ATIU
REEF RESOURCES
BASELINE ASSESSMENT.

BEN PONIA
KORI RAUMEA
SONNY TATUAVA
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MINISTRY OF MARINE RESOURCES
Government of the Cook Islands

Head Office address: PO Box 85, Avarua, Rarotonga, Cook Islands.
Tel: +682 28722 Fax: +682 29721 E-mail: rar@mmr.gov.ck

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SUMMARY.

This report is intended to provide information of what reef resources are present at Atiu and their abundance. A total of 19 reef resources considered of social and biological importance were surveyed. They include, Ariri, Atuke, Belligerent Rock-shell, Etu, Karikao, Kina, Mangeongeo, Mapi, Matu Rori, Paua, Pupu, Popoto, Poreo, Rori Pua, Rori Puakatoro, Rori Toto, Ungakoa, Vana and Paua Kura. The highest diversity of species was found at Te Vai site on the windward side of the island.

The distribution of some species is affected by site factors. Generally, higher abundance is found on the windward and lagoon area of Te Vai. Site factors such as more food, coral habitat and protection by high wave action may account for Te Vai possessing greater abundance of resources. In contrast, Tarapaku site is a raised bench reef that is exposed and dry during low tides. This site generally has the lowest abundance of resources. Some species are further affected in distribution depending on the distance from the reef.

The resource with the largest population size is the Rori Pua (240 000 animals). The Rori Toto also has one of the largest population numbers (150 000). The other resource with large numbers is the Paua Kura (130 000). The sea urchin species of Kina and Vana are not as abundant on Atiu (the overall density was 0.007 and 0.002 per sqm, respectively) compared to the fringing and barrier reefs of Rarotonga and Aitutaki (densities of up to 6 per sqm were observed). Also, some resource species found elsewhere in the Cooks were not observed – this includes the Rori Matie and Avake. The population size of Kina and Vana is less then 10 000. Other resource species with a similarly low abundance include Ariri, Etu, Karikao, Paua, Poreo and Pupu.

The resources with 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 major harvests occurring that the Ministry first assesses the sustainable harvest limits. An example of such a 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 the scarce resources to rejuvenate.

INTRODUCTION.

Atiu (also know as Enua-manu) is a volcanic island that was uplifted by tectonic activity several million years ago and is fringed by a raised coral cliff known as makatea. There is a small population of approximately 900 persons, most residing in settlements located in the middle of the island. Atiu is the third largest of the Cook Islands (26.9 sqkm area) with a reef circumference of approximately 20 Kilometers.

There is little documentation of reef resources of Atiu. 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 Atiu was undertaken during a visit in May 1998. Field staff comprised of Marine Resources personnel from Rarotonga. Staff from the Ministry of Outer Island Development (Agriculture dept) at Atiu, and other self employed persons 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, Te Vai, Tautara and Tarapaku (**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**.

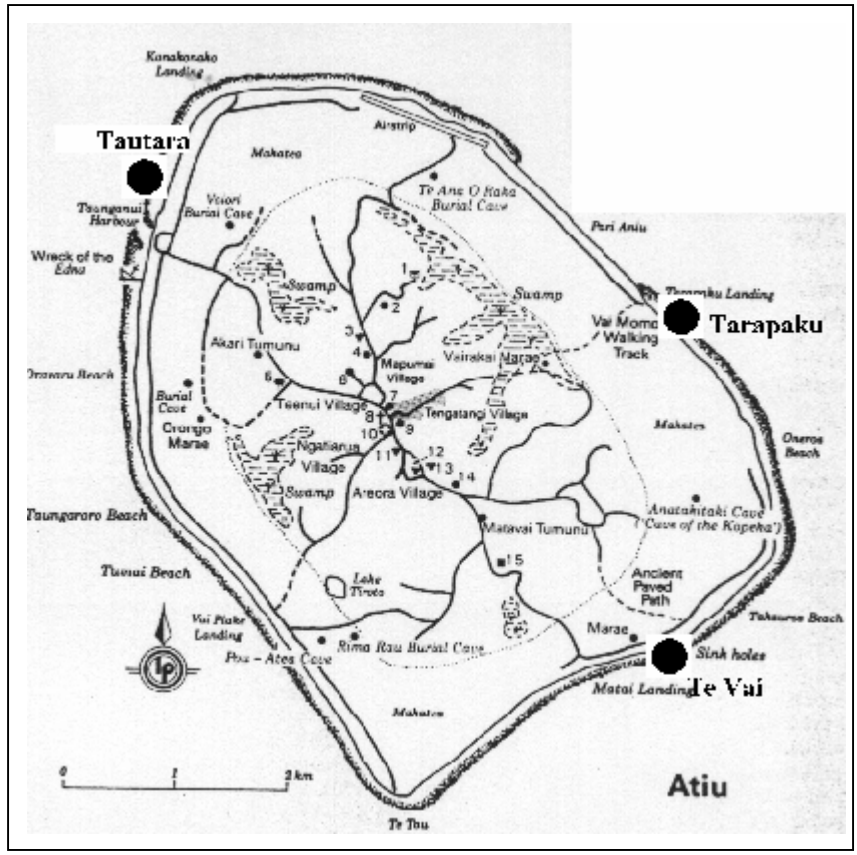

Figure 1 Map of Atiu island showing the three sample sites used in this survey.

RESULTS.

Resource Diversity.
There was a total of 19 reef resource species recorded at Atiu (refer to **Template A**). They include,
Ariri (Rough Turban-shell, *Turbo setosus*),
Atuke, (Brown Pencil-urchin, *Heterocentrotus mammillatus*),
Belligerent Rock-shell, (*Thais armigera*),
Etu (Blue Starfish, *Linckia laevigata*),
Karikao, (Rose Mouthed Turban-shell, *Astrea rhodostoma*),
Kina (Pink Sea-urchin, *Echinometra mathaei*),
Mangeongeo, (Mollusc, Muricidae family, Drupa genus – most common species is the Mulberry drupe, *Drupa morum* and *Drupa ricinius ricinus*),
Mapi, (Star shaped limpet, *Patella flexuosa* and Chapman's limpet, *Patella chapum* and less common is the Cap limpet, *Patelloidea conoidalis*),
Matu Rori, (Soft Black Sea-cucumber, *Holothoria leucospilota*),
Paua, (Rugose Giant-clam, *Tridacana maxima*),
Paua Kura, (Prow Pitar Venus clam, *Pitar prova?*),
Popoto, (Mollusc, Conidae family – most common species are *Conus ebraeus*, *Conus eburneus* and *Conus chaldaeus*),
Poreo, (Cowrie sp., Cypraeidae family, *Cyprea tigris* most common species),
Pupu, (Mollusc, Muricidae family, Drupa genus – most common species is Grape drupe, *Morula uva* and Grandular drupe, *Morula grandulata*),
Rori Pua, (Flower Sea-cumber, *Holothuria cinerascens*),
Rori Puakatoro, (Red Surf-fish, *Actinopyga mauritiana*),
Rori Toto, (Sandy Sea-cucumber, *Holothuria atra*),
Ungakoa, (Large Worm shell, *Dendropoma maxima*),
and Vana (Long Spine urchin, *Echinothrix diadema*).

There were 15 different reef species recorded at Te Vai site, 16 reef species were found at Tautara and a total of only 9 reef species at Tarapaku (**Table 1**). The most common resource recorded was the Rori Pua, a total of 633 animals were reported. Several species were rarely encountered, (less then 10 of these animals counted). These species include, Atuke, Etu, Karikao, Paua, Poreo and Vana.

The percentage of 20 meter quadrants which a resource was recorded may be an indication of how often one may expect to see the species (i.e "Occur" column, **Table 1**). And, since the Rori Toto occurred in approximately 50% of the quadrants surveyed, 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 30% probability include, Mangeongeo, Rori Pua, and Paua Kura. The remaining resources have a < 20% probability of being encountered.

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

Site	Te Vai		Tautara		Tarapaku		Total	
Resource	Occur	Count	Occur	Count	Occur	Count	Occur	Count
Ariri	14%	15	0%	0	0%	0	**5%**	**15**
Atuke	5%	3	9%	6	0%	0	**5%**	**9**
Etu	0%	0	2%	1	0%	0	**1%**	**1**
Karikao	7%	3	7%	6	0%	0	**5%**	**9**
Kina	2%	1	5%	2	7%	13	**5%**	**16**
Mangeo	27%	109	9%	12	34%	84	**23%**	**205**
Mapi	14%	27	0%	0	5%	6	**6%**	**33**
Matu Rori	11%	13	9%	19	2%	1	**8%**	**33**
Paua	0%	0	9%	6	0%	0	**3%**	**6**
Paua Kura	2%	1	25%	69	34%	218	**20%**	**288**
Popoto	9%	8	9%	14	5%	13	**8%**	**35**
Poreo	0%	0	9%	5	0%	0	**3%**	**5**
Pupu	7%	8	7%	7	0%	0	**5%**	**15**
Rock-shell	11%	7	11%	17	5%	3	**9%**	**27**
Rori Pk'toro	5%	2	18%	12	7%	14	**10%**	**28**
Rori Pua	18%	13	59%	620	0%	0	**26%**	**633**
Rori Toto	73%	261	52%	98	23%	27	**49%**	**386**
Ungakoa	14%	17	5%	4	16%	8	**11%**	**29**
Vana	0%	0	7%	6	0%	0	**2%**	**6**

The diversity index, *H'* indicates that the most diverse site surveyed at Atiu was Te Vai site (*H'* = 0.697) (**Table 2**) (Refer to General Materials and Methods, about diversity index). But the site with the most even spread of species numbers was Tarapaku, i.e evenness, *J'* = 0.631. The site with the least amount of reef diversity and evenness was Tautara (*H'* = 0.570, *J'* = 0.474). This is because at Tautara site a large population of Rori Pua skews the diversity in the area. A special statistical test to compare diversity concluded that the diversity between Te Vai and Tautara are significantly different (P > 0.05).

Table 2 Diversity index of resources at Atiu.

Test statistic	Te Vai	Tautara	Tarapaku
Diversity, *H'*	0.697	0.570	0.602
Maximum Diversity, H_{max}	1.176	1.204	0.954
Evenness, *J'*	0.593	0.474	0.631

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 animals with less then 10 animals were not analysed for distribution patterns because there were too few of these animals for tests to have adequate statistical power.

The Mapi, Rori Pua and Rori Toto had distribution patterns that were different among sites or distances from the reef edge. But in all three cases *a posteriori* testing was unable to differentiate the specific distance were these species was found. However, significant site differences were found. For instance, the highest density of Mapi and Rori Toto was found at windward area of Te Vai site that includes a small lagoon area. The highest density of Rori Pua is at Tautara site which is on the leeward side of the island.

The Ariri, Mangeongeo and Rori Puakatoro had distribution patterns that were affected by an interactive effect of sites versus distance. Because of the relatively low abundance of these resources the trends were not always readily apparent. However it can be noted that the Ariri and Mangeongeo have the highest density at Te Vai site close to the reef edge. Since this is on the leeward site this zone has high wave action may offer protection from natural predators and harvest pressure. The highest density of Rori Puakatoro was found at Tautara close to the reef edge but even so the abundance of Rori Puakatoro is low.

Statistical tests of the distribution at sites and distance from the reef of the Kina, Matu Rori, Popoto, Rock-shell, Pitar Venus and Ungakoa failed to find any significant pattern. This leads to the conclusion that these resources may either be randomly placed at the reef or that the distribution is affected by a factor that has not been tested. The remaining species were not tested for distribution patterns because there was too few animals to reveal any significant trends.

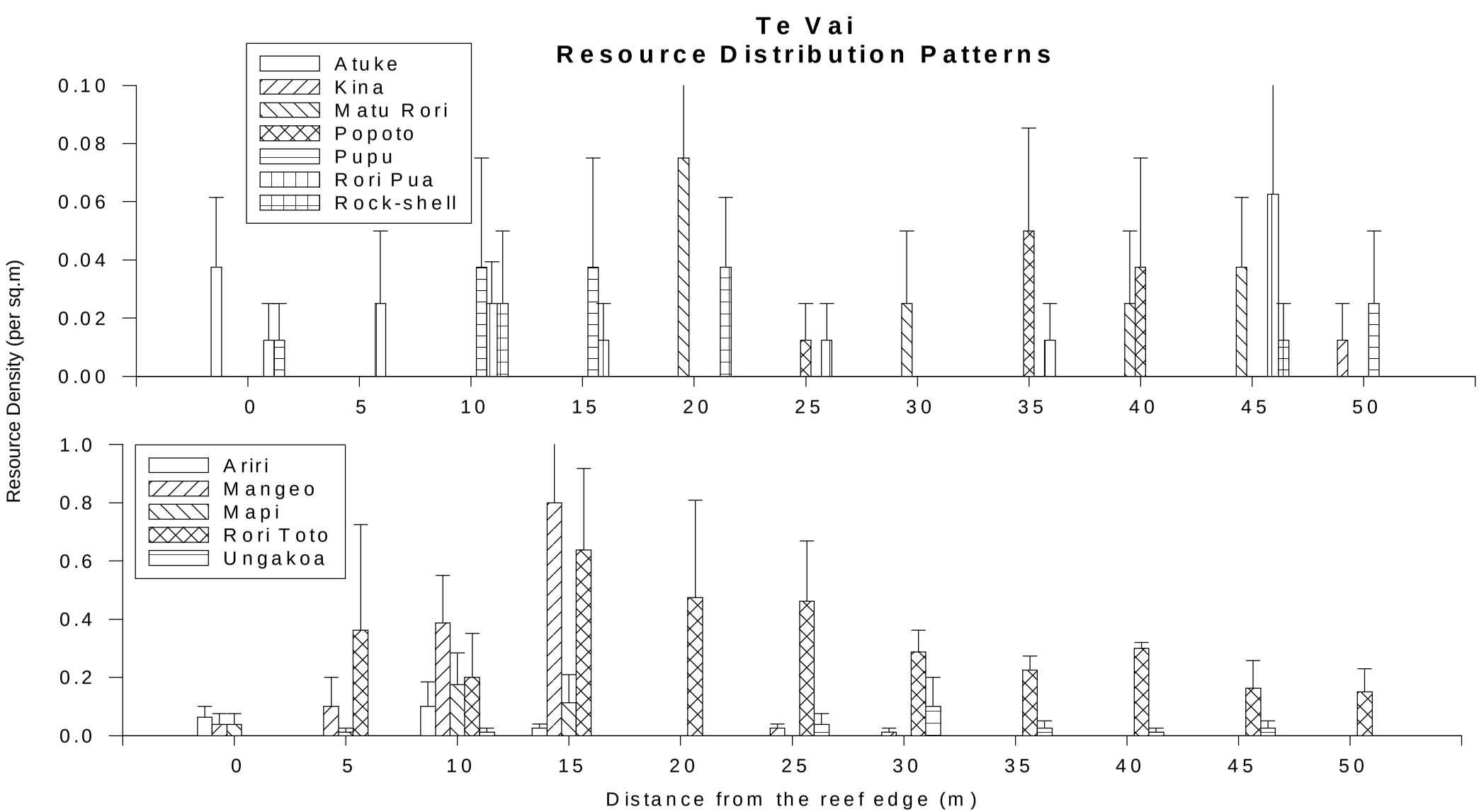

Figure 2 Graph of reef resources distribution patterns at Te Vai site.

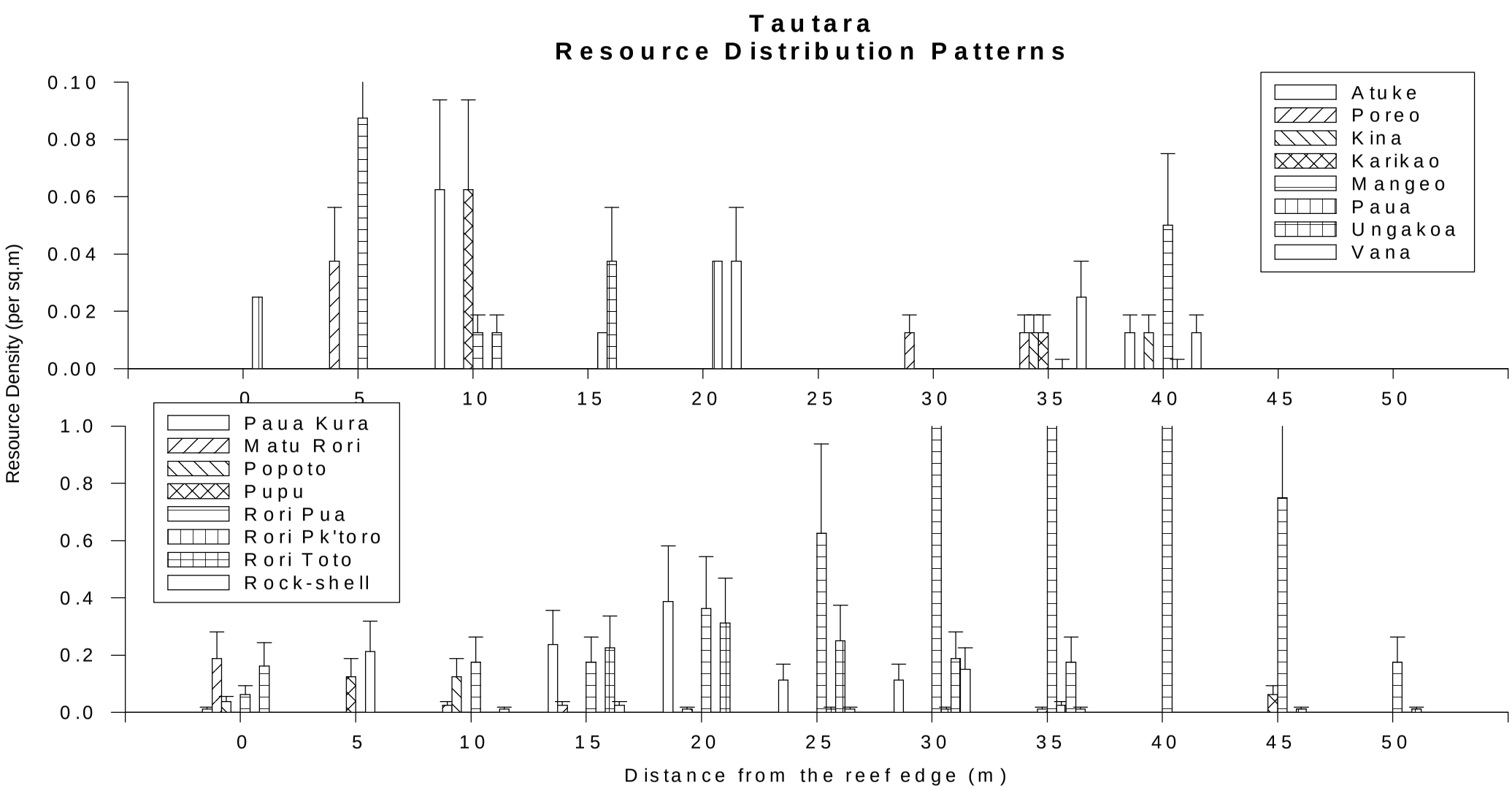

Figure 3 Graph of reef resources distribution patterns at Tautara site.

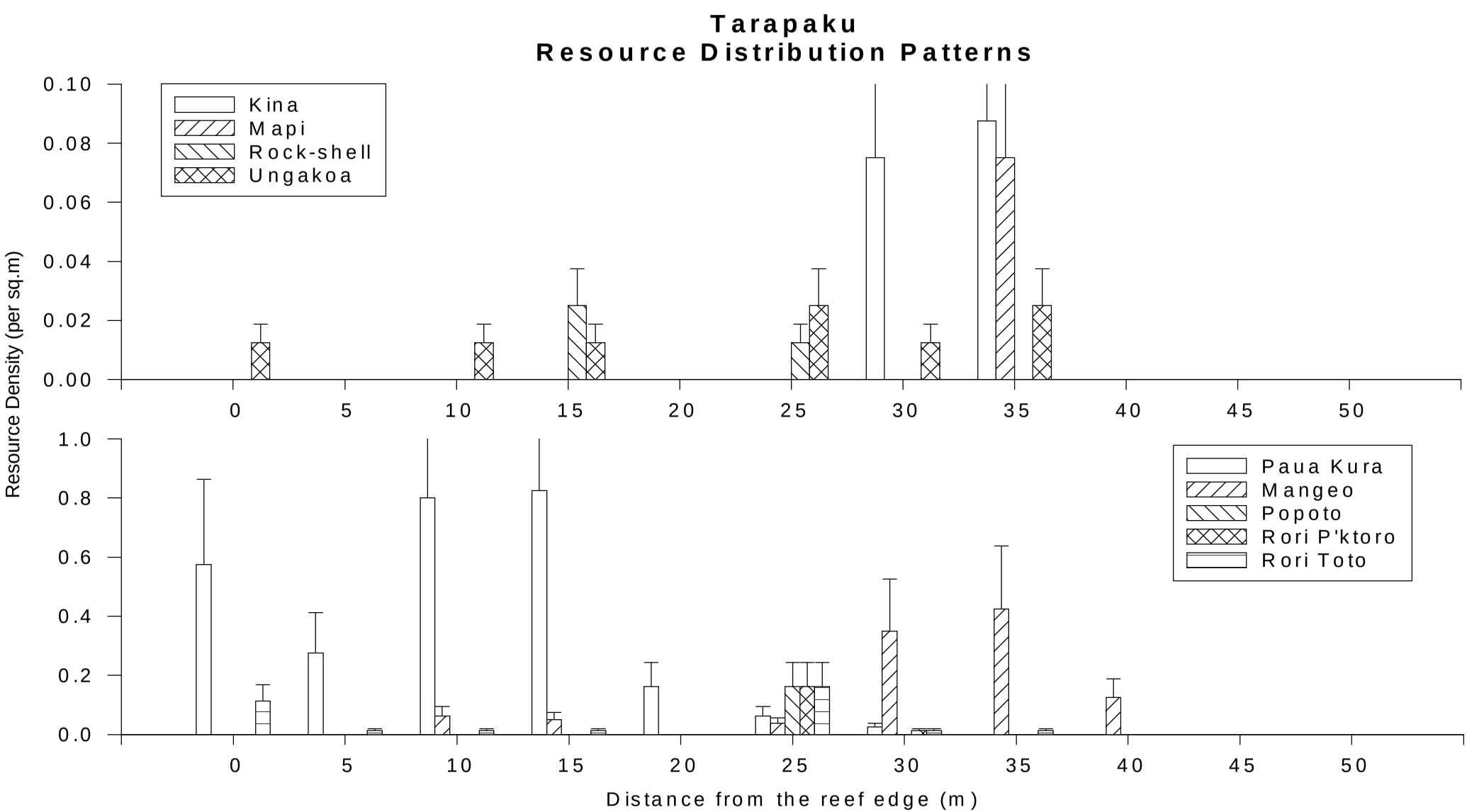

Figure 4 Graph of reef resources distribution patterns at Tarapaku site.

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

Resource	Tests	Result	Density (per sq.m)	Conclusion
Atuke	Not done		Overall density = 0.004	-no density patterns with site or distance.
Etu	Not done		Overall density = <0.001	-no density patterns with site or distance.
Karikao	Not done		Overall density = 0.004	-no density patterns with site or distance.
Paua	Not done		Overall density = 0.002	-no density patterns with site or distance.
Poreo	Not done		Overall density = 0.002	-no density patterns with site or distance.
Pupu	Not done		Overall density = 0.010	-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 x distance = *	Overall density = 0.006	-highest densities occur at Te Vai site close to reef edge.
Kina	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.007	-no density patterns with site or distance.
Mangeo	2-way ANOVA	site x distance = *	Overall density = 0.083	-highest densities occur at Te Vai site close to reef edge.
Mapi	2-way ANOVA Tukeys HSD	site = * distance = *	*Te Vai* = 0.031 (subset 1) *Tautara* = 0.000 (subset 2) *Tarapaku* = 0.008 (subset 2)	-*Te Vai* density > *Tautara* and *Tarapaku* 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.

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

Resource	Tests	Result	Density (per sq.m)	Conclusion
Matu Rori	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.013	-no density patterns with site or distance.
Popoto	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.014	-no density patterns with site or distance.
Rori Pua	2-way ANOVA Tukeys HSD	site = ** distance = **	*Tautara* = 0.776 (subset 1) *Te Vai* = 0.015 (subset 2) *Tarapaku* = 0.000 (subset 2)	-*Tautara* density > *Te Vai* and *Tarapaku* density. -no difference in density with distance from reef edge distinguished.
Rori Puakatoro	2-way ANOVA	site x distance = *	Overall density = 0.083	-highest densities occur at Tautara site close to reef edge.
Rock-shell	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 Tukeys HSD	site = * distance = *	*Te Vai* = 0.300 (subset 1) *Tautara* = 0.122 (subset 2) *Tarapaku* = 0.038 (subset 2)	-*Te Vai* density > *Tautara* and *Tarapaku* density. -no difference in density with distance from reef edge distinguished.
Paua Kura	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.116	-no density patterns with site or distance.
Ungakoa	2-way ANOVA	site = n.s distance = n.s	Overall density = 0.012	-no density patterns with site or distance.

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 Atiu 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 Rori Pua, the total population (plus or minus 95% Confidence Interval – see General Materials and Methods, for an explanation of confidence intervals), was 240 000 ± 740 000. Another resource of relatively high abundance is the Rori Toto (150 000 ± 250 000) and Paua Kura, (130 000 ± 290 000). Resources with a small total population (less then 10 000) include Atuke, Etu, Karikao, Paua, Popoto, Poreo, Pupu, 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 Atiu. The confidence intervals can be reduced by surveying more sites.

Table 4 Population size of reef resources at Atiu.

Resource	Density (Per Sq.m)	Std. Error	Abundance	95% C.I
Ariri	0.006	0.006	**5 700**	**18 100**
Atuke	0.003	0.002	**3 400**	**6 300**
Etu	0.000	0.000	**400**	**1 200**
Karikao	0.003	0.002	**3 400**	**6 300**
Kina	0.007	0.005	**7 200**	**17 400**
Mangeo	0.085	0.036	**84 700**	**113 300**
Mapi	0.013	0.009	**13 000**	**29 200**
Matu Rori	0.013	0.006	**12 600**	**18 900**
Paua	0.002	0.002	**2 300**	**7 300**
Popoto	0.014	0.003	**14 400**	**8 600**
Poreo	0.002	0.002	**1 900**	**6 000**
Pupu	0.006	0.003	**5 700**	**9 100**
Rock-shell	0.010	0.005	**10 500**	**14 500**
Rori P'katoro	0.012	0.005	**11 800**	**16 100**
Rori Pua	0.240	0.232	**239 800**	**739 700**
Rori Toto	0.148	0.077	**148 500**	**245 300**
Ungakoa	0.012	0.004	**11 700**	**13 600**
Paua Kura	0.127	0.090	**127 400**	**287 900**
Vana	0.002	0.002	**2 300**	**7 200**

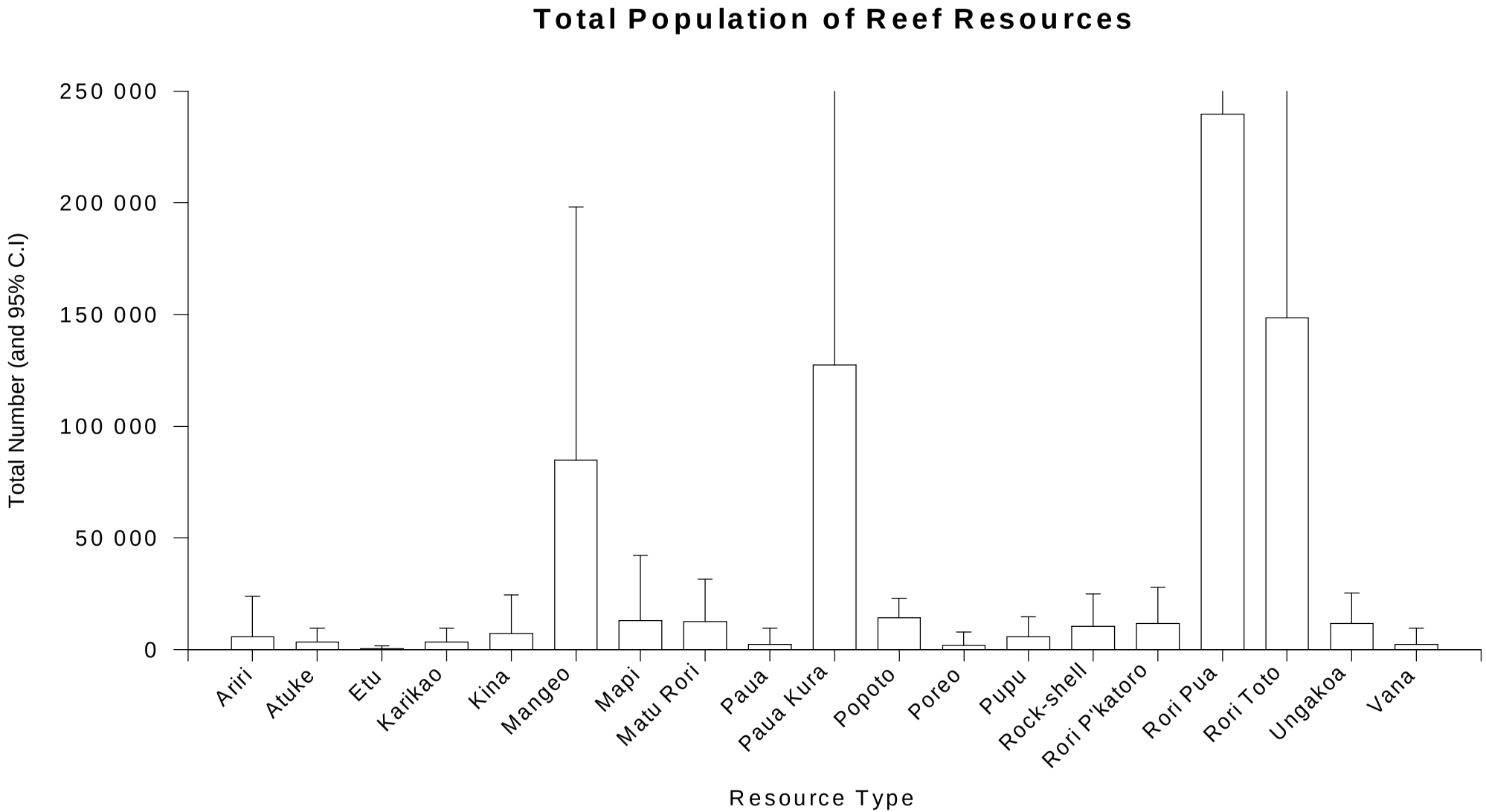

Figure 5 Population size of reef resources at Atiu.

DISCUSSION.

Many of the 19 resource types reported in this survey are generally of low value in subsistence food or commercial terms. Of the three sites sampled, Te Vai was found to have the highest diversity index. The lowest diversity occurs at Tautara area that is dominated by a large population of Rori Pua. Tarapaku site had the most even spread of species abundance - in fact all of the species found at this site had a relatively low abundance.

Te Vai site was found to have significantly greater densities of Mapi and Rori Toto. Te Vai may be a favourable habitat because adjacent to the reef is a small lagoon. The lagoon ecosystem is generally productive in food supply (many of the resources feed on algal detritus) and the diverse coral cover offers a range of habitat types. And also Te Vai is located on the windward side and the high wave action may offer protection from natural predators and harvesting. In contrast Tarapaku is a raised bench reef with little diversity in substrate cover and the reef may become exposed and dry over the low tides. The highest abundance of Rori Pua was found at Tautara site, the area has many small patches of coral with crevices that is a favourable refuge for this species. Some resources also had distribution patterns that were both affected by site and distance from the reef. This includes the Ariri and Mangeongeo that is most abundant at the edge of the reef at Te Vai. Also the Rori Puakaotoro which had the highest density close to the reef edge at Tarapaku area. No distribution patterns were found for the remaining resource types as there were too few numbers for a significant trend to be concluded.

The largest resource population is the Rori Pua, with a population on Atiu of approximately 240 000 animals. The Rori Toto also has a large population size (150 000). Absent from this survey was the Rori Matie (*Stichopus chloronotus*), which is another species of sea cucumber that is common on other islands in the Cooks. A large population of the Paua Kura was also calculated (130 000). All of the sea urchins noted had populations that were less then 10 000. On the fringing and barrier reefs the Kina and Vana is often one of the dominant resources (Ponia and Raumea, 1998a, 1988b). A common species of sea urchin that was absent from the survey was the Avake (*Tripneustes gratilla*)

Aside from the Kina and Vana, other populations with a small number (<10 000) include Ariri, Etu, Karikao, Kina, Paua, Poreo, Pupu and Vana. Because of the relative scarcity of these 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. For instance, in 1988, there was 100 Paua in every 20 square meter area (Sims and Howard, 1988) on the reef, but today only 1 Paua is found per 20 square meters (Ponia, 1998). It is recommended that prior to any large harvests 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.

ACKNOWLEDGEMENTS.

Field surveys at Atiu were capably assisted by Marine Resources staff member Ioane Katara and from Atiu; Maara Mataio, and Joe Napara. Gerald McCormick, Natural Heritage Project, provided assistance in marine taxonomy and standardisation of local names. The Marine Resources Secretary Raymond Newnham provided logistical support. Appreciation is also extended to the Atiu Mayor, Roger Malcom and the Atiu Chief Executive Officer, Tekorona Tekorona for their support and assistance in this survey.

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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. Summary of ANOVA tests for distribution patterns.

b. Summary of mean density for sites and reef distances surveyed. (Site 1 =Te Vai, Site 2 = Tautara, Site 3 = Tarapaku. 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, 10 = 45 m and 11 = 50 meters from reef edge).

Ariri

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	.93	93	.01		
SITE	.12	2	.06	6.18	.003
DISTANCE	.17	10	.02	1.67	.101
SITE BY DISTANCE	.34	18	.02	1.87	.028

Kina

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	1.18	93	.01		
SITE	.02	2	.01	.60	.553
DISTANCE	.20	10	.02	1.58	.125
SITE BY DISTANCE	.33	18	.02	1.43	.137

Mangeongeo

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	6.59	93	.07		
SITE	.86	2	.43	6.08	.003
DISTANCE	4.26	10	.43	6.01	.000
SITE BY DISTANCE	4.21	18	.23	3.30	.000

Mapi

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.17	93	.02		
SITE	.24	2	.12	5.26	.007
DISTANCE	.64	10	.06	2.75	.005
SITE BY DISTANCE	.63	18	.04	1.51	.103

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

Mean	SITE	G r p 2	G r p 3	G r p 1

```
      .0000    Grp 2
      .0300    Grp 3
      .0895    Grp 1      *
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Matu Rori

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.32	93	.02		
SITE	.00	2	.00	.01	.994
DISTANCE	.25	10	.02	.99	.460
SITE BY DISTANCE	.75	18	.04	1.67	.059

Popoto

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.37	93	.03		
SITE	.01	2	.00	.10	.906
DISTANCE	.45	10	.05	1.77	.076
SITE BY DISTANCE	.78	18	.04	1.70	.053

Rori Pua

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	10.88	93	.12		
SITE	12.27	2	6.13	52.41	.000
DISTANCE	5.51	10	.55	4.71	.000
SITE BY DISTANCE	7.37	18	.41	3.50	.000

```
Multiple Range Tests:  Tukey-HSD test with significance level .050
(*) Indicates significant differences which are shown in the lower triangle
                         G G G
                         r r r
                         p p p
                         3 1 2
     Mean      SITE
      .0000    Grp 3
      .0696    Grp 1
      .7403    Grp 2      * *
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Rori Puakatoro

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	1.54	93	.02		
SITE	.14	2	.07	4.12	.019
DISTANCE	.61	10	.06	3.66	.000
SITE BY DISTANCE	1.35	18	.07	4.52	.000

Rock-shell

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.02	93	.02		
SITE	.02	2	.01	.43	.649
DISTANCE	.27	10	.03	1.23	.284
SITE BY DISTANCE	.28	18	.02	.71	.792

Rori Toto

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	9.66	93	.10		
SITE	1.43	2	.71	6.86	.002
DISTANCE	3.23	10	.32	3.11	.002
SITE BY DISTANCE	3.03	18	.17	1.62	.070

```
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
Multiple Range Tests:  Tukey-HSD test with significance level .050
(*) Indicates significant differences which are shown in the lower triangle
                         G G G
                         r r r
                         p p p
                         3 2 1
     Mean      SITE
      .0375    Grp 3
      .1216    Grp 2
      .2966    Grp 1      * *
- - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Pitar Venus

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	11.19	93	.12		
SITE	.77	2	.38	3.19	.046
DISTANCE	1.87	10	.19	1.55	.133
SITE BY DISTANCE	2.97	18	.17	1.37	.164

Ungakoa

Source of Variation	SS	DF	MS	F	Sig of F
WITHIN+RESIDUAL	2.31	93	.02		
SITE	.06	2	.03	1.12	.331
DISTANCE	.12	10	.01	.48	.898
SITE BY DISTANCE	.29	18	.02	.65	.854

Ariri

Value	Label	Mean
For Entire Population		.0060
SITE	1.00	.0170
SITE	2.00	.0000
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
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	.0333
DISTANCE	10.00	.0000
DISTANCE	11.00	.0313

Atuke

For Entire Population		.0036
SITE	1.00	.0034
SITE	2.00	.0068
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
DISTANCE	3.00	.0208
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000

DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0042
DISTANCE	10.00	.0000
DISTANCE	11.00	.0188

Etu

For Entire Population		.0004
SITE	1.00	.0000
SITE	2.00	.0011
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
DISTANCE	3.00	.0000
DISTANCE	4.00	.0042
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Kina

For Entire Population		.0065
SITE	1.00	.0011
SITE	2.00	.0023
SITE	3.00	.0181
DISTANCE	1.00	.0042
DISTANCE	2.00	.0000
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0250
DISTANCE	8.00	.0333
DISTANCE	9.00	.0042
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Karikao

For Entire Population		.0036
SITE	1.00	.0034
SITE	2.00	.0068
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
DISTANCE	3.00	.0208
DISTANCE	4.00	.0042
DISTANCE	5.00	.0042
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0042
DISTANCE	9.00	.0042
DISTANCE	10.00	.0000

DISTANCE	11.00	.0000
Mangeongeo		
For Entire Population		.0827
SITE	1.00	.1239
SITE	2.00	.0136
SITE	3.00	.1167
DISTANCE	1.00	.0000
DISTANCE	2.00	.0292
DISTANCE	3.00	.0250
DISTANCE	4.00	.0167
DISTANCE	5.00	.0042
DISTANCE	6.00	.0208
DISTANCE	7.00	.1167
DISTANCE	8.00	.4083
DISTANCE	9.00	.1875
DISTANCE	10.00	.0500
DISTANCE	11.00	.0188
Mapi		
For Entire Population		.0133
SITE	1.00	.0307
SITE	2.00	.0000
SITE	3.00	.0083
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0625
DISTANCE	9.00	.0583
DISTANCE	10.00	.0063
DISTANCE	11.00	.0188
Matu Rori		
For Entire Population		.0133
SITE	1.00	.0148
SITE	2.00	.0216
SITE	3.00	.0014
DISTANCE	1.00	.0625
DISTANCE	2.00	.0125
DISTANCE	3.00	.0167
DISTANCE	4.00	.0125
DISTANCE	5.00	.0083
DISTANCE	6.00	.0000
DISTANCE	7.00	.0250
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000
Paua		
For Entire Population		.0024

SITE	1.00	.0000
SITE	2.00	.0068
SITE	3.00	.0000
DISTANCE	1.00	.0083
DISTANCE	2.00	.0000
DISTANCE	3.00	.0000
DISTANCE	4.00	.0042
DISTANCE	5.00	.0125
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Poreo

For Entire Population		.0020
SITE	1.00	.0000
SITE	2.00	.0057
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0125
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0042
DISTANCE	8.00	.0042
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Popoto

For Entire Population		.0141
SITE	1.00	.0091
SITE	2.00	.0159
SITE	3.00	.0181
DISTANCE	1.00	.0125
DISTANCE	2.00	.0000
DISTANCE	3.00	.0542
DISTANCE	4.00	.0167
DISTANCE	5.00	.0042
DISTANCE	6.00	.0583
DISTANCE	7.00	.0000
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Pupu

For Entire Population		.0097
SITE	1.00	.0091
SITE	2.00	.0182
SITE	3.00	.0000
DISTANCE	1.00	.0083

DISTANCE	2.00	.0417
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0167
DISTANCE	9.00	.0125
DISTANCE	10.00	.0313
DISTANCE	11.00	.0000

Rori Pua

For Entire Population		.2806
SITE	1.00	.0148
SITE	2.00	.7761
SITE	3.00	.0000
DISTANCE	1.00	.0208
DISTANCE	2.00	.0208
DISTANCE	3.00	.0583
DISTANCE	4.00	.0625
DISTANCE	5.00	.1208
DISTANCE	6.00	.2125
DISTANCE	7.00	.4542
DISTANCE	8.00	.9083
DISTANCE	9.00	.7208
DISTANCE	10.00	.3875
DISTANCE	11.00	.0938

Rori Puakatoro

For Entire Population		.0150
SITE	1.00	.0023
SITE	2.00	.0244
SITE	3.00	.0194
DISTANCE	1.00	.0000
DISTANCE	2.00	.0708
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0000
DISTANCE	6.00	.0583
DISTANCE	7.00	.0083
DISTANCE	8.00	.0083
DISTANCE	9.00	.0042
DISTANCE	10.00	.0063
DISTANCE	11.00	.0000

Rock-shell

For Entire Population		.0109
SITE	1.00	.0080
SITE	2.00	.0193
SITE	3.00	.0042
DISTANCE	1.00	.0000
DISTANCE	2.00	.0042
DISTANCE	3.00	.0042
DISTANCE	4.00	.0167
DISTANCE	5.00	.0000
DISTANCE	6.00	.0083

DISTANCE	7.00	.0625
DISTANCE	8.00	.0042
DISTANCE	9.00	.0083
DISTANCE	10.00	.0000
DISTANCE	11.00	.0063

Rori Toto

For Entire Population		.1593
SITE	1.00	.2966
SITE	2.00	.1216
SITE	3.00	.0375
DISTANCE	1.00	.1417
DISTANCE	2.00	.0583
DISTANCE	3.00	.1042
DISTANCE	4.00	.1542
DISTANCE	5.00	.2000
DISTANCE	6.00	.2917
DISTANCE	7.00	.2250
DISTANCE	8.00	.2750
DISTANCE	9.00	.0667
DISTANCE	10.00	.1875
DISTANCE	11.00	.0063

Trow Pitar

For Entire Population		.1161
SITE	1.00	.0011
SITE	2.00	.0784
SITE	3.00	.3028
DISTANCE	1.00	.1958
DISTANCE	2.00	.0917
DISTANCE	3.00	.2667
DISTANCE	4.00	.3583
DISTANCE	5.00	.1833
DISTANCE	6.00	.0583
DISTANCE	7.00	.0458
DISTANCE	8.00	.0000
DISTANCE	9.00	.0000
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Ungakoa

For Entire Population		.0117
SITE	1.00	.0193
SITE	2.00	.0045
SITE	3.00	.0111
DISTANCE	1.00	.0042
DISTANCE	2.00	.0083
DISTANCE	3.00	.0125
DISTANCE	4.00	.0250
DISTANCE	5.00	.0333
DISTANCE	6.00	.0208
DISTANCE	7.00	.0042
DISTANCE	8.00	.0083
DISTANCE	9.00	.0042
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000

Vana

For Entire Population		.0024
SITE	1.00	.0000
SITE	2.00	.0068
SITE	3.00	.0000
DISTANCE	1.00	.0000
DISTANCE	2.00	.0000
DISTANCE	3.00	.0000
DISTANCE	4.00	.0000
DISTANCE	5.00	.0125
DISTANCE	6.00	.0000
DISTANCE	7.00	.0000
DISTANCE	8.00	.0083
DISTANCE	9.00	.0042
DISTANCE	10.00	.0000
DISTANCE	11.00	.0000