ASSESSMENT OF MARINE INVERTEBRATES AND BENTHIC HABITAT AT AVATIU HARBOUR PRIOR TO DEVELOPMENT

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SUMMARY

The proposal for development of Avatiu harbour, to accommodate additional berthing and docking facilities for the Cook Islands offshore fishing fleet, includes the excavation and blasting of the harbour basin to a depth of four metres below sea level, the reconstruction of the western breakwater, and the development of facilities including wharves and quays.

Development of this scale can have deleterious impacts on the environment and this report assesses the likely impacts on the marine resources and benthic communities in the vicinity of the development site and at the development site itself.

Invertebrate resources, and percentage benthic composition were surveyed and recorded at the development site and at two control sites. The two control sites were both within one kilometre of the development site, one adjacent to Avarua harbour and the second adjacent to the proposed Avatiu harbour site. Invertebrate resources and benthic composition were surveyed using the belt transect method.

The results indicated that at all three sites surveyed the densities of resources were low. The development site, comprising of 56% rubble, 21% rock, 12% silt and 6% sand, is generally barren and lacking in suitable reef structures for important fish and invertebrate resources/communities to become established.

The two control sites recorded higher densities of resources with both sites also recording greater diversities of species. This was due to the nature of the substrate as at these sites sand coverage and coral/algae coverage were significantly higher and therefore a more suitable habitat for sand dwelling species.

The most significant impact from this type of development to marine fauna will be sedimentation and the potential smothering of the coral colonies in the vicinity of the development site, with the sediment dispersed by tidal and current movement. Although there are no significant resources or coral colonies at the development site the

surrounding areas are likely to be affected. However, with the correct mitigation measures in place, such as the use of the existing rock wall or similar structure acting as a barrier to contain the sediment whilst blasting, and blasting at low tide, the impacts can be minimised.

We are unable to comment on physical characteristics of the harbour design from basic to extreme oceanographic or weather events. It should be noted that a qualified marine engineer or persons with experience in the field should be consulted prior to commencement of the construction work to ensure quality assurance and quality control.

It is recommended that circulation modelling be completed for the development site and surrounding area and also more attention paid to coastal erosion issues adjacent to the proposed development site.

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1.0 INTRODUCTION

The Cook Islands Tuna Fishing industry is set to increase and currently further expansion of the fleet is constrained due to the lack of berth space in the current harbour. The proposed development coastline extends from the existing boat ramp to 250 east and approximately 100 meters wide. The proposed harbour basin would be formed by excavating and blasting the reef down to a depth of 4.0m below sea level. A breakwater system is proposed of approximately 350m and would be reconstructed approximately 20 m back from the and parallel to the reef edge. The facility is to provide additional docking and berthing facilities to support the Cook Islands offshore fishing fleet. The vessels in the fleet range from 10 to 33 meters with a maximum draft of 3.5 meters.

Coastal infrastructure and development on a small island can impact adversely on the biology of marine organisms and coastal processes. In addition, deleterious impacts can also result along the natural and built shorelines at, and adjacent to, development sites. Consequently, it is important to monitor development activities and their positive and negative impacts to the environment. In this way negative and deleterious impacts of the development can be captured immediately and remedied, where possible, in a timely and appropriate fashion. Further information gained from such monitoring can be useful for future coastal development.

This paper delivers a coastal environmental evaluation of benthic structure and invertebrates for the fishing boat harbour facility at Avatiu, Rarotonga, Cook Islands. This report comments on the impact on marine invertebrates of the proposed harbour development and adjacent coastline.

The present study was set-up with the objective of advising the Cook Islands Ports Authority with timely and appropriate advice on the impacts of the harbour facility on living resources at, and adjacent to, the development site and strategies for addressing these impacts. Since Rarotonga is a small island with limited shoreline area, the loss of any or coastal property represents a significant one. In addition, developing economies

can be seriously affected by damage to or loss of civil infrastructure and residential facilities from natural hazards, like coastal erosion.

Harbour development plans were consulted to assess the dimensions and quantities of various components of the Avatiu harbour facility. Environmental (biological) information was collected during site visits. These included abundance indices of various invertebrates (indicator species for environmental condition), benthic cover and beach sediment characteristics.

Map 1: Locations of Development Site and Control Sites surveyed

2.0 METHODOLOGY

The methods employed in this assessment were standard marine biology survey practices, where control sites were chosen for comparison to development site. The control sites had similar morphological features to the development sites. To avoid any unnecessary variation in the data, three observers during low tide conducted all counts and estimates. The area is normally barren of fish species during low tide and at high tide surveyors were unable to conduct any meaningful underwater visual census of fishes due to shallow water depth.

2.1 Study sites

Three reef sites were surveyed, the development site at Avatiu harbour and two 'control sites', one adjacent to Avarua harbour and the second adjacent to the proposed Avatiu harbour development site. The average depth for all sites surveyed was 0.3 –0.75 meters at high tide and during low tide the reef structure is exposed.

Figure 1 shows the location of the survey sites. Both the control sites, at Avarua harbour and Avatiu, are within 1km of the proposed development site.

2.2 Assessment of a selection of invertebrates

The marine habitat from shoreline to reef was surveyed at each site using the strip transect method to determine the mean density and variance (± SE) of a selection of diurnal reef invertebrate species (English *et al* 1997). Table 1 lists the species selected.

At each site six, 2m wide transects were randomly chosen and surveyed from the shoreline out to the reef edge (perpendicular to the reef edge). Observers recorded the number of a selection of invertebrates and percentage cover of benthic substrate at all survey sites. Due to the structure of the reef flat all transect lengths varied within the survey areas in order to cover shore to reef edge. In order to calculate the number of invertebrates per $100m^2$-density information was standardised for each location (Appendix A).

Table 1: Reef invertebrate species surveyed

Common	Scientific	Local (Raro)
Rough Turban-shell	*Turbo setosus*	Ariri
Brown Pencil-urchin	*Heterocentrotus mammillatus*	Atuke
Short Spine Sea-urchin	*Tripnestus gratilla*	Avake
Blue Starfish	*Linckia laevigata*	Etu
Rose-Mouthed Turban-shell	*Astrea rhodostoma*	Karikao
Pink Sea-urchin	*Echinometra spp*	Kina
Soft Black Sea-cucumber	*Holothuria leucospilota*	Matu Rori
Rugose Giant Clam	*Tridacna maxima*	Paua
Flower Sea-cucumber	*Holothuria cinerascens*	Rori Pua
Hebrew Cone	common spps *Conus ebraeus*	Popoto
Green Sea cucumber	*Stichopus chloronotus*	Rori matie
Red Surf-fish	*Actinopyga maurutiana*	Rori Puakatoro
Sandy Sea-cucumber	*Holothuria atra*	Rori Toto
Trochus	*Trochus niloticus*	Trochus
Large Worm shell	*Dendropoma maxima*	Ungakoa
Long Spine Sea-urchin	*Echinothrix diadema*	Vana

2.3 Assessment of benthic structure and community

At each transect line surveyors recorded the percentage cover of corals, algae and the type of substrate present. Percentages were recorded for each 5m x 2m section of the transect. For each site the overall percentage cover for each community and structure type were calculated.

Percentage cover of each of the following community types were recorded as:

- Coral massive
- Coral submassive
- Coral encrusting
- Acoropora digitate
- Actopora tabular
- Dead coral
- Turf algae
- Halimeda
  Macroalgae

Appendix B shows, photographically, the types of benthic structure that were assessed along each transect line.

At each site percentage cover of different substrate types were also recorded. Table 2 described the type of substrate surveyed and the distinctions between them.

Table 2: Categories of benthic structure

Category	Description
Rock	Larger than 256mm
Rubble	64mm – 256mm
Sand	0.0625mm – 2mm
Silt	0.004mm – 0.062

(from: Maharaj 2000)

Percentage composition of benthic cover and community type is presented in pie-graph form.

3.0 RESULTS

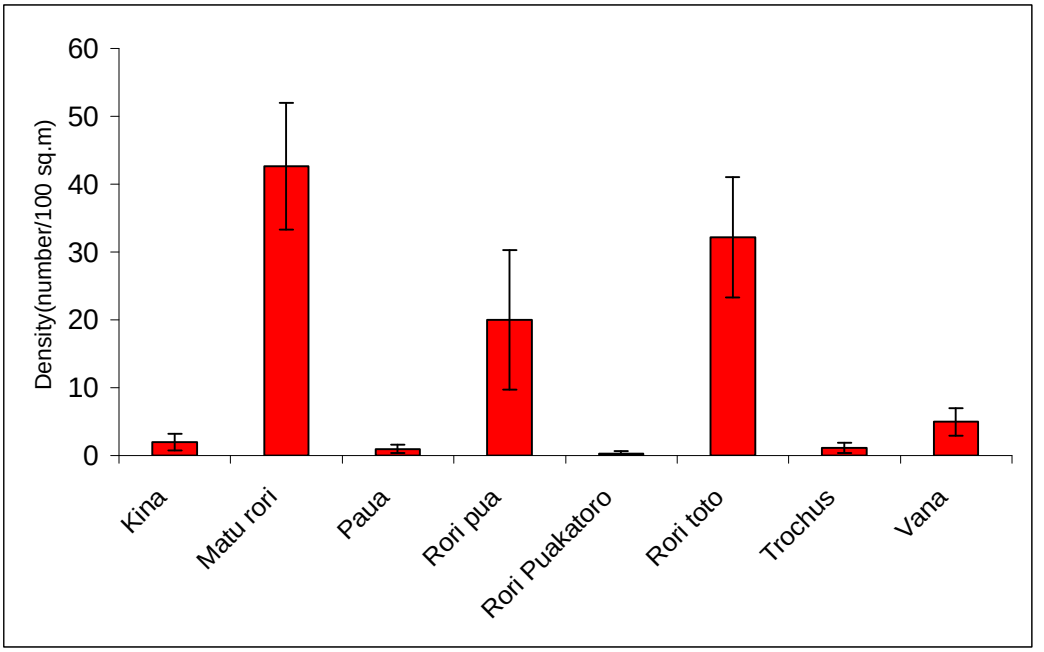
The proportion of area covered during the survey varied for each location studied, these were 23% for the proposed development site, 14% for control site 1 and 20 % for control site 2. The results of the survey are presented in graph form showing density of each reef resource per 100m². "I" bars indicate the standard error around the estimate of density.

3.1 Invertebrates

3.1.1 Control Site 2 - Avatiu

Of the 16 indicator invertebrates selected for the survey, eight were recorded at this site. The dominant resource was matu rori with an average density of 42 individuals/100m² (see Figure 1 below). Very low densities of paua, kina, rori puakatoro, trochus, and vana were recorded at this site, all with densities of 5 individuals or less /100 sq.m.

Figure 1: Density of Resources at Control Site 2 - Avatiu

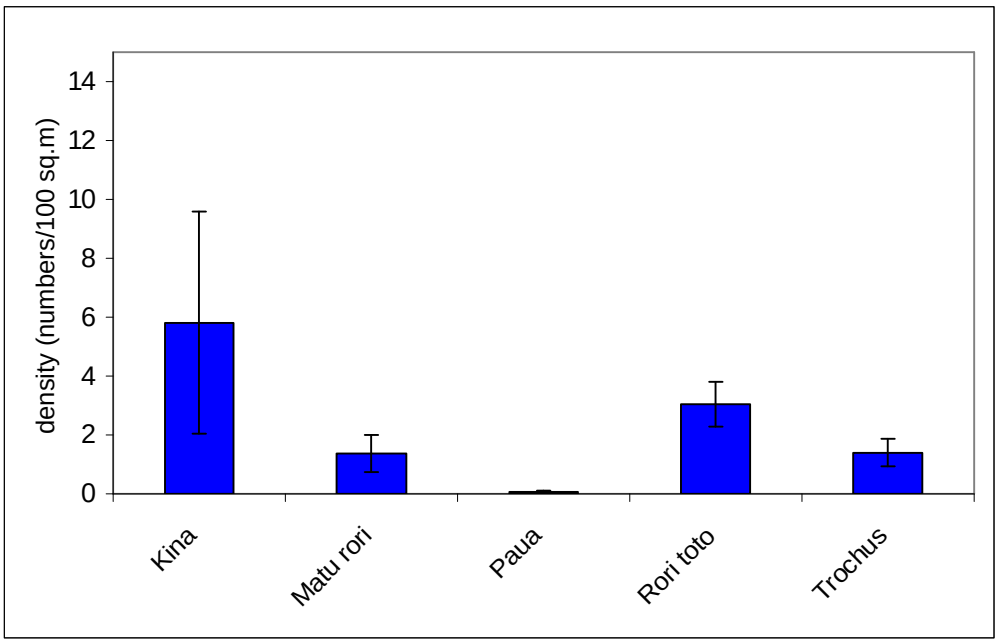


3.1.2 Development site - Avatiu Harbour

Very low densities of resources present at the survey site were recorded, (see Figure 2 below). Five species were present with Kina being the most dominant at a density of

5.8/100 sq.m. A very low count of Paua was present at the site with only 1 individual (juvenile) present in the survey area.

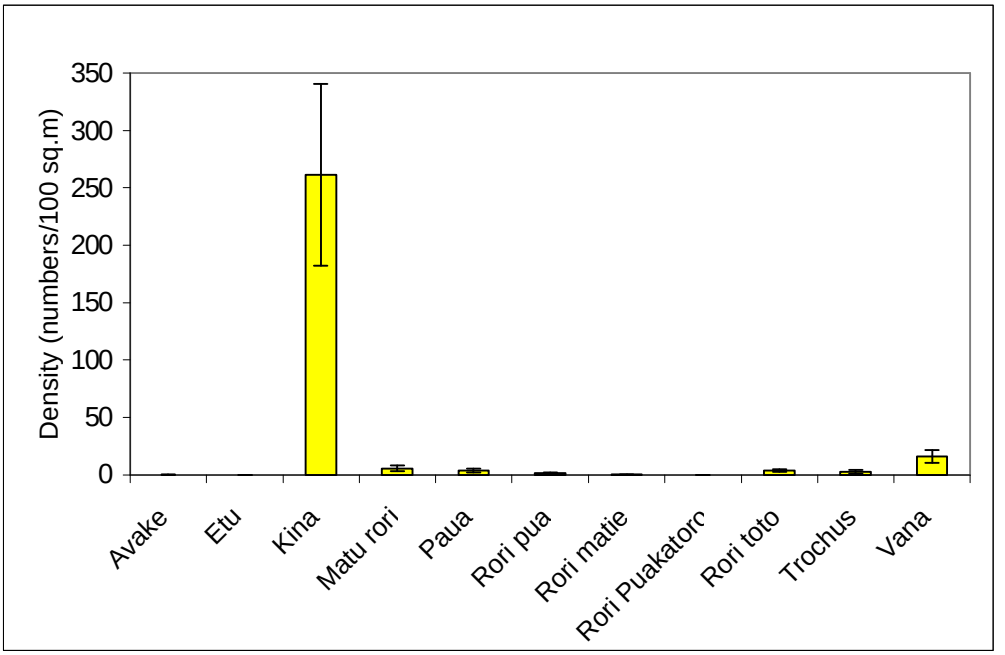
Figure 2: Density of Resources at Avatiu Harbour



3.1.3 Control site 1 - Avarua

This site recorded the largest diversity of species, in comparison to the other sites studied, and although eleven resources were present only seven are shown below as their average density were not greater than 1 individual per 100m², (see Figure 3 below). Kina was recorded as the dominant resource at a density of 261 individuals/100m². Other resources present such as Paua, Rori pua, Matu rori, Rori toto, Trochus and Vana recorded densities of 16 individuals or less/100 m².

Figure 3: Density of Resources at Control Site 1 - Avarua



3.2 Comparison of Invertebrate Densities between sites

Resources present at the development site are fewer and at lower densities than recorded at the two control sites, (see Figure 4 & 5). The largest density of a resource at the development site was Kina. Overall densities of resources at the three sites are low.

Figure 4: Densities of Resources at Development site and Control sites

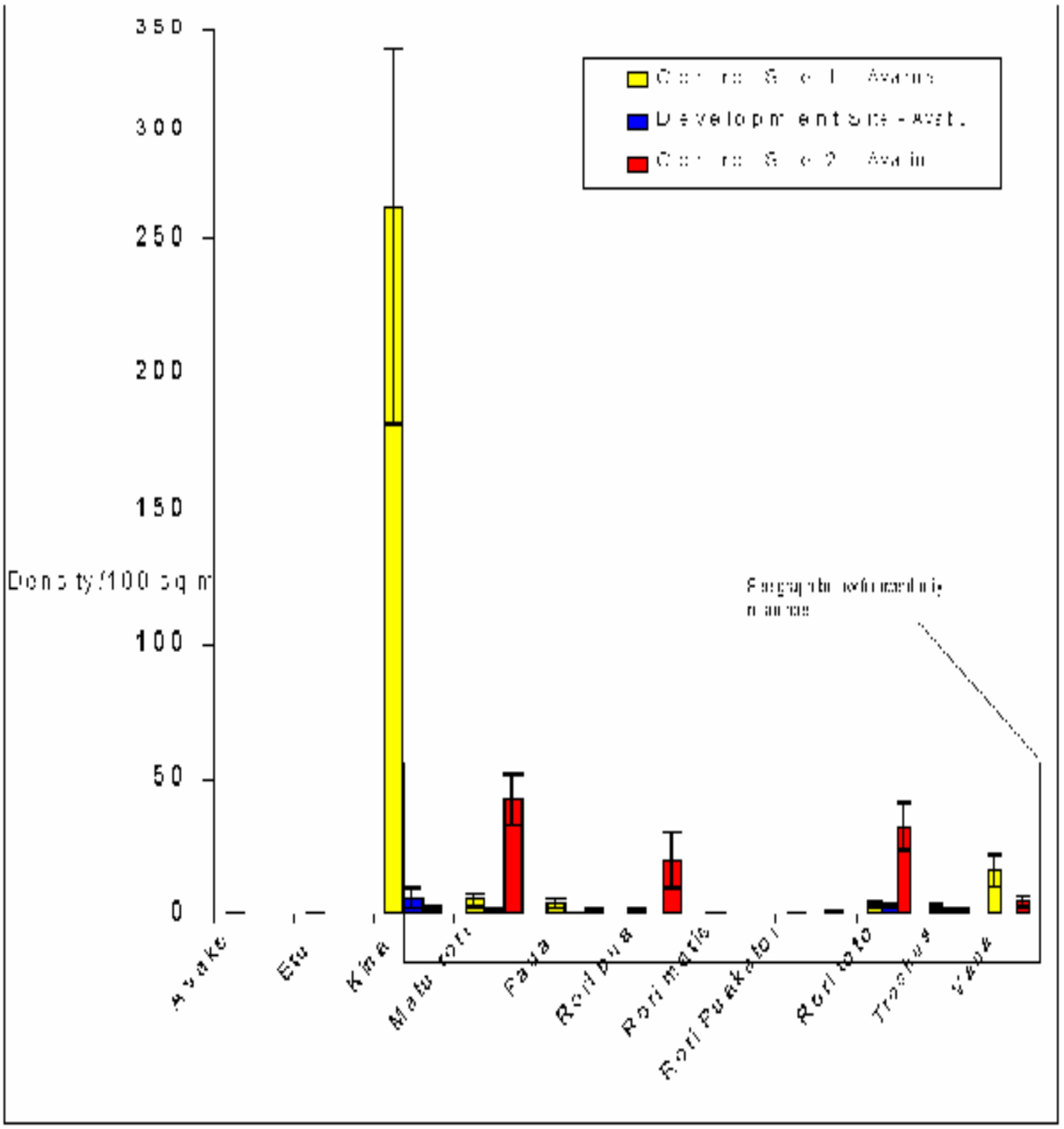
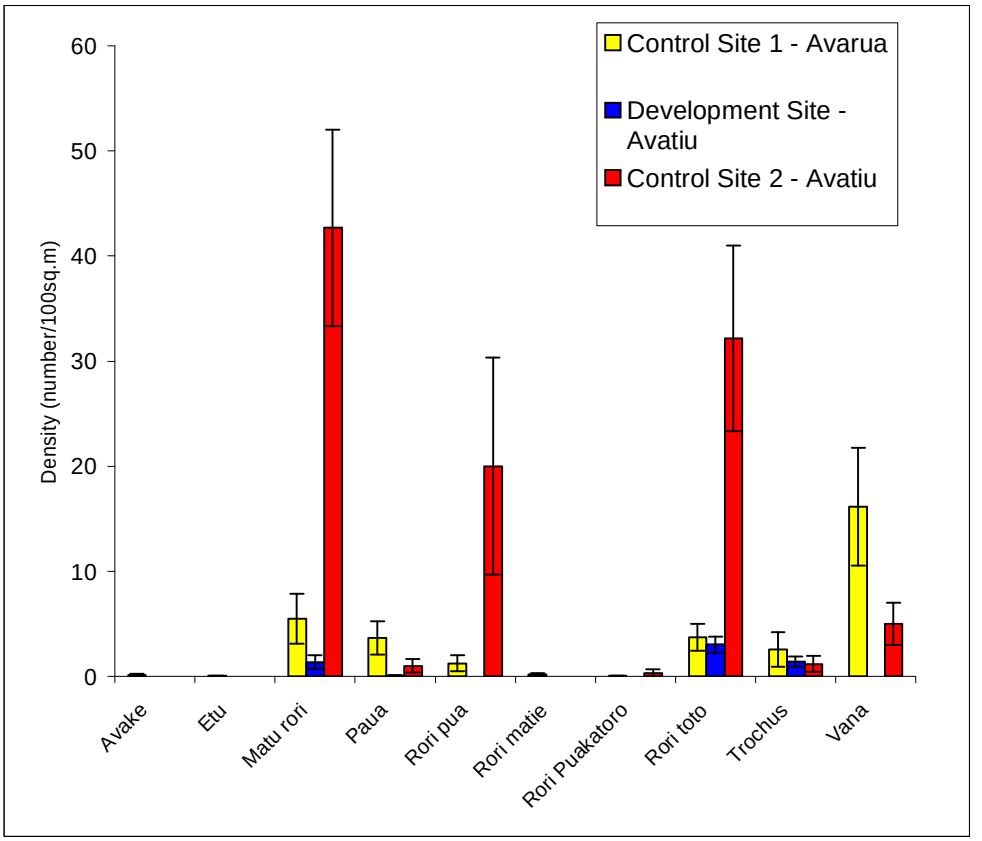


Figure 5: Less Abundant Resources at Development Site and Control Sites

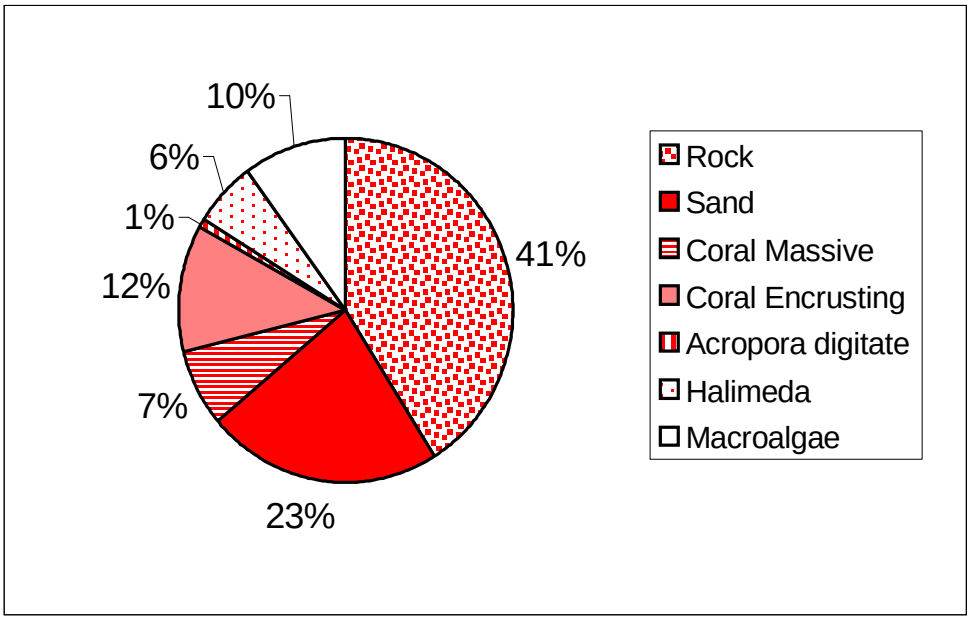


3.3 Benthic Composition

3.3.1 Control Site 2 – Avatiu

The substrate at Control site 2 is dominated by Rock (41%) followed by Sand (23%). Live coral cover accounts for 19% of the site surveyed with a high proportion of this recorded as encrusting coral. Macroalgae at this site accounts for 10% and includes species of *Amphiroa fragilissima*, *Padina boryana*, *Caulerpa peltata*, and *Chlorodesmis fastigiata* (see Appendix C).

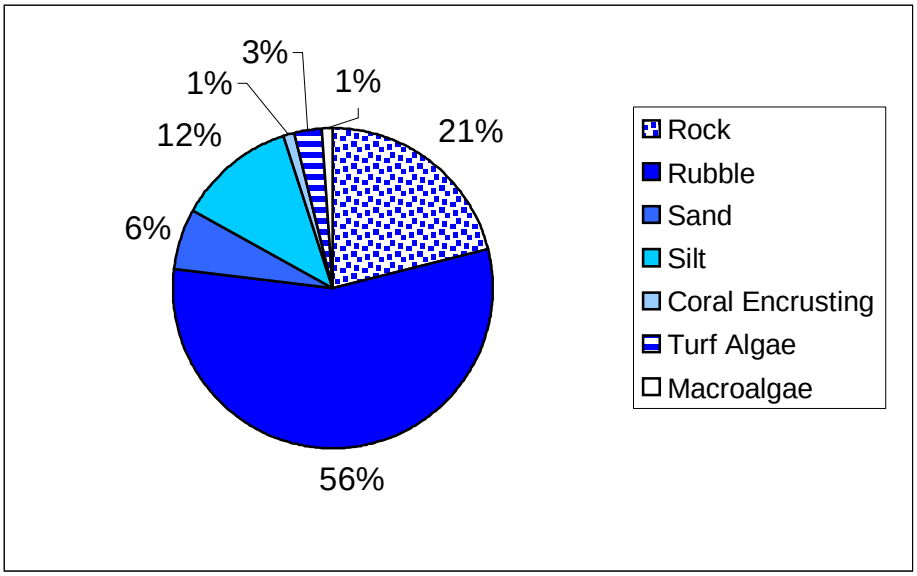
Figure 6: Percentage Benthic Composition at Control Site 2 - Avatiu



3.3.2 Development Site – Avatiu

The proposed development site adjacent to Avatiu harbour is characterised by 56% rubble, 21% rock 12% silt and 6% sand, (Figure 7). Coral cover is very low and was recorded as only 1%, the remainder comprised of 3% turf algae and 1% of macroalgae was recorded (see Appendix D).

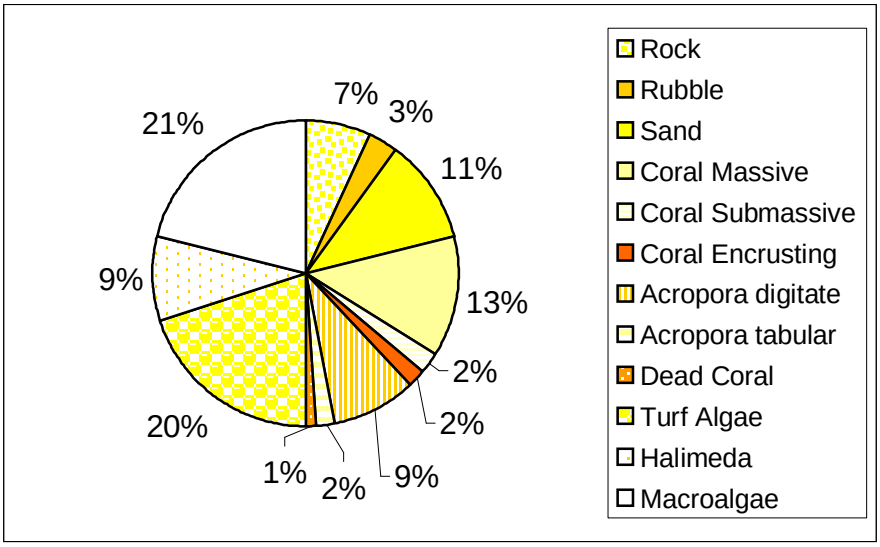
Figure 7: Percentage Benthic Composition at Development Site - Avatiu



3.3.3 Control Site 1 – Avarua

The survey site at Avarua is characterised by Macroalgae (21%), and Turf Algae (20%) see Figure 8. Macroalgae present include *Padina sp. Chlorodesmis fastigiata, Chnoospora minima minima, Chladophora patentiramea, Caulerpa peltata* and *Byropsis pennata var. secunda.* Turf Algae present include *Caulerpa sp.* and *Goniastrea sp.* Coral cover was relatively higher at this site with the total cover recorded at 29%, (see Appendix E).

Figure 8: Percentage Benthic Composition at Control Site 1



4.0 DISCUSSION AND CONCLUSION

This report will be useful as a reference for further evaluating the impacts to reef flat communities following the proposed development at the area west of the adjacent Avatiu harbour. There is sufficient reason to be concerned about the effects blasting, excavating and dredging has on reef communities. The construction activities of building a harbour could have negative impact on the biology and physical parameters of adjacent coastline, reef and reef slope coral/fish/invertebrate communities. The impacts could be serious and long term, however if the development and construction program is well planned and executed the effects on adjacent reef communities could be minimised.

The community structure of each site surveyed varied and were less diverse than other sites survey around Rarotonga (refer to Saywood A, *et al* 2002). By comparison the three sites surveyed had significantly lower densities of invertebrates than 15 other sites surveyed around the Rarotonga coast four months prior to this survey (Saywood A, *et al* 2002). Amongst the three sites surveyed for this report the proposed development site is generally barren and lacks suitable reef structures for significantly important fish and invertebrate populations/communities to become established. Of the three sites surveyed the proposed development site had invertebrate resources with densities lower than 6 individuals per 100m². Low densities are associated to the nature of the substrate i.e. there is unlikely to be high densities of the sand dwelling species due to the high percentage cover of rock and rubble. In addition the exposed reef during low tide are inappropriate for some invertebrate and fish to colonise the area, some invertebrates and fishes will be inclined to use the area as forage or refuge during high tide then vacate it during low tide. This is supported by anecdotal information from subsistence fishermen who use the area; suggesting that big eye mackerel occasionally use the area as refuge (during season) when large travally are roaming in the harbour, and occasionally small schools of juvenile Mullidae (goatfish), Acanthridae (surgeon fish) and Siganidae (rabbit fish) have been reported to use the area as forage ground during high tide.

A rock-armoured revetment type breakwater system was established in 1986. We were unable to locate references that could provide information on the status of coral cover, invertebrate and fish communities in this area prior to the establishment of the rock wall protection system. Hence the reasons for the low population of resources and generally poor live coral cover in the proposed development site cannot be quantified. However there is reason to believe that the construction of the foreshore/harbour protection system (rock wall) which extends from the current harbour entrance, along the reef then to the foreshore has disrupted, if not, cut off reef long-shore current movement in the west to east and visa-versa direction. The lack of current on a reef top would cause live coral and microorganisms suitable as foraging ground for many invertebrate and fishes to be smothered by silt. The protection structure coupled with the reef exposure during low tide would have attributed to the lack of living resources in the proposed development site.

The removal of the reef substrate in the area will have a fractional impact on the reef resources in the town area. The potential greatest impact would be the amount of sediment movement resulting in the smothering of coral colonies in the surrounding areas. Studies have shown that silt and sediments are sources that can smother and kill coral as well as negatively affecting the feeding process of the zooxanthellae (photosynthesis) (MMR May 2000). Apart from loss of 16,000 square meters of reef coral mortality may occur in surrounding areas because of sedimentation. Means of minimising sediment deposits on surrounding coral cover (reef slope) would be to blast, excavate, dredge on the outgoing tide or to conduct the blasting work over as short a period as possible. However efforts to minimise sedimentation should not grossly undermine the successful and timely completion of the project. It would be an option to have the wall or similar structure in place during excavation, which would allow fine sediments to either sink to the bottom or be carried out through the channel opening during the out going tide. The ecological cost of losing living resources in the area is likely to be relatively small.

On the present scale and given that the “Environmental Guidelines for the Construction of boat passages/harbours on Coral reefs” are adhered to, the improvements to the

existing harbour appear to be ecologically sound. The negative immediate effects, such as loss of reef, fish, invertebrates, in the vicinity are not likely to be a serious problem and in time the fish resources and coral will recolonise the area. Invertebrate populations are relatively low hence their loss due to the development is unluckily to cause any major problem to the reef ecosystem in the area.

Based on the data collected and analysis, it is concluded that:

- The three sites surveyed recorded low densities of resources in comparison with other sites located around Rarotonga, largely due to the nature of the substrate.
- The proposed development site is barren to living marine organisms and of low ecological significance in comparison to other sites around Rarotonga.
- The greatest impact of the development is likely to be the effects of sedimentation on the surrounding area, with smothering of coral communities.
- Mitigation measures to minimise this impact include leaving in place the existing rock wall or erecting a similar structure whilst excavation takes place.
- Negative biological or ecological impacts of the development are not considered to be a serious problem as over time fish resources and coral colonies will re-establish in the adjacent areas.

5.0 RECOMMENDATIONS

Please note that we cannot design for, nor comment on, the impacts of the development on physical characteristic of the harbour design from basic to extreme oceanographic or weather events, like storms and cyclones. It should be noted that a qualified marine engineer or persons with experience in the field should be consulted prior to commencement of the construction work to ensure quality assurance and quality control. The work should involve circulation modelling, which would assist planners in the execution of their duty. It is therefore recommend that:

- More attention needs to be given to coastal erosion issues adjacent to the proposed development site. A continuos beach observation and monitoring program may be required during and after the harbour construction, and if erosion occurs repair works need to be considered to mitigate further damage.
- On and island like Rarotonga, even a small change on the coast can be significant. Codes of practice for coastal structure design and engineering (if available) should be adhered to. An environmental impact assessment (EIA) should precede any construction activity. The EIA should include all boundary conditions, such as meteorology, oceanography, sedimentation, coastal dynamics, and biology/ecology.