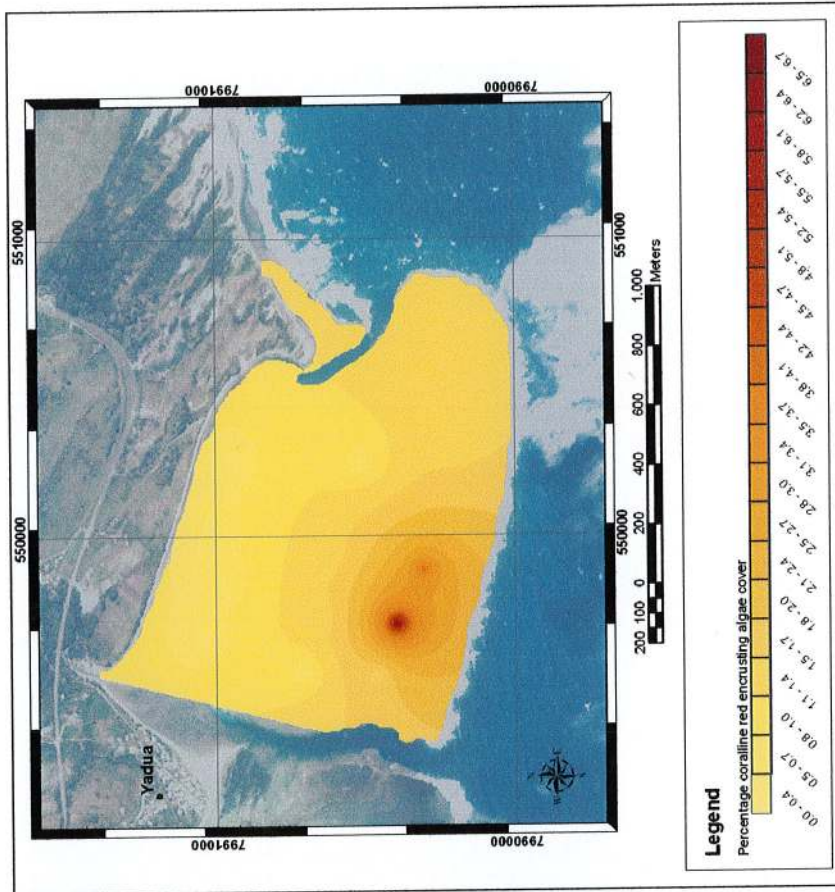


Figure 9. Percentage red coralline algae cover for the *i qoliqoli*

7.2.3 Fish

Density of fish species varies along the coast of the *i qoliqoli*. As a result of the large numbers of juvenile fish recorded, Wrasse show particularly high densities reaching as high as 207 fish per 500m² reef area in some regions (figure 10). Such densities are however the exception rather than the rule and drop rapidly to low densities across much of the *I qoliqoli*.

While not a group commonly targeted by fishermen, Butterflyfish (*Chaetodontidae*) are good indicators of reef health. The distribution of Butterflyfish is incredibly patchy and fish are rare across much of the *i qoliqoli* (figure 11). There are two patches of high fish density on the in the outside zone on the western boundary and on the middle of the *iqoliqoli* where fish density reaches up to 26.2 fish per 500m².

Grouper again show a very patchy distribution (figure 12). Density ranged from 0 to 6.6 fish per 500m². Grouper tend to be more abundant in the middle and out reef zones and highest densities are seen towards the eastern reef boundary.

While Parrotfish absent from most of the *i qoliqoli*, they show incredibly high density in the central zone towards the eastern boundary where density reaches as high as 24.7 fish per 500m² reef area (figure 13).

Rabbitfish are rare across much of the *i qoliqoli* (figure 14) The greatest density of fish occurs in the central zone towards the eastern boundary where density reaches 6.5 fish per 500m² reef area.

In the outer zone towards the eastern edge of the reef, Snapper reach densities of 6.8 fish per 500m² reef area. Another area of density lies in the inner zone close to the Yadua channel (figure 15). Elsewhere, Snapper were largely absent.

Surgeonfish are found at densities between 0 and 35.2 fish per 500m² reef area (figure 16). The population is densest in the middle and outer zones towards the eastern edge of the reef area.

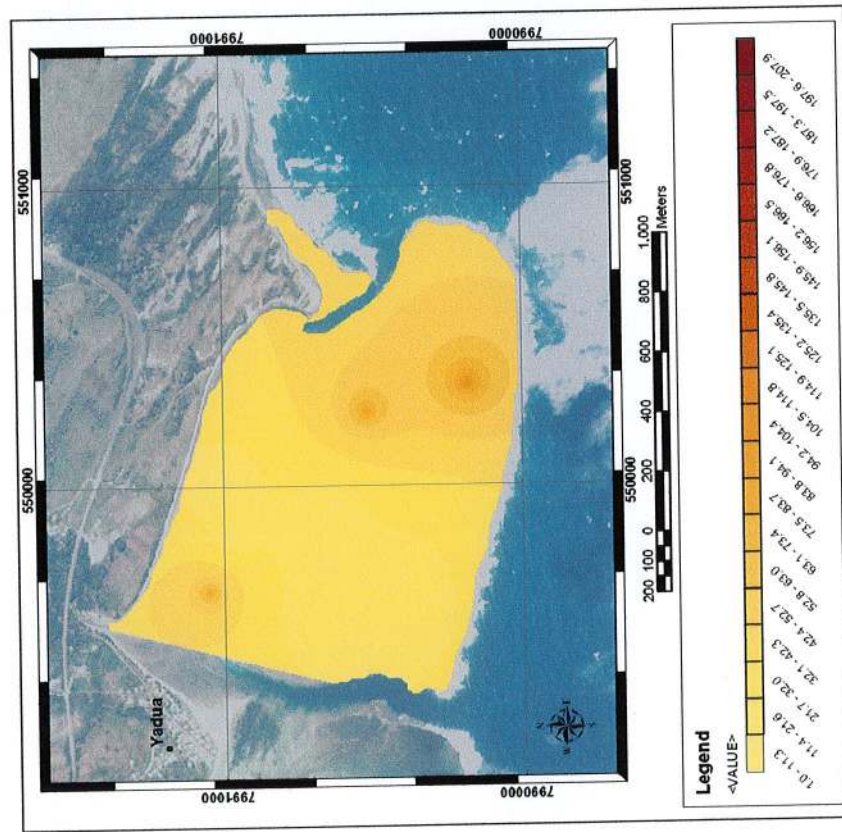


Figure 10. Density of Wrasse (*Labridae*) per 500m² reef area

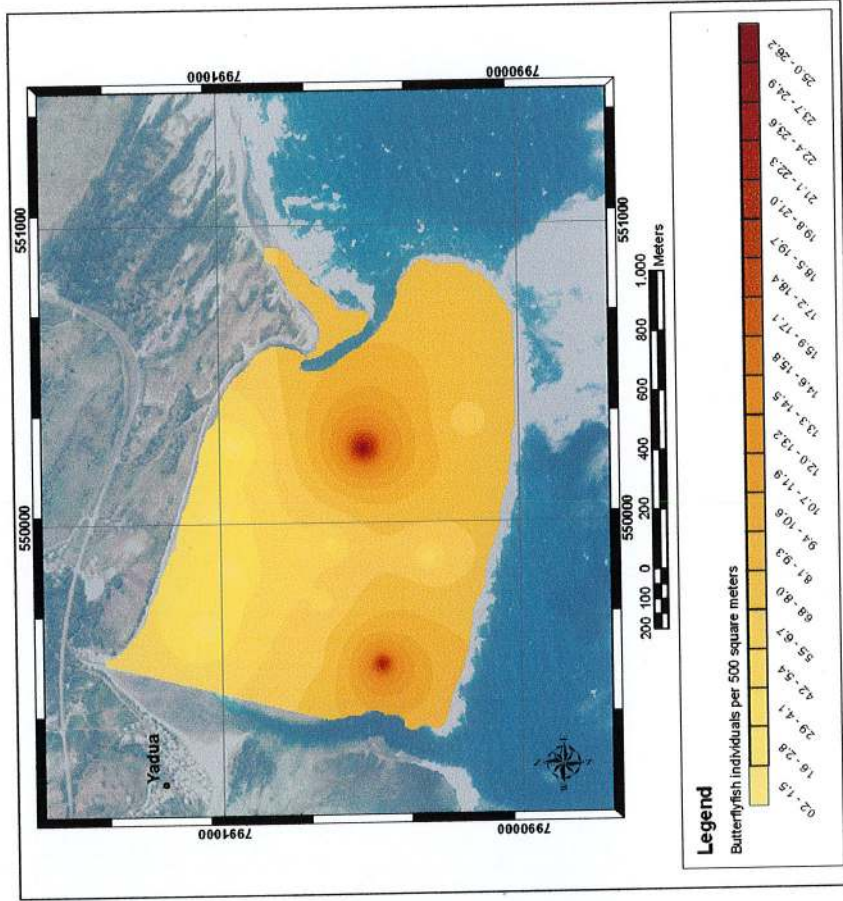


Figure 11. Density of Butterflyfish (*Chaetodontidae*) per 500m² reef area.

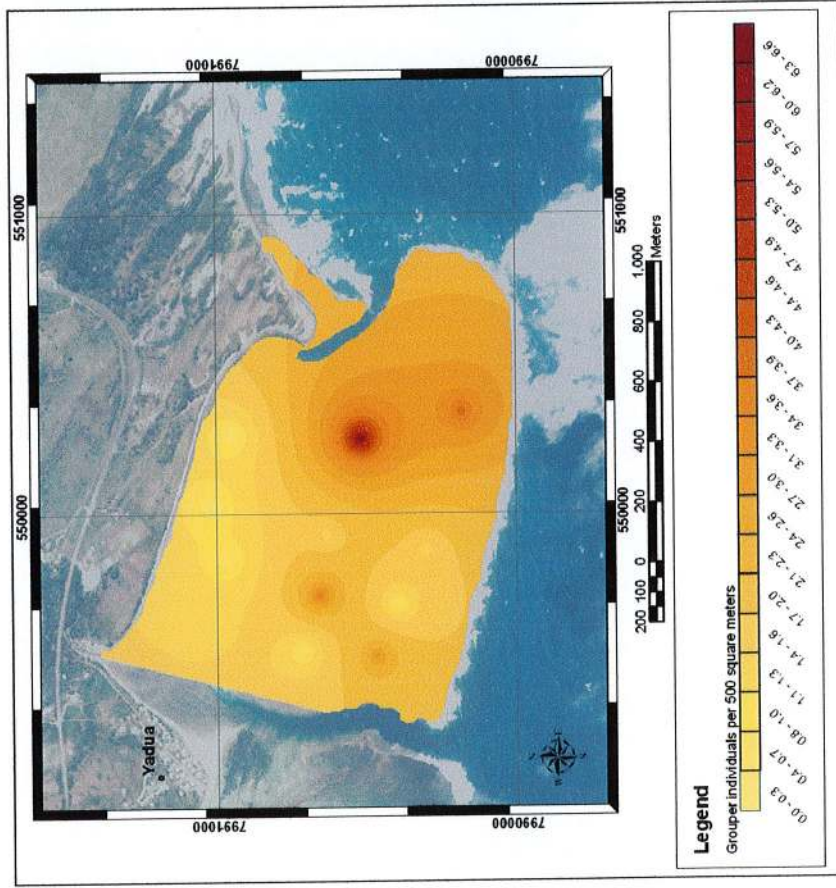


Figure 12. Density of Grouper (*Seranidae*) per 500m² reef area.

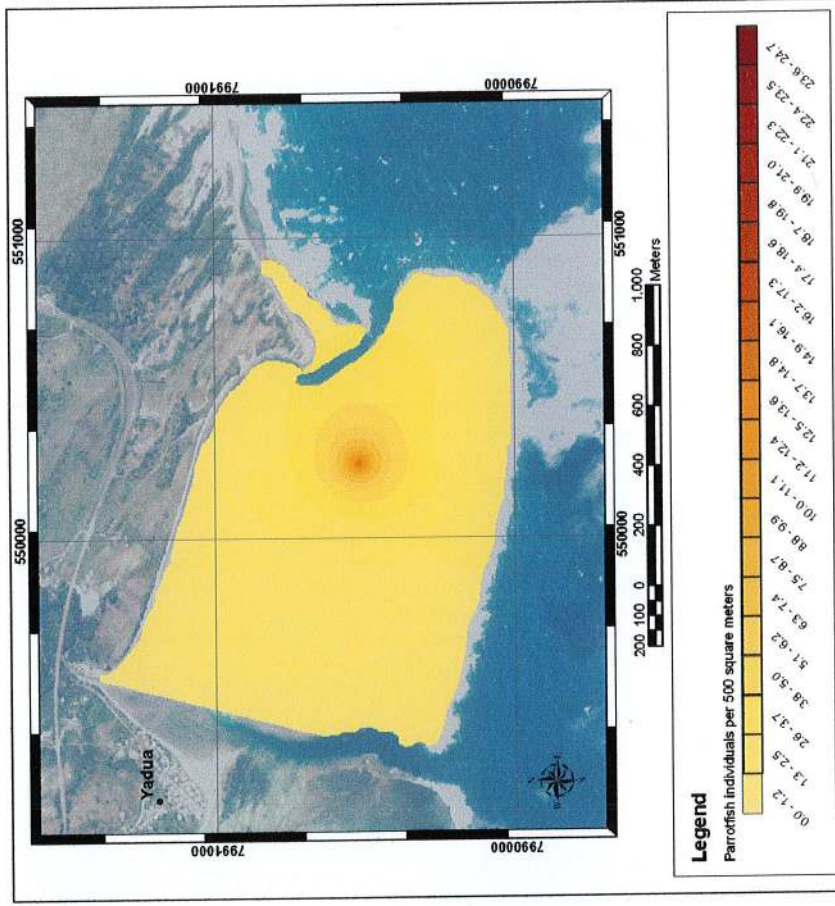


Figure 13. Density of Parrotfish (*Scaridae*) per 500m² reef area.

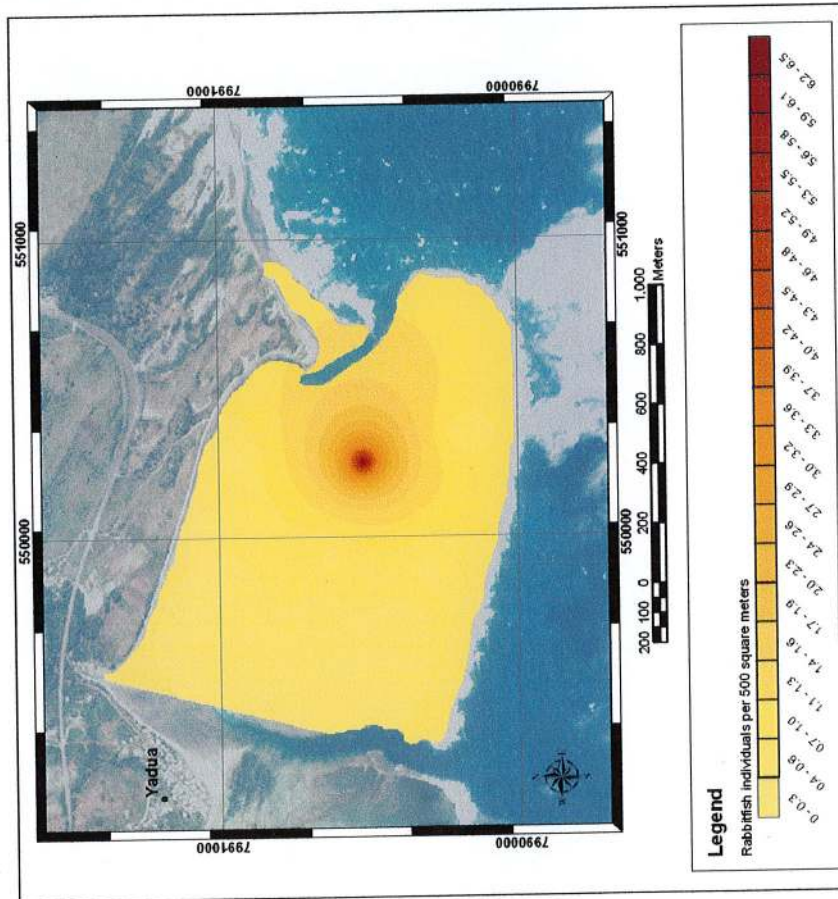


Figure 14. Density of Rabbitfish (*Siganidae*) per 500m² reef area.

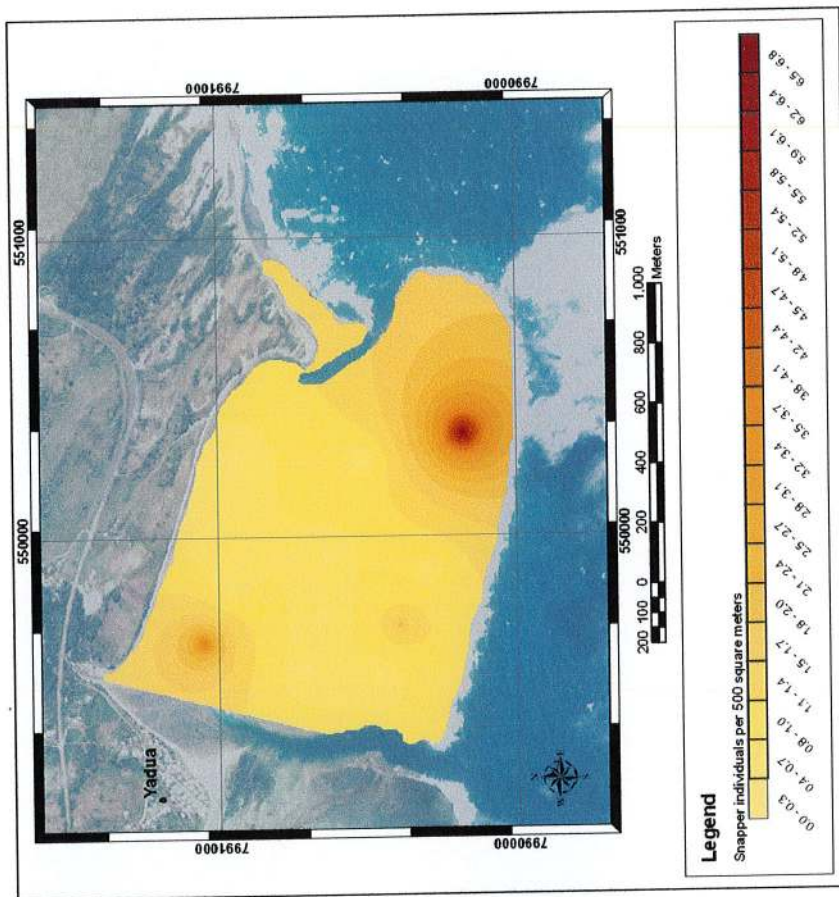


Figure 15. Density of Snapper (*Lutjanidae*) per 500m² reef area

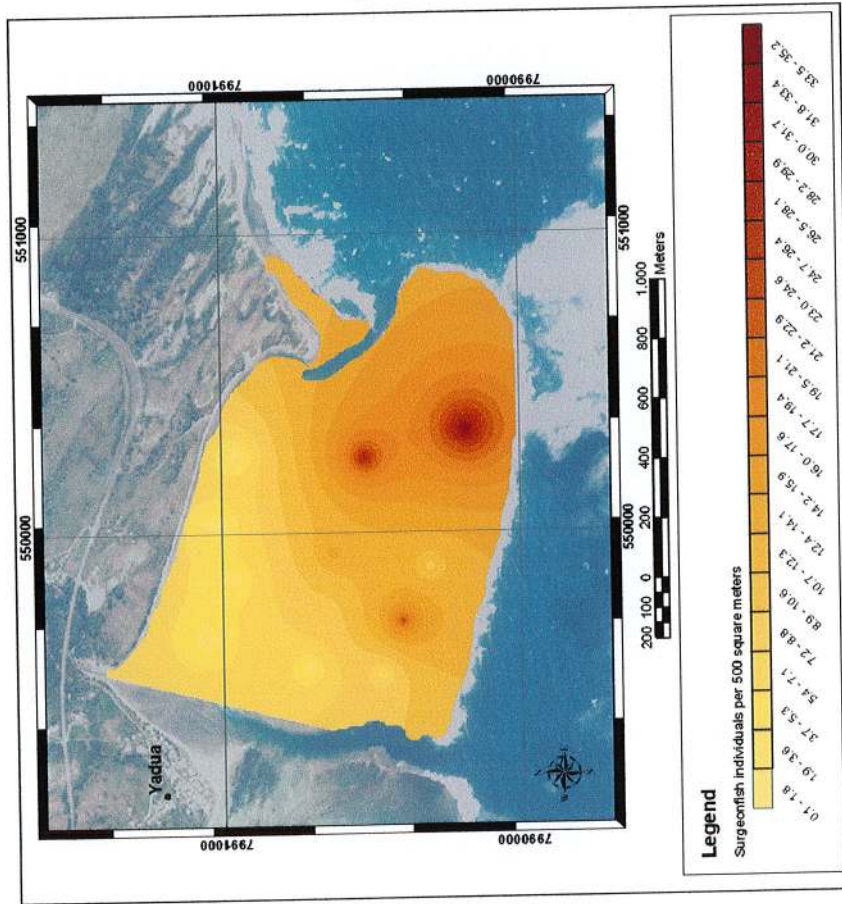


Figure 16. Density of Surgeon (*Acanthuridae*) per 500m² reef area.

7.2.4 Invertebrate data

No Giant clams, Octopus or Crown of thorns were seen. Maps showing their distribution have therefore been omitted from this report.

There are very few sea cucumbers across the *i qoliqoli*, with most sea cucumbers concentrated in the central zone of the reef platform towards the western boundary (figure 17). Density ranges from 0 to 11.6 sea cucumbers per 200m² reef area.

Numbers of short spined seaurchin are high in the *i qoliqoli* (figure 18). The population is desest in the central zone where density reaches as high as 133.2 urchins per 200m² reef area.

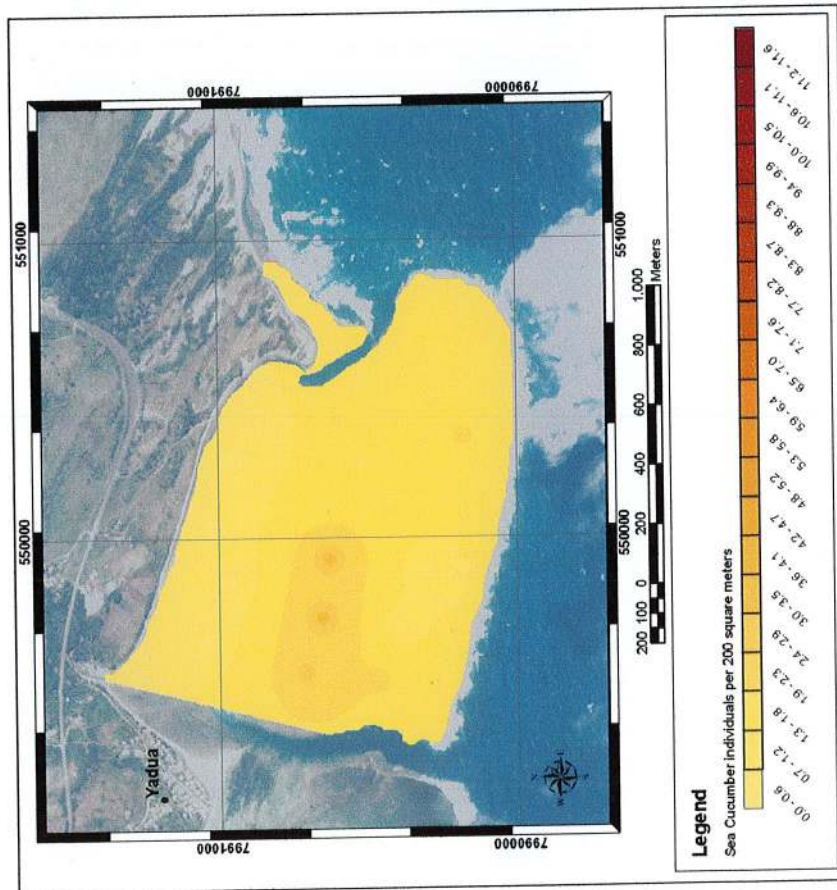


Figure 17. Density of Sea Cucumbers (*Holothuridae*) per 200m² reef area.

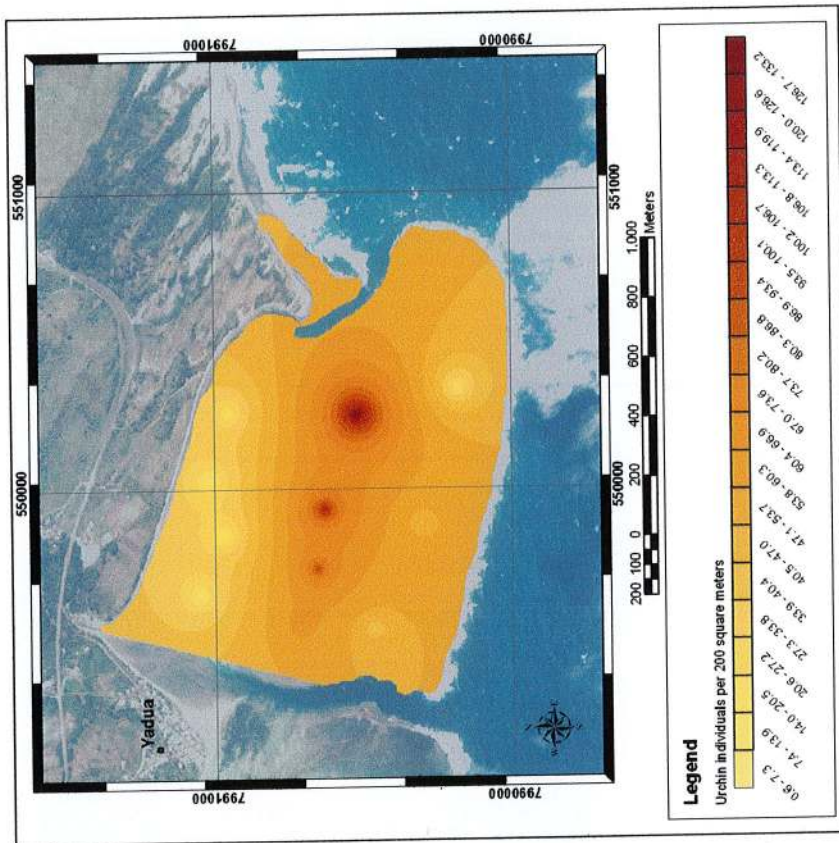


Figure 18. Density of short spined urchin (*Tripneustes* sp) per 200m² reef area.

8 Discussion

Species composition and abundance can be explained by interactions between species and substrate types as well by a series of anthropogenic influences.

8.1 *Distribution and Abundance Interactions*

As demonstrated by the contour maps in the results section, different substrates and species show marked differences in their distribution and abundance throughout the *i qoliqoli*. Many of the distributions of fish, invertebrates and the substrates themselves show close affiliation one another. It is important to remember however that given the small size of the area surveyed many patterns may not be as apparent as in other *I qoliqoli* with a greater area of back reef habitat.

Unlike bedrock, rubble does not provide a suitable stable substrate for coral and algal settlement. Though bedrock and rubble may provide shelter for organisms, they do not contribute to energy flows between trophic levels without coral or algal settlement. An area of bedrock is more homogeneous with lower habitat complexity and lower available surface area than comparable areas of coral habitat (figure 19). This leads to a lower number of available niches for different species to exploit. An area dominated by bedrock as opposed to hard coral or algae will therefore have a lower carrying capacity and a less productive fishery.

Bedrock tends to be densest in the outer and mid reef zones (figure 5). The high level of settlement, particularly by algae (figure 7), in the outer reef zone would suggest that conditions here are supportive of algal growth and therefore suggest that recruitment levels may be low. It is apparent that Rubble tends to be more abundant in the middle reef zone and back from the margins of river channels (figure 6). Broken coral and rock is brought in by breakers and deposited in this relatively calm back reef region.

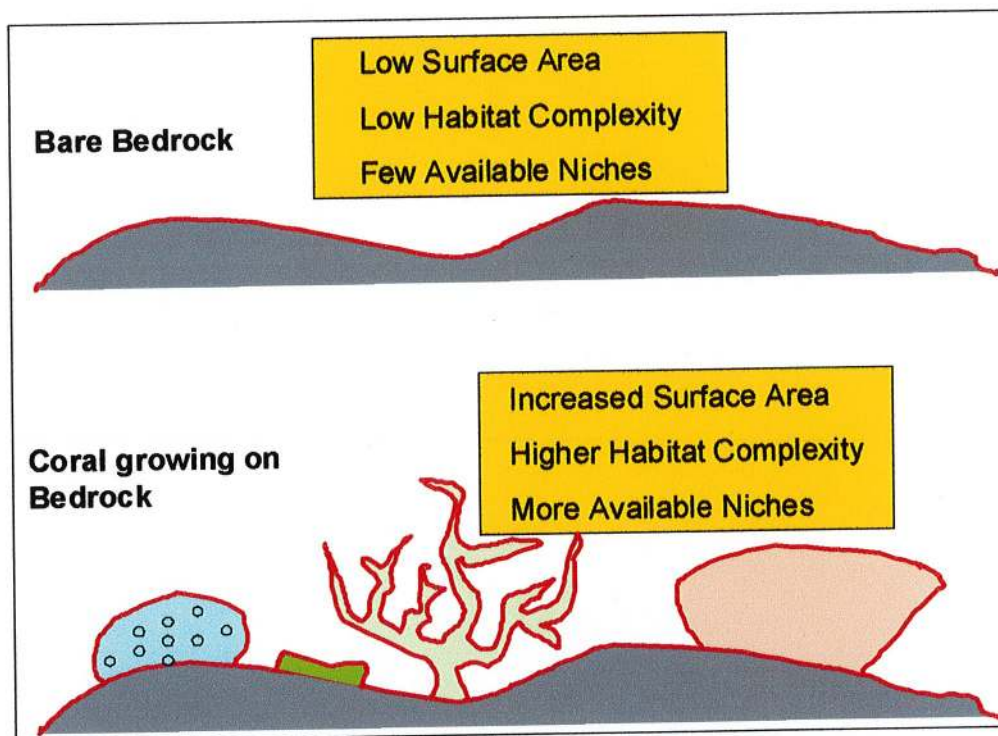


Figure 19. Simplified diagram showing affect of coral growth on surface area (red line) and thereby habitat complexity and niche availability as opposed to bare bedrock only

Coral and algae form the basis of most coral reef food webs. The importance of such primary producers on the rest of the ecosystem can be seen when looking at other biological variables. Though it makes up a small percentage of total reef cover, many fish and invertebrate groups show their highest abundance in or close to sections with a relatively high hard coral coverage, as seen in the central zone towards the eastern reef boundary.

Live coral cover is an important measure of ecosystem health. Not only does coral form the base of many food webs, but it also provides shelter for many reef organisms. As a group, Butterflyfish depend heavily on coral as a food source. The distribution of Butterflyfish closely matches that of live hard coral with comparable regions of high density (figures 4 and 11). A close association between Surgeonfish, Parrotfish, Snapper and Grouper with coral rich habitat is seen and this supports observations in other regions (figures 12, 13, 15 and 16) (Coral Cay Conservation, 2005^{1,2}). The observation of a greater density of Rabbitfish in this habitat however appears to go against the pattern seen in most other iqolqoli (figure 14) (Coral Cay Conservation, 2005²). The overall low abundance of fish, and live hard coral may be connected to this. Most of the above groups are highly targeted by local fishermen

and their relative abundance compared to elsewhere in the *i qoliqoli* is indicative of the health and value of these regions.

Though many species may be associated with coral rich habitat there are a few exceptions. Though Sea urchins show high density within the coral rich zones, they are also abundant throughout the central zone and may be more related to high bedrock habitat in their distribution (figure 5 and 18). Sea urchins are known to feed on the fine filamentous algae, which grows on such a substrate. The distribution of Surgeonfish while high in the areas of highest coral cover is also high in areas of high rubble cover/high algae habitat in the outer reef zone. Though observing Surgeonfish in such habitat appears rare elsewhere in the *i qoliqoli*, this pattern of dominance over one area is not uncommon and has been witnessed elsewhere on the Coral Coast (Coral Cay Conservation, 2005²).

An inverse relationship between algae and live coral cover is evident (figures 5 and 8). Though algal cover is high everywhere in the *i qoliqoli*, the highest coral cover is seen in an areas where algal cover is significantly lower.

As a rule, the *i qoliqoli* consists of algal dominated rather than coral dominated reef platform. Coral and algae, like other organisms, will grow better under different conditions. In the clear, nutrient poor waters of the tropics coral tends to dominate suitable substrate unless these conditions are perturbed. The data therefore suggests external influences on the environment. Algae might be expected to dominate the outer surge zone, where high levels of surge and wave impact are combined with low water level, the abundance of algae over the rest of the *i qoliqoli* is a concern.

A degree of competitive exclusion between Surgeonfish and Rabbitfish has been highlighted as a possibility elsewhere on the coast (Coral cay conservation, 2005^{2, 3}). Surgeonfish may form shoals to monopolise feeding opportunities, marginalising other herbivorous fish species in the process. Whether this is indeed happening is difficult to discern, however an inverse relationship between Rabbitfish and Surgeonfish is apparent.

Wrasse are relatively abundant in most regions of the *i qoliqoli* (figure 10). Food availability and diet may again be an important consideration. Most Wrasse are planktivorous or carnivorous, feeding on small invertebrates, parasites and other organisms. This may explain their more widespread distribution. Other fish which tend to feed either on larger prey, coral, or vegetable matter will therefore not compete with Wrasse for much of their diet. Though it is not clear from the evidence presented, juveniles account for a large proportion of Wrasse recorded. Given their size juvenile wrasse may find shelter from predation in a variety of habitats including those dominated by both coral and algae as well as the outer surge habitat. Larger fish must either seek shelter through shoaling behaviour or use of natural crevices and overhangs. This may restrict their range to coral rich habitat to a greater degree.

Given the scope of this report it is difficult to be certain of the degree to which the factors of intra and inter species interaction, food availability, and shelter interact. Further study would be required to disentangle the details relating to distribution of fish stocks.

The higher abundance of herbivorous fish such as Surgeonfish, Parrotfish, and Rabbitfish as opposed to carnivorous fish like Grouper and Snapper (figures 11 to 17) may indicate the presence of overfishing. This supports the findings of Jennings and Polunin (1995²) who found that areas that were fished heavily tend to show greater proportions of herbivorous species as opposed to carnivorous species.

8.2 Anthropogenic Impacts

Though not analysed directly during this study, the anthropogenic influences of nutrient enrichment, sedimentation, fishing, harvest for aquarium trade, as well as recreational use have been highlighted in the Coral Coast region (IAS¹, 2002). Anthropogenic impacts relate directly to the population pressure in an environment. The population trends for most of the Coral coast region are highlighted in figure 20. Between 1966 and 1995 the number of households increased steadily in Nasigatoka district.

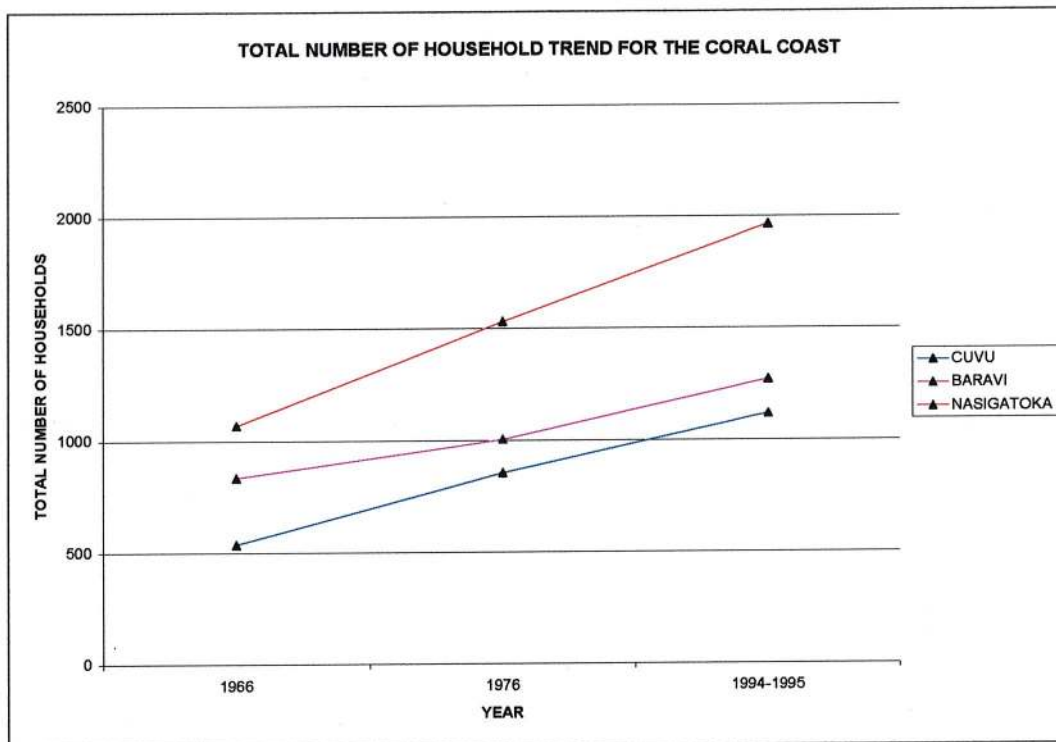


Figure 20. Graph showing trend in number of households for three legislative districts that make up the Coral Coast region. The iqoliqoli is contained within Nasigatoka district. (Institute of Applied Sciences-University of the South Pacific, Unpublished data).

Population pressure is not restricted to local villages. The tourist industry of Fiji has shown a high level of growth over the same period, much of which has been concentrated on the Coral Coast. Current and future development plans in the district and surrounding region make this a very real concern.

8.2.1 Nutrient Enrichment

Nutrient enrichment leads to an increase in levels of algae and may result in a shift from coral to algae dominated reef (McCook, 1999). Algal dominated reefs have been noted to have lower fish stocks, less tourism appeal and lower levels of biodiversity. Main sources of these nutrients are human and animal waste, fertiliser, and detergent use. Algae is the dominant biotic benthic cover variable in the *i* qoliqoli (table 2, figure 7). This supports the view that some nutrient enrichment occurs. Low Nitrate (NO_3^-) and Phosphate (PO_4^{3-}) levels are usually the limiting factor of algal growth in tropical systems. Without measures of these nutrients in the area it is difficult to verify that nutrient enrichment is taking place directly. Elsewhere on the Coral Coast,

measurements have been taken. A study of nutrients in Baravi district in 2002, showed that levels of Nitrates and Phosphates outside Hideaway resort and Votua village were above levels shown to support coral growth and therefore lead to algal growth (IAS, 2002). This evidence has been highlighted as a contributing factor to the high levels of algae, specifically *Sargassum sp.*, outside of hotels and villages in the region (Coral Cay Conservation¹, 2005). Villages, pig waste and hotel wastewater were identified as the main sources of nitrate in the area (Thaman et al, 2005). Use of pit toilets and poor septic systems in many village communities results in nutrients leaching into the coastal system. Additionally the positioning of pigpens over and around rivers and coastal fronts leads to the direct transfer of nutrient rich effluent. Though many tourist establishments have made concerted efforts to improve their systems, some tourism businesses are still using inadequate treatment plants.

Overall, levels of algae in the *i qoliqoli* are extremely high suggesting that elevated nutrient levels are a big problem in the *i qoliqoli*. As highlighted in Baravi district the factors of domestic, industrial and animal effluent are likely nutrient sources. Additionally the area may suffer nutrient input through inland agricultural practice. Some sugar cane farming does occur in the region. Aside from Yadua, there are no settlements on or near the reef platform. There is no clear concentration of algae immediately outside of Yadua however given the river channel between the village and the reef area it is hard to know the source of the nutrients. Figure 21 highlights how a reef may experience a shift in prevalence of coral and algae under elevated nutrient conditions. If an area experiences regular disturbance, given that high levels of algae are already present in the region, this trend may continue. The importance of high coral cover habitat in sustaining rich fisheries has been highlighted above. Creating the conditions that tend towards coral reef establishment over algal settlement should therefore be a high priority in the management of local fisheries.

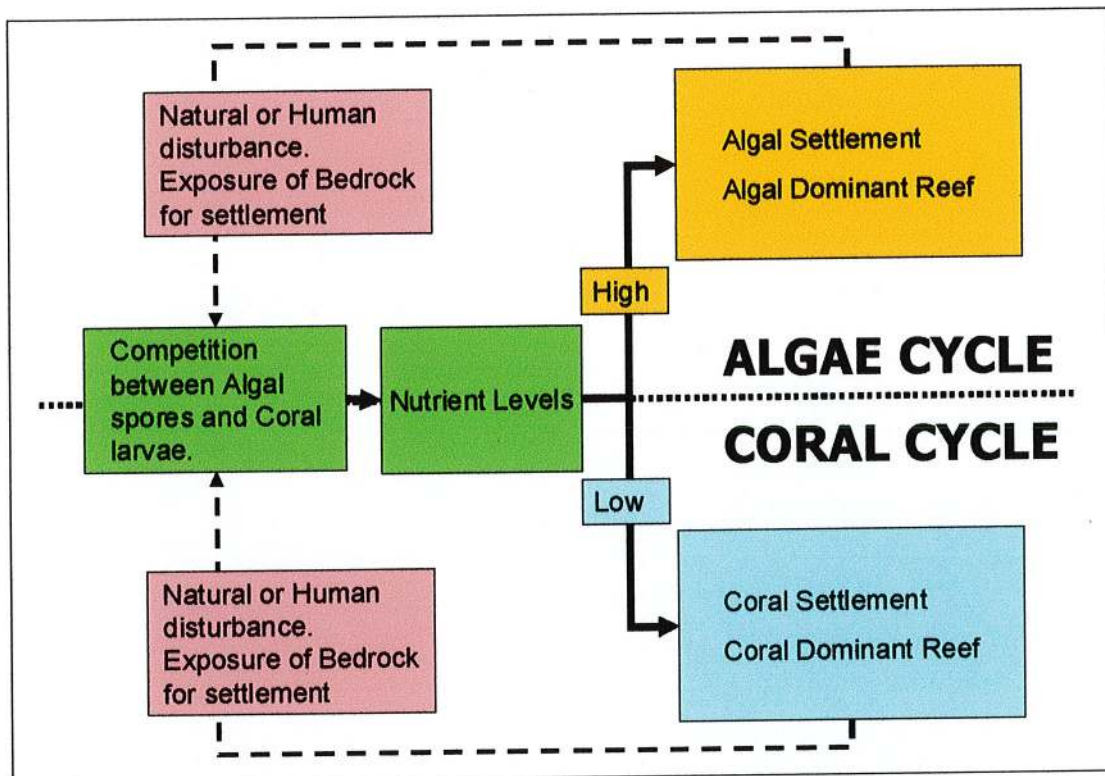


Figure 21. Influence of Nutrient levels on Coral and Algae reef development.

One problem in determining the effects of nutrient elevation lies with a lack of oceanographic understanding. Without a detailed study of local currents it is difficult to be clear of what the ultimate destination of these nutrients is. Nutrients sourced from within the *iqoliqoli* may be transported elsewhere while at the same time the *i qoliqoli* may be suffering from external nutrient input. The dominance of algae across the *i qoliqoli* may reflect runoff from agriculture and small settlements along this stretch of coastline as well as nutrients sourced from further a field. The significant concentration of algae around the margins of river channels and bays as well as the outer reef zone may be a reflection of a volume of nutrients entering the system by this route. The strong currents experienced in different regions of the reef platform mean that nutrients may be concentrated in unexpected places where eddies occur as opposed to near to obvious nutrient sources.

Though the causal link between nutrients and algal overgrowth of corals is well established, it is important to note that other factors may also be important. The abundance of herbivores such as sea urchins and herbivorous fish to graze the algae may affect reef composition (McClanahan, 1997; McCook, 1999). Phase shift from algae to coral reef may also occur if herbivorous species are overfished or in low

numbers due to habitat degradation. Maintaining stocks of herbivorous species such as Rabbitfish, Surgeonfish, Parrotfish and Sea urchins is critical in this regard.

8.2.2 Sedimentation

Sediment brings further nutrients into the system. It may smother coral and lead to a build up of sand and mud based communities. Sediment covers feeding appendages and blocks sunlight from reaching the photosynthetic Zooxanthellae that live symbiotically within coral. Potential causes of sedimentation may include deforestation, agricultural clearance, coastal engineering and development. Removal of vegetation removes the root structure that binds the soil, preventing it from washing away when rains come. Loose soil will wash downstream with the rain and into the coastal system if natural sediment-traps such as the mangroves and seagrass beds have also been removed or damaged

Though no specific tests of sedimentation levels were carried out in the course of this study, very little was observed during surveys. Given the high currents often recorded, it is unlikely that much sediment settles in the back reef area, but rather is carried outside the break area or settles in the river channels. Through impacts to outer reef areas, sedimentation may reduce levels of recruitment into the system. This in turn would reduce the likelihood of reversion back to coral-reef platform in the future. Few studies have been carried out into either the effects of sedimentation, general reef health or recruitment to and from the reef area behind the break zone. Further studies would be desirable to this end. While not a current priority for management, the potential impact of sediment should not be ignored and potentially damaging activities carefully considered and mitigated.

8.2.3 Fishing pressure

Fishing provides a vital source of food, sustaining local communities. Evidence sourced from the local community over the course of this study supports that documented elsewhere (Adams 1998; Hunt, 1999; IAS¹, 2002; Jennings and Polunin, 1995).

The majority of fishing pressure along the Coral Coast is concentrated on the back reef platform, with each village or settlement concentrating its fishing effort on the reef area directly in front. Very little fish is exported from each village, but rather shared or sold between families and the village community. Opinion along the coral coast suggests that fishing has become harder, with a decline in the number and size of fish. A more in depth survey would be required to substantiate this. While this may be true, fishing pressure must be considered a potential impact on the reef system. As discussed in section 8.1 the comparatively low numbers of carnivorous species in the *i qoliqoli* may be indicative of overfishing. Concentration of fishing pressure on herbivorous species may also contribute to an increase in algal cover as discussed in section 8.2.1. Though many people from the villages of the *i qoliqoli* work in outside business, many people remain reliant on supplies grown on individual plantations or sourced from the sea rather than from Sigatoka town.

The targeting of young and juvenile fish is a concern. Minimum net size currently designated by Ministry of Fisheries stands at 3½ inch and 1½ inch (Garfish fishery only). It is unclear if these net limits are being adhered to. Though the Ministry of Fisheries does publish minimum catch sizes, it is unclear to what level the size of fish harvested is regulated and it is likely that fish of all sizes and ages are taken. Much of the back reef area where fishing effort is concentrated functions as a nursery for juvenile and sub-adult populations. By continuing to target young and immature fish the result is that few make it to full adult size. Those that do may in turn be targeted by spear fisherman. The knock on effect this has on the dynamics, reproductive output and recruitment of populations could explain some of the patterns in fish abundance witnessed.

Fishing methods employed in the *i qoliqoli* are probably similar to those witnessed in other subsistence and artisanal fisheries (Hunt, 1999). Mask and snorkel are used to spear fish and the use of hand lines is also common. Spear fishing, particularly at night targets large individuals of certain species. As already discussed, the targeting of particular age classes has the potential to influence the dynamics of whole populations.

At low tide gleaning takes place whereby people (usually women) walk out onto the reef platform in search of invertebrates such as *Octopus*, shellfish, edible seacucumbers and urchins. The widespread adoption of gleaning practices may explain the overall low numbers of all invertebrates recorded. Over 50% of the subsistence catch on Viti Levu is taken by women, who are generally fishing from the shore for family consumption (Adams 1998). Management of this mode of fishing is therefore potentially very important.

Seine netting is another fishing method utilised. This involves a team of fishermen making a wide circle, which is then constricted forcing the fish within into a tight shoal, which can be stunned and netted. This method not only impacts the reef directly as fishermen walk over and beat the reef to herd fish, but also has the disadvantage of being unspecific in the species targeted.

Use of *Derris*, known locally as 'Duva', root was witnessed sporadically along the Coral Coast, however it is not clear to what degree it continues to be used. Though localised, Duva is unspecific in its target organism and if left in place after use may continue to have an effect and should be discouraged.

There was no evidence of dynamite fishing the use of cyanide or other destructive fishing types in the *i qoliqoli*.

8.2.4 Harvest for the Aquarium trade

Live Rock is not harvested inside the *i qoliqoli*. Live rock refers to bedrock or coral rubble with a growth of red coralline algae on its surface. This commodity is highly

prised by the aquarium trade due to its aesthetic qualities and role as a biofilter. The potential damaging effects of Live Rock extraction have been documented for other geographic areas and work is currently under way by the Marine Aquarium Council to examine the specific impact along the coral coast. There is little or no collection of fish for the aquarium trade from the *i qoliqoli*.

8.2.5 Coastal construction

Though the economic and social benefits of development are often clear, the environmental impact on land and marine systems is often harder to see and quantify. Construction projects can range in size from the building of single houses and sheds to the building of large resorts and villages. With the dominance of the tourism industry in the region the majority of large-scale development in the region concerns the building of tourism facilities. Development of this area of the *iqoliqoli* has so far been minimal though may be a concern in other areas of the *iqoliqoli* that were not researched.

8.2.6 Recreation

Given the low numbers of tourists also make direct use of the *i qoliqoli* activities such as swimming, snorkelling, glass bottom boat rides, kayaking, sailing, fishing and reef-walking. SCUBA do not currently require management

8.2.7 Pollution

Pollution is a concern in the *i qoliqoli*. Villagers use the shoreline and seafront as a place to dump rubbish. The large population centre within the *iqoliqoli* leads to a high volume of Non-biodegradable waste. Rubbish such as plastic takes a very long time to degrade and may smother coral heads or choke marine animals. Agricultural and industrial chemicals and poisons may leach into the marine system and are a potential threat to the *i qoliqolis* resources.

8.2.8 Current Management

Though there may be management elsewhere in the *iqoliqoli*, there was no evidence or mention of any pertaining to the reef area surveyed.

8.3 Marine Resource Management

With the reversion of *i qoliqoli* ownership back to the local indigenous communities, the onus of *i qoliqoli* management is set to change. The role of government departments and associated agencies will be to provide the framework within which community decision making can operate. Management of the marine resources of the *i qoliqoli* is a complex undertaking but imperative if stocks are to be secured for future generations. A series of impacts on the *i qoliqoli* are apparent from the data collected and serve to highlight the need for a number of management activities in the area.

It is vitally important to understand the source of problems affecting the *i qoliqoli* inshore fishery. As discussed in previous sections, nutrient enrichment, and fishing pressure are the biggest concerns to reef and ecosystem health. Sedimentation, coastal development, and pollution is also of concern. There are a number of active steps that can be taken to mitigate these concerns, and to speed up the process restoration. Ultimately good management can lead to an increase in the carrying capacity of an area as well as its inherent stability.

Management of stocks on a local level for local consumption is often very effective as impacts on the system may be easier to both identify and manage. There may however be situations where the source of problems is external to the *i qoliqoli*. Communication between different communities, local businesses as well as relevant government and non-government organisations is important in finding solutions to these issues.

8.3.1 Fisheries management

It is unclear to what degree the reef area surveyed is fished and what communities rely on it. Communities within the *iqoliqoli* are probably less reliant on the sea as a source of protein than neighbouring *iqoliqoli*. The area of reef surveyed however represents a very small area for a potentially large population. The principles of sound management however remain the same.

Overfishing

The problem of overfishing can be tackled both directly and indirectly. Removal of fish before they are reproductively mature needs to be managed. Fish should not be removed below certain sizes. To this end use of nets with too small a gauge is discouraged. The ministry of fisheries publishes minimum catch sizes for fish (appendix 2). These size limits could be used as a guide to local communities in their management of the *i qoliqoli* to increase the size and reproductive capacity of fish populations. The reasoning behind these sizes however needs to be conveyed to local communities to enable management practices to be adapted accordingly. Other potential methods of managing overfishing include limiting how much effort individuals put into fishing. This could include how many trips they may make, and/or how long they may spend on these trips.

The Fiji Locally Managed Marine Areas (FLMMA) network is active in Fiji and elsewhere on the Coral Coast. FLMMA involves both government and non-government agencies in Fiji. Through FLMMA villages develop Resource Management Plans for their *i qoliqoli*. The FLMMA programme aids communities in developing the capacity to make management decisions through the addition of scientific knowledge to their traditional knowledge of marine lifecycles and dynamics. Villages improve their capacity to monitor and make decisions about their marine environment. Monitoring *Tabu* areas is an important part of this approach and concentrates on a few easily recognisable food species such as Parrotfish. This model may prove useful to this *i qoliqoli* in managing their own resources.

***Tabu* or Marine Protected Area management**

Identification of areas for management as *Tabu* or Marine Protected Area (MPA) is an important step in managing human activities, safeguarding ecosystem health and fish stocks for future generations. In a no take *Tabu* area fish will live longer and grow to a larger size. Larger fish tend to produce more eggs and offspring than smaller fish. As population increases even more eggs and offspring will be produced, swelling the population further until the carrying capacity of the area is reached. At this point fish will move out of the area or 'spillover' and replenish the surrounding fishing grounds. Other potential benefits of *Tabu* areas include an increase in intrinsic value of the marine ecosystem for tourism.

Other factors are also important in designating areas for protection. The composition of the benthic community in an area is of critical importance as it forms the basis of communities in terms of nutrient source and shelter. Though some coral reef species show strong special affiliation living within distinct home ranges, many species are ephemeral, and move between patches of habitat. As already discussed, coral cover is the best indicator that an area is of value due to its links with important food species and the shelter it provides. The protection of the most productive habitat will yield better returns.

Size is an important criterion. The area currently under *Tabu* management is in excess of the 20 to 25% thought to be necessary for the successful functioning of an MPA or *Tabu* area.

One important consideration when positioning MPAs or *Tabu* sites is to identify source and sink areas. A source area will feed into sink areas. Knowledge of currents is important in this regard as coral, invertebrates and many fish have planktonic stages in their lifecycle that disperse on these currents. Protection of the areas from which animals are dispersing will lead to the best results in terms of spill over

The protection of spawning aggregation sites should be included in resource management plans. Many families of reef fish will aggregate in order to spawn and are particularly susceptible to overfishing at these times. While smaller fish tend to

aggregate on the back reef and lagoon area, other important food fish will aggregate on outer reef slopes, in reef channels, promontories and drop offs.

While *Tabu* or area protection can be used to manage whole ecosystems, it can also be used to manage certain target fisheries. The link between the position of *Tabu* areas and the number of Octopus has been highlighted in this *I qoliqoli* as elsewhere (Coral Cay Conservation, 2005). Communities must decide what species they want to manage in their *i qoliqoli*. No take areas, seasonal closure (for example to protect spawning aggregations) and management of other activities are all options that should be considered. Such decisions however bring with them increased problems in terms of enforcement to ensure that they function as management methods.

One critical attribute of a successful MPA or *Tabu* management system is the inclusion of a realistic time frame. While many *Tabu* have been in place for over five years, *Tabu* may be put in place or lifted for a number of different reasons. Bearing in mind that many species take a long time to reach maturity, an area is unlikely to function as a source area, feeding peripheral fisheries if it is lifted and moved every few years. Some species of parrotfish for example can take up to 10 years to reach reproductive maturity and reproductive output increases with successive years after this point. *Tabu* should be committed enough to achieve this longevity yet flexible enough to adapt to changes in impacts and *i qoliqoli* use.

Current fish stocks are very low suggesting that the *i qoliqoli* is probably overfished or has a very low carrying capacity. The area of study is comparatively small. While there is no such thing as a bad *Tabu*, it may not be feasible to create a *Tabu* site in the area given the dependent population. The area may already be receiving some benefits from the *Tabu* of Yadua village that lies adjacent to the western boundary. One option would be to protect some of the habitat on the eastern fringe of the reef platform, thus protecting some of the coral rich habitat while helping to feed into and develop stocks in the more degenerated zone, which would remain an open fishery.

Though theoretically simple, these actions are often difficult to put into practice. The development of a plan that identifies the community's needs, pressing concerns and

possible management approaches is an important step. Such a plan needs to extend beyond a list of planned activities, giving weight to the value and steps required in achieving specific aims. In order to achieve these aims an understanding of the dependant population and how the area is fished would be required. Following on from this it would be possible to highlight those regions that require management. The survey carried out represents only a small proportion of the fishing ground available to the local population. The estuary fisheries in and around Sigatoka river may be more important in terms of the local population and therefore form the more immediate management concern. Continual monitoring of any management action is required. The benefit of approaches such as FLAMMA is that they help communities to build the capacity to do this.

8.3.2 Managing other impacts

Nutrient enrichment

In terms of marine resources, the carrying capacity of the *i qoliqoli* is currently compromised by impacts peripheral to the marine system. Management of nutrient enrichment sources is of major importance for long term sustainability of the *i qoliqoli*. Algal reef dominance due to nutrient enrichment is a large concern. High value coral reef habitat will support a greater abundance and diversity of marine life.

A good example of wastewater management on the Coral Coast is provided by the Integrated Coastal Management (ICM) initiative further along the coast. Here efforts lie with reducing the volume of nutrients entering the system through the relocation of piggeries away from water sources and the exploration of methods for managing the waste. Use of manure in areas where fertiliser use is heavy can reduce nutrient levels. Piggery management has been identified as one of the more achievable management mechanisms in the short term however there are examples within the initiative of alternative management systems for human waste through use of natural composting and wetland systems. *The Fijian* a resort in the next *i qoliqoli* has been lauded for its own wetland management system. Initiatives in the neighbouring *i qoliqoli* are also in place to tackle the threats of sedimentation such as through the planting of mangrove species (principally *Rhizophora* sp.) around river entrances that may have additional

benefits within the *iqoliqoli*. Development and other population pressures are addressed through the inclusion of all stakeholders in the programme.

Though the level of technical support may not currently be available to Nasigatoka district there is a desire to ultimately extend the approach into other regions. The exchange of ideas, approaches and ethos is encouraged. The provincial office has an important role in the communication and facilitation of these ideas and practical solutions. Steps are essential in reducing nutrient enrichment otherwise algal reefs will continue to dominate the *i qoliqoli*.

While not without value there are a number of activities involved in restocking of marine areas, such as coral replanting, that without having solved this problem lose a lot of their value. Such activities represent a huge investment without any long-term guarantee for the return on the time and resources put in. As discussed previously, under elevated nutrient scenarios any bedrock exposed during environmental disturbance is likely to return to algae dominated reef. This therefore works against the long-term viability of encouraging coral settlement through these activities. Remove the impact of nutrients and provided an adequate source area of coral remains (in *Tabu* areas or in outer reef systems) reefs will return to the coral cycle.

Sedimentation

Mangrove planting around river and stream mouths is encouraged as a means to reduce sedimentation through natural settlement and management. Mangroves have additional benefits in helping to filter out pollutants, providing nursery habitat for fish and a source of timber if harvested sensibly. Though propagules may travel long distances, generally the reproductive and dispersal abilities of mangroves are much less than coral and algae. Replanting of mangroves can kick start this process through vegetative growth and the ultimate creation of local source areas.

9 Conclusion

Local communities remain dependent on the marine environment for a large proportion of daily sustenance. The distribution of fish, invertebrate and benthic classes is uneven across the backreef area within the *i qoliqoli*. The combination of an increased population as well as more efficient fishing gear, impact further upon these resources. A high level of algae cover implies that a high level of nutrient enrichment also occurs, however though it is probably the greatest problem facing fisheries management it is perhaps the hardest to manage. The issues of nutrient enrichment and potential overfishing are of great concern for the health of the *i qoliqoli*.

Very few steps have been taken towards the management of the *i qoliqoli*. This survey provides an indication of the health and resources of the western region of the *i qoliqoli* but does not cover, for example, the estuarine fishery of Sigatoka river mouth (though it may be indirectly connected to it). Many of the management concerns and potential solutions outlined above, however have wide ranging significance.

In order to ascertain what management steps are required a more thorough understanding of the dependant population and how the area is fished would be hugely beneficial. Following on from this critical first step it would be possible to develop a considered management plan to provide the framework for future management. The local community should look to the member groups of FLMMA, local groups and others with previous experience in achieving this aim. Monitoring is an important step in ascertaining the value of management decisions and should be incorporated wherever possible. A *Tabu* area could be placed over the eastern edge of the reef platform, thus generating benefit from both the new *Tabu* and the *Tyabu* in the neighbouring *i qoliqoli* however such a decision would require a careful examination as to what current fishing requirements can accommodate.

Awareness activities are important in facilitating the development of a good management plan and ethos working towards the sustainable management of marine

resources. Additionally, capacity building activities such as Fish Warden training schemes build the ability to perform accurate and useful community monitoring which is one of the key tenets towards the long-term viability of Marine Protected Areas. Management initiatives should maintain a strong focus in allowing the system to recover and in ensuring stability of the system for the long term.

10. Recommendations

1. Review of Fisheries Law for Fiji is required. Legislation should aid local communities by providing the legislative framework within which they can manage their resources.
2. Provide, encourage and arrange appropriate awareness activities to develop understanding of the reasoning behind legislation in order to engender community support for it.
3. Follow the examples and experience set by the Integrated Coastal Management (ICM) and Fijian Locally Managed Marine Areas (FLMMA) approaches should be adopted where possible. The benefit of including all stakeholders in major management decisions is apparent and it provides a realistic means to manage and address natural resource and coastal zone concerns towards long-term improvement over short-term gain.
4. Develop a plan that identifies the community's needs, pressing concerns and possible management approaches. Such a plan needs to extend beyond a list of planned activities, giving weight to the value and steps required in achieving specific aims.
5. The issue of nutrient enrichment is critical and awareness and education programmes are required to this end. Efforts are required in reducing the volume of nutrients entering the system. This could involve moving pigpens away from watercourses and coastal fronts and managing pig waste as the primary step in this process.
6. Encourage, educate and assist in different fisheries management options as a means to increase overall fish size and abundance. These might include restrictions on size, target species, season, and effort.

7. Support and enable studies of studies and initiatives working to these ends in particular looking at management of nutrients and the various factors important in the planning and management of *Tabu* areas such as recruitment and source/sink studies.
8. Support and enable alternative means of income and sustenance as a way of lessening the fishing pressure on the back reef *i qoliqoli* area, provided the environmental impact of doing so is minimal. These might include tourism tours and expansion of pastoral agriculture.

11. Appendices

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Appendix 2:

Recording forms showing Data variables recorded

TARGET FISH

Butterflyfish
(Big) Long-Nosed
Klein's
Vagabond
Pyramid
Eastern Triangle
Latticed
Redfin
Chevroned
Saddled
Threadfin
Teardrop
Longfin Bannerfish
Masked Bannerfish
Humphead Bannerfish
Pennant Bannerfish

	SECTION A	SECTION B	SECTION C	SECTION D
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				

Angelfish
Regal
Bicolour
Emperor
Blue-girdled
Dusky
Semicircle
Lemonpeel

17				
18				
19				
20				
21				
22				
23				
24				

Surgeonfish
Convict
"Ringtail" spp.
Brush-tail tang
"Bristletooth" sp.
Sailfin tang
Mimic
Unicorn spp.

25				
26				
27				
28				
29				
30				
31				
32				

Tuna/ Mackerel
Narrow-banded king mackerel

33				
34				

Fusilier
"Blue and yellow" sp.
Bluestreak

35				
36				
37				

Damselfish
Blue-Green Chromis
Black Bar Chromis
Other "Chromis" sp.
Threespot dascyllus
Humbug dascyllus
Reticulated dascyllus
Whitebelly
Staghorn
Talbot's demoiselle
Blue devil
Lemon
Golden
Black
"Anemone fish" sp.
"Sergeant" sp.

38				
39				
40				
41				
42				
43				
44				
45				
46				
47				
48				
49				
50				
51				
52				
53				

Wrasse
Diana's hogfish
Mesothorax hogfish
Humphead
Red-banded
Checkerboard
Twotone
Crescent
Sixbar
Jansen's
Cigar
Bird
Rockmover
Blackedged thicklip
Cleaner
Sling-jaw

54				
55				
56				
57				
58				
59				
60				
61				
62				
63				
64				
65				
66				
67				
68				
69				

Goatfish
Half-and-half
Two-barred
Dash-and-dot
Multibarred
Blackstriped
Yellowfin

70				
71				
72				
73				
74				
75				
76				

Triggerfish
Redtooth
Orangestriped
Clown
Blackbelly Picassofish
Pinktail
Scythe
Halfmoon
Picasso
Moustache / Titan

77				
78				
79				
80				
81				
82				
83				
84				
85				
86				

Groupers
Flagtail
Peacock
Humpback
"Honeycomb" sp.
Lyretail
Saddleback/ Chinese coral
Leopard Coral
Soapfish
Anthias

87				
88				
89				
90				
91				
92				
93				
94				
95				
96				

Parrot Fish
Bumphead
Bicolour juv.

97				
98				
99				

Spinecheek
Twoline

100				
101				

Snapper
Two-spot
Black-and-white
Bluelined
Twinspot
Fivelined
Paddletail

102				
103				
104				
105				
106				
107				
108				

TARGET FISH (CONT)

		SECTION A	SECTION B	SECTION C	SECTION D
Rabbitfish	109	☐	☐	☐	☐
Foxface	110	☐	☐	☐	☐
Pencil-streaked	111	☐	☐	☐	☐
Uspi	112	☐	☐	☐	☐
Dartfish	113	☐	☐	☐	☐
Blackfin	114	☐	☐	☐	☐
Cardinalfish	115	☐	☐	☐	☐
Pyjama	116	☐	☐	☐	☐
Blackstriped	117	☐	☐	☐	☐
Puffer	118	☐	☐	☐	☐
Blackspotted	119	☐	☐	☐	☐
Goby	120	☐	☐	☐	☐
Sphinx	121	☐	☐	☐	☐
Brownbarred	122	☐	☐	☐	☐
Toby	123	☐	☐	☐	☐
Spotted	124	☐	☐	☐	☐
Blenny	125	☐	☐	☐	☐
Yellowtail poison fang	126	☐	☐	☐	☐
Bicolour	127	☐	☐	☐	☐

OTHER MAJOR FAMILIES

Jack / Trevally	128	☐	☐	☐	☐
Sweetlips	129	☐	☐	☐	☐
Barracuda	130	☐	☐	☐	☐
Moorish Idol	131	☐	☐	☐	☐
Emperor	132	☐	☐	☐	☐
Spadefish / Batfish	133	☐	☐	☐	☐
Porcupine	134	☐	☐	☐	☐
Trunk / Box / Cowfish	135	☐	☐	☐	☐
Squirrelfish / Soldierfish	136	☐	☐	☐	☐
Filefish	137	☐	☐	☐	☐
Lionfish	138	☐	☐	☐	☐
Scorpionfish / Stonefish	139	☐	☐	☐	☐
Lizardfish	140	☐	☐	☐	☐
Hawkfish	141	☐	☐	☐	☐
Sandperch	142	☐	☐	☐	☐
Sharksucker	143	☐	☐	☐	☐
Needlefish	144	☐	☐	☐	☐
Pipefish	145	☐	☐	☐	☐
Trumpetfish	146	☐	☐	☐	☐
Moray Eel	147	☐	☐	☐	☐

FURTHER SPECIES

☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐
☐	☐	☐	☐

TARGET INVERTS

<u>Annelid Worms</u>				
Segmented Worms	141	☐	☐	☐
Feather Duster	142	☐	☐	☐
Christmas Tree	143	☐	☐	☐

Anthropoda : Crustacea

Shrimps	145	☐	☐	☐	☐
Spiny Lobster	146	☐	☐	☐	☐
Crab	147	☐	☐	☐	☐

Mollusca :

Gastropods:	Abalone	148	☐	☐	☐	☐
	Murex sp.	149	☐	☐	☐	☐
	Conch	150	☐	☐	☐	☐
	Cowrie	151	☐	☐	☐	☐
	Triton	152	☐	☐	☐	☐
	Cone Shell	153	☐	☐	☐	☐
	Drupella sp.	154	☐	☐	☐	☐
	Limpet	155	☐	☐	☐	☐
	Topshell	156	☐	☐	☐	☐
	Nudibranch	157	☐	☐	☐	☐
	Worm Snail	308	☐	☐	☐	☐
	Other	158	☐	☐	☐	☐
Bi-Valves:	Oyster	159	☐	☐	☐	☐
	Giant Clam	160	☐	☐	☐	☐
	Other Clam	161	☐	☐	☐	☐
	Other	162	☐	☐	☐	☐
Chiton		163	☐	☐	☐	☐
Cephalopods:	Cuttlefish	164	☐	☐	☐	☐
	Squid	165	☐	☐	☐	☐
	Octopus		☐	☐	☐	☐

Echinodermata:

Sea Stars:		166	☐	☐	☐	☐
	Acanthaster planci (COT)	167	☐	☐	☐	☐
	Linkia laevigata (Blue)	168	☐	☐	☐	☐
	Nardoa sp. (Brown)	169	☐	☐	☐	☐
	Culcita novaeguineae	170	☐	☐	☐	☐
	Protoreaster nodosus	171	☐	☐	☐	☐
	Choriaster granulatus	172	☐	☐	☐	☐
	Other	173	☐	☐	☐	☐
	Brittle Star	174	☐	☐	☐	☐
	Feather Star	175	☐	☐	☐	☐
	Basket Star	176	☐	☐	☐	☐
Sea Urchin:	Short Spine	177	☐	☐	☐	☐
	Long Spine	178	☐	☐	☐	☐
Sea Cucumber:			☐	☐	☐	☐
	Synaptid	179	☐	☐	☐	☐
	Other	180	☐	☐	☐	☐
	H. edulis	301	☐	☐	☐	☐
	H. scabra	302	☐	☐	☐	☐
	H. noblis	303	☐	☐	☐	☐
	H. fuscogilva	304	☐	☐	☐	☐
	Bohadshia marmorata	305	☐	☐	☐	☐
	Actinopyga mauritana	306	☐	☐	☐	☐
	Stichopus chlorinatus	307	☐	☐	☐	☐
<u>Tunicate (Phylum Chordata)</u>		181	☐	☐	☐	☐

Bryozoan (Phylum Bryozoa)

FURTHER SPECIES:

Dead Coral	5	Branching	13	29	<i>Seriopora hystrix</i>	52	<i>Dendrophylliidae</i>	
Rubble	6	Encrusting	13	30	<i>Stylophora pistillata</i>	53	<i>Tubastrea micrantha</i>	81
		Lumpy	13	31	<i>Stylophora mordax</i>	54	<i>Turbinaria reniformis</i>	82
		Rope	13	32				
		Vase	13	33				
MICROALGAE					Acroporidae		Merulinidae	
<i>Oyano-Bacteria</i> : Blue-Green	7	<i>Otocoerallia</i> : Soft Coral Forms	14		Bottlebrush <i>Acropora</i> sp.	55	<i>Hydrophora</i> sp.	83
		Deadman's Fingers	14	34	"Foliose" <i>Montipora</i> sp.	56	<i>Merulina scabricula</i>	84
MACROALGAE		Leather	14	35			Miscellaneous	
<i>Chlorophyta</i> : Green	8	Tree	14	36	Poritidae		Brain	Small
Green Filamentous	8	Pulsing	14	37	Massive <i>Porites</i>	57		Medium
<i>Ventricaria</i> sp.	8	Sea Fan	14	38	<i>Porites cylindrica</i>	58		Large
	8	Sea Whip	14	39	<i>Porites nigrescens</i>	59		
<i>Bomatella</i> sp.	8	Bamboo	14	40	<i>Porites rus</i>	60		
Finger - <i>Nemoris</i> sp.	8	Organ pipe	14	41	<i>Goniopora / Alveopora</i> sp.	61		
Grape - <i>Caulerpa</i> sp.	8	Flower	14	42				
Calcified - <i>Halimeda</i> sp.	8				Agariciidae			
- <i>Tydemania</i> sp.	8	Other Cnidarians	15		<i>Pavona clavus</i>	62		
Spongy <i>Codium</i> sp.	8	Black Coral	15	43	<i>Pachyseris speciosa</i>	63		
		Anemone (Sea and tube)	15	44	<i>Pachyseris rugosa</i>	64		
		Zoanthid	15	45				
<i>Phaeophyta</i> : Brown	9	Jellyfish (Medusa)	15	46	Fungiidae			
<i>Dityda</i> sp. (Flat-Branching)	9	Hydroid	15	47	<i>Oenadis echinata</i>	65		
<i>Padina</i> sp. (Fan Blade)	9	Coralimorph	15	48	<i>Harpolitha limax</i>	66		
<i>Lobophora</i> sp. (Blade/Ruffle)	9				<i>Polyphyllia talpina</i>	67		
<i>Hydroclathrus</i> sp.	9	HARD CORAL			Upsidedown bowl	68		
<i>Turbinaria</i> sp. (Pyramid)	9	Life Forms						
Brown Filamentous	9				Coulinidae			
<i>Sargassum</i> sp. (Bladder)	9	ACROFORA:	16		<i>Galaxea</i> sp.	69		
		BRANCHING	17					
<i>Rhodophyta</i> : Red	10	ENCRUSTING	18		Pectiniidae			
Encrusting coralline algae	10	SUBMASSIVE	19		<i>Pectinia lactuca</i>	70		
<i>Galaxaura</i> sp.	10	DIGITATE	20		<i>Mycedium elephantotus</i>	71		
<i>Amphiroa</i> sp.	10	TABULATE	21					
<i>Jania</i> sp.	10		21		Mussidae			
Red Filamentous	10	NONACROFORA:			<i>Lobophyllia</i> sp.	72		
Sheet	10	BRANCHING	22					
<i>Gracilaria</i> sp.	10	ENCRUSTING	23		Favidae			
		FOLIOSE	24		<i>Favia</i> sp.	73		
MARINE PLANTS		MASSIVE	25		<i>Favites</i> sp.	74		
Sea Grass	11	SUBMASSIVE	26		<i>Diploastrea heliopora</i>	75		
<i>Thalassia</i> sp.	11	MUSHROOM	27		<i>Echinopora lamellosa</i>	76		
<i>Halophila</i> sp.	11							
		OTHER			Caryophylliidae			
Mangroves	12	FIRE (<i>Millepora</i>)	28		<i>Euphyllia</i> sp.	77		
		BLUE (<i>Halopora</i>)	29		<i>Pterogya</i> sp.	78		

BACKGROUND INFORMATION

Data Identifier _____	Start Easting _____
Reef Unit _____	Start Northing _____
Transect Number _____	End Easting _____
Transect Section _____	End Northing _____
Survey Date _____	Wind Strength (1-6) _____
Start Time _____	Wind Direction (from) _____
End Time _____	Current Strength (none, weak, mod, strong) _____
Marshall _____	Current Direction (Towards) _____
Fish Recorder _____	Horizontal vis _____
Invertebrate Recorder _____	Temperature _____
Point data Recorder _____	Salinity _____

SURFACE IMPACTS

Algae ☐	Litter ☐
Driftwood ☐	Nets ☐
Surface sewage ☐	Other impacts _____

UNDERWATER IMPACTS

Bleaching ☐	Coral disease ☐
Coral Damage ☐	Litter ☐
Other impacts _____	

ACTIVITIES

Gleaning ☐	Line Fishing ☐
Coral Harvesting ☐	Snorkelling ☐
Spear Fishing ☐	Swimming ☐
Net Fishing ☐	Reef Walking ☐
Boating ☐	Other activities _____

Appendix 3

Minimum Fish Catch Sizes

Ministry of Fisheries

SIXTH SCHEDULE

(Regulation 18)

(Minimum size limits for fish)

Common Name	Fijian	Family	Genus	Minimum (mm)
Barracuda.....		Sphyranidae	<i>Sphyrona</i>	300
Crevally, Trevally, Pompano		Carangidae	<i>Caranx</i>	300
Grey Mullet		Mugilidae	<i>Mugil</i>	200
Glassperch, Aholehole		Ducilidae	<i>Duels</i>	150
Ketang, Spinefoot Rabbitfish		Siganidae	<i>Siganus</i>	200
Long-jawed Mackeral		Scombridae	<i>Rastrelliger</i>	200
Longtom, Garfish, Greengar		Belonidae	<i>Belone</i>	300
Milk Fish		Chanidae	<i>Chanos</i>	300
Mojarra		Gerridae	<i>Gerres</i>	100
Parrotfish		Callydonidae	<i>Scarichthys</i>	250
Pouter, Slimy, Soapy, Peperek		Leognathidae	<i>Gazza</i>	100
Rock Cod, Grouper, Salmon Cod (excluding small red spotted cod)		Serranidae	<i>Serranus</i>	250
Sea Bream, Pig-faced Bream		Lethrinidae	<i>Lethrinus</i>	250
Small Sea Bream		Lethrinidae	<i>Lethrinus</i>	150
Small Sea Bream		Lethrinidae	<i>Lethrinus</i>	200
Surgeon Fish		Hepatidae	<i>Hepatus</i>	200
Surmullet, Goatfish, Whiskercod		Mullidae	<i>Mulloidichthys</i>	150
Snapper		Lutjanidae	<i>Lutjanus</i>	300
Unicorn-fish, Leather Jacket		Hepatidae	<i>Naso</i>	300

