MITIARO
REEF RESOURCES
BASELINE ASSESSMENT.

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TABLE OF CONTENTS.

LIST OF TABLES AND FIGURES.

SUMMARY.

This report is intended to provide information of the invertebrate reef resources present at Mitiaro and their abundance. Three sites were surveyed (Omotu, Parava and Kakeanaga Onu) and a total of 13 reef resources considered of social and biological importance identified. They include Ariri, Belligerent Rock-shell, Karikao, Mangeongeo, Mapiii, Paua, Paua Kura, Pupu, Popoto, Rori Puakatoro, Rori Toto, Ungakoa, and Vana. The highest diversity of species is at Omoto site.

The distribution of some species is affected by site or distance factors. Higher abundance of Mangeongeo and Mapiii is found close to the reef edge. Greater abundance of Rock-shell occurs at the windward site of Parava. These species appear to favour zones of high wave action. A possible cause may be that areas of high wave action offer protection from natural predators and do not become dry and exposed over the low tide.

The resource with the largest population size is the Mangeongeo (210 thousand animals). The Popoto and Pupu populations also exceed 100 thousand. The Paua Kura, Ungakoa and Vana had the smallest population size, numbering only several thousand. The population size of the more valuable species includes Paua (13 thousand), Rori Puakatoro (10 thousand) and Rori Toto (20 thousand).

There are several resource species that are conspicuously absent. Amongst the Sea-cucumber (*Holothuria*) species this includes Rori Matie, Rori Pua and Matu Rori. Mitiaro is the only island in the southern Cook group that the Matu Rori has not been observed by our survey team. Oddly, the Rori Pua is one of the common resources on neighbouring Atiu. The species of Sea-urchin (*Echinoderm*) that were not seen in the survey include Avake, Atuke and Kina. The sea urchin species that was recorded (Vana) had a population of only 1 500. Yet the Kina and Vana are often the most common of resources and reach densities of up to 6 per sq.m on Rarotonga. The only other southern group island where the Kina was not seen was Mauke. All of the absent species are sought after as reef food and harvest pressure may partially account for their scarcity.

The reef resource populations have a small population size are vulnerable to being over harvested because a critical number of breeders must always be present to sustain the population. Information from this survey of the abundance and distribution of the resources present is a first step to formulating a management plan of the reef resources. It is recommended that prior to any large harvests or commercial activity regarding these resources that the Ministry first assesses the sustainable harvest limit. An example of such an inter-relationship is the Trochus fishery at Aitutaki. This survey coincided with a Trochus introduction. It is hoped that because the Trochus is highly reproductive and fast growing that it will become an alternative food source to the scarce food types and by reducing harvest pressure allow those scarce resources to rejuvenate.

INTRODUCTION.

Mitiaro Island is located among the Southern Cook group is in close proximity to Atiu and Mauke. Like its neighbouring islands, Mitiaro is a sunken island that was upraised by tectonic activity and coral cliffs known as Makatea surround the island. The total land area of the island is approximately 22 sq.km and the circumference of the bench reef is approximately 18 kilometers. Mitiaro has a population of about 300 persons whom mostly reside at Takaue village.

There is little documentation of reef resources of Mitiaro. An ongoing project of the Ministry of Marine Resources is to assess the reef resources (of biological and social significance) of the Cook Islands. The information collected will contribute to a nation-wide database of reef resource types and distributions in the Cook Islands. This has numerous scientific, educational and management implications. Specifically, this survey is intended to describe the common reef resource types, their distribution patterns and population size.

GENERAL MATERIALS AND METHODS.

The survey of Mitiaro was undertaken during a visit in May 1998. Field staff comprised of Marine Resources personnel from Rarotonga. A staff member (Matapo Makara) from the Ministry of Outer Island Development at Mitiaro also provided assistance.

Three sites on the fringing bench reef were surveyed to determine the distribution patterns and abundance of "reef resource" species. The survey sites were Omotu, Parava and Kakeanga Onu (**Figure 1**). For the purpose of this study, reef resources are defined as any species of edible, cultural or potential commercial value that inhabits the reef area. This category does not include fin-fish.

At each survey site, four replicate line transects of 50 m length were placed perpendicular to the reef edge. Two observers would search a 2 m band on either side of the transect line and as they progress down the line would record the resource types and counts within 5 m length segments, (each 5 m section being equivalent to a "quadrant" of 20 m^2 area).

The Shannon-Weiner diversity index (Zar, 1984) was calculated at each site to measure the diversity of resources. If a reef site is dominated by only a few species then a low diversity index occurs. Accordingly, the distribution is not even and the index also becomes a measure of heterogeneity or evenness. The index also has a special test to compare whether the diversities of two sampled populations are the same (Hutcheson in Zar, 1984). The equations relating to diversity are appended in **Append. 1**.

The resource species were each examined statistically for density distribution patterns among the survey sites and with distance from the reef edge (in 5 m increments). A two-way ANOVA model was used which tested the two factors (1) site and (2) distance from reef. Where significant differences ($P < 0.05$) in density were found the data set was further examined *a posteriori* with Tukeys HSD test to differentiate between different subsets. To improve homoscedasity of variance the raw data for some species was log + 1 transformed prior to statistical analysis. Reef species that rarely occur were not examined for a distribution pattern because the statistical power of these tests would be unacceptably low.

A simple stratified assessment of the total population numbers for the various resources was calculated. The resource density from the three survey sites was pooled to calculate an overall mean and the population estimate derived as the product of the mean density and the area of reef habitat.

Statistical treatment of data was performed using *SPSS version 6* software package. Whenever possible, means are presented with the standard error (s.e), which is a measure of variability associated with the mean. Assuming normality of the data distribution, the standard error can be used to derive confidence intervals (CI) about the mean estimate. For instance, a 95% confidence interval provides a range of values for the estimated mean that has a 95% probability to encompass the true mean. The working equations for standard error and confidence intervals are appended in **Append. 1**.

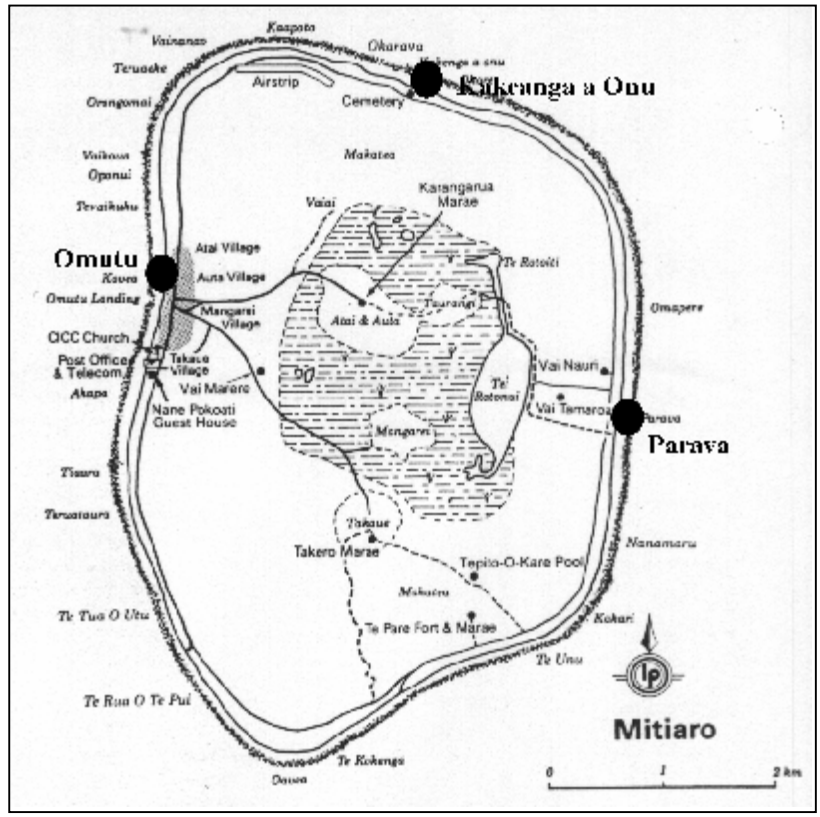

Figure 1 Map of Mitiaro island showing the three sample sites used in this survey.

RESULTS.

Resource Diversity.

There was a total of 13 reef resource species recorded at Mitiaro (refer to **Template A**). They include,

1. Ariri (Rough Turban-shell, *Turbo setosus*),
2. Belligerent Rock-shell, (*Thais armigera*),
3. Karikao, (Rose Mouthed Turban-shell, *Astrea rhodostoma*),
4. Mangeongeo, (Mollusc, Muricidae family, Drupa genus – most common species is the Mulberry drupe, *Drupa morum* and *Drupa ricinius ricinus*),
5. Mapii, (Star shaped limpet, *Patella flexuosa* and Chapman's limpet, *Patella chapum* and less common is the Cap limpet, *Patelloidea conoidalis*),
6. Paua, (Rugose Giant-clam, *Tridacana maxima*),
7. Paua Kura, (Large Pacific Jewel-Box shell, *Chama pacifica*),
8. Popoto, (Mollusc, Conidae family – most common species are *Conus ebraeus*, *Conus eburne* and *Conus chaldaeus*),
9. Pupu, (Mollusc, Muricidae family, Drupa genus – most common species is Grape drupe, *Morula uva* and Grandular drupe, *Morula grandulata*),
10. Rori Puakatoro, (Red Surf-fish, *Actinopyga mauritiana*),
11. Rori Toto, (Sandy Sea-cucumber, *Holothuria atra*),
12. Ungakoa, (Large Worm shell, *Dendropoma maxima*) and
13. Vana (Long Spine Sea-urchin, *Echinothrix diadema*).

There were 11 different reef species recorded at Omotu site, 9 reef species were found at Parava and Kakeanga Onu (**Table 1**). The most common resource recorded was the Mangeongeo, a total of 553 animals were reported. Several species were rarely encountered, (less then 10 of these animals counted). These species include the Paua Kura, Ungakoa and Vana.

The percentage of 20 meter quadrants which a resource was recorded may be an indication of the probability that one may expect to see the species during a trip to the reef (i.e "Occur" column, **Table 1**). The Pupu occurred in almost half the transects and so it is expected that there is a 50% chance that this resource will be encountered on a trip to the reef. Similarly, resources which may be expected to be seen at the reef with a 20% to 50% probability include Mangeongeo, Popoto and Rori Toto. The remaining resources have a < 20% probability of being encountered.

Table 1 The percentage occurrence and counts of reef resources at Mitiaro.

Site	Omotu		Parava		Kakeanga Onu		Total	
Resource	Count	Occur	Count	Occur	Count	Occur	Count	Occur
Ariri		0%	22	10%	15	13%	**37**	**8%**
Karikao	16	15%		0%		0%	**16**	**5%**
Mangeo	333	50%	141	33%	79	48%	**553**	**43%**
Mapiii	48	10%	57	13%	153	35%	**258**	**19%**
Paua		0%	18	10%	16	10%	**34**	**7%**
Paua Kura	5	8%		0%		0%	**5**	**3%**
Popoto	251	83%	84	23%	18	15%	**353**	**40%**
Pupu	93	40%	72	48%	135	53%	**300**	**47%**
Rock-shell	7	10%	46	30%	3	8%	**56**	**16%**
Rori Pk'toro	4	10%	19	10%	4	5%	**27**	**8%**
Rori Toto	9	20%	26	23%	19	20%	**54**	**21%**
Ungakoa	3	5%		0%		0%	**3**	**2%**
Vana	4	8%		0%		0%	**4**	**3%**

The diversity index, *H'* indicates that the most diverse site surveyed at Mitiaro was Parava site (*H'* = 0.854) (**Table 2**) (Refer to General Materials and Methods, about diversity index). This site with also had the most even spread of species numbers, i.e evenness, *J'* = 0.895. The site with the least amount of reef diversity and evenness was Omotu (*H'* = 0.625, *J'* = 0.600). This is because at Omotu site a large population of Mangeongeo and Popoto skews the diversity in the area. A special statistical test to compare diversity concluded that the diversity between Parava and Omotu are significantly different (P > 0.05).

Table 2 Diversity index of resources at Mitiaro.

Test statistic	Omotu	Parava	Kakeanga Onu
Diversity, *H'*	0.625	0.854	0.701
Maximum Diversity, H_{max}	1.041	0.954	0.954
Evenness, *J'*	0.600	0.895	0.735

Distribution Patterns.

The results of the distribution patterns of resources with distance from the reef and among sites have been portrayed (**Figures 2, 3** and **4**) to enable a representation of the reefs.

The statistical results are summarised in a tabular form (**Table 3**). A statistically significant (or positive) test can be thought of a 95% probability chance to be correct. For instance, if a significantly high number of Mangeongeo are found at the 5 meter distance from the reef, then chances that this pattern is true has about a 95% probability. The resources with less then 10

individuals recorded during the survey were not analysed for distribution patterns because there were too few for tests to have adequate statistical power.

The results of the statistical tests conclude that the Mangeongeo and Mapiii had significant ($P < 0.05$) distribution patterns depending on the distance from the reef edge. The density of Mangeongeo was significantly greater within the 15 meter band closest to the reef edge. Most Mapiii were found in the 5 meter band at the reef edge. These molluscs are able to attach themselves firmly to the reef and withstand the high wave action that occurs at the reef edge.

Only the Rock-shell had density patterns affected by site. Parava site on the windward side of the island had significantly greater abundance of Rock-shell compared to the other sampling sites.

The Popoto had a distribution pattern that was affected by distance from the reef and sites. At Omotu on the leeward side of the island the Popoto occur within the whole 50 meter width of the reef, but at Parava (windward side) it was mostly found within 5 meters of the reef edge.

The Ariri, Paua, Pupu, Rori Puakatoro and Rori Toto were tested for distribution patterns. However, the tests concluded that sites or distance from the reef do not affect abundance of the resources. Although it should be noted that there it is difficult to find significant patterns when there is a low density, as is the case here. The Paua Kura, Karikao, Ungakoa, Vana and Ariri were not tested because there was too few animals for any real trends to emerge.

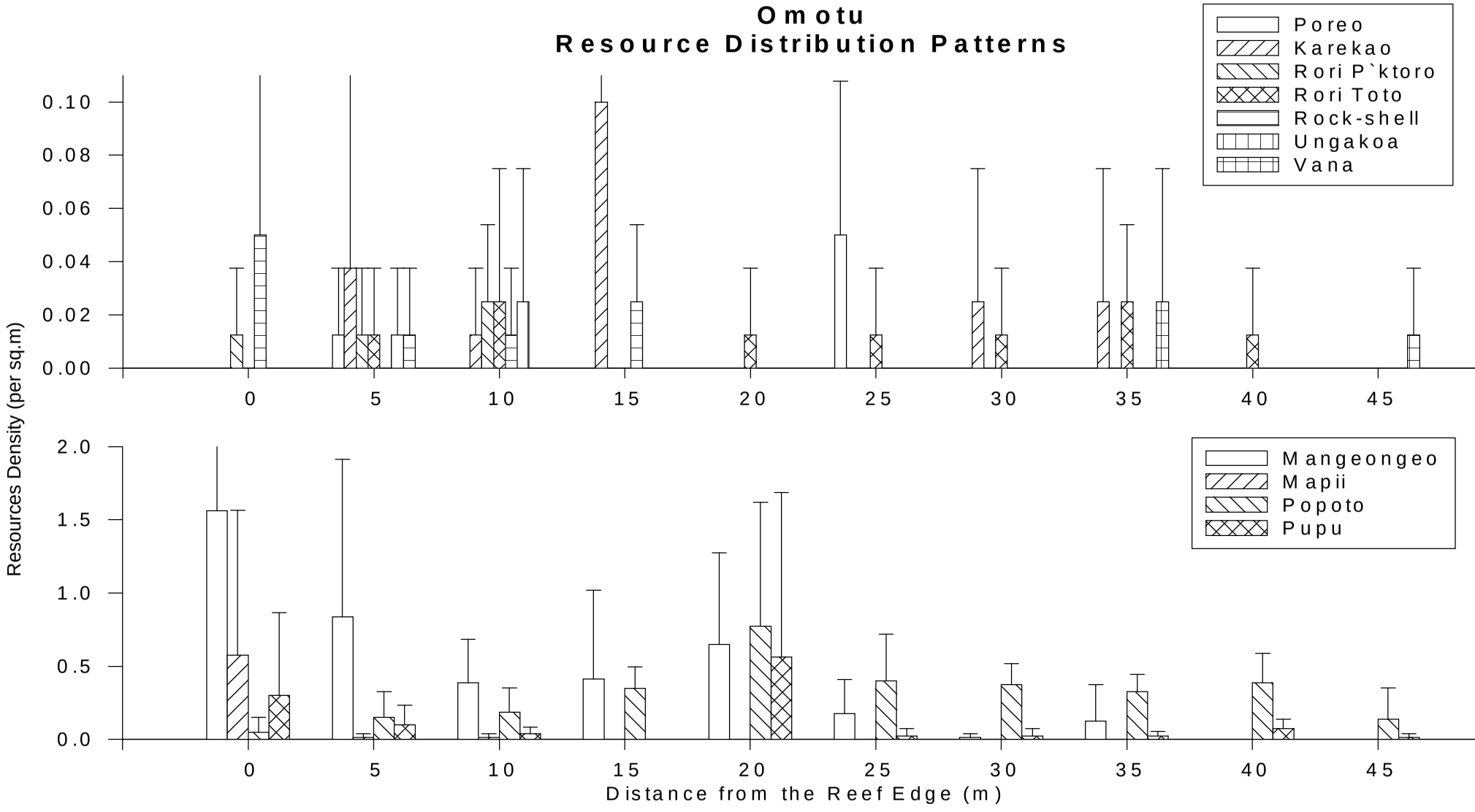

Figure 2 Graph of reef resources distribution patterns at Omotu site.

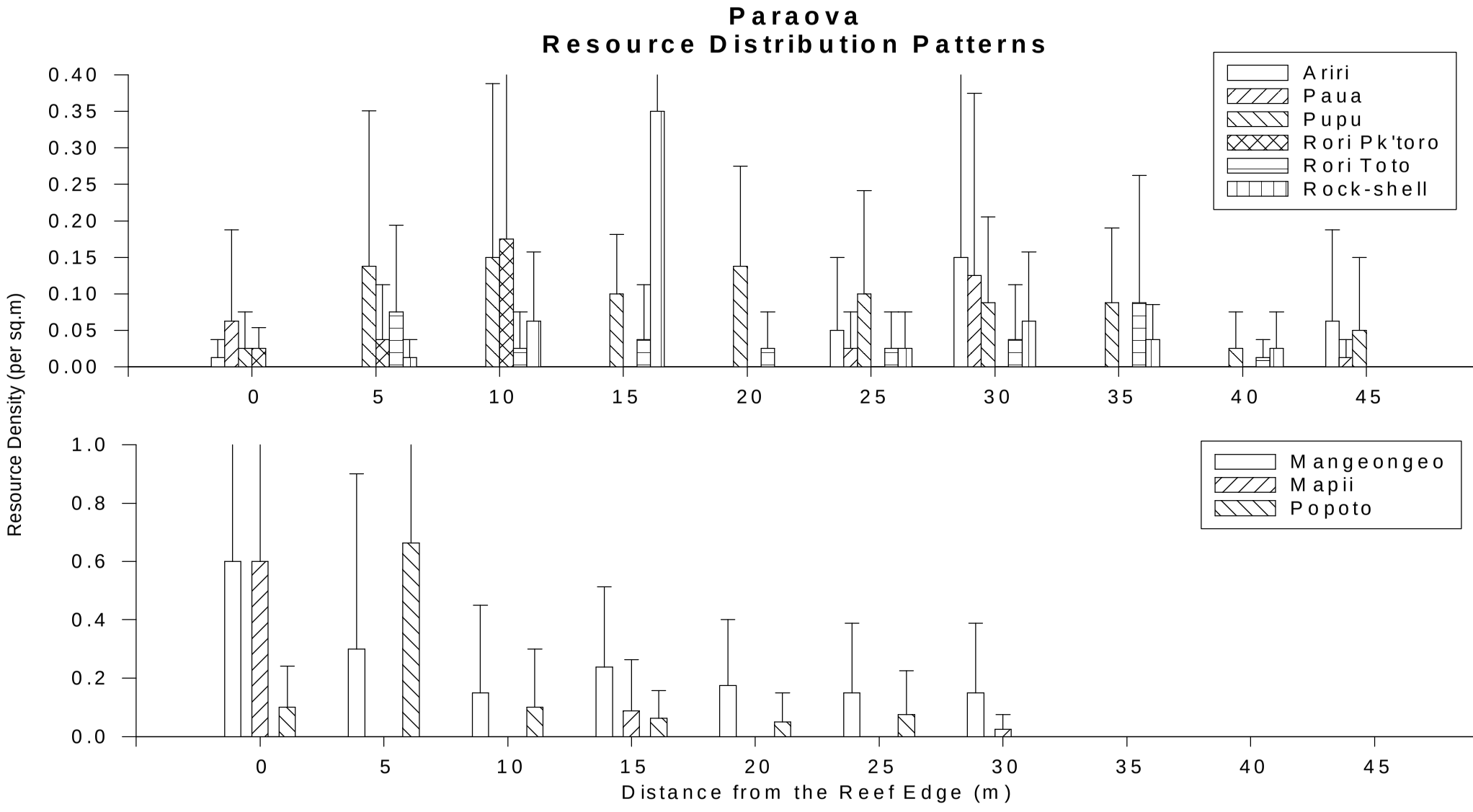

Figure 3 Graph of reef resources distribution patterns at Parava site.

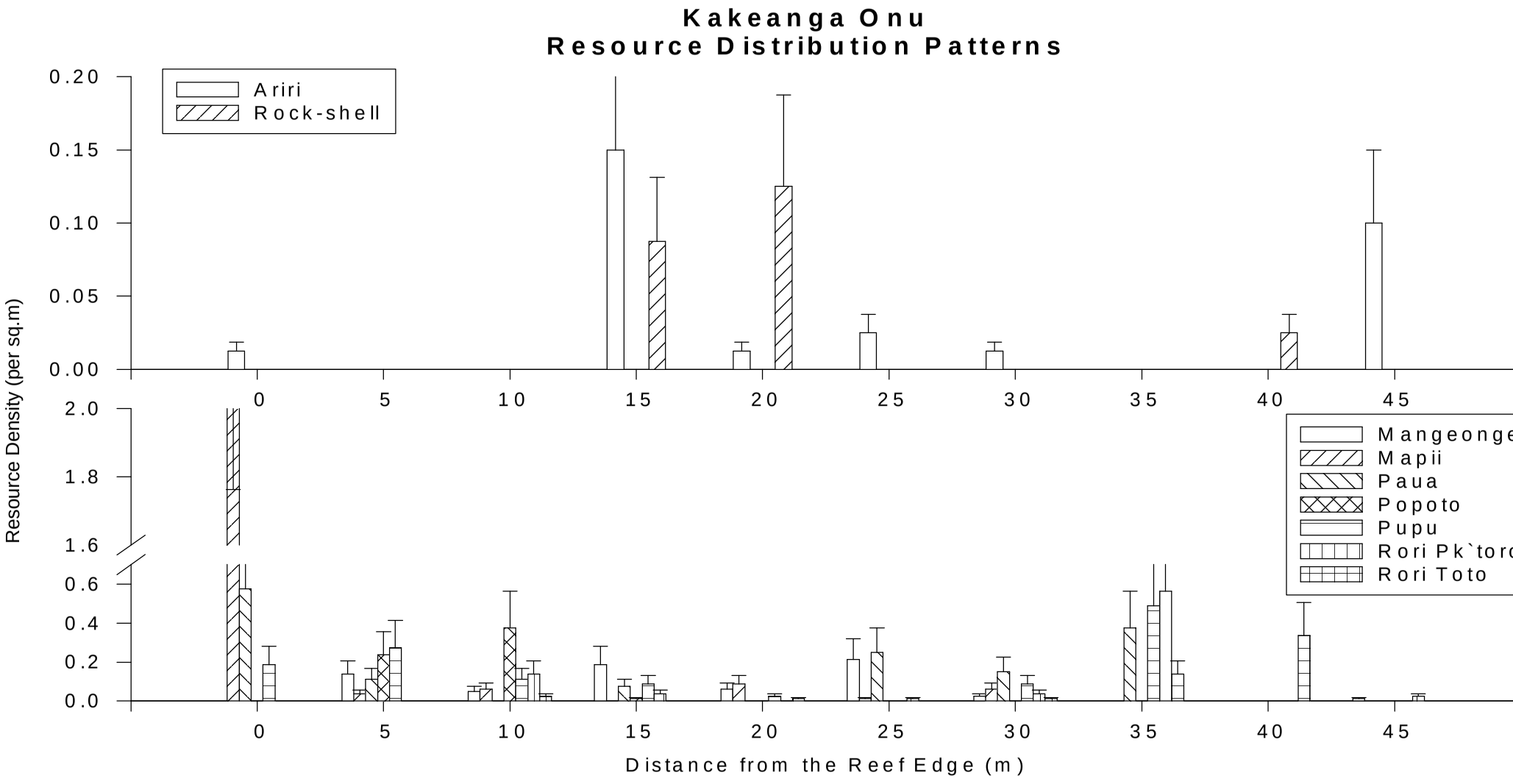

Figure 4 Graph of reef resources distribution patterns at Kakeanga Onu site.

Table 3 Resource distribution patterns at Mitiaro survey sites and with distance from the reef edge.

Resource	Tests	Result	Density (per sq.m)	Conclusion
Paua Kura	Not done		Overall density = 0.002	-no density patterns with site or distance.
Karikao	Not done		Overall density = 0.007	-no density patterns with site or distance.
Ungakoa	Not done		Overall density = 0.001	-no density patterns with site or distance.
Vana	Not done		Overall density = 0.002	-no density patterns with site or distance.
Ariri	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.015	-no density patterns with site or distance.
Mangengeo	2-way ANOVA Tukeys HSD	site = n.s distance = **	40 meter density = 0.000 (subset 1) 45 meter density = 0.000 (subset 1) 35 meter density = 0.050 (subset 1) 30 meter density = 0.088 25 meter density = 0.158 10 meter density = 0.208 20 meter density = 0.288 5 meter density = 0.454 (subset 2) 15 meter density = 0.313 (subset 2) 0 meter density = 0.746 (subset 2)	-no density patterns with site. -the density close to the reef edge (0-15 meters) > density far from the reef edge (35-45 meters).
Mapiii	2-way ANOVA Tukeys HSD	site = * distance = **	25 meter density = 0.000 (subset 1) 35 meter density = 0.000 (subset 1) 40 meter density = 0.000 (subset 1) 45 meter density = 0.000 (subset 1) 30 meter density = 0.030 (subset 1) 20 meter density = 0.033 (subset 1) 15 meter density = 0.050 (subset 1) 10 meter density = 0.063 (subset 1) 5 meter density = 0.092 (subset 1) 0 meter density = 0.808 (subset 2)	-no density patterns with site could be distinguished. -the density at the reef edge (0 meter) > density at all other distances from the reef.

n.s = non significant difference found among levels of factor, P > 0.05. * = significant difference found between levels of factors, P < 0.05
** = highly significant difference found between levels of factors, P < 0.001. Unless indicated, no significant interactive effects between site and distance factors found.

Table 3 Resource distribution patterns at Mitiaro survey sites and with distance from the reef edge.

Resource	Tests	Result	Density (per sq.m)	Conclusion
Paua	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.014	-no density patterns with site or distance.
Pupu	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.125	-no density patterns with site or distance.
Popoto	2-way ANOVA	site x distance = *	Overall density = 0.147	-highest densities occur at Omotu site close to reef edge.
Rori P'ktoro	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.011	-no density patterns with site or distance.
Rori Toto	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.023	-no density patterns with site or distance.
Rock-shell	2-way ANOVA Tukeys HSD	site = * distance = n.s	*Kakeanga Onu* = 0.005 (subset 1) *Omotu* = 0.005 (subset 1) *Parava* = 0.024 (subset 2)	-*Parava* density > *Omotu* and *Kakeanga* density. -no difference in density with distance from reef edge distinguished.

n.s = non significant difference found among levels of factor, P > 0.05. * = significant difference found between levels of factors, P < 0.05
** = highly significant difference found between levels of factors, P < 0.001. Unless indicated, no significant interactive effects between site and distance factors found.

Total Population Size.
The total population of resources for the whole of Mitiaro was calculated based on the survey results of density of species per square meter and the area of reef (taken simply as the circumference of the reef and a 50 meter width) (**Table 4**).

The most abundant resource is the Mangeongeo, the total population (plus or minus 95% Confidence Interval – see General Materials and Methods, for an explanation of confidence intervals), was 210 000 ± 370 000. The other resources with a population size greater then 100 thousand is the Popoto (130 000 ± 340 000) and Pupu, (110 000 ± 90 000). Resources with a small total population (less then 10 000) include Karikao, Paua Kura, Ungakoa and Vana. The population estimates are graphed in **Figure 5**. The majority of population size estimates have a wide confidence interval. This variability reflects the uneven distribution of species around Mitiaro. Surveying more sites can reduce the confidence intervals.

Table 4 Population size of reef resources at Mitiaro.

Resource	Density (Per Sq.m)	Std. Error	Abundance	95% C.I
Ariri	0.015	0.008	**13 900**	**31 400**
Karikao	0.007	0.007	**6 000**	**25 800**
Mangeongeo	0.230	0.096	**207 400**	**370 100**
Mapiii	0.108	0.042	**96 800**	**162 700**
Paua	0.014	0.007	**12 800**	**27 600**
Paua Kura	0.002	0.002	**1 900**	**8 100**
Popoto	0.147	0.087	**132 400**	**335 600**
Pupu	0.125	0.023	**112 500**	**89 700**
Rock-shell	0.023	0.017	**21 000**	**66 400**
Rori Pk'toro	0.011	0.006	**10 100**	**24 200**
Rori Toto	0.023	0.006	**20 300**	**23 900**
Ungakoa	0.001	0.001	**1 100**	**4 800**
Vana	0.002	0.002	**1 500**	**6 500**

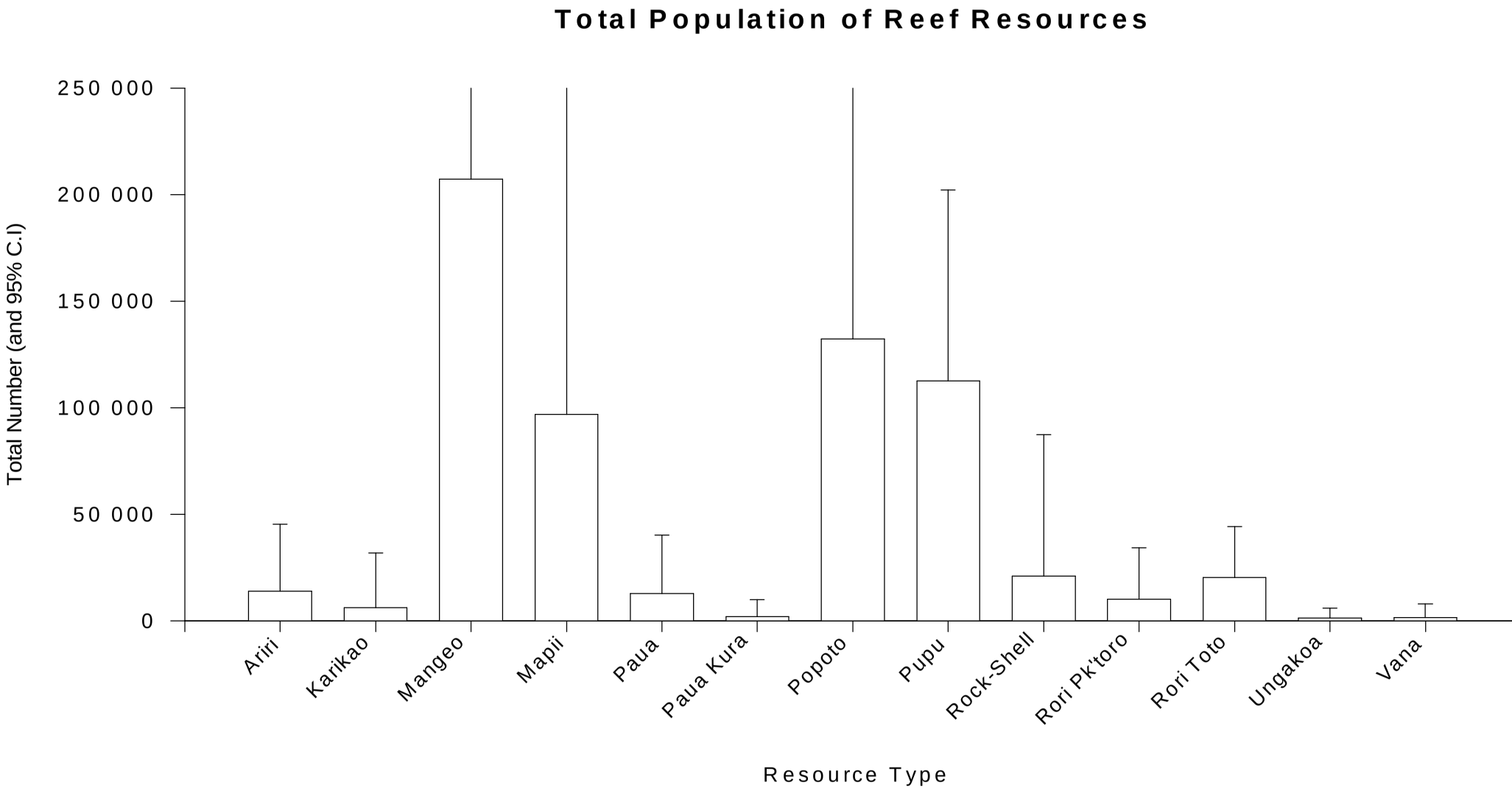

Figure 5 Population size of reef resources at Mitiaro.

DISCUSSION.

Many of the 13 resource types reported in this survey are generally of low value in subsistence food or commercial terms. Of the three sites sampled, Parava was found to have the highest diversity index and most even number of species. The lowest diversity occurs at Omoto, which is dominated by a large population of Mangeongeo and Popoto.

Mangeongeo and Mapiii had distribution patterns depending on how far from the reef edge they are. Both resources had significantly higher abundance close to the reef edge. These animals are able to firmly attach themselves to the reef edge and are not dislodged by the high wave action that occurs in this zone. The wave surge offers protection from natural predators. The animals may also prefer this area because they are relatively immobile and this zone is not likely to become dry and exposed during low tide periods.

Only the Belligerent Rock-shell (*Thais sp*) was distributed differently according to site. The abundance at Parava on the windward side of the island was greater then other sites surveyed (on the lee side). Generally, more wave action occurs on the windward side and this is likely to be one of the factors responsible for higher abundance of Rock-shell at Parava.

Both site and distance affect the abundance of Popoto. Higher densities occur at Omotu site close to the reef edge. No distribuion patterns were identified for the remaining resources.

On Mitiaro, the resource with the largest population is the Mangeongeo, with a population of approximately 210 thousand animals. The Popoto and Pupu were the only other populations to exceed 100 thousand. Of the more valuable resources, there was a population of 13 thousand Paua, 10 thousand Rori Puakatoro and 20 thousand Rori Toto. There were some resources with small population sizes numbering only several thousand in total. These include Paua Kura, Ungakoa and Vana.

There are several resource species that are conspicuously absent. Amongst the Sea-cucumber (*Holothuria*) species this includes the Rori Matie (*Stichopus chloronotus*), Rori Pua (*Holothuria cinerascens*) and Matu Rori (*Holothuria leucospilota*). Mitiaro is the only island in the southern Cook group that the Matu Rori has not been observed by our survey team. The Rori Pua is one of the common resources on neighbouring Atiu. The species of Sea-urchin (*Echinoderm*) that were not seen in the survey include Avake (*Tripneustes gratilla*), Atuke (*Heterocentrotus mammillatus*) and Kina (*Echinometra mathaei*). The only common sea urchin (Vana) had a population of 1 500. The Vana and Kina are often the most common of resources and reach densities of up to 6 per sq.m on Rarotonga (Ponia and Raumea, 1998a, 1988b). The only other southern group island where the Kina was not seen was Mauke. All of the absent species are sought after as reef food and harvest pressure may partially account for their absence.

Because of the relative scarcity of the reef resources they are vulnerable to being over harvested. We have seen how even the once enormous population of Paua on the large reef of Aitutaki was quickly reduced, mostly over-fished by unscrupulous attitudes. The density of Paua on the reef is now 100 times less then it was 10 years ago (Sims and Howard, 1988; Ponia, 1998). It is recommended that prior to any large harvests on Mitiaro that the Ministry firstly assesses the sustainable harvest limit. Such a relationship current exists with the Trochus fishery at Aitutaki.

This survey trip was conducted in conjunction with a Trochus (*Trochus niloticus*) transfer and it is hoped that the Trochus will become established in large numbers. Biologically, they are closely related to the Ariri that is already present on the reef. The Trochus are more suited to harvest pressure because it is highly reproductive and fast growing. It is therefore anticipated that in the future the Trochus may provide an alternative reef food source and reduce fishing pressure on these scarce food types.

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APPENDICES.

APPENDIX I

A. The Shannon-Weiner diversity index, H' is

$$H' = \frac{n \log n - \sum_{(i=1)}^{(k)} f_i \log f_i}{n}$$

where, n = sample size; f_i = number of observations in category i.

B. Where maximum possible diversity for k categories is

$$H'_{max} = \log k$$

C. Evenness J' may be calculated as

$$J' = \frac{H'}{H_{max}}$$

D. The *t* -test of the null hypothesis that the diversity of two sampled populations is equal whereby

$$t \text{ statistic} = \frac{H'_1 - H'_2}{s_{H'1} - s_{H'2}}$$

where, $s_{H'1-H'2} = sqrt(s^2_{H'1} + s^2_{H'2})$ and $s^2_H = \frac{\sum f_i \log^2 f_i - (\sum f_i \log f_i)^2 / n}{n^2}$

E. *Standard Error s.e, or (variance of mean)*

Standard error, s.e = sqrt(standard deviation) / *n*
where ***n*** = number of samples.

F. *Confidence intervals, C.I (95% confidence)*

95% Confidence Interval (CI) = (s.e) $t_{2,0.05}n-1$
with ***t*** value derived from ***t* table** with ***n*** - 1 degrees of freedom.

APPENDIX II

a. Statistical tests (2-way ANOVA, Tukeys HSD) for distribution patterns of resources.

Ariri

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.96	90	.03		
DISTANCE	.20	9	.02	.67	.730
SITE	.12	2	.06	1.83	.166
DISTANCE BY SITE	.49	18	.03	.83	.660

Mangeongeo

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	17.81	90	.20		
DISTANCE	7.70	9	.86	4.32	.000
SITE	1.31	2	.66	3.31	.041
DISTANCE BY SITE	3.96	18	.22	1.11	.354

Multiple Range Tests: Tukey-HSD test with significance level .050
(*) Indicates significant differences which are shown in the lower triangle

Mean	DISTANCE	G G G G G G G G G G r r r r r r r r r r p p p p p p p p p p 1 9 0 8 7 6 3 5 2 4 1
.0000	Grp 9	
.0000	Grp10	
.1265	Grp 8	
.2917	Grp 7	
.4198	Grp 6	
.4613	Grp 3	
.5308	Grp 5	
.6059	Grp 2	* *
.6560	Grp 4	* *
.7300	Grp 1	* *

Mapii

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	8.52	90	.09		
DISTANCE	5.51	9	.61	6.46	.000
SITE	1.18	2	.59	6.22	.003
DISTANCE BY SITE	1.51	18	.08	.88	.599

Multiple Range Tests: Tukey-HSD test with significance level .050
(*) Indicates significant differences which are shown in the lower triangle

Mean	DISTANCE	Grp 6	Grp 8	Grp 9	Grp 10	Grp 7	Grp 5	Grp 4	Grp 3	Grp 2	Grp 1
.0000	Grp 6										
.0000	Grp 8										
.0000	Grp 9										
.0000	Grp10										
.0292	Grp 7										
.0333	Grp 5										
.0500	Grp 4										
.0625	Grp 3										
.0917	Grp 2										
.8083	Grp 1	*	*	*	*	*	*	*	*	*	

Paua

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.76	90	.03		
DISTANCE	.20	9	.02	.73	.683
SITE	.11	2	.05	1.76	.179
DISTANCE BY SITE	.54	18	.03	.97	.497

Pupu

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	14.21	90	.16		
DISTANCE	1.80	9	.20	1.27	.266
SITE	.55	2	.28	1.75	.180
DISTANCE BY SITE	2.14	18	.12	.75	.748

Popoto

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	9.06	90	.10		
DISTANCE	1.03	9	.11	1.14	.342
SITE	8.84	2	4.42	43.92	.000
DISTANCE BY SITE	3.92	18	.22	2.17	.009

Rori Puakatoro

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	1.97	90	.02		
DISTANCE	.36	9	.04	1.82	.075
SITE	.03	2	.02	.70	.501
DISTANCE BY SITE	.22	18	.01	.56	.920

Rori Toto

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	3.91	90	.04		
DISTANCE	.37	9	.04	.96	.480
SITE	.07	2	.03	.79	.459
DISTANCE BY SITE	.61	18	.03	.78	.723

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Rock-Shell

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	3.16	90	.04		
DISTANCE	.48	9	.05	1.53	.151
SITE	.39	2	.20	5.59	.005
DISTANCE BY SITE	.64	18	.04	1.01	.458

Multiple Range Tests: Tukey-HSD test with significance level .050
(*) Indicates significant differences which are shown in the lower triangle

Mean	SITE	Grp 3	Grp 1	Grp 2
.0226	Grp 3			
.0401	Grp 1			
.1517	Grp 2	*	*	

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b. Summary of mean density of resources with sites and reef distances surveyed.
Note abbreviations;
Site 1 = Omotu, Site 2 = Parava, Site 3 = Tekakeanga Onu. Distance 1 = 0 meters from reef edge, 2 = 5 m, 3 = 10 m, 4 = 15 m, 5 = 20 m, 6 = 25 m, 7 = 30 m, 8 = 35 m, 9 = 40 m and 10 = 45 m from reef edge).

Ariri

Value	Label	Mean
For Entire Population		.0154
SITE	1.00	.0000
SITE	2.00	.0275
SITE	3.00	.0188
DISTANCE	1.00	.0125
DISTANCE	2.00	.0042
DISTANCE	3.00	.0000
DISTANCE	4.00	.0417
DISTANCE	5.00	.0000
DISTANCE	6.00	.0250
DISTANCE	7.00	.0500
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0208

Karikao

Value	Label	Mean
For Entire Population		.0067
SITE	1.00	.0200
SITE	2.00	.0000
SITE	3.00	.0000

DISTANCE	1.00	.0000
DISTANCE	2.00	.0125
DISTANCE	3.00	.0042
DISTANCE	4.00	.0333
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0083
DISTANCE	8.00	.0083
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Mangeongeo

Value	Label	Mean
For Entire Population		.2304
SITE	1.00	.4163
SITE	2.00	.1762
SITE	3.00	.0988
DISTANCE	1.00	.7458
DISTANCE	2.00	.4542
DISTANCE	3.00	.2083
DISTANCE	4.00	.3125
DISTANCE	5.00	.2875
DISTANCE	6.00	.1583
DISTANCE	7.00	.0875
DISTANCE	8.00	.0500
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Mapii

Value	Label	Mean
For Entire Population		.1075
SITE	1.00	.0600
SITE	2.00	.0713
SITE	3.00	.1912
DISTANCE	1.00	.8083
DISTANCE	2.00	.0917
DISTANCE	3.00	.0625
DISTANCE	4.00	.0500
DISTANCE	5.00	.0333
DISTANCE	6.00	.0000
DISTANCE	7.00	.0292
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Paua

Value	Label	Mean
For Entire Population		.0142
DISTANCE	1.00	.0292
DISTANCE	2.00	.0375

DISTANCE	3.00	.0000
DISTANCE	4.00	.0208
DISTANCE	5.00	.0000
DISTANCE	6.00	.0083
DISTANCE	7.00	.0417
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0042
SITE	1.00	.0000
SITE	2.00	.0225
SITE	3.00	.0200

Paua Kura

Value	Label	Mean
For Entire Population		.0021
SITE	1.00	.0063
SITE	2.00	.0000
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0042
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0167
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Popoto

Value	Label	Mean
For Entire Population		.1471
SITE	1.00	.3137
SITE	2.00	.1050
SITE	3.00	.0225
DISTANCE	1.00	.0500
DISTANCE	2.00	.2708
DISTANCE	3.00	.1500
DISTANCE	4.00	.1417
DISTANCE	5.00	.2750
DISTANCE	6.00	.1583
DISTANCE	7.00	.1250
DISTANCE	8.00	.1125
DISTANCE	9.00	.1417
DISTANCE	10.00	.0458

Pupu

Value	Label	Mean
For Entire Population		.1250
SITE	1.00	.1162

SITE	2.00	.0900
SITE	3.00	.1687
DISTANCE	1.00	.2250
DISTANCE	2.00	.2167
DISTANCE	3.00	.1250
DISTANCE	4.00	.1375
DISTANCE	5.00	.2917
DISTANCE	6.00	.0917
DISTANCE	7.00	.0500
DISTANCE	8.00	.0500
DISTANCE	9.00	.0375
DISTANCE	10.00	.0250

Rock-shell

Value Label		Mean
For Entire Population		.0233
DISTANCE	1.00	.0167
DISTANCE	2.00	.0042
DISTANCE	3.00	.0250
DISTANCE	4.00	.1292
DISTANCE	5.00	.0042
DISTANCE	6.00	.0083
DISTANCE	7.00	.0208
DISTANCE	8.00	.0125
DISTANCE	9.00	.0083
DISTANCE	10.00	.0042
SITE	1.00	.0087
SITE	2.00	.0575
SITE	3.00	.0038

Rori Puakatoro

Value Label		Mean
For Entire Population		.0113
SITE	1.00	.0050
SITE	2.00	.0238
SITE	3.00	.0050
DISTANCE	1.00	.0125
DISTANCE	2.00	.0167
DISTANCE	3.00	.0708
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0125
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Rori Toto

Value Label		Mean
For Entire Population		.0225

SITE	1.00	.0113
SITE	2.00	.0325
SITE	3.00	.0238
DISTANCE	1.00	.0000
DISTANCE	2.00	.0292
DISTANCE	3.00	.0167
DISTANCE	4.00	.0125
DISTANCE	5.00	.0167
DISTANCE	6.00	.0375
DISTANCE	7.00	.0458
DISTANCE	8.00	.0375
DISTANCE	9.00	.0250
DISTANCE	10.00	.0042

Ungakoa

Value	Label	Mean
For Entire Population		.0013
SITE	1.00	.0038
SITE	2.00	.0000
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0042
DISTANCE	3.00	.0083
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000

Vana

Value	Label	Mean
For Entire Population		.0017
SITE	1.00	.0050
SITE	2.00	.0000
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0042
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0083
DISTANCE	9.00	.0000
DISTANCE	10.00	.0042