

# 3<sup>RD</sup> MONITORING SURVEY OF THE RAROTONGA RA'UI



April 2002

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## SUMMARY

In 1998 the first *Ra'ui* areas to be designated were Nikao, Matavera, Aroko and Tikioki. Aroa was designated in 2000.

This is the third annual monitoring survey since the re-introduction of the *Ra'ui* on Rarotonga Island. It also incorporates the baseline information collected prior to the implementation of the *Ra'ui* and the annual survey results since the baseline assessment in 1998.

The invertebrate resource at the *Ra'ui* reef sites were identified as a key indicator species for monitoring. Belt transects were utilised and information of density and diversity of species were collected.

At the time of surveying all *Ra'ui* areas were closed for the harvesting of resources, although the Nikao *Ra'ui* had been lifted for one day on 1<sup>st</sup> April 2002, three weeks prior to surveying.

The results indicated that at all *Ra'ui* sites higher densities of resources are present than at the 'control sites' surveyed and that, with the exception of results obtained for Matavera/Pouara, *Ra'ui* species diversity was either the same within the *Ra'ui* and at the control sites or the *Ra'ui* yielded a higher species diversity.

A handful of species dominate each *Ra'ui*. At Aroa, Tikioki, Matavera/Pouara and Nikao the dominant species was Kina, whilst at Aroko Rori toto dominates the *Ra'ui*. At Matavera/Pouara and Nikao Trochus was present as the next most abundant species.

Notable changes occurring since the previous survey are a five-fold increase in density of Rori toto and a 4.5 fold increase in Matu rori at Aroko *Ra'ui*. A 42% increase in Kina, 78% increase of Rori matie and a twelve-fold decrease in Vana at Tikioki *Ra'ui*. A five-fold increase in Trochus at Matavera/Pouara and 25% increase in density of Kina, 37% increase in Rori toto and a 50% increase in density of Matu rori at Nikao *Ra'ui*. At Aroa a four-fold increase in Kina density, and a doubling of population of Matu rori.

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## 1.0 INTRODUCTION

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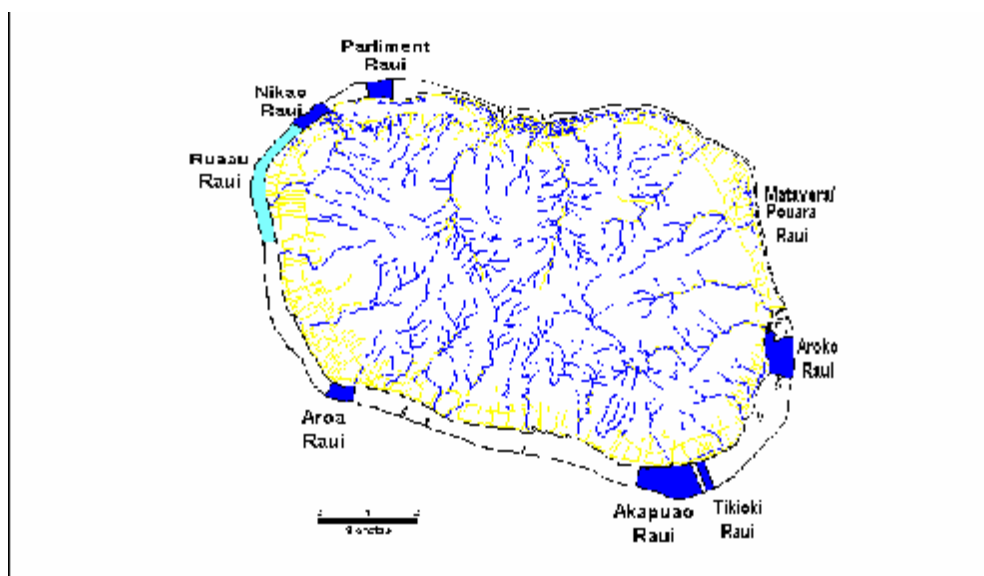
This is the third annual monitoring survey of the Rarotonga *Ra'ui* areas focusing on five *Ra'ui* areas designated since the implementation of the *Ra'ui* system. The *Ra'ui* is a traditional system of managing natural resources and, in this case, is a method whereby the harvesting of marine species in an area is prohibited for a designated period. The *Ra'ui* is imposed by Traditional Leaders with the support of the community. The aim of this system is to allow the resources to rejuvenate, as the areas designated have been perceived to be under threat from over harvesting. The *Ra'ui* can be lifted at any time and then reinstated, banning the harvesting of the reef resources in the designated area. They can also be moved to other areas.

The purpose of this report is to monitor the resources and report to the Traditional Leaders and Stakeholders regarding whether the *Ra'ui* system of managing the natural resources has been successful in that the reef resources have been able to rejuvenate. Previous survey results, from the initial baseline assessments undertaken before the implementation of the *Ra'ui* areas (Ponia and Raumea 1998), and the subsequent routine yearly surveys monitoring ecological change (Ponia et al 2000 and Raumea et al 2001), following the designation, have been compared at all *Ra'ui* areas in an effort to assess the effectiveness of the implementation in each specific area. Significant changes in individual reef resources are also assessed.

### 1.1 Areas with *Ra'ui* status

As of April 2002 there are currently 8 areas with *Ra'ui* status established around Rarotonga (Map 1). There is one permanent reserve, Tikiiki, and one reserve where only the harvesting of *Trochus* is prohibited, Ruaau. The 5 *Ra'ui* areas that are surveyed are Aroko, Aroa, Nikao, Matevera, Tikiiki. The newest *Ra'ui* is Parliament *Ra'ui*. Appendix A indicates the progress of *Ra'ui* over the five year period since the initial designations.

**Map1: Rarotonga *Ra'ui* Areas**



## 2.0 MATERIALS AND METHODS

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As with previous monitoring exercises (Ponia et al 1998, Raumea et al 2000 and Raumea et al 2001) the focus was on the invertebrate species (animals without backbones). The invertebrates are relatively slow moving and therefore easy to count and also any change in the invertebrate population should be indicative of changes occurring within the reef ecosystem.

The methodology adopted for this survey is similar to that used in the initial baseline surveys conducted in February 1998 (Ponia et al 1998). Reef invertebrates were quantified using a 50 meter rope transect of 2 meters in width. This was laid perpendicular to the outer reef, as close as possible to the reef edge. Two observers would search along the left and right of the transect and count the invertebrates found within each 5 meter sector. In addition to this it was decided that, in order to enable comparison and as a method of assessing the significance of the *Ra'ui* areas as a viable means of regenerating resources, sites outside of the *Ra'ui* areas would be surveyed and used as 'control sites'.

Depending on the size of each *Ra'ui* area a varying number of transects were surveyed.

- ◆ **Aroko *Ra'ui*** - 3 sites were surveyed. Two of these sites were located inside the *Ra'ui* area and the other was the control site. At each site 4 replicate 50 meter transects were surveyed.
- ◆ **Aroa *Ra'ui*** - 2 sites were surveyed. One site was located inside the *Ra'ui*, one was the control site. At each site 6 transect surveys were carried out.
- ◆ **Tikioki** - 2 sites were surveyed. One site was located within the *Ra'ui* area and the other site was located outside the boundary, as the control site. At each site 4 transects were surveyed.
- ◆ **Matevera/Pouara** - 3 sites were surveyed. One site was located inside the *Ra'ui* area and the other sites were located either side of the *Ra'ui* area and were the control sites. At each site 4 replicate transects were carried out.
- ◆ **Nikao** - 5 sites were surveyed. Two sites outside the designated area as control sites and three sites inside the *Ra'ui*. At each site 4 transects were carried out.

As with previous surveys only the invertebrates with social or biological significance were recorded. The following list of invertebrate species, with their local, common and scientific names, were surveyed:

Ariri, (Rough Turban-shell, *Turbo setosus*)  
Atuke, (Brown Pencil-urchin, *Heterocentrotus mammillatus*)  
Avake, (Short Spine Sea-urchin, *Tripneustes gratilla*)  
Etu, (Blue Starfish, *Linckia laevigata*)

Karikao, (Rose-Mouthed Turban-shell, *Astrea rhodostoma*)  
Kina, (Pink Sea-urchin, *Echinometra spp.*)  
Matu Rori, (Soft Black Sea-cucumber, *Holothuria leucospilota*)  
Paua, (Rugose Giant Clam, *Tridacna maxima*)  
Rori Pua, (Flower Sea-cucumber, *Holothuria cinerascens*)  
Popoto, (Hebrew Cone, most common species *Conus ebraeus*)  
Rori Matie, (Green Sea-cucumber, *Stichopus chloronotus*)  
Rori Pua, (Flower Sea-cucumber, *Holothuria cinerascens*)  
Rori Puakatoro, (Red Surf-fish, *Actinopyga maurutiana*)  
Rori Toto, (Sandy Sea-cucumber, *Holothuria atra*)  
Trochus, (*Trochus niloticus*)  
Ungakoa, (Large Worm shell, *Dendropoma maxima*)  
Vana, (Long Spine Sea-urchin, *Echinothrix diadema*)

For each *Ra'ui* area the mean number of each species, both inside the *Ra'ui* and outside was calculated with standard error and 95% confidence interval also calculated. Standard error shows the variation of the mean population for each resource with small error bars indicative of good survey practice, in that sufficient areas of the reserve were surveyed.

The standard error is then used to derive Confidence intervals (CI) about the mean estimate. A 95% CI provides a range of values for the estimated mean that has a 95% probability to encompass the true mean.

Results of the survey are presented in graph form showing density of each reef resource per 100 square meters. Percentage cover of each reef resource, inside and outside the *Ra'ui* area, is also calculated, see Appendix B.

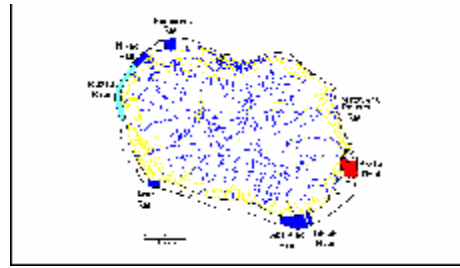
Results from this survey are also presented alongside results from the previous surveys, with resources per 100 square meters being calculated for previous years' results, enabling comparison of resources from 1998 to present, (Appendix C – G). Percentage change in reef resources since the start of monitoring of the *Ra'ui* areas is also calculated.



### 3.0 AROKO RA'UI

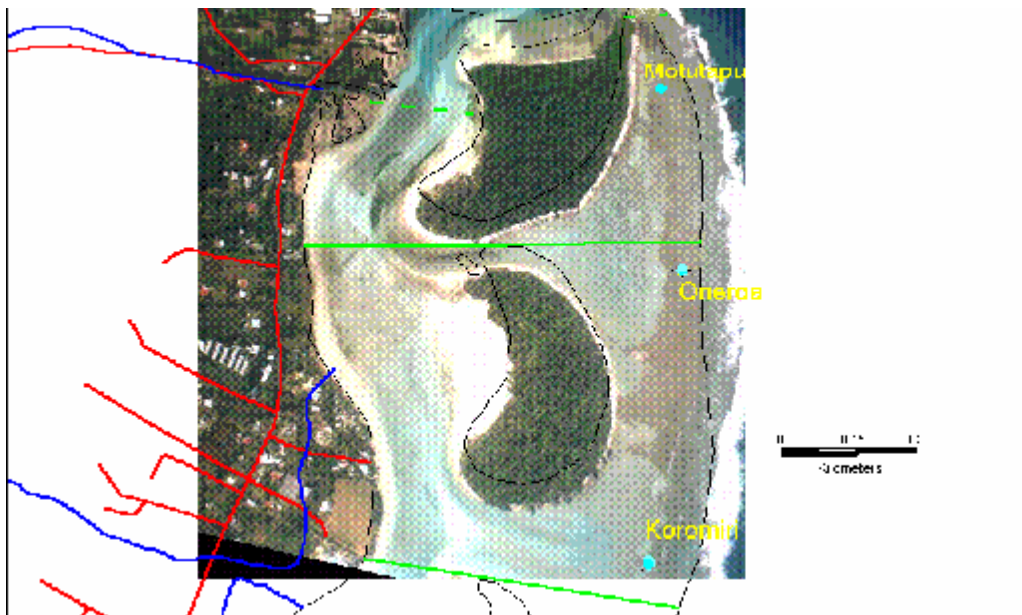
#### 3.1 Geographical Description

Aroko *Ra'ui* was originally designated in 1998. The *Ra'ui* covers 47 hectares and is dominated by three islets. The *Ra'ui* is also adjacent to a river and a large reef passage.



Map 2 below shows the location of the *Ra'ui* boundaries, marked in green, and location of the survey sites, marked in blue. Previous boundaries are marked in a dashed green line.

**Map 2: Aroko *Ra'ui* Survey Sites**



#### 3.2 Current *Ra'ui* Status

At the time of surveying the *Ra'ui* had not been lifted.

#### 3.3 Reef Resources

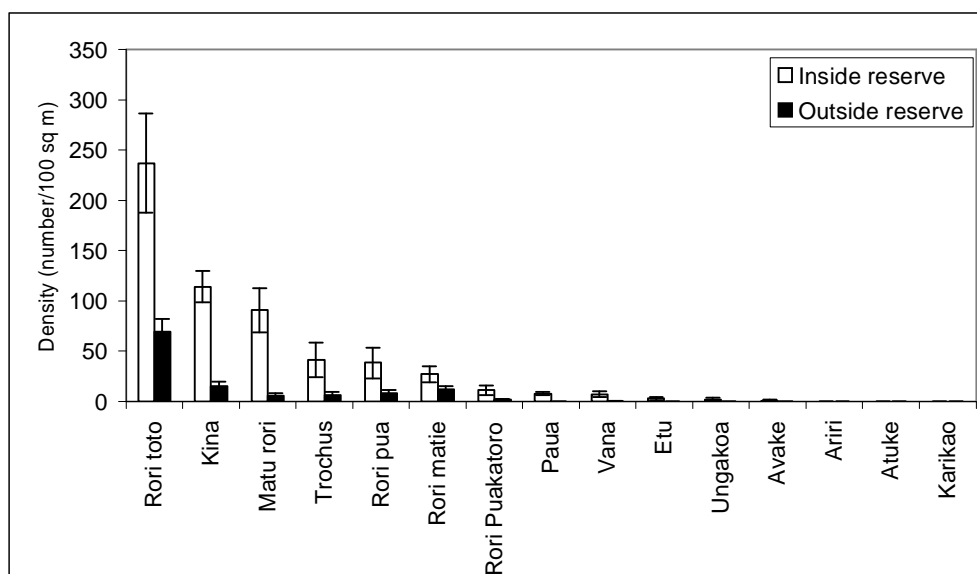
At the two sites surveyed within the designated *Ra'ui* area the following 13 reef resources were present, see Table 1.

**Table 1: Aroko Reef Resources**

Reef Resource	Inside Ra'ui	% of resource	Control site	% of resource
<b>Rori Toto</b> , (Sandy Sea-cucumber, <i>Holothuria atra</i> )	4	<b>41</b>	4	<b>58</b>
<b>Kina</b> , (Pink Sea-urchin, <i>Echinometra spp.</i> )	4	<b>20</b>	4	<b>13</b>
<b>Matu Rori</b> , (Soft Black Sea-cucumber, <i>Holothuria</i> )	4	<b>16</b>	4	<b>5</b>
<b>Trochus</b> , ( <i>Trochus niloticus</i> )	4	<b>8</b>	4	<b>5</b>
<b>Rori Pua</b> , (Flower Sea-cucumber, <i>Holothuria cinerascens</i> )	4	<b>7</b>	4	<b>7</b>
<b>Rori Matie</b> , (Green Sea-cucumber, <i>Stichopus Chloronotus</i> )	4	<b>5</b>	4	<b>10</b>
<b>Paua</b> , (Rugose Giant Clam, <i>Tridacna maxima</i> )	4	<b>2</b>		
<b>Rori Puakatoro</b> , (Red Surf-fish, <i>Actinopyga maurutiana</i> )	4	<b>2</b>	4	<b>&lt;2</b>
<b>Vana</b> , (Long Spine Sea-urchin, <i>Echinothrix diadema</i> )	4	<b>2</b>	4	<b>&lt;1</b>
<b>Ariri</b> , (Rough Turban-shell, <i>Turbo setosus</i> )	4	<b>&lt;1</b>		
<b>Avake</b> , (Short Spine Sea-urchin, <i>Tripneustes gratilla</i> )	4	<b>&lt;1</b>		
<b>Etu</b> , (Blue Starfish, <i>Linckia laevigata</i> )	4	<b>&lt;1</b>		
<b>Ungakoa</b> , (Large Worm Snail, <i>Dendropoma maxima</i> )	4	<b>&lt;1</b>		

At the control site, outside the designated Ra'ui area, fewer reef resources were present with only 8 recorded.

**Figure 1 – Aroko Ra'ui Species Density**



### 3.4 Dominant resources

#### 3.4.1 Inside Reserve

The Aroko Ra'ui is dominated by 8 invertebrate species. These include Rori Toto, accounting for 41% of the resources detected, Kina accounting for 20%, and Matu Rori accounting for 16%. Trochus accounts for 8% and Rori Pua 7% (see Table 1).

Density of the reef resources per 100 square meters present inside the *Ra'ui* area is significantly higher than at the control site, with the greatest difference in density being Rori Toto at 237/100 sq.m compared to 69 /100 sq.m at the control site (Appendix C).

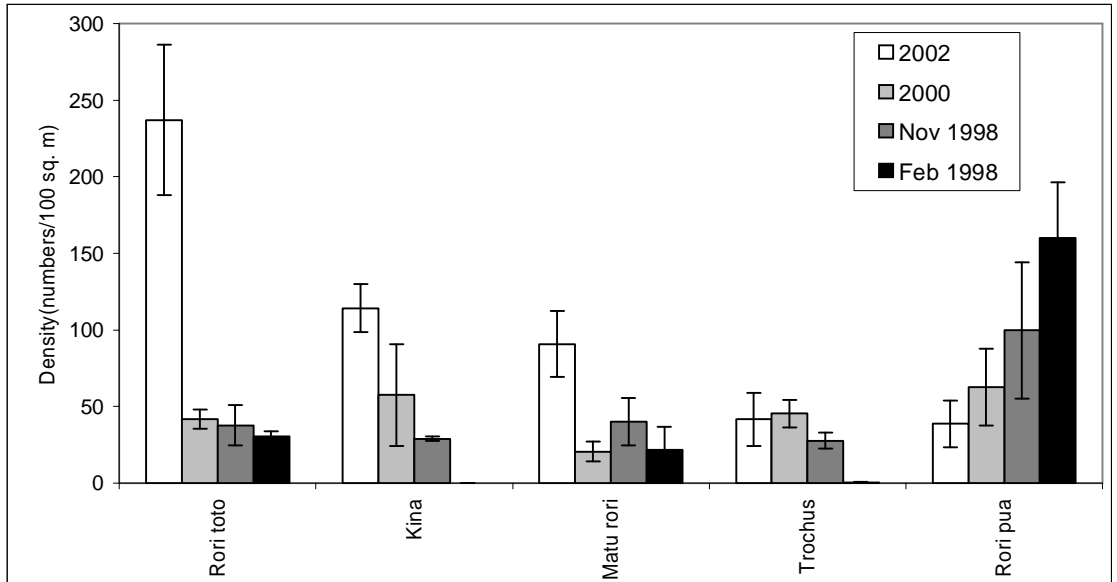
The density of the resource Rori toto (plus or minus 95% Confidence Interval) was 237/100 sq.m +/- 96 individuals. Other prominent species recorded are Kina 114/100sq.m +/- 30 individuals and Matu rori 90/100sq.m +/- 42 individuals. The density of Trochus was high at 41/100sq.m, although the results indicated a poor S.E therefore resulting in a C.I of +/- 33 individuals. Results for Rori Pua indicate a low population at 38/100 sq.m +/- 30 individuals (Figure 1).

### **3.4.2 Outside Reserve**

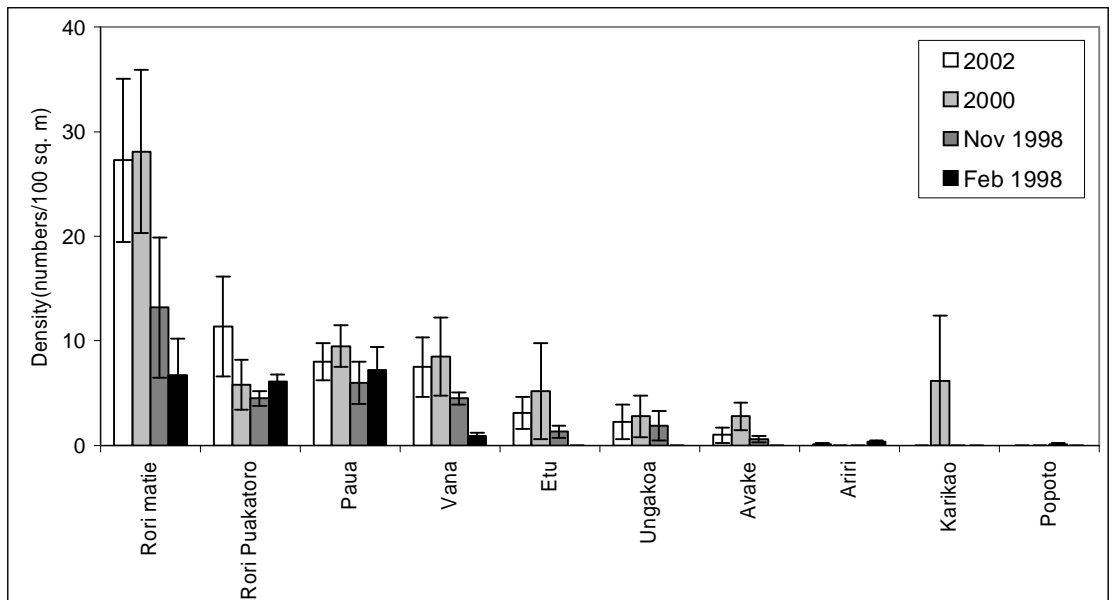
Outside of the *Ra'ui* area again Rori Toto is the dominant resource accounting for 58% of the resources present, however the density of the resource is significantly lower than inside at 70/100 sq.m +/- 25 individuals. Kina account for 13%, (at only 15/100 sq.m +/- 9 individuals), and Matu Rori only 5%, (at 6/100 sq.m +/- 4 individuals). The four transects that were surveyed however, varied significantly in substrate as in some cases no invertebrates were found along the transect.

Overall resources show low densities outside the *Ra'ui* area.

**Figure 2 –Highly Abundant Invertebrate Resources at Aroko Ra’ui 1998 – 2002**



**Figure 3 Lesser Abundant Invertebrate Resources at Aroko Ra’ui 1998-2002**



### 3.5 Population Changes

The baseline survey of February 1998 indicated that the most dominant resources were, in highest density order, Rori Pua, Rori toto, Matu rori with Rori matie and Paua identical in density, Figure 2. Small changes were evident in November 1998 survey with the dominant resource again being Rori Pua but with a smaller population. Kina was also present, but at relatively low density, 29 individuals/100 sq.m. By 2000 the density of Kina recorded had doubled (Appendix C).

In comparison with the 2000/01 2<sup>nd</sup> Monitoring Survey of the Rarotonga *Ra'ui* (Ponia et al 2000), in which 13 resources were found, results from this survey show that there was only one resource not found within the *Ra'ui*, being Karikao (Rose Mouthed Turban Shell, *Astrea rhodostoma*). This however, should not perhaps be attributed to the resource no longer being present at the reserve but could simply be due to surveying error or the non-occurrence in the areas surveyed.

Since the previous survey resource density has, on the whole increased, with the exception being Rori Pau which shows a constant decrease since the baseline survey in February 1998. Since the 2000 survey the decrease in resource density has been 40%.

Rori Pua has characterised the *Ra'ui* since the baseline survey but this years results show a shift in species with dominance within the *Ra'ui* area with the most dominant being Rori toto with a density of 237 individuals/100 sq. m. This is over a five-fold increase in density previously recorded in 2000. Matu Rori has increased in density 4.5 fold and the density of Kina has doubled.

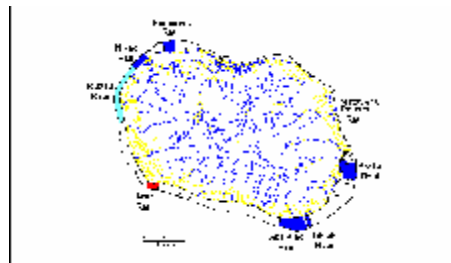
Density of Trochus has increased significantly since the initial baseline survey with a density to date recorded at 41.5/100 sq. m compared to the initial low density recorded of 1/100 sq. m in the baseline survey.

Low densities, Figure 3, of Paua, Vana, Etu, Ungakoa, Avake and Ariri are exhibited since the baseline survey in 1998, all of which have not recorded a density over 10/100 sq. m. Popoto and Karikao were not recorded in surveying this year.

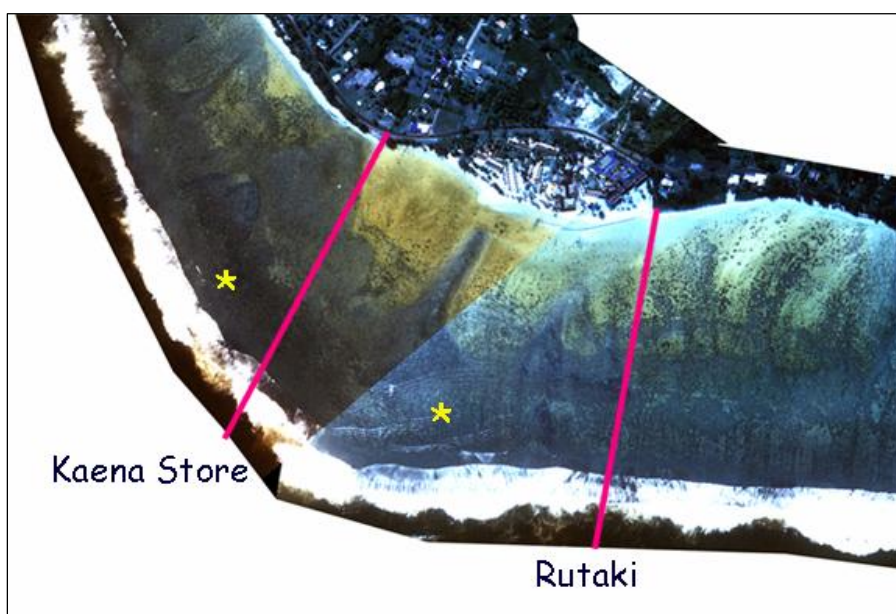
#### 4.0 AROA RA'UI

##### 4.1 Geographical Description

The *Ra'ui* is located on the western side of Rarotonga, covers 16 hectares and includes areas from the Southerly-West end of the Rarotongan Hotel, after the stream and the stretch towards the Kaena Restaurant.



Map 3 Aroa Ra'ui Survey Areas



##### 4.2 *Ra'ui* Status

At the time of surveying the *Ra'ui* had not been lifted.

##### 4.3 Reef Resources

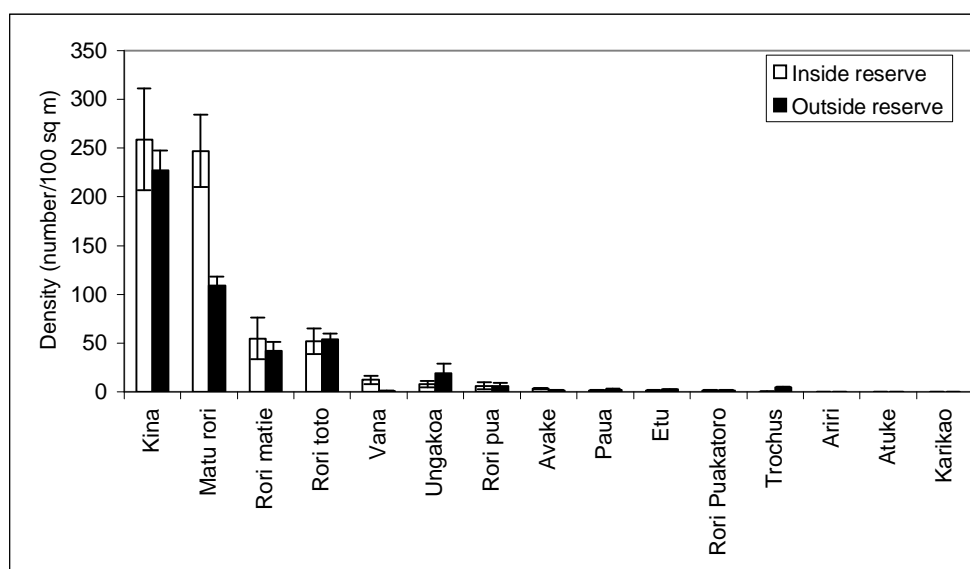
2 sites were surveyed, one site inside the *Ra'ui*, from Kaena Store to Rutaki, and one as the control site, Kaena Store to Kavara, (Map 3). At each site 6 transects were surveyed.

**Table 2: Aroa Reef Resources**

Reef Resource	Inside Ra'ui	% of resource	Control site	% of resource
<b>Kina</b> , (Pink Sea-urchin, <i>Echinometra spp.</i> )	4	<b>40</b>	4	<b>48</b>
<b>Matu Rori</b> , (Soft Black Sea-cucumber, <i>Holothuria</i> )	4	<b>38</b>	4	<b>23</b>
<b>Rori Matie</b> , (Green Sea-cucumber, <i>Stichopus Chloronotus</i> )	4	<b>9</b>	4	<b>9</b>
<b>Rori Toto</b> , (Sandy Sea-cucumber, <i>Holothuria atra</i> )	4	<b>8</b>	4	<b>12</b>
<b>Ungakoa</b> , (Large Worm Snail, <i>Dendropoma maxima</i> )	4	<b>2</b>	4	<b>4</b>
<b>Vana</b> , (Long Spine Sea-urchin, <i>Echinothrix diadema</i> )	4	<b>2</b>	4	<b>&lt;1</b>
<b>Rori Pua</b> , (Flower Sea-cucumber, <i>Holothuria cinerascens</i> )	4	<b>1</b>	4	<b>2</b>
<b>Avake</b> , (Short Spine Sea-urchin, <i>Tripneustes gratilla</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Etu</b> , (Blue Starfish, <i>Linckia laevigata</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Paua</b> , (Rugose Giant Clam, <i>Tridacna maxima</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Rori Puakatoro</b> , (Red Surf-fish, <i>Actinopyga maurutiana</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Trochus</b> , ( <i>Trochus niloticus</i> )	4	<b>&lt;1</b>	4	<b>1</b>

The diversity of reef resources recorded at both sites was identical with 12 resources present. Percentage cover of resources showed similar results both inside and outside the reserve, Table 2.

**Figure 4 – Aroa Ra'ui Species Diversity**



#### 4.4 Dominant Resources

Table 2 and Figure 4 above indicate that both inside and outside the designated Ra'ui area the four most dominant resources are Kina, Matu rori, Rori matie and Rori toto.

##### 4.4.1 Inside Reserve

Kina and Matu rori characterise the Aroa Ra'ui with similar densities of 258 individuals/100 sq.m +/- 101 individuals (40%), and 247/100 sq.m +/- 72 individuals

(38%) respectively. Lower densities of Rori Matie, (54/100 sq.m +/- 41 individuals), and Rori toto, (52/100 sq.m +/- 25 individuals), were also present.

Matu rori shows the greatest population difference as inside the reserve the resource is over double the density outside at 247/100 sq.m inside the reserve compared to 108/100 sq.m outside.

The resources with the lowest density recorded were Rori Puakatoro, density of 1.3/100 sq.m, and Trochus with density averaging less than 1/100 sq.m.

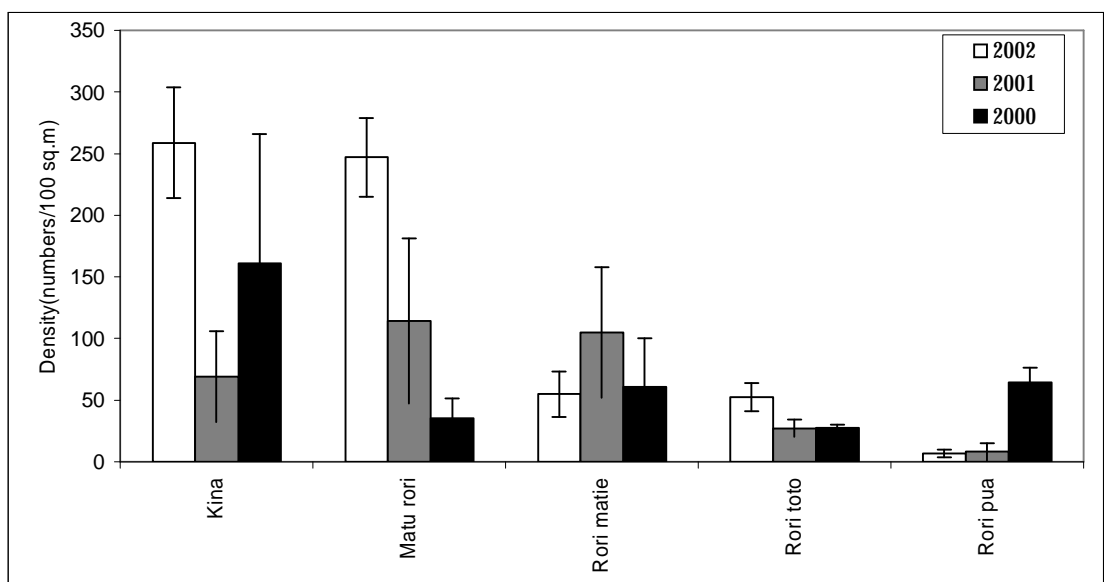
#### 4.4.2 Outside Reserve

Five resources are present at the control site at higher densities than occurred inside the *Ra'ui*, although still present at relatively low densities.

Rori toto's population density is 54/100 sq.m (+/-11 individuals), only 2 individuals/100sq.m higher than inside the reserve. Ungakoa is present with a density of 19/100 sq.m (+/- 19 individuals), compared to 8/100 sq.m (+/- 5) inside, Paua 2/100 sq.m (+/- 1) compared to 1.6/100 sq.m (+/- 1) inside, Etu 2.5/100 sq.m (+/- 1.5) compared to 1/100 sq.m inside, and Trochus with the marginally higher density of 5/100 sq.m (+/- 2) compared to less than 1/100 sq.m insider the reserve.

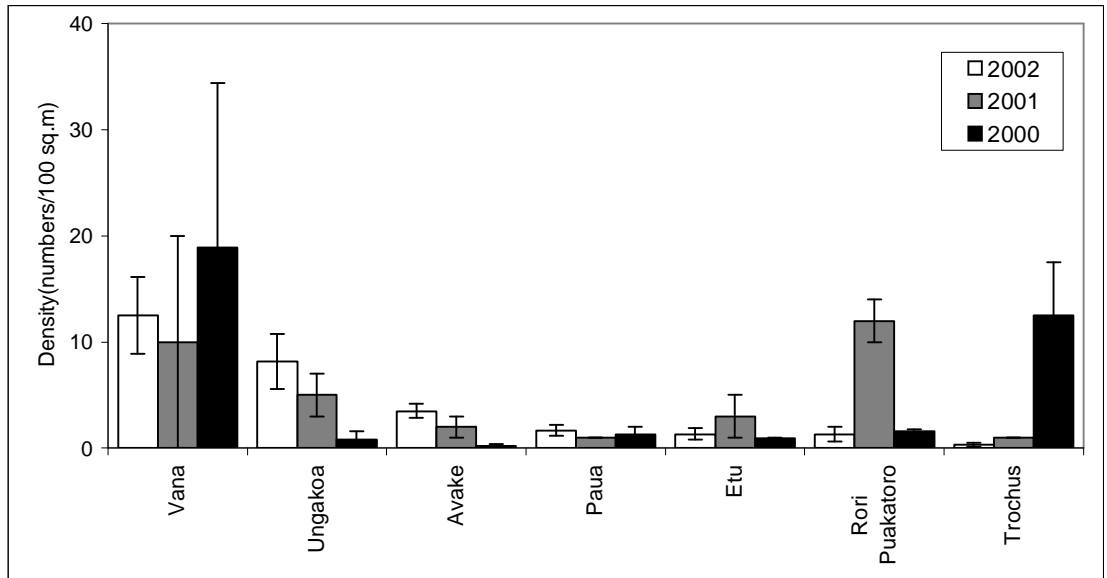
Kina is again the resource with the highest density at 227/100 sq.m (+/-40) and accounts for 48% of the resources surveyed. Matu rori is less dominant at 108/100 sq.m (+/- 18), accounting for 23 % of the resources, less than 50% of the population inside the reserve.

**Figure 5 –Highly Abundant Invertebrate Resources at Aroa *Ra'ui* 2000 – 2002**





**Figure 6 – Lesser Abundant Invertebrate Resources at Aroa Ra’ui 2000 –2002**



#### 4.5 Population Changes

In the baseline survey (Raumea et al 2000) thirteen species were recorded at Aroa Ra’ui. The First survey of the Ra’ui recorded twelve species, with no Paua being recorded, and again twelve species have been recorded, with the exclusion of Popoto, in this year’s survey. Since designation in 2000 the Aroa Ra’ui has been characterised by differing dominant species yearly.

The baseline survey, conducted in 2000 (Raumea et al 2000), indicated that the dominant resource was Kina with a population of 161/100 sq.m. In 2001 survey results the reserve was characterised by a high population of Matu rori, 114/100 sq.m and this year the dominant species has reverted back to Kina, at 258/100 sq.m, an increase of 60% on 2000 figures, Figure 5.

The Matu rori population has doubled since 2001 survey, whilst the population of Rori matie has decreased by 49%. The most significant change in population has occurred with Rori Pua. In 2000 survey the population of this resource was 64/100 sq.m compared to today’s survey result showing only 6.5/100 sq.m, (Appendix D).

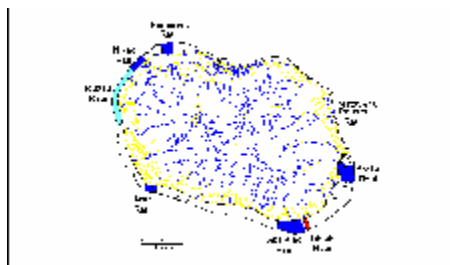
No significant changes in population have occurred for resources showing low densities in 2000 such as Ungakoa, Avake, Paua, Etu, Figure 6. The exception being Rori Puakatoro with a density increase six-fold in 2001 since the baseline survey in 2000. Density of this resource however was recorded in this survey as marginally lower, 1.3/100 sq.m, than the original figure recorded of 2/100 sq.m.

Trochus has also decreased significantly since the baseline survey where a density of 13/100 sq.m was recorded compared to an average of less than 1/100 sq.m in this years survey. This decrease can be accounted for as there was a Trochus harvest in 2000.

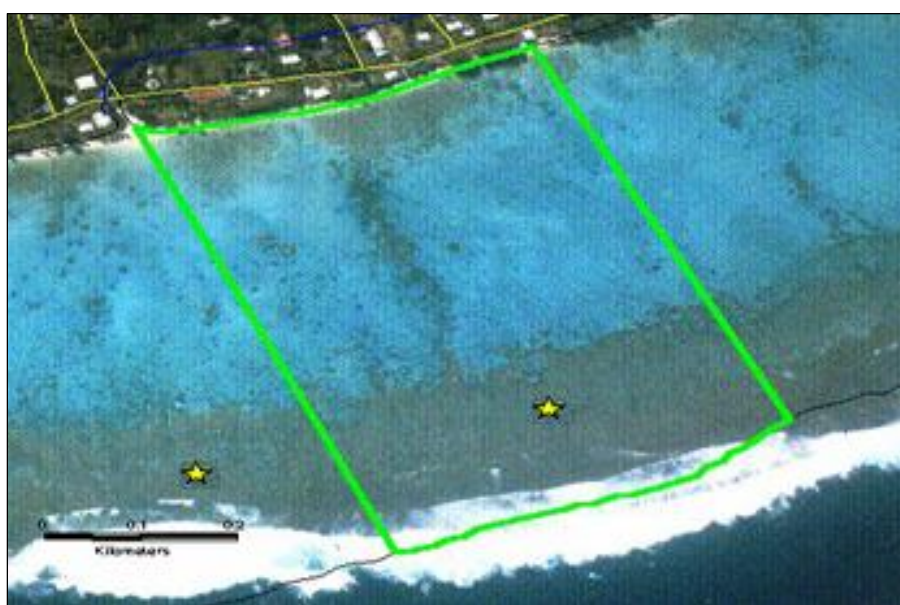
## 5.0 TIKIOKI RA'UI

### 5.1 Geographical description

Tikioki has a lagoon area of 47 hectares. The boundaries are at Tikioki road and the beach cargo. It is a very popular area for recreational users and for tour operators, (snorkelling, glass bottom boats).



**Map 4: Tikioki Ra'ui Survey Sites**



### 5.2 Current *Ra'ui* Status

At the time of surveying the *Ra'ui* had not been lifted.

### 5.3 Reef Resources

2 sites were surveyed, (Map 4). One site was located within the *Ra'ui* area, Fruits of Rarotonga, and the other site was located outside the boundary, as the control site, Beach Cargo. At each site 4 transects were surveyed

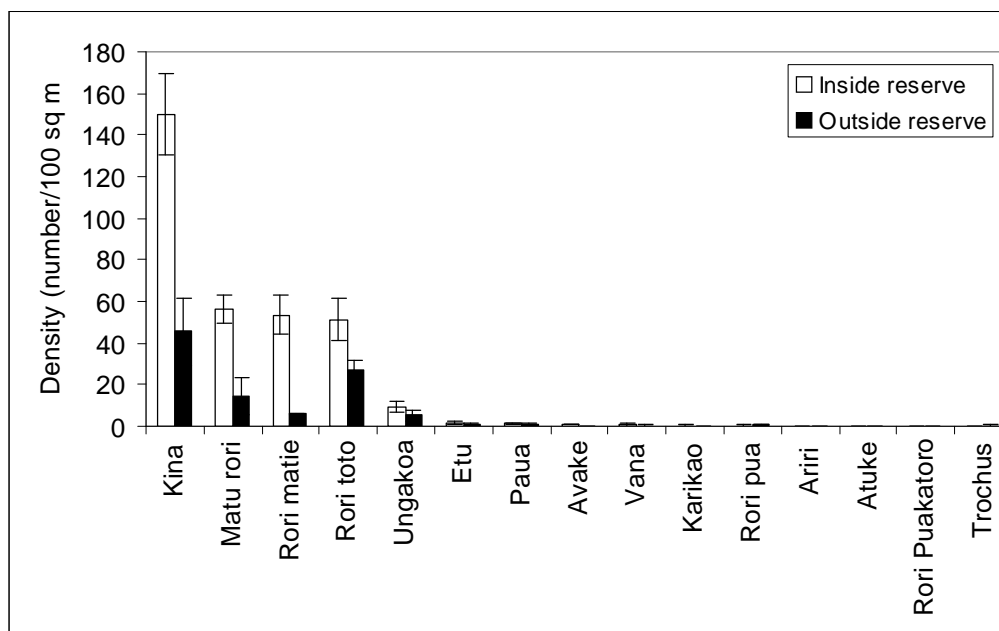
**Table 3: Tikioki Reef Resources**

Reef Resource	Inside Ra'ui	% of resource	Control site	% of resource
<b>Kina</b> , (Pink Sea-urchin, <i>Echinometra spp.</i> )	4	<b>46</b>	4	<b>45</b>
<b>Matu Rori</b> , (Soft Black Sea-cucumber, <i>Holothuria</i> )	4	<b>17</b>	4	<b>14</b>
<b>Rori Matie</b> , (Green Sea-cucumber, <i>Stichopus Chloronotus</i> )	4	<b>16</b>	4	<b>6</b>
<b>Rori Toto</b> , (Sandy Sea-cucumber, <i>Holothuria atra</i> )	4	<b>15</b>	4	<b>27</b>
<b>Ungakoa</b> , (Large Worm Snail, <i>Dendropoma maxima</i> )	4	<b>3</b>	4	<b>5</b>
<b>Avake</b> , (Short Spine Sea-urchin, <i>Tripneustes gratilla</i> )	4	<1		
<b>Etu</b> , (Blue Starfish, <i>Linckia laevigata</i> )	4	<1	4	<b>1</b>
<b>Karikao</b> , (Rose Mouthed Turban shell, <i>Astrea rhodostoma</i> )	4	<1		
<b>Paua</b> , (Rugose Giant Clam, <i>Tridacna maxima</i> )	4	<1	4	<b>1</b>
<b>Rori Pua</b> , (Flower Sea-cucumber, <i>Holothuria cinerascens</i> )	4	<1	4	<1
<b>Vana</b> , (Long Spine Sea-urchin, <i>Echinothrix diadema</i> )	4	<1	4	<1

With in Tikioki Ra'ui 11 reef resources were found, whilst at the control site only 9 were present, Table 3.

Percentage of individuals studied inside and outside the reserve show Kina as the dominant with 46% of the resources inside and 45% of the resources outside.

**Figure 7 – Tikioki Ra'ui Species Diversity**



#### 5.4 Dominant Resources

Table 3 and Figure 7 above indicate that the four most dominant resources inside the Ra'ui are, in density order, Kina, Matu rori, Rori matie and Rori toto. Outside the reserve,

at the control site, the most dominant, again in density order, are Kina, Rori toto, Matu rori and Rori matie.

#### 5.4.1 Inside reserve

Tikioki *Ra'ui* is characterised by Kina, with population of 150/100 sq.m (+/-38 individuals) and accounts for 46% of the resources surveyed. Matu rori, Rori matie and Rori toto display similar densities of 56/100 sq.m +/- 13, 53/100 sq.m +/- 18, and 51/100 sq.m +/-19 individuals respectively (see Appendix E).

Reserves with lower density recorded are Etu, Puaa, Avake, Vana, Karikao and Rori Pua with populations of less than 2/100 sq.m.

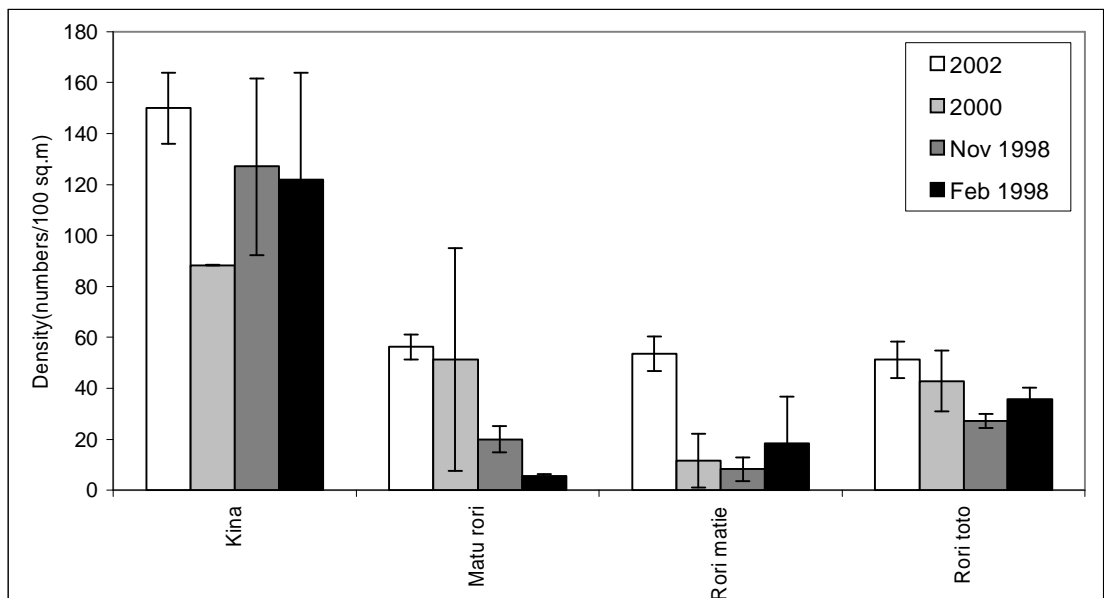
No population of *Trochus* were recorded inside the *Ra'ui*.

#### 5.4.2 Outside reserve

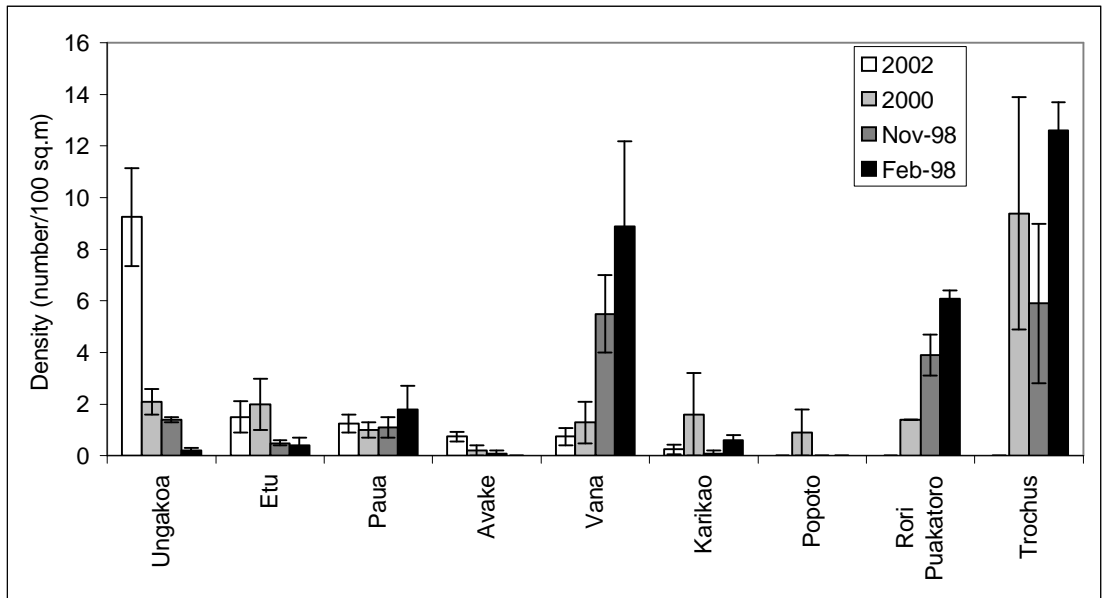
Lower densities of resources were present at the control site with the dominant species being Kina at 46/100 sq.m (+/- 31 individuals).

No resources at the control site display higher densities than inside the reserve.

**Figure 8 –Highly Abundant Invertebrate Resources at Tikioki *Ra'ui* 2000 – 2002**



**Figure 9 – Lesser Abundant Invertebrate Resources at Tikioki *Ra’ui* 1998-2002**



### 5.5 Population Changes

The baseline survey in 1998 (Ponia et al 1998) recorded 12 resources within the Tikioki *Ra’ui*. This survey recorded 11 resources, the difference being non-occurrence of *Mangeongoe*.

Since the initial baseline assessment in February 1998 Tikioki *Ra’ui* has been characterised by 4 dominant resources (see Figure 8). Of the four dominant resources *Kina* is the most dominant. The initial baseline survey recorded a density of 122/100 sq.m, with the resource increasing marginally in November 1998. Survey results in 2000 showed a marked decrease in the resource with a density of 87/100 sq.m. Density of *Kina* in 2002 is 150/100 sq.m, an increase of 42% on previous survey results (see Appendix F).

Other dominant resources, *Rori toto*, *Rori matie* and *Matu rori* all show an increase in density since the last survey, with *Rori matie* recorded as a 78% increase in density since 2000.

Resources present at lower densities, shown in Figure 9, occur at densities of less than 13/100 sq.m. Resources showing the most significant changes in density are *Ungakoa*, *Vana*, *Rori Puakatoro* and *Trochus*. With the exception of *Ungakoa* all these resources have decreased since the baseline survey. The density of *Ungakoa* has increased 4.5 times since surveying in 2000.

The density of *Trochus* has decreased significantly from the initial level recorded of 12.6/100 sq.m in 1998 baseline survey to 5.9/100 sq.m six months later. The density of

the resource showed an increase in 2000 rising to a level of 9.4/100 sq.m whilst this years survey results show no Trochus recorded in the *Ra'ui*.

Levels of Rori Puakatoro have also decreased since the baseline survey. A density of 6/100sq.m was recorded in 1998 (Ponia et al 1998) decreasing to a level of 1.4/100 sq.m in 2000 and no occurrence recorded of this resource in this years' survey.

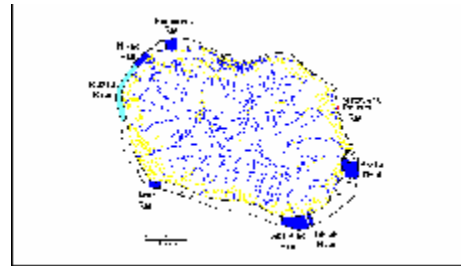
The density of Vana has also decreased since the initial baseline survey where a density of 8.9/100 sq.m was recorded compared to an average of >1/100 sq.m.

A density of Popoto was only recorded in surveying in 2000.

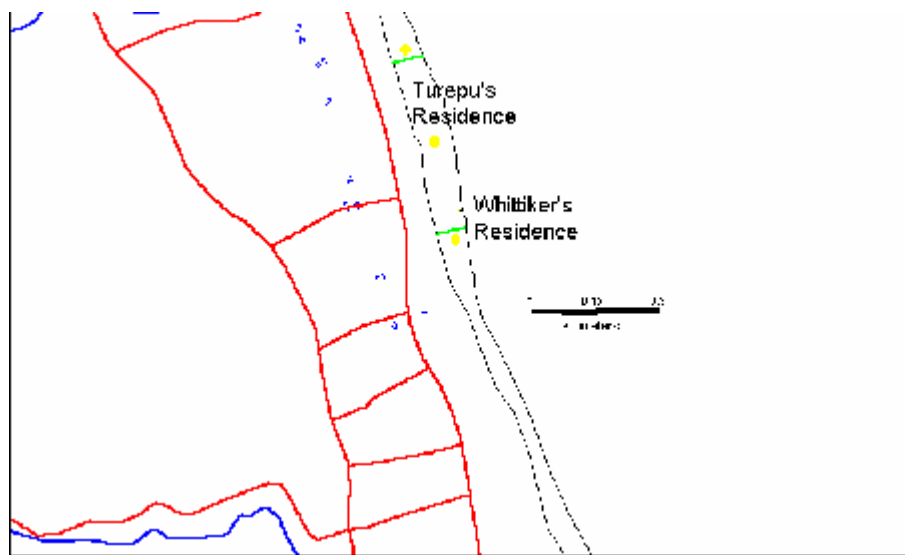
## 6.0 MATAVERA/POUARA RA'UI

### 6.1 Geographical description

Matavera *Ra'ui* is situated on the Eastern side of Rarotonga and is the smallest of all the *Ra'ui* areas, 5 hectares. It is almost entirely composed of coral reef sub-strata. Map 5 shows the boundaries in green and the sites surveyed yellow.



**Map 5: Matavera/Pouara *Ra'ui* Survey Sites**



### 6.2 Current *Ra'ui* Status

At the time of surveying *Ra'ui* had not been lifted.

### 6.3 Reef Resources

Of the 3 sites surveyed one site was located inside the *Ra'ui* area, and the other control sites were located either side of the *Ra'ui*. At each site 4 replicate transects were carried out.

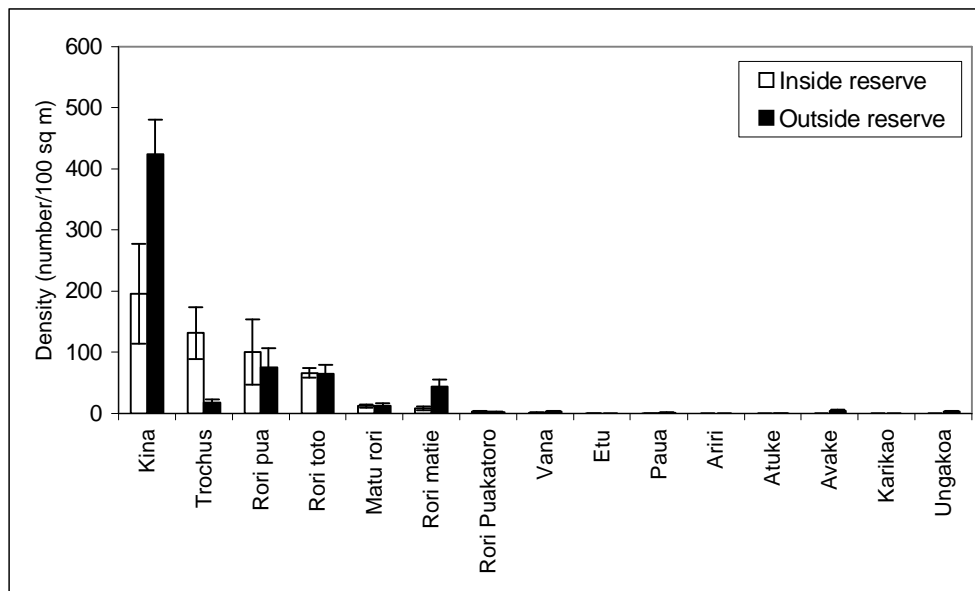


**Table 4: Matavera/Pouara Reef Resources**

Reef Resource	Inside Ra'ui	% of resource	Control site	% of resource
<b>Kina</b> , (Pink Sea-urchin, <i>Echinometra spp.</i> )	4	<b>38</b>	4	<b>65</b>
<b>Trochus</b> , ( <i>Trochus niloticus</i> )	4	<b>25</b>	4	<b>3</b>
<b>Rori Pua</b> , (Flower Sea-cucumber, <i>Holothuria cinerascens</i> )	4	<b>19</b>	4	<b>12</b>
<b>Rori Toto</b> , (Sandy Sea-cucumber, <i>Holothuria atra</i> )	4	<b>13</b>	4	<b>10</b>
<b>Matu Rori</b> , (Soft Black Sea-cucumber, <i>Holothuria</i> )	4	<b>3</b>	4	<b>2</b>
<b>Rori Matie</b> , (Green Sea-cucumber, <i>Stichopus Chloronotus</i> )	4	<b>&lt;2</b>	4	<b>7</b>
<b>Etu</b> , (Blue Starfish, <i>Linckia laevigata</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Paua</b> , (Rugose Giant Clam, <i>Tridacna maxima</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Rori Puakatoro</b> (Red Surf-fish, <i>Actinopyga mauritiana</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Vana</b> , (Long Spine Sea-urchin, <i>Echinothrix diadema</i> )	4	<b>&lt;1</b>	4	<b>&lt;1</b>
<b>Avake</b> , (Short Spine Sea-urchin, <i>Tripneustes gratilla</i> )			4	<b>&lt;1</b>
<b>Ariri</b> , (Rough Turban-shell, <i>Turbo setosus</i> )			4	<b>&lt;1</b>
<b>Atuke</b> , (Brown Pencil Sea-urchin, <i>Heterocentrotus mammillatus</i> )			4	<b>&lt;1</b>
<b>Ungakoa</b> , (Large Worm Snail, <i>Dendropoma maxima</i> )			4	<b>&lt;1</b>

Within the Ra'ui 10 reef resources were recorded compared to 14 resources found at the control sites, Table 4.

**Figure 10 – Matavera/Pouara Ra'ui Species Diversity**



#### 6.4 Dominant Resources

Table 4 and Figure 10 above indicate the four most dominant resources inside the Ra'ui as Kina, Trochus, Rori Pua and Rori toto. Outside the Ra'ui Kina is dominant.

### 6.4.1 Inside reserve

Kina accounts for 38% of resources surveyed (196/100 sq.m +/-160 individuals), Trochus 25%, (131/100 sq.m +/- 83), Rori Pua 19% and Rori toto 13%.

Resource density of Kina is 54% lower than outside the reserve.

Low densities of resources, Rori Puakatoro, Vana, Etu, Paua, and Ariri were recorded, with none of these resource exceeding 5/100 sq.m (see Appendix F).

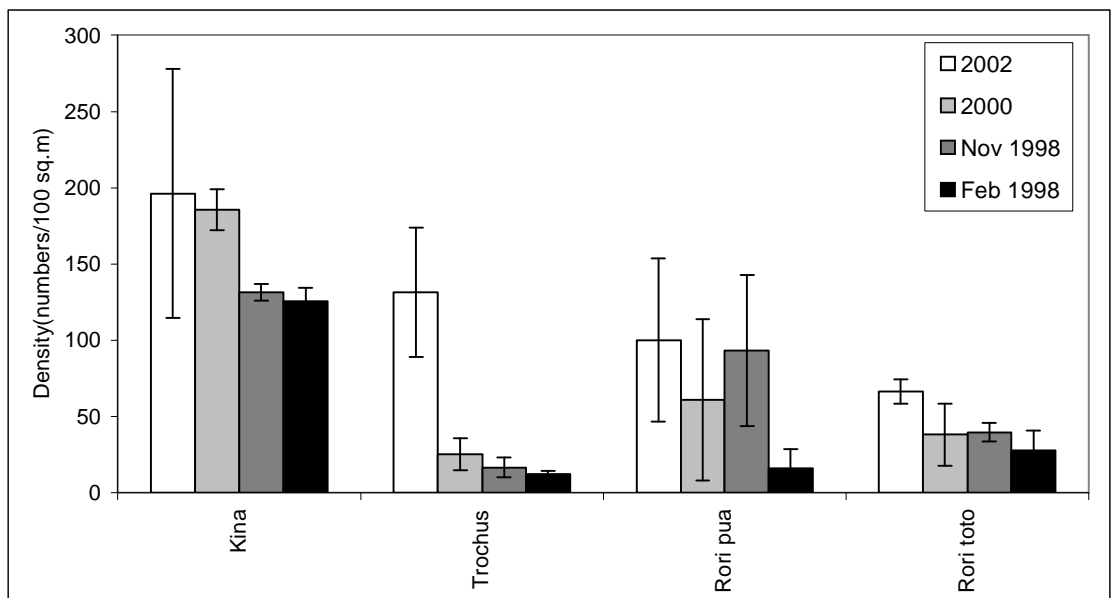
### 6.4.2 Outside reserve

A high density of Kina (423/100 sq.m) is present accounting for 65% of the resources surveyed. A low density of Trochus was found at 18/100 sq.m, accounting for just 3% of the resources.

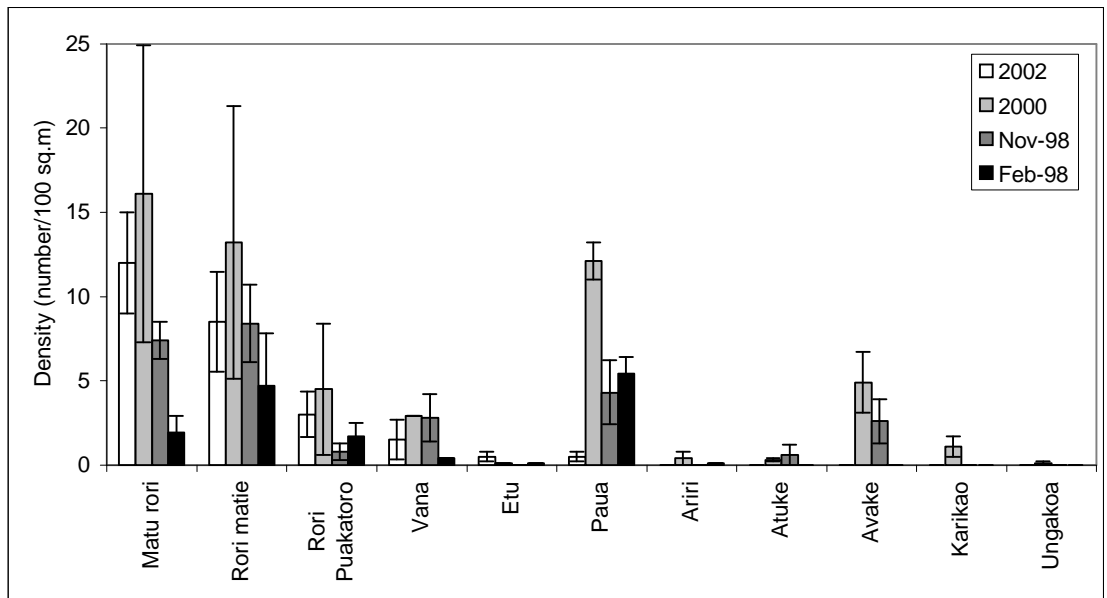
A higher densities of Rori matie, at 44/100 sq.m compared to 9/100 sq.m was also present.

A higher diversity of resources were present, although at low densities, outside the reserve with Ariri, Atuke, Avake, Karikao and Ungakoa occurring in addition to those inside the reserve.

**Figure 11 –Highly Abundant Invertebrate Resources at Matavera Ra’ui 1998 – 2002**



**Figure 12 – Lesser Abundant Invertebrate Resources at Matavera/Pouara Ra’ui 1998-2002**



## 6.5 Population Changes

Compared to the previous survey results (Ponia et al 2000) a lower species diversity was recorded at 10 species as opposed to 15 for the previous survey. Species not recorded during this survey are Ariri, Avake, Atuke, Ungakoa and Karikao.

Results show that 4 resources are dominant within the *Ra’ui*, (Figure 11). These are Kina, Trochus, Rori pua and Rori toto, with Kina being the most predominant with a density of 196/100 sq.m. The resource with the most significant increase in population is Trochus at a density of 131/100 sq.m as opposed to 25/100 sq.m during the previous survey (Ponia et al 2000). Roro toto shows a gradual increase from 27/100 sq.m in the initial baseline survey to 66/100 sq.m, (Appendix F).

Resources of lower density (under 25/100 sq.m) show significant changes since the baseline assessment in February 1998, (Figure 12).

The Sea cucumbers show the most varied changes. The density of Matu rori in 1998 was recorded as 1.9/100 sq.m, with the highest density recorded in 2000 at 16/100 sq.m, dropping to 12/100 sq.m in this year’s survey, a decrease of 25%.

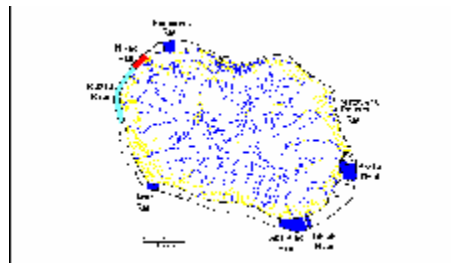
The density of Rori matie peaked in 2000 with a density of 13/100 sq.m recorded. Survey results this year show a 38% decrease in density to 8.5/100 sq.m.

Paua shows the greatest change since the last survey in 2000, as in 2000 the density of this resources was recorded at 12/100 sq.m whilst this year’s survey results indicate a significantly lower density of, on average, 0.5/100 sq.m, a decrease of 96% of the resource.

## 7.0 NIKAO RA'UI

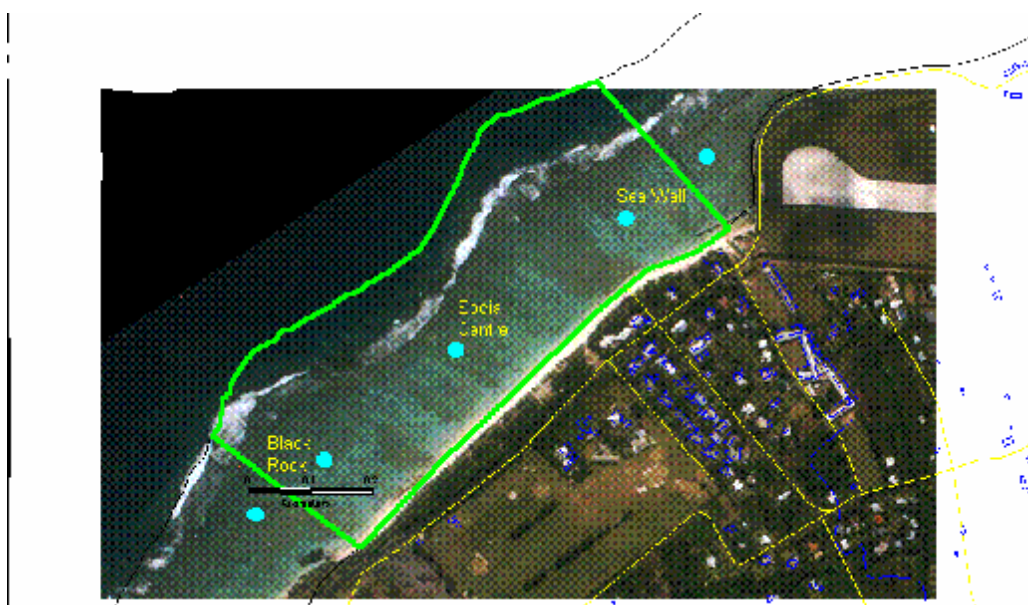
### 7.1 Geographical description

Nikao *Ra'ui* is situated on the North-Western side of the Island, encompasses a lagoon area of 25 hectares, comprising of a loose aggregation of coral reef patch reefs (Ponia and Raumea 1998), and a beachfront of 800 meters. The area is one of the most popular public beaches.



Map 6 below shows the boundary outlined in green with the survey sites highlighted in blue.

**Map 6: Nikao *Ra'ui* Survey Sites**



### 7.2 Current *Ra'ui* Status

At the time of surveying the *Ra'ui* had not been lifted, however 3 weeks prior to surveying the *Ra'ui* was lifted for one day, Easter Monday, 1<sup>st</sup> April 2002.

### 7.3 Reef Resources

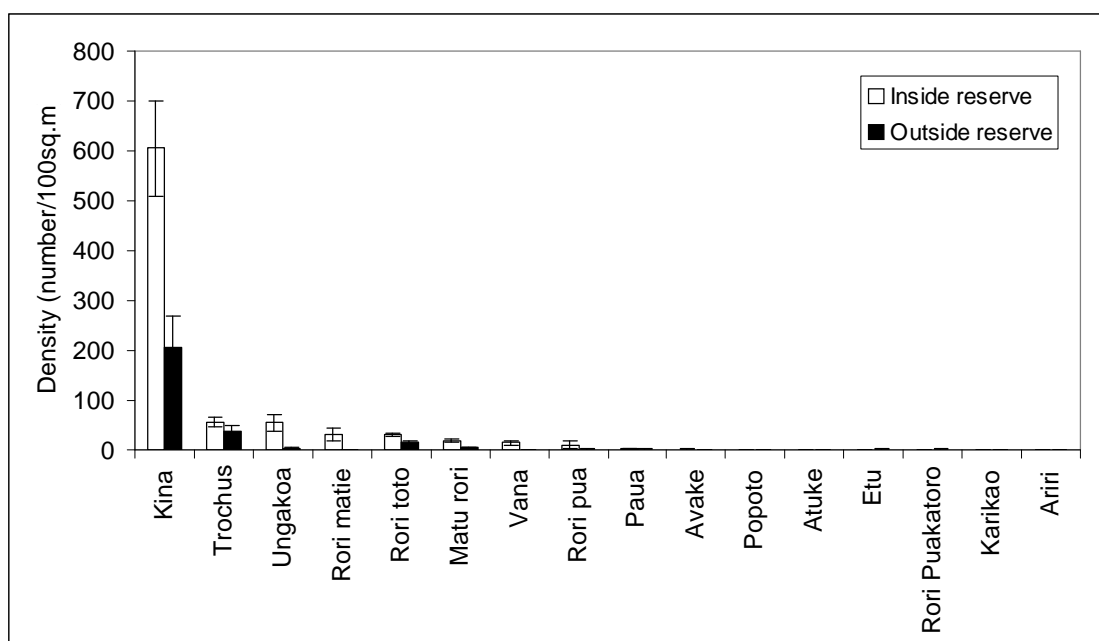
In total 5 sites were surveyed, two outside the *Ra'ui* as control sites and three inside, (see Map 6 above)

**Table 5: Nikao Reef Resources**

Reef Resource	Inside Ra'ui	% of resource	Control site	% of resource
<b>Kina</b> , (Pink Sea-urchin, <i>Echinometra spp.</i> )	4	<b>73</b>	4	<b>75</b>
<b>Ungakoa</b> , (Large Worm Snail, <i>Dendropoma maxima</i> )	4	<b>8</b>	4	<2
<b>Trochus</b> , ( <i>Trochus niloticus</i> )	4	<b>6</b>	4	<b>14</b>
<b>Rori Matie</b> , (Green Sea-cucumber, <i>Stichopus Chloronotus</i> )	4	<b>5</b>	4	<1
<b>Rori Toto</b> , (Sandy Sea-cucumber, <i>Holothuria atra</i> )	4	<b>3</b>	4	<b>6</b>
<b>Matu Rori</b> , (Soft Black Sea-cucumber, <i>Holothuria</i> )	4	<b>2</b>	4	<b>2</b>
<b>Rori Pua</b> , (Flower Sea-cucumber, <i>Holothuria cinerascens</i> )	4	<2	4	<1
<b>Vana</b> , (Long Spine Sea-urchin, <i>Echinothrix diadema</i> )	4	<b>2</b>	4	<1
<b>Avake</b> , (Short Spine Sea-urchin, <i>Triplonotus gratilla</i> )	4	<1	4	<1
<b>Atuke</b> , (Brown Pencil Sea-urchin, <i>Heterocentrotus Mammillatus</i> )	4	<1		
<b>Etu</b> , (Blue Starfish, <i>Linckia laevigata</i> )	4	<1	4	<1
<b>Karikao</b> , (Rose mouthed Turban-shell, <i>Astrea rhodostoma</i> )	4	<1		
<b>Paua</b> , (Rugose Giant Clam, <i>Tridacna maxima</i> )	4	<1	4	<1
<b>Popoto</b> , ( <i>Conus ebraeus</i> )	4	<1		
<b>Rori Puakatoro</b> (Red Surf-fish, <i>Actinopyga mauritiana</i> )	4	<1	4	<1

15 resources were present inside the Ra'ui and 12 outside the Ra'ui, (Table 5).

**Figure 13 – Nikao Ra'ui Species Diversity**



#### 7.4 Dominant Species

Table 5 and Figure 13 above indicate Kina as the dominant resource, accounting for a high percentage of the resources both inside and outside of the reserve, 73% and 75% respectively.

### 7.4.1 Inside reserve

Kina characterises the reserve with a population of 605/100 sq.m (C.I +/-185 individuals) and accounts for 73% of the reserves surveyed. Lower densities of the resources Trochus, Ungakoa Rori matie and Rori toto were recorded with Trochus accounting for only 6%, Ungakoa 8%, Rori matie 5% and Rori toto 3% of resources.

Populations of less than 5/100 sq.m were present for the reserves Paua, Avake, Popoto, Atuke, Etu, Rori Puakatoro, Karikao and Ariri .

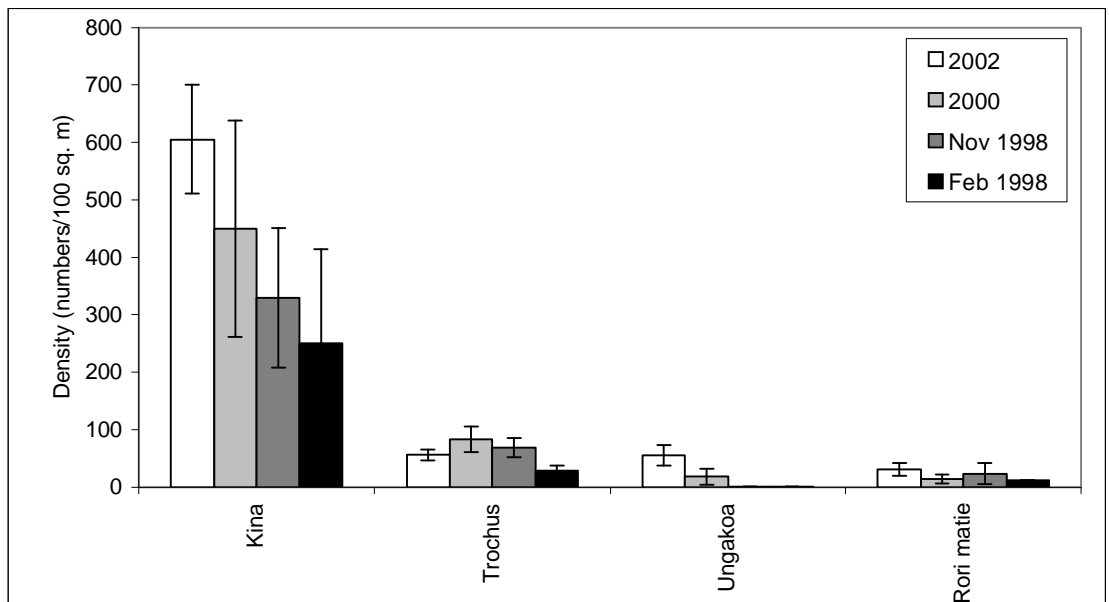
### 7.4.2 Outside reserve

Density of resources was considerably lower than inside the reserve. Again, the most dominant was Kina with a population of 205/100 sq.m (C.I +/-122 individuals) accounting for 75% of resources surveyed.

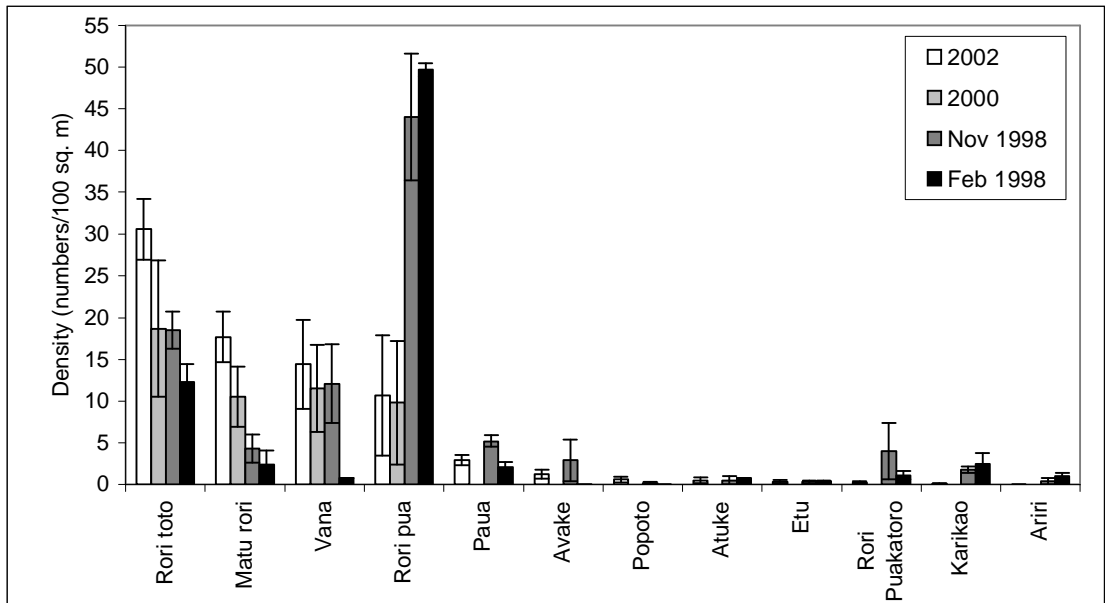
Atuke, Karikao and Popoto were not present in the survey area outside the reserve.

Results of surveying in this *Ra'ui* are relatively low due to the *Ra'ui* being lifted and reinstated prior to surveying.

**Figure 14 –Highly Abundant Invertebrate Resources at Nikao *Ra'ui* 1998 – 2002**



**Figure 15 –Lesser Abundant Invertebrate Resources at Nikao *Ra’ui* 1998 –2002**



## 7.5 Population Changes

Changes in diversity of resources found in the *Ra’ui* since the baseline survey in 1998 have occurred. The baseline survey and 2000 survey recorded 13 resources, whilst to date 15 resources were recorded (Appendix G).

Since the baseline survey in 1998 the dominant resource remains the same, Kina, although present survey results indicate a much higher density of the resource at 605/100 sq.m as opposed to 251/100 sq.m in 1998, and 450/100 sq.m in 2000 (Figure 14).

Trochus populations have fluctuated from 28/100 sq.m in the baseline survey peaking in 2000 at 83/100 sq.m and falling to the present result of 56/100 sq.m.

The density of the resource Ungakao has increased since the baseline survey where a density of 1/100 sq.m was recorded. Results in 2000 indicate an increase of 94% and on 2000 figures the increase this year has been 67%, with a density of 55/100 sq.m recorded.

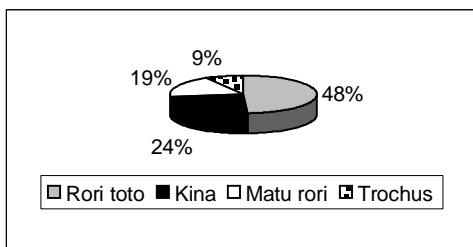
Densities of Rori Pua have shown the greatest decrease since the baseline survey (Figure 15). Density of this resource have dropped 80% to a level of 10/100 sq.m recorded this year. This however could possibly be explained due to the fact that this resource tends to inhabit the area of reef near the wave break and therefore surveying is made difficult on days of high wave surge, which in turn would mean a low level are recorded.

## 8.0 DISCUSSION AND CONCLUSION

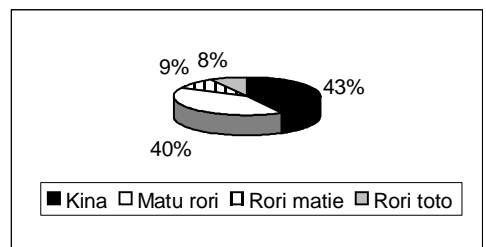
The invertebrate stocks within the *Ra'ui* areas are dominated by a handful of species (Figure 16). With the exception of Aroko *Ra'ui* the dominant species is Kina accounting for, 79%, 48%, 43%, and 40% of the resources present at Nikao, Tikioki, Aroa and Matavera respectively. The dominant species at Aroko *Ra'ui* is Rori Toto accounting for 48% of the resources present.

**Figure 16: Dominant Resources**

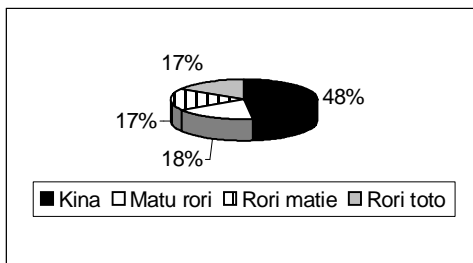
### Aroko



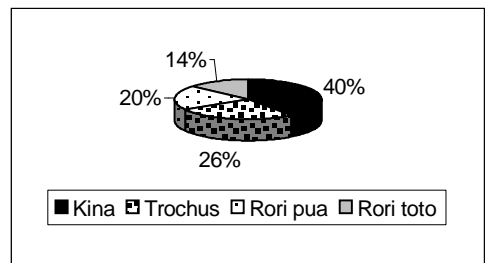
### Aroa



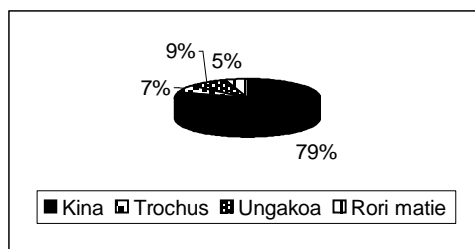
### Tikioki



### Matavera/Pouara



### Nikao



At Aroko *Ra'ui* the lagoon is largely comprised of sand or sandbanks and sand/rubble (Ponia and Raumea 1998) which can account for the high densities of Rori Toto recorded.



Other dominant invertebrate resource types at Aroko, Matavera/Pouara and Nikao include Trochus. Rori pau was recorded as a dominant species only at Matavera *Ra'ui*, whilst Ungakoa was recorded as a dominant species at Nikao *Ra'ui*.

Overall Nikao *Ra'ui* recorded the highest densities of species.

Control sites surveyed at each *Ra'ui* area yielded interesting sets of results. At all *Ra'ui*'s results obtained showed that higher densities of each resource were found within the reserve, and therefore seems to indicate that the *Ra'ui* is working as a means of increasing invertebrate stocks.

Since the previous survey, (Ponia et al 2000), there have been noticeable changes in the density levels of the resources at each *Ra'ui*. In summary the changes are as follows:

- 1) **Aroko *Ra'ui***: Five-fold increase in density of Rori toto, density of Kina has doubled, Matu rori has increased 4.5 fold, whilst Rori pau has decreased in density by 40%.
- 2) **Tikioki *Ra'ui***: Increase in Kina by 42%, Rori matie increased 78%. Vana has decreased twelve-fold, Rori puakatoro and Trochus were not present in the *Ra'ui*.
- 3) **Matavera *Ra'ui***: Five-fold increase in Trochus density, 96% decrease in Paua resource.
- 4) **Nikao *Ra'ui***: 25% increase in density of Kina, 37% increase in Rori toto, three-fold increase in density of Ungakoa. Density of Matu rori has increased by 50%.

Since the previous survey (Raumea et al 2001):

- 5) **Aroa *Ra'ui***: An almost four-fold increase in Kina density, doubling of population of Matu rori, and density of Rori puakatoro has decreased nine-fold.

Sub-strata of survey areas is an important factor to consider when assessing the results and it is necessary to take into account the preferred habitat of the individual species. Rori toto, Matu rori and Rori matie are benthic feeders, therefore in areas of high cover of sand along the transects one would expect higher numbers of these species. In some cases transect lines running over rocky substrate yielded high levels of Kina and low populations of Rori toto, Matu rori and Rori matie. At the Tikioki *Ra'ui* the non-occurrence of species such as Rori puakatoro and Trochus at the transect lines cannot be interpreted that the species does not exist within the *Ra'ui* but simply that at the points of surveying these species were not present.

Results indicated that the high densities of the sand dwelling species such as, Matu rori, Rori toto, resulted largely from a high percentage cover of sand along the transect lines. This is reflected in the 95% CI calculated for each resource as in some cases confidence interval is low due to the spread of resources. At some transect sites no resources or very low numbers of species were present. In cases where a species was not recorded this does not indicate that the resource was no longer present but simply could be explained due to transect lines not covering enough of a variety of sub-strata within the *Ra'ui*.

Low-recorded densities of the species that inhabit the wave surge area such as Rori pau, at Nikao can perhaps be attributed to surveying difficulties. On days of high wave surge surveyors experienced problems in counting and recording the species accurately. In addition to Rori pau, Ariri and Atuke also inhabit the wave surge area of the reef and therefore the area surveyed does not perhaps cover enough of their habitat to gain a true record of density of the resource within the reserve. The results therefore obtained for these resources are low which can be attributed to biased survey methodology.

Also, at the Nikao *Ra'ui*, transects yielding the lowest densities of resources were located in areas where there was a high percentage cover of coral rubble and bare sandy patches.

Another factor affecting survey results at Aroa are that the *Ra'ui* area boundary commences directly after the stream inlet. The water quality near the shore is affected in that it is very turbid and consequently fewer species were recorded at this transect site as opposed to those recorded nearer the far boundary.

Nikao *Ra'ui* has the highest densities recorded out of all the *Ra'ui* areas surveyed, even though the *Ra'ui* was lifted for one day three weeks prior to surveying. Resources present were, overall, still present at higher levels than previously recorded in 2000 (Raumea et al 2000).

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## APPENDIX A - CHRONOLOGY

Baseline assessment of <i>Ra'ui</i> Areas	1998	Ponia, B., and Raumea, K.
Matavera <i>Ra'ui</i> designated	1998	
Aroko <i>Ra'ui</i> designated	1998	
Tikioki <i>Ra'ui</i> designated	1998	
Nikao <i>Ra'ui</i> designated	1998	
First Monitoring Survey of Rarotonga <i>Ra'ui</i>	Nov 1998	Ponia, B., Raumea, K., and Turua, T.
Second Monitoring Survey of Rarotonga <i>Ra'ui</i>	2000	
Parliament <i>Ra'ui</i>	2000	
Aroa <i>Ra'ui</i> designated	May 2000	
First Monitoring Survey of Aroa <i>Ra'ui</i>	2001	Raumea, K., Roi, N., Turua, T., Makikiriti, N.
Third Monitoring Survey of Rarotonga <i>Ra'ui</i>	April 2002	Saywood, A., Makikiriti, N., Turua, T.

**APPENDIX B -  
PERCENTAGE RESOURCES RECORDED AT EACH RA'UI**

<b>MATAVERA</b>					<b>AROA</b>				
	<i>INSIDE</i>	%	<i>OUTSIDE</i>	%		<i>INSIDE</i>	%	<i>OUTSIDE</i>	%
Kina	785	<b>38</b>	3390	<b>65</b>	Kina	1553	<b>40</b>	1362	<b>48</b>
Trochus	526	<b>25</b>	144	<b>2.8</b>	Matu rori	1482	<b>38</b>	653	<b>23.2</b>
Rori pua	400	<b>19</b>	607	<b>11.6</b>	Rori matie	329	<b>8.5</b>	255	<b>9</b>
Rori toto	265	<b>13</b>	522	<b>10</b>	Rori toto	314	<b>8</b>	324	<b>11.5</b>
Matu rori	48	<b>2.5</b>	100	<b>1.9</b>	Vana	75	<b>2</b>	4	<b>0.2</b>
Rori matie	34	<b>1.6</b>	354	<b>6.8</b>	Ungakoa	49	<b>1.3</b>	116	<b>4.1</b>
Rori	12	<b>0.6</b>	18	<b>0.4</b>	Rori pua	39	<b>1</b>	37	<b>1.3</b>
Puakatoro					Avake	21	<b>0.5</b>	8	<b>0.3</b>
Vana	6	<b>0.3</b>	24	<b>0.5</b>	Paua	10	<b>0.3</b>	14	<b>0.5</b>
Etu	2	<b>0.1</b>	2	<b>0.04</b>	Etu	8	<b>0.2</b>	15	<b>0.5</b>
Paua	2	<b>0.1</b>	13	<b>0.3</b>	Rori Puakatoro	8	<b>0.2</b>	8	<b>0.4</b>
Ariri	0	<b>0</b>	2	<b>0.04</b>	Trochus	2	<b>0.05</b>	28	<b>1</b>
Atuke	0	<b>0</b>	3	<b>0.06</b>	Ariri	0		0	
Avake	0	<b>0</b>	35	<b>0.7</b>	Atuke	0		0	
Karikao	0	<b>0</b>	0	<b>0</b>	Karikao	0		0	
Ungakoa	0	<b>0</b>	27	<b>0.5</b>		3890		2824	
	2080		5241						
<b>AROKO</b>					<b>TIKIOKI</b>				
	<i>INSIDE</i>	%	<i>OUTSIDE</i>	%		<i>INSIDE</i>	%	<i>OUTSIDE</i>	%
Rori toto	1897	<b>41</b>	278	<b>58</b>	Kina	600	<b>46</b>	182	<b>45.3</b>
Kina	914	<b>19.6</b>	62	<b>13</b>	Matu rori	225	<b>17.3</b>	56	<b>14</b>
Matu rori	727	<b>15.6</b>	24	<b>5</b>	Rori matie	214	<b>16.5</b>	23	<b>6</b>
Trochus	332	<b>7.2</b>	25	<b>5</b>	Rori toto	205	<b>15.8</b>	109	<b>27</b>
Rori pua	309	<b>6.6</b>	33	<b>7.1</b>	Ungakoa	37	<b>2.9</b>	20	<b>5</b>
Rori matie	218	<b>4.7</b>	48	<b>10</b>	Etu	6	<b>0.5</b>	4	<b>1</b>
Rori	91	<b>2</b>	8	<b>1.7</b>	Paua	5	<b>0.4</b>	4	<b>1</b>
Puakatoro					Avake	3	<b>0.2</b>	0	<b>0</b>
Paua	64	<b>1.4</b>	0	<b>0</b>	Vana	3	<b>0.2</b>	1	<b>0.3</b>
Vana	60	<b>1.4</b>	1	<b>0.2</b>	Karikao	1	<b>0.07</b>	0	<b>0</b>
Etu	25	<b>0.5</b>	0		Rori pua	1	<b>0.07</b>	2	<b>0.5</b>
Ungakoa	18	<b>0.4</b>	0		Ariri	0		0	
Avake	8	<b>0.2</b>	0		Atuke	0		0	
Ariri	1	<b>0.02</b>	0		Rori Puakatoro	0		0	
Atuke	0		0		Trochus	0		1	<b>0.3</b>
Karikao	0		0			1300		402	
	4664		479						

<b>NIKAO</b>				
	<b>INSIDE</b>	<b>%</b>	<b>OUTSIDE</b>	<b>%</b>
Kina	5905	<b>73</b>	1642	<b>75</b>
Trochus	430	<b>6</b>	298	<b>14</b>
Ungakoa	631	<b>8</b>	25	<b>1.2</b>
Rori matie	358	<b>4.5</b>	2	<b>0.1</b>
Rori toto	244	<b>3</b>	129	<b>6</b>
Matu rori	167	<b>2.1</b>	47	<b>2.2</b>
Vana	154	<b>2</b>	4	<b>0.2</b>
Rori pua	122	<b>1.5</b>	12	<b>0.6</b>
Paua	26	<b>0.3</b>	10	<b>0.5</b>
Avake	15	<b>0.2</b>	2	<b>0.1</b>
Popoto	7	<b>0.09</b>	0	
Atuke	6	<b>0.07</b>	0	
Etu	2	<b>0.03</b>	11	<b>0.5</b>
Rori Puakatoro	1	<b>0.01</b>	11	<b>0.5</b>
Karikao	1	<b>0.01</b>	0	
Ariri	0		0	
	8069		2193	

**APPENDIX C –  
AROKO RA’UI**

Species	2002			2000			2000			Nov-98			Nov-98			Feb-98			Feb-98		
	Ave	S.e	100 m2	Ave	S.e	1 m2	Ave	S.e	Adjusted *	Ave	S.e	1 m2	Ave	S.e	Adjusted *	Ave	S.e	1 m2	Ave	S.e	Adjusted *
Rori toto	237.13	49.15	0.42	0.06	42	6.30	0.38	0.13	38	13.2	0.30	0.03	30	3.3							
Kina	114.25	15.61	0.57	0.33	57	33.1	0.29	0.02	29	1.5	0.00	0.00	0	0							
Matu rori	90.88	21.78	0.21	0.06	21	6.3	0.40	0.15	40	15.3	0.22	0.15	22	15.2							
Trochus	41.50	17.33	0.45	0.09	45	8.9	0.28	0.05	28	5.3	0.01	0.00	1	0.1							
Rori pua	38.63	15.35	0.63	0.25	63	25.1	1.00	0.45	100	44.6	1.60	0.37	160	36.6							
Rori matie	27.25	7.78	0.28	0.08	28	7.8	0.13	0.07	13.20	6.7	0.07	0.04	7	3.5							
Rori	11.38	4.80	0.06	0.02	6	2.4	0.05	0.01	4.50	0.7	0.06	0.01	6	0.7							
Puakatoro																					
Paua	8.00	1.76	0.10	0.02	10	2	0.06	0.02	6.00	2	0.07	0.02	7	2.2							
Vana	7.50	2.84	0.09	0.04	9	3.7	0.05	0.01	4.50	0.6	0.01	0.00	1	0.3							
Etu	3.13	1.51	0.05	0.05	5	4.6	0.01	0.01	1.30	0.6	0.00	0.00	0	0							
Ungakoa	2.25	1.66	0.03	0.02	3	2	0.02	0.01	1.90	1.4	0.00	0.00	0	0							
Avake	1.00	0.73	0.03	0.01	3	1.3	0.01	0.00	0.60	0.3	0.00	0.00	0	0							
Airi	0.13	0.13	0.00	0.00	0	0.00	0.00		0.00	0	0.00	0.00	0	0.1							
Karikao	0.00	0.00	0.06	0.06	6	6.2	0.00	0.00	0.00	0	0.00	0.00	0	0							
Popoto	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0.10	0.1	0.00	0.00	0	0							

\* Values adjusted in order to correlate with 2002 figures (per 100m<sup>2</sup>)

**APPENDIX D -  
AROA RA'UI**

Species	2002 100 m2		2001 1 m2		2001 Adjusted *		2000 1 m2		2000 Adjusted *	
	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e
Kina	258.83	44.96	0.69	0.37	69	37	1.61	1.05	161	104.8
Matu rori	247.00	31.97	1.14	0.67	114	67	0.35	0.16	35	15.9
Rori matie	54.83	18.48	1.05	0.53	105	53	0.61	0.39	61	39.4
Rori toto	52.33	11.25	0.27	0.07	27	7	0.28	0.03	28	2.5
Rori pua	6.50	3.07	0.08	0.07	8	7	0.64	0.12	64	11.9
Vana	12.50	3.63	0.10	0.10	10	10	0.19	0.16	19	15.5
Ungakoa	8.17	2.57	0.05	0.02	5	2	0.01	0.01	1	0.8
Avake	3.50	0.66	0.02	0.01	2	1	0.00	0.00	0	0.2
Paua	1.67	0.53	0.01	0.00	1	0	0.01	0.01	1	0.7
Etu	1.33	0.53	0.03	0.02	3	2	0.01	0.00	1	0.1
Rori	1.33	0.70	0.12	0.02	12	2	0.02	0.00	2	0.2
Puakatoro										
Trochus	0.33	0.18	0.01	0.00	1	0	0.13	0.05	13	5

\* Values adjusted in order to correlate with 2002 figures (per 100m<sup>2</sup>)



APPENDIX E-  
TIKIOKI RA'UI

Species	2002		2000		2000		2000		Nov-98		Nov-98		Feb-98		Feb-98	
	100 m2		1 m2		Adjusted *		Adjusted *		Adjusted *		Adjusted *		Adjusted *		Adjusted *	
	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e	Ave	S.e
Kina	150.00	13.88	0.88	0.00	88.40	0.1	1.27	0.35	127.10	34.7	1.22	0.42	122.00	42		
Matu rori	56.25	4.95	0.51	0.44	51.30	43.8	0.20	0.05	19.90	5.2	0.05	0.01	5.40	0.9		
Rori matie	53.50	6.69	0.12	0.11	11.50	10.6	0.08	0.05	8.20	4.6	0.18	0.18	18.40	18.3		
Rori toto	51.25	7.14	0.43	0.12	42.80	11.9	0.27	0.03	27.10	2.7	0.36	0.05	35.70	4.6		
Ungakoa	9.25	1.90	0.02	0.01	2.10	0.5	0.01	0.00	1.40	0.1	0.00	0.00	0.20	0.1		
Etu	1.50	0.61	0.02	0.01	2.00	1	0.01	0.00	0.50	0.1	0.00	0.00	0.40	0.3		
Paua	1.25	0.34	0.01	0.00	1.00	0.3	0.01	0.00	1.10	0.4	0.02	0.01	1.80	0.9		
Avake	0.75	0.18	0.00	0.00	0.20	0.2	0.00	0.00	0.10	0.1	0.00	0.00	0.00	0		
Vana	0.75	0.34	0.01	0.01	1.30	0.8	0.06	0.02	5.50	1.5	0.09	0.03	8.90	3.3		
Karikao	0.25	0.18	0.02	0.02	1.60	1.6	0.00	0.00	0.10	0.1	0.01	0.00	0.60	0.2		
Popoto	0.00	0.00	0.01	0.01	0.90	0.9	0.00	0.00	0.00	0	0.00	0.00	0.00	0		
Rori	0.00	0.00	0.01	0.00	1.40	0	0.04	0.01	3.90	0.8	0.06	0.00	6.10	0.3		
Puakatoro																
Trochus	0.00	0.00	0.09	0.05	9.40	4.5	0.06	0.03	5.90	3.1	0.13	0.01	12.60	1.1		

\* Values adjusted in order to correlate with 2002 figures (per 100m<sup>2</sup>)

**APPENDIX F –  
MATAVERA  
RA’UI**

Species	2002			2000			2000			Nov-98			Nov-98			Feb-98			Feb-98		
	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	
Kina	196.25	81.73	1.85	185.40	13.5	13.5	1.32	0.06	0.06	131.60	5.5	5.5	1.25	0.09	0.09	125.40	8.8	8.8	125.40	8.8	
Trochus	131.50	42.50	0.25	25.10	10.5	10.5	0.17	0.06	0.06	16.50	6.4	6.4	0.12	0.02	0.02	12.30	1.8	1.8	12.30	1.8	
Rori pua	100.00	53.49	0.61	60.80	52.9	52.9	0.93	0.50	0.50	93.20	49.6	49.6	0.16	0.13	0.13	15.80	12.6	12.6	15.80	12.6	
Rori toto	66.25	8.08	0.38	38.00	20.5	20.5	0.40	0.06	0.06	39.50	6	6	0.28	0.13	0.13	27.60	13.3	13.3	27.60	13.3	
Matu rori	12.00	3.00	0.16	16.10	8.8	8.8	0.07	0.01	0.01	7.40	1.1	1.1	0.02	0.01	0.01	1.90	1	1	1.90	1	
Rori matie	8.50	2.96	0.13	13.20	8.1	8.1	0.08	0.02	0.02	8.40	2.3	2.3	0.05	0.03	0.03	4.70	3.1	3.1	4.70	3.1	
Rori	3.00	1.35	0.05	4.50	3.9	3.9	0.01	0.01	0.01	0.80	0.5	0.5	0.02	0.01	0.01	1.70	0.8	0.8	1.70	0.8	
Puakatoto																					
Vana	1.50	1.19	0.03	2.90	0	0	0.03	0.01	0.01	2.80	1.4	1.4	0.00	0.00	0.00	0.40	0	0	0.40	0	
Etu	0.50	0.29	0.00	0.10	0	0	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0.10	0	0	0.10	0	
Paua	0.50	0.29	0.12	12.10	1.1	1.1	0.04	0.02	0.02	4.30	1.9	1.9	0.05	0.01	0.01	5.40	1	1	5.40	1	
Ariri	0.00	0.00	0.00	0.40	0.4	0.4	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0.10	0	0	0.10	0	
Atuke	0.00	0.00	0.00	0.30	0.1	0.1	0.01	0.01	0.01	0.60	0.6	0.6	0.00	0.00	0.00	0.00	0	0	0.00	0	
Avake	0.00	0.00	0.05	4.90	1.8	1.8	0.03	0.01	0.01	2.60	1.3	1.3	0.00	0.00	0.00	0.00	0	0	0.00	0	
Karikao	0.00	0.00	0.01	1.10	0.6	0.6	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0.00	0	0	0.00	0	
Ungakoa	0.00	0.00	0.00	0.10	0.1	0.1	0.00	0.00	0.00	0.00	0	0	0.00	0.00	0.00	0.00	0	0	0.00	0	

\* Values adjusted in order to correlate with 2002 figures (per 100m<sup>2</sup>)

**APPENDIX G –  
NIKAO RA’UI**

Species	2002			2000			2000			2000			Nov-98			Nov-98			Feb-98			Feb-98				
	100 m2			1 m2			Adjusted *			Adjusted *			Adjusted *			Adjusted *			Adjusted *			Adjusted *				
	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e	Ave	S.e	S.e		
Kina	605.33	94.65	4.50	1.88	450	188	3.30	1.21	330	121.2	251	1.64	163.5	251	1.64	163.5	251	1.64	163.5	251	1.64	163.5	251	1.64	163.5	
Trochus	56.17	9.44	0.83	0.22	83	22.2	0.68	0.17	68	16.7	0.28	0.09	9.4	28	0.09	9.4	28	0.09	9.4	28	0.09	9.4	28	0.09	9.4	
Ungakoa	55.17	17.95	0.18	0.14	18	13.9	0.01	0.00	1	0.1	0.01	0.00	0	1	0.01	0	1	0.01	0	1	0.01	0	1	0.01	0	
Rori matie	30.67	11.56	0.14	0.08	14	8	0.24	0.18	24	18.1	0.12	0.00	0	24	0.12	0	24	0.12	0	24	0.12	0	24	0.12	0	
Rori toto	30.58	3.66	0.19	0.08	19	8.2	0.19	0.02	19	2.2	0.12	0.02	2.1	19	0.12	2.1	19	0.12	2.1	19	0.12	2.1	19	0.12	2.1	
Matu rori	17.67	3.02	0.11	0.04	11	3.6	0.04	0.02	4	1.7	0.02	0.02	1.7	4	0.02	1.7	4	0.02	1.7	4	0.02	1.7	4	0.02	1.7	
Vana	14.42	5.33	0.12	0.05	12	5.2	0.12	0.05	12	4.7	0.01	0.00	0	12	0.01	0	12	0.01	0	12	0.01	0	12	0.01	0	
Rori pua	10.67	7.20	0.10	0.07	10	7.4	0.44	0.08	44	7.6	0.50	0.01	0.8	44	0.50	0.8	44	0.50	0.8	44	0.50	0.8	44	0.50	0.8	
Paua	2.92	0.61	0.13	0.08	13	8.2	0.05	0.01	5	0.7	0.02	0.01	0.6	5	0.02	0.6	5	0.02	0.6	5	0.02	0.6	5	0.02	0.6	
Avake	1.25	0.55	0.09	0.06	9	5.5	0.03	0.03	3	2.5	0.00	0.00	0	3	0.00	0	3	0.00	0	3	0.00	0	3	0.00	0	
Popoto	0.58	0.34	0.01	0.00	1	0.3	0.00	0.00	0	0.1	0.00	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	0	0.00	0	
Atuke	0.50	0.36	0.01	0.01	1	0.5	0.01	0.01	1	0.5	0.01	0.01	0	1	0.01	0	1	0.01	0	1	0.01	0	1	0.01	0	
Etu	0.33	0.19	0.00	0.00	0	0.1	0.00	0.00	0	0.2	0.00	0.00	0.1	0	0.00	0.1	0	0.00	0.1	0	0.00	0.1	0	0.00	0.1	
Rori	0.25	0.13	0.01	0.00	1	0.2	0.04	0.03	4	3.4	0.01	0.01	0.5	4	0.01	0.5	4	0.01	0.5	4	0.01	0.5	4	0.01	0.5	
Puakatoro																										
Karikao	0.08	0.08	0.00	0.00	0	0.2	0.02	0.00	2	0.4	0.03	0.01	1.3	2	0.03	1.3	2	0.03	1.3	2	0.03	1.3	2	0.03	1.3	
Airi	0.00	0.00	0.00	0.00	0	0.1	0.00	0.00	0	0.4	0.01	0.00	0.4	0	0.01	0.4	0	0.01	0.4	0	0.01	0.4	0	0.01	0.4	

\* Values adjusted to correlate with 2002 figures (per 100m<sup>2</sup>)