Te Angiangi and Te Tapuwae o Rongokako Marine Reserves: Intertidal Paua and Kina Monitoring

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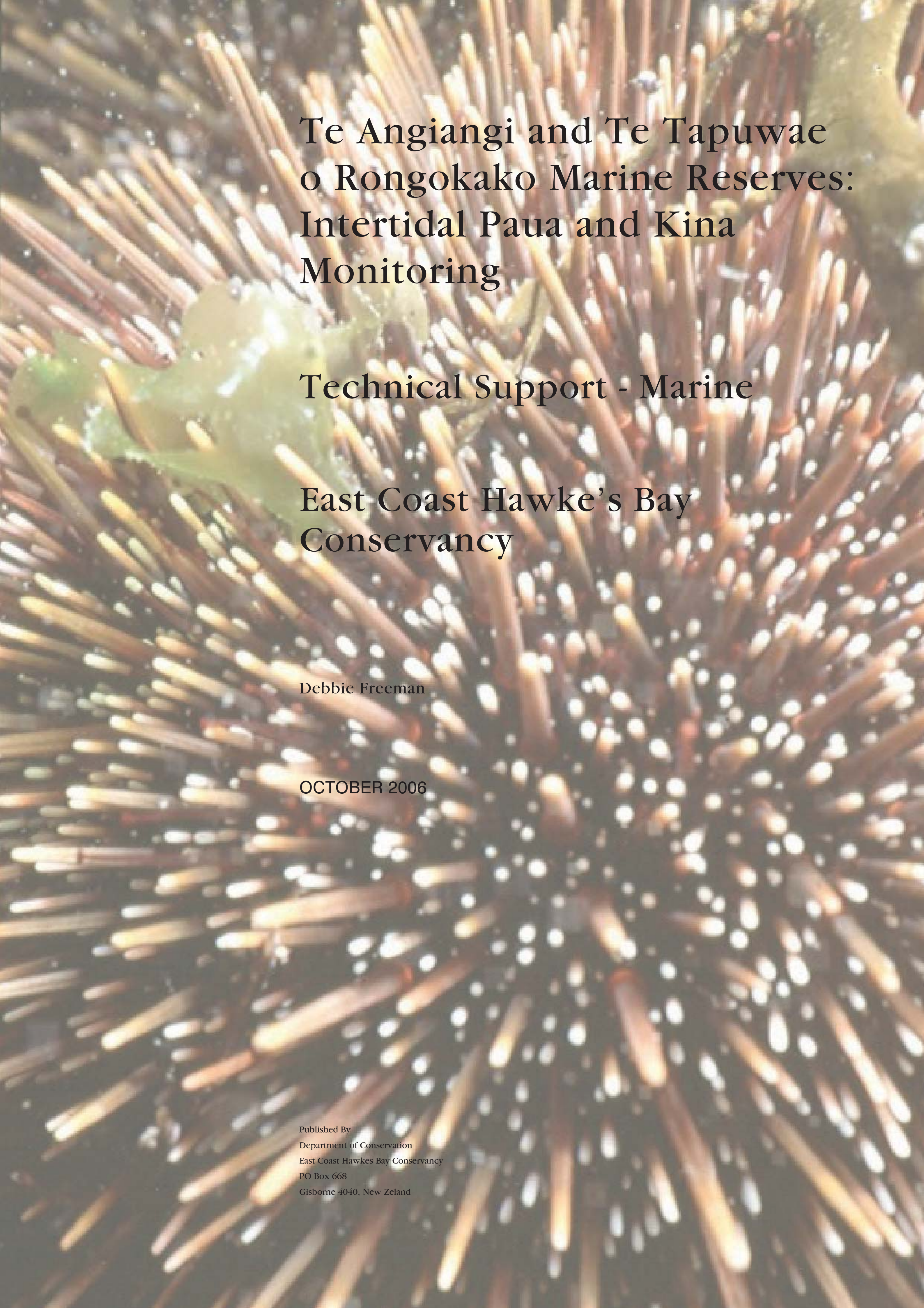
Department of Conservation
Te Papa Atawhai



Te Angiangi and Te Tapuwae o Rongokako Marine Reserves: Intertidal Paua and Kina Monitoring

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East Coast Hawke's Bay Conservancy

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Abstract

Between 1999 and 2003, intertidal populations of paua *(Haliotis spp)* and kina *(Evechinus chloroticus)* were monitored at sites within and outside two East Coast North Island marine reserves to establish whether these species were demonstrating any response to protection. Within both Te Angiangi and Te Tapuwae o Rongokako Marine Reserves, the densities of intertidal kina were low compared to their respective non-reserve sites, but a wider size range of kina was present within the reserves. Paua were more abundant within both reserves than their respective non-reserve sites, and paua within the reserves were also on average larger. The influence of hydrodynamics, recruitment variability, species interactions, available habitat and protection effects on the population dynamics of paua and kina are discussed.

Introduction

Abalone, or paua *(Haliotis spp)* and kina *(Evechinus chloroticus)* are important invertebrate grazer species in many of New Zealand's marine communities. There are three species of paua that occur in New Zealand waters – the black-foot paua *(Haliotis iris)*, the yellow-foot paua (Haliotis australis) and the white-foot paua *(Haliotis virginia)*. All except the latter species are harvested commercially from wild populations (Schiel 1992) and all three species are taken recreationally.

The black-foot paua is a shallow rocky reef species, being most abundant at less than 5 metres depth and occasionally being found down to 20 metres depth, but generally less than 10 metres (Walsby & Morton 1982, Schiel 1992, Annala & Sullivan 1996). The population dynamics, including the relative abundance and size composition of the paua, vary over small (hundreds of metres) spatial scales (Schiel & Breen 1992, McShane *et al* 1994a), but paua are generally larger and more abundant south of 41oS latitude (Schiel 1992) and legal (>125mm) paua are generally only found in pockets along the northern and central coasts of the North Island (Murray 1982). Juvenile paua live and feed beneath rocks and boulders, then move from these cryptic habitats when they are 60-70mm in length (3-5 years old) and have reached sexual maturity (Schiel 1992, McShane *et al* 1994b).

The kina *(Evechinus chloroticus)*, is an echinometrid echinoid, or sea urchin, endemic to New Zealand. It is found along the coasts of mainland New Zealand and inshore islands (Dix 1970), on shallow rocky reefs, cobbled areas and to a lesser extent, on sandy-muddy substrates (Andrew 1988). This species has also been recorded in the intertidal zone (Don 1975, Kerrigan 1987), but little has been published about the population dynamics or ecology of these intertidal populations of kina.

Evechinus chloroticus is accepted as playing an important role within many of New Zealand's subtidal reef communities. It grazes on a variety of algae, including the habitat-forming kelp *Ecklonia radiata*, and the relationship between kina and kelp has been the subject of much marine ecological research in New Zealand (for example Don 1975, Andrew 1982, Babcock *et al* 1999).

This report details the findings of monitoring intertidal paua and kina populations within and surrounding Te Angiangi and Te Tapuwae o Rongokako Marine Reserves, aimed at establishing whether populations of these species have demonstrated any response to protection.

SITE DESCRIPTIONS

Te Angiangi Marine Reserve is located on the Central Hawke's Bay coast, between Aramoana and Blackhead Beach (Figure 1). Established in 1997, it protects an area of 446 hectares and contains habitats that are representative of the Central Hawke's Bay coastal and marine environment (Department of Conservation 1994).

Te Tapuwae o Rongokako Marine Reserve was established in November 1999 as a result of a joint application between Ngati Konohi and the Director-General of the Department of Conservation (Department of Conservation 1998). It protects 2452 hectares of coastal and marine habitats that are representative of the coast between East Cape and Mahia Peninsula. It is located approximately 16 kilometres north of Gisborne, in the rohe moana of Ngati Konohi (Figure 2).

Both marine reserves are characterised by extensive intertidal reef platforms extending from headlands. These reef platforms support diverse assemblages of algae and invertebrates and are intersected with channels and pools which provide habitat for a range of intertidal and subtidal species (see cover photo).

Methods

In September 1999, monitoring of populations of kina *(Evechinus chloroticus)* and paua *(Haliotis spp)* in intertidal crevices and channels was initiated within and adjacent to Te Angiangi Marine Reserve (Department of Conservation 2001). 10 channels in the rocky reef platforms within the reserve and 10 at both Pourerere and Blackhead were sampled (Figure 1). In September 2000, 2001, 2002 and 2003 this survey was repeated, although on occasions some channels that were surveyed in 1999 could not be relocated and additional channels were surveyed instead.

The channels surveyed during the baseline survey of Te Tapuwae o Rongokako Marine Reserve and adjacent non-reserve locations (Freeman 2001) were resurveyed in October 2001, 2002 and 2003 (Figure 2). 10 channels were surveyed within the marine reserve: 3 at the Causeway (Tapuwaeorongokako Point), 5 along the sandstone rampart and 2 within the shallow moat area near Pariokonohi Point); 8 were surveyed at Makorori (3 within the shallow moat and 5 along the sandstone rampart) and 5 were surveyed at Turihaua Reef. 7 of the marine reserve channels were sampled in 2004, but adverse sea conditions prevented any of the non-reserve channels from being surveyed. Habitat descriptions are given in Freeman (2001).

Channels were identified using a handheld GPS and photographs. For each channel, all paua and kina were measured, either *in situ* or by carefully removing the animal. For kina, test diameter was recorded (to the nearest millimetre) and for paua, shell length was recorded (to the nearest millimetre).

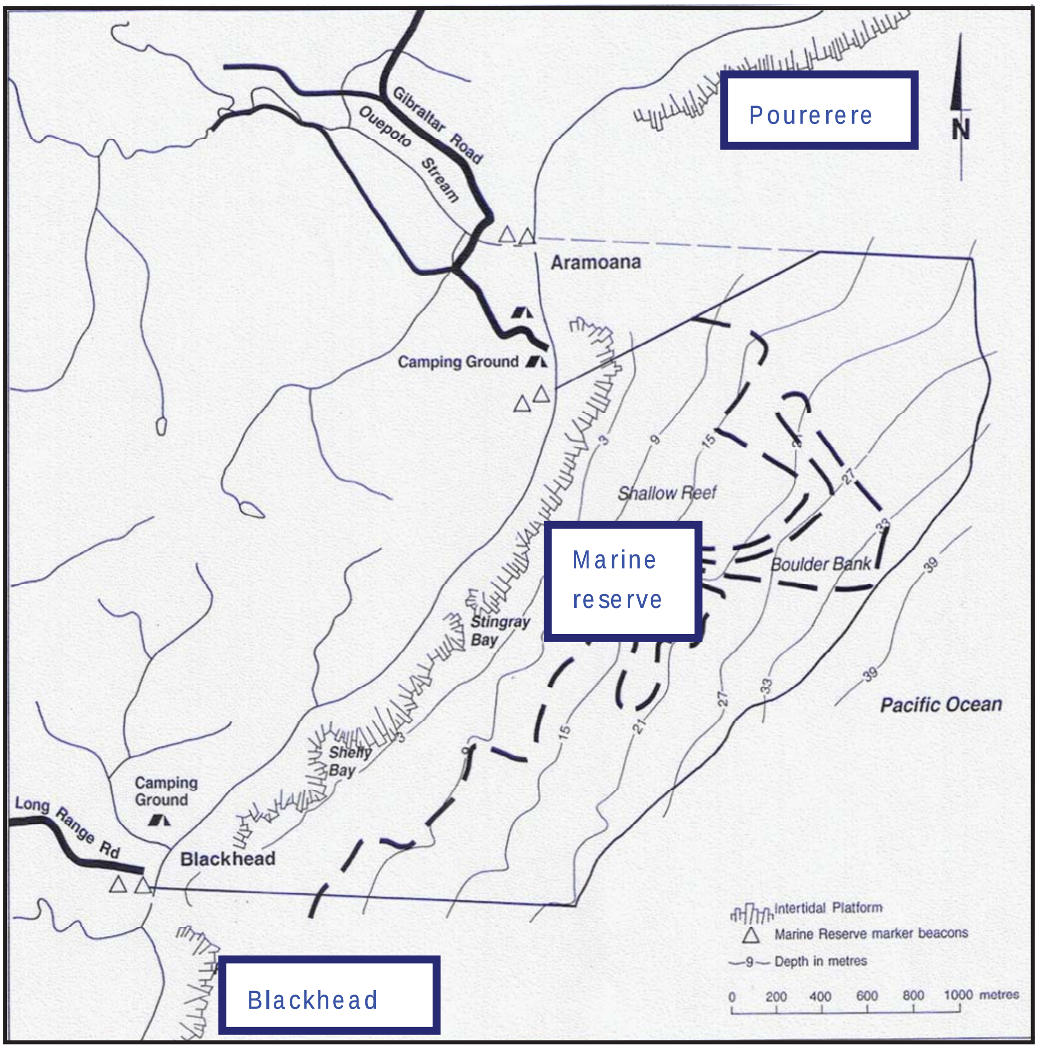

Figure 1. Intertidal reef platforms along the Central Hawke's Bay coast, surveyed for kina and paua populations. Channels through the intertidal reef platforms at Pourerere, Blackhead and within the marine reserve were surveyed.

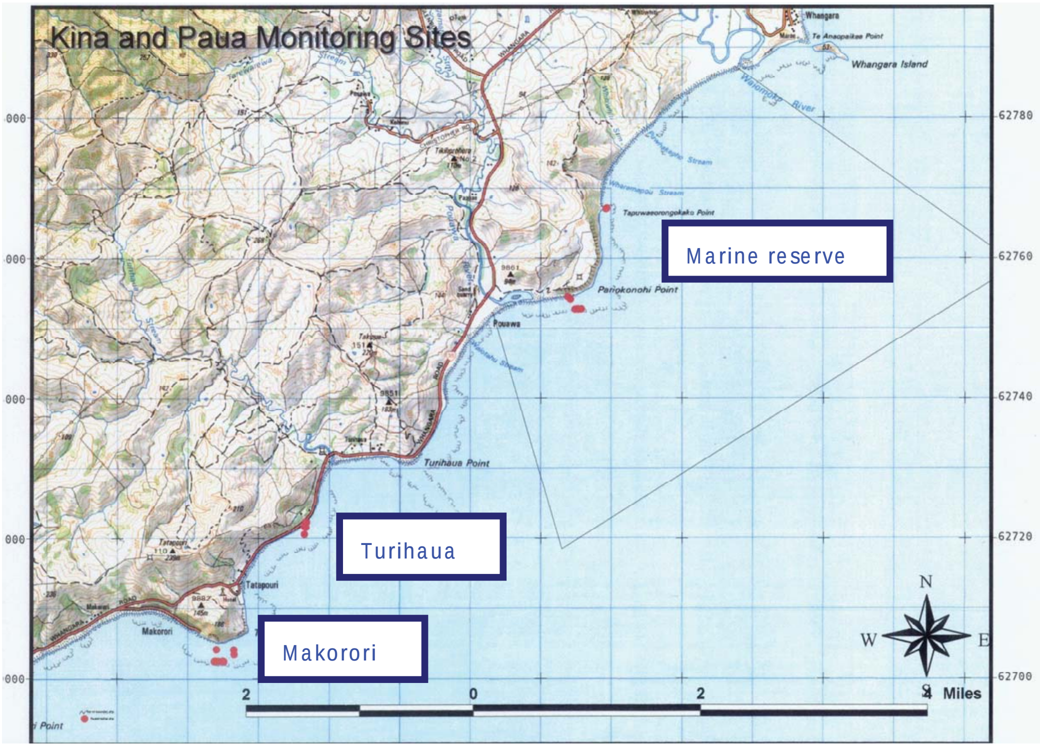

Figure 2. Locations surveyed near Gisborne for intertidal populations of paua and kina. Channels in the intertidal reef platforms within Te Tapuwae o Rongokako Marine Reserve and at Makorori and Turihaua were surveyed between 2000 and 2004.

Results

CENTRAL HAWKE'S BAY

Populations of paua and kina at the two non-reserve locations sampled (Blackhead and Pourerere) demonstrated very similar patterns over time in terms of both abundance and size frequency distribution. Between 1999 and 2001, the density of kina steadily increased at the two non-reserve locations and remained stable between 2001 and 2003 (Figure 3). In contrast, the density of kina within Te Angiangi Marine Reserve remained low and stable between 1999 and 2003.

The size frequency distributions of kina at Blackhead and at Pourerere were similar for each year sampling was undertaken and clear cohorts were apparent at these locations (Figure 4, Table 1). A particularly clear recruitment pulse was evident in 2000, where large numbers of kina of between 20 and 40mm test diameter were recorded. This affected the average size of kina at the non-reserve locations, with a significant decrease in average kina size between 1999 and 2000 (Figure 5). This recruitment pulse was less evident within the marine reserve that year. Since 2000, kina of a test diameter greater than 80mm comprised a greater proportion of the marine reserve population than of the two non-reserve populations.

The mean density of paua within Te Angiangi Marine Reserve was slightly higher than at the two non-reserve locations between 2000 and 2003, although there was considerable variability in the densities at all locations sampled (Figure 6).

A wide size range of paua was recorded at all three locations surveyed (Figure 7). During some years, the sample sizes were low but in general large paua of a shell length greater than 120mm were more common within the marine reserve than at the two non-reserve locations. The average size of paua within the marine reserve increased between 1999 and 2001 and remained relatively stable between 2001 and 2003 (Figure 5). In 2003, paua within the marine reserve were on average approximately 15mm larger than those outside the reserve.

Figure 3. Mean density of intertidal kina within Te Angiangi Marine Reserve and at Pourerere and Blackhead. Densities are given as the number of kina per metre of intertidal channel.

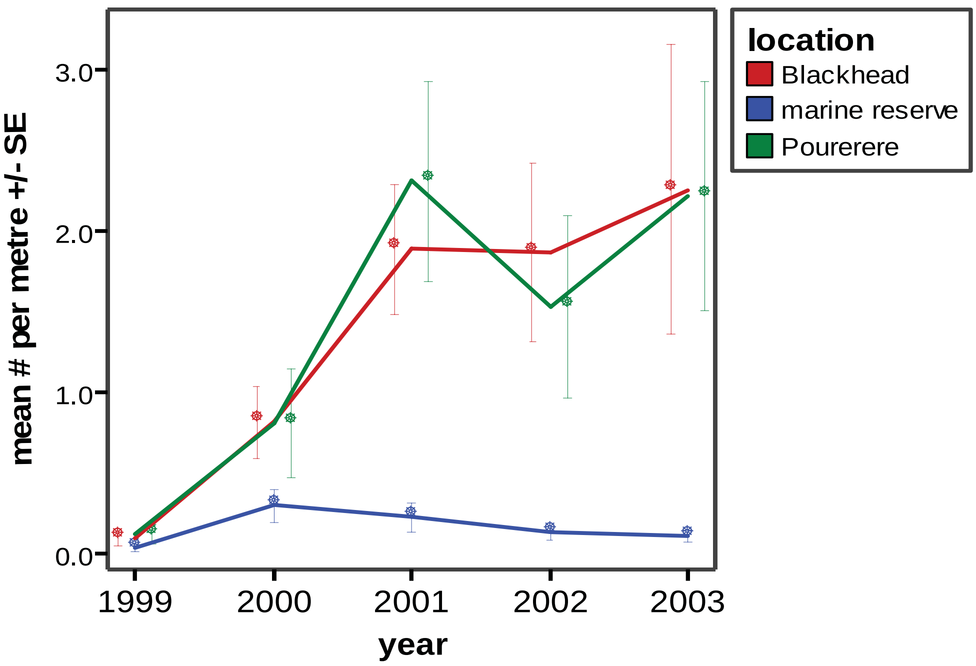

Figure 4. Size frequency distributions (% frequency) of intertidal kina within Te Angiangi Marine Reserve and at Pourerere and Blackhead. Sizes are test diameters. Sample sizes are given in Table 1.

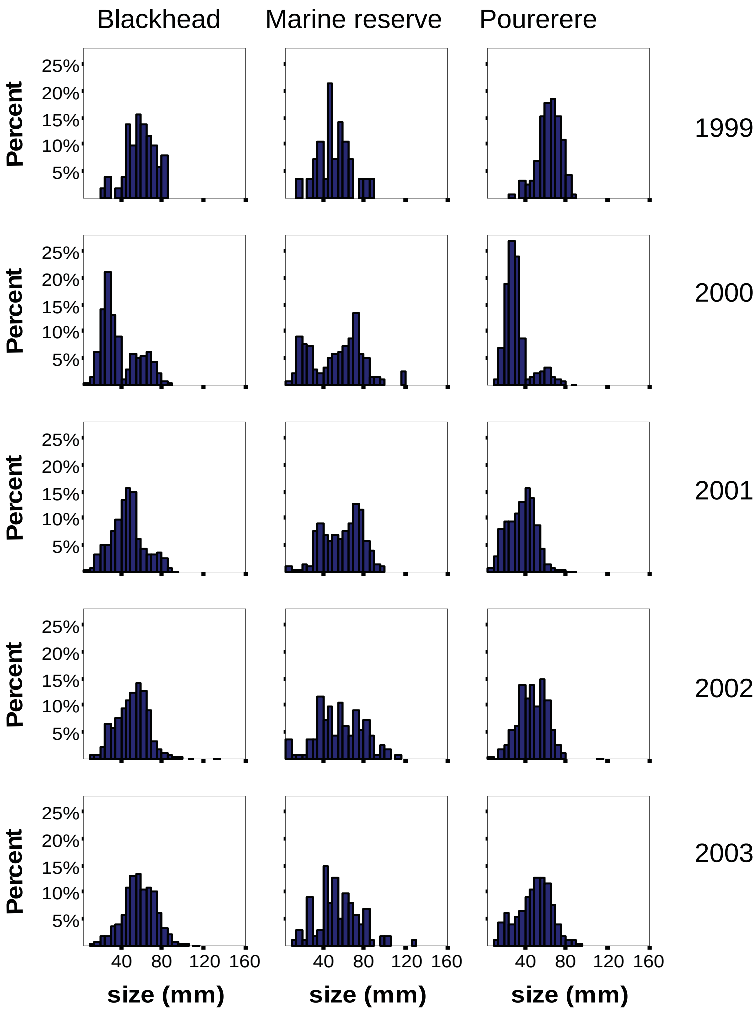

TABLE 1. SAMPLE SIZES FOR KINA POPULATIONS.

Year	Blackhead	Marine reserve	Pourerere
1999	51	28	118
2000	400	261	801
2001	1371	221	2266
2002	1109	112	590
2003	991	101	1717

Figure 5. Mean size of kina and paua within Te Angiangi Marine Reserve and at Pourerere and Blackhead between 1999 and 2003. For kina, sizes are test diameters; for paua, sizes are shell lengths.

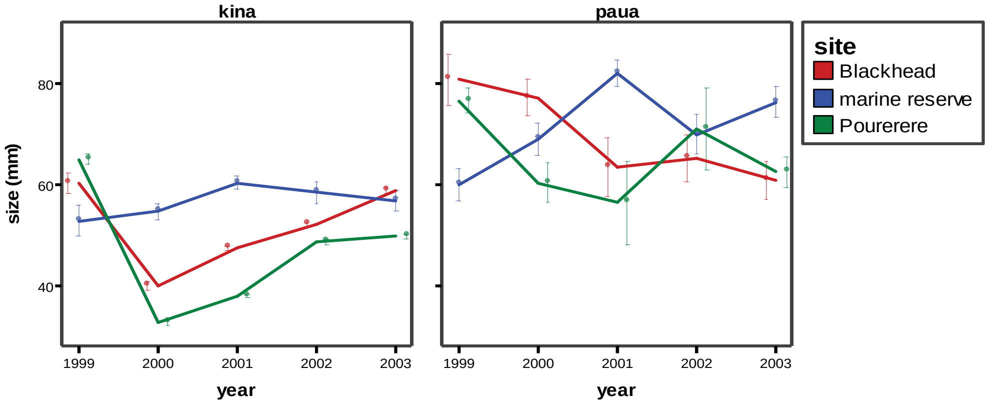

Figure 6. Mean density of paua within Te Angiangi Marine Reserve and at Pourerere and Blackhead between 1999 and 2003.

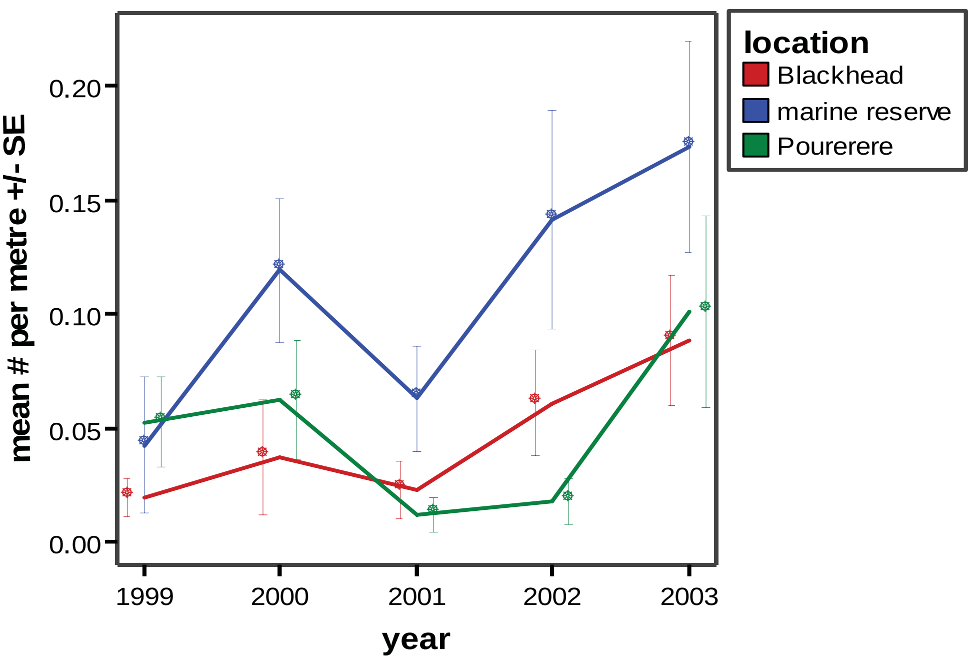

Figure 7. Size frequency distributions (% frequency) for intertidal paua populations within Te Angiangi Marine Reserve and at Pourerere and Blackhead between 1999 and 2003. Sample sizes are given in Table 2.

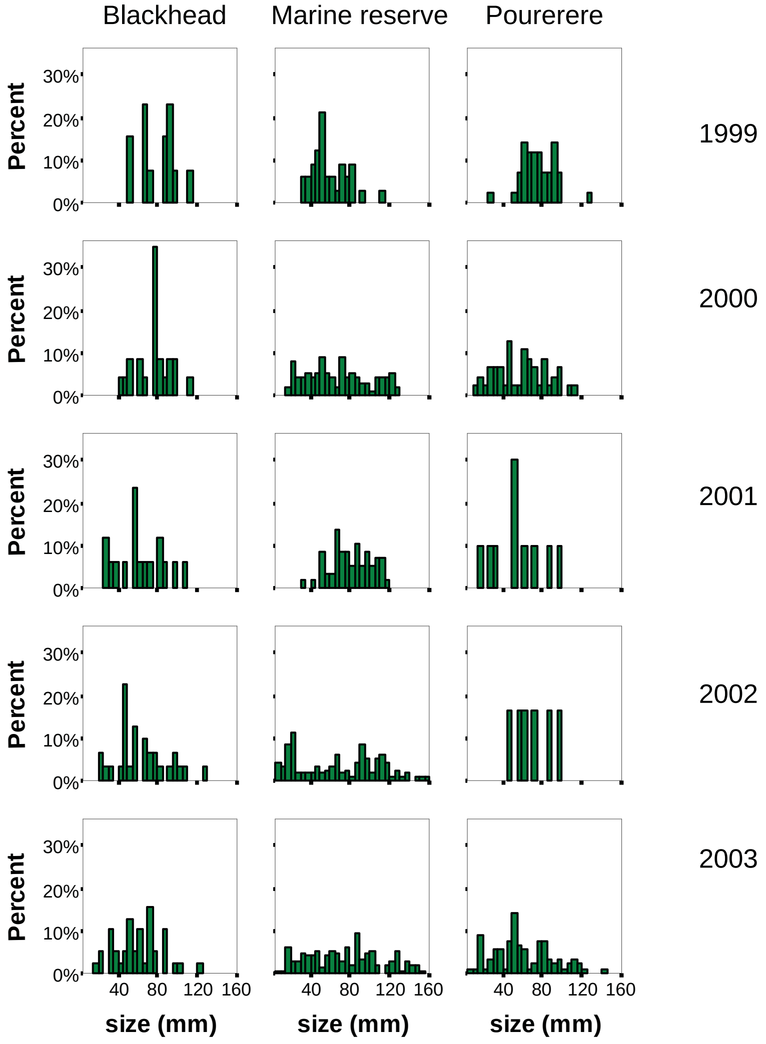

TABLE 2. SAMPLE SIZES FOR PAUA.

Year	Blackhead	Marine reserve	Pourerere
1999	13	33	42
2000	23	100	47
2001	17	58	10
2002	31	117	6
2003	39	149	91

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Between 2000 and 2002, the densities of kina were high and variable at both non-reserve locations, but particularly at Turihaua (Figure 8). The density of kina within the reserve remained low between 2000 and 2004 both on the reef platform and on the more complex habitat on the sandstone rampart on the seaward margin of the Pouawa reef platform and at the Causeway (Tapuwaeorongokako Point). Kina populations from Makorori and Turihaua were of a similar size frequency distribution, with both populations tending to be dominated by individuals of a test diameter between 20 and 60mm (Figure 9, Table 3). A wider size range of kina was sampled within the marine reserve, but there was little difference in the average size of kina within the reserve and at the non-reserve locations (Figure 10).

Despite availability of paua habitat at Makorori, only low densities of small paua were recorded at that location between 2000 and 2003 (Figure 10, 11). The density of paua increased within the marine reserve between 2000 and 2001, then remained stable from 2001 to 2004. Only in the marine reserve was the paua sample size large enough to enable analysis of size frequency distribution. A wide size range of paua was recorded, ranging from just a few millimetres in shell length to legal-sized animals (Figure 12).

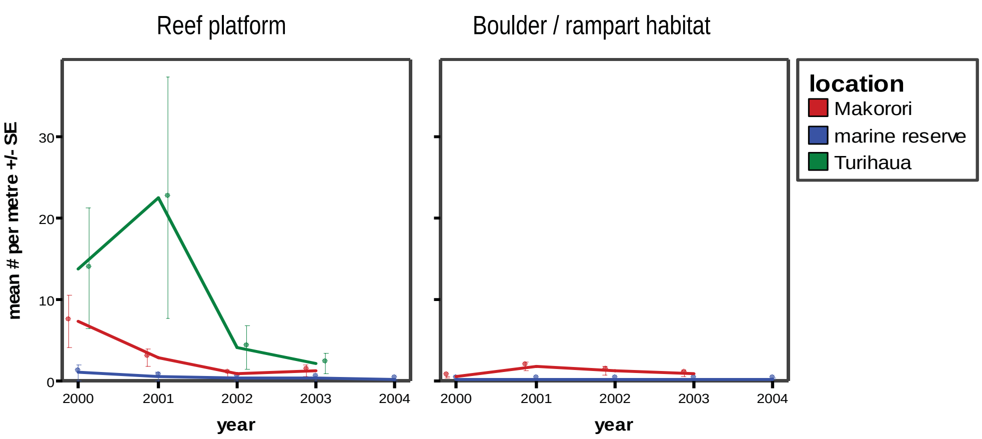


Figure 8. Density of intertidal kina within Te Tapuwae o Rongokako Marine Reserve and at Turihaua and Makorori. The graph on the left gives the mean density of kina on the flat intertidal reef platforms; the graph on the right gives the mean density on the more complex boulder and sandstone rampart habitats at Makorori and the reserve.

Figure 9. Size frequency distributions for kina within Te Tapuwae o Rongokako Marine Reserve and at Turihaua and Makorori. Sample sizes are given in Table 3.

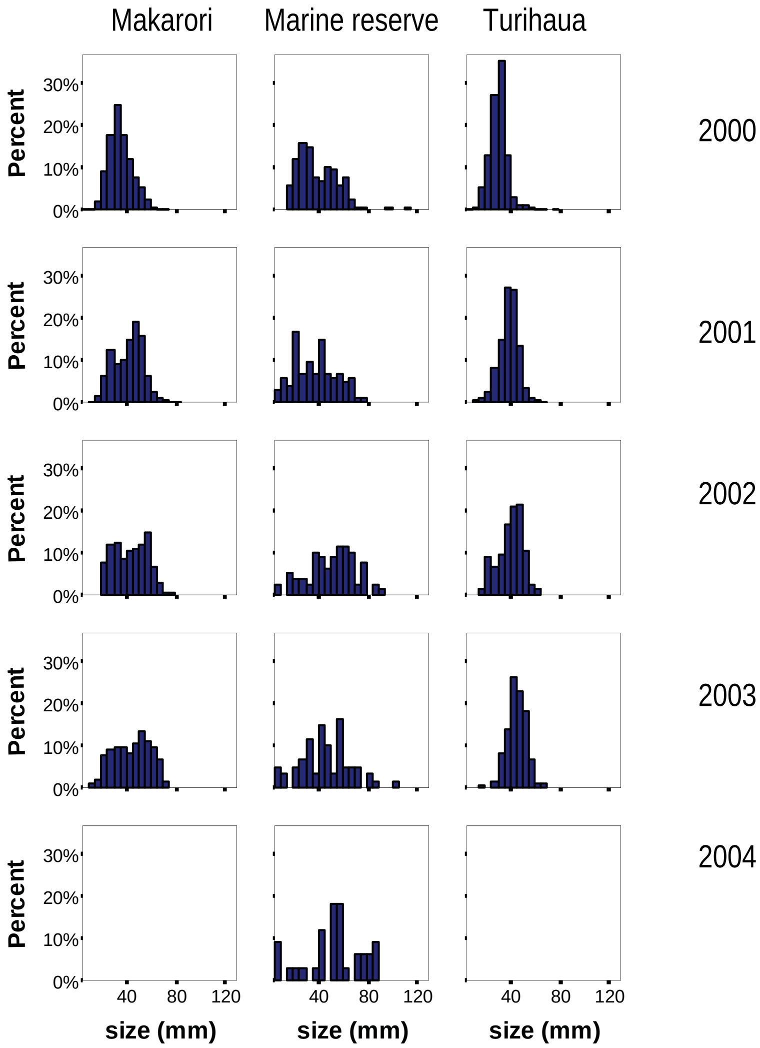


TABLE 3. SAMPLE SIZES FOR KINA.

Year	Makorori	Marine reserve	Turihaua
2000	697	160	1298
2001	481	102	1953
2002	215	78	332
2003	218	61	189
2004		33	

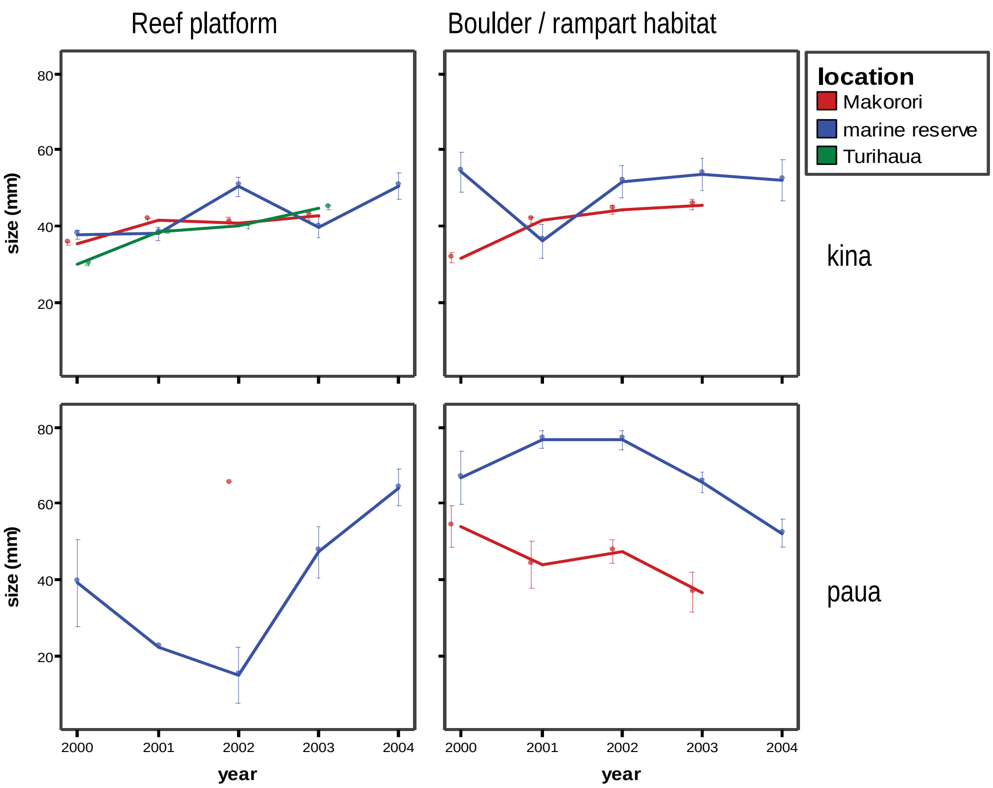


Figure 10. Mean sizes of kina and paua within Te Tapuwae o Rongokako Marine Reserve and at Makorori and Turihaua. The graphs on the left are data from the flat intertidal reef platforms at all three locations, and the graphs on the right are from the more complex boulder / rampart habitats at Makorori and the reserve. Sizes are test diameters for kina and shell lengths for paua.

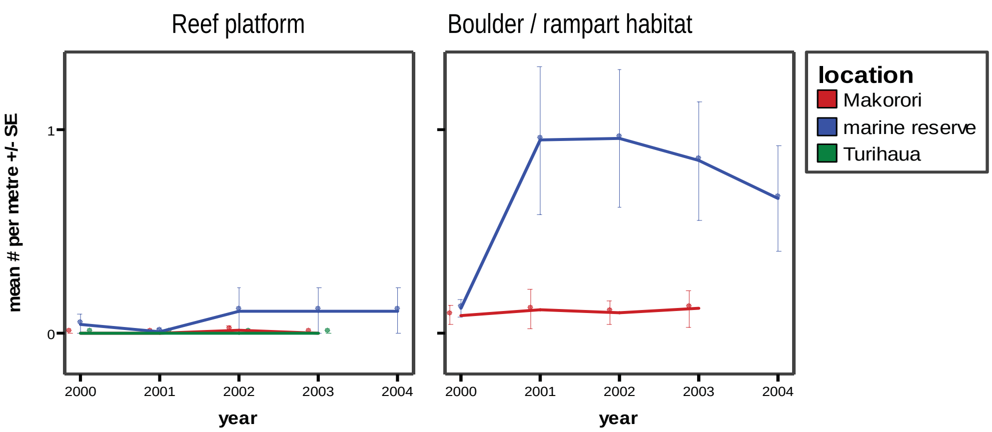
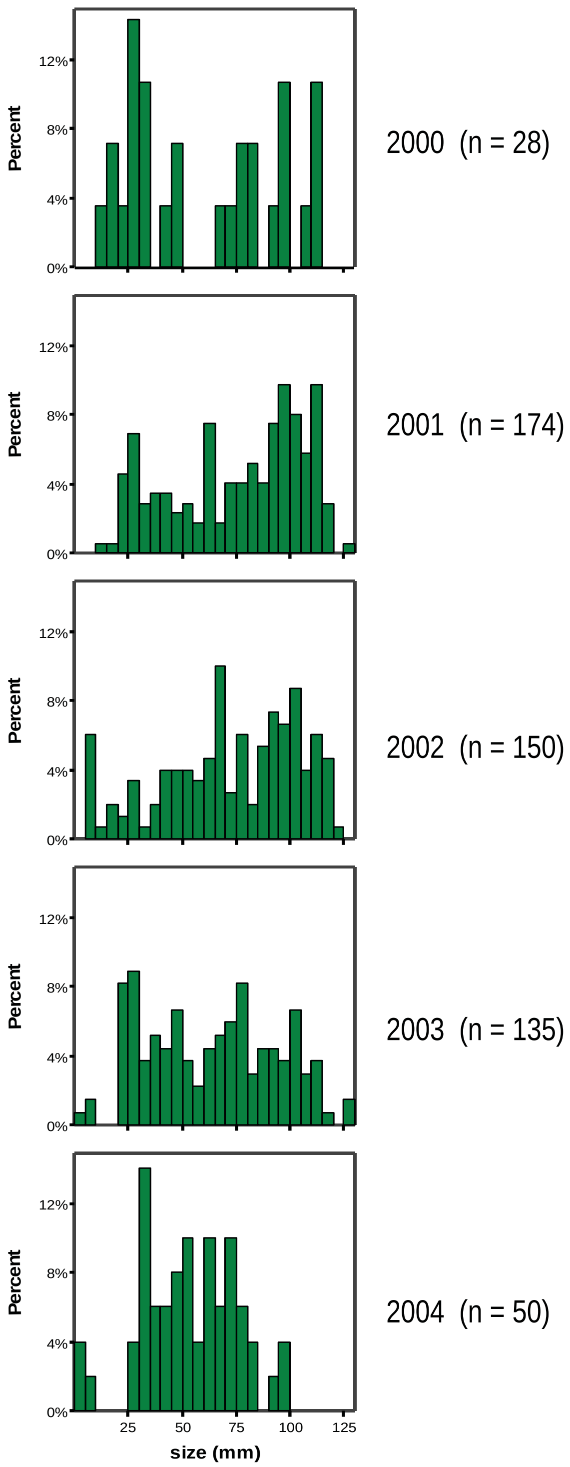


Figure 11. Mean densities of paua within Te Tapuwae o Rongokako Marine Reserve and at Makorori and Turihaua.

Figure 12. Size frequency distributions (% frequency) for intertidal paua within Te Tapuwae o Rongokako Marine Reserve. Insufficient numbers of paua were sampled outside the reserve for construction of size frequency histograms.



Discussion

The variation in the lengths, depths and widths of the channels and pools surveyed made accurate measurement of the density of paua and kina difficult. Some channels were narrow cracks in the reef platforms, whereas others contained pools and ledges, which significantly increased the available habitat for both paua and kina. In addition, some channels contained rocks and / or boulders, which is known to be a preferred habitat of paua (Schiel 1992). Furthermore, some channels became filled with sand, sediment and / or seagrass *(Zostera muelleri)* between sampling years, which influenced the amount and nature of available habitat within the channels. However, approximate measurements of density were produced for the paua and kina populations within and outside the two marine reserves and give some indication of the effect of protection on the populations.

The density of intertidal kina has remained low and stable within both marine reserves. In contrast, the densities at locations outside the reserves have been variable and occasionally high. The density of kina at Pourerere and Blackhead Reef increased in 2001, primarily due to a recruitment event the previous year, which resulted in an influx of juveniles at these locations. In 2001, kina were significantly larger within the marine reserve than at either of the two non-reserve locations sampled and also larger than in the reserve in 1999 and 2000. This was due primarily to the higher proportion of subadult kina (<60mm) at the two non-reserve locations and a higher proportion of adult kina (>75mm) within the reserve. Similarly, the high density of kina at Turihaua in 2000 and 2001 can be explained by the influx of juveniles to the population. The highest density recorded in a channel at that location was 78 kina per metre of channel, recorded in 2001.

All kina populations sampled, but particularly the non-reserve populations, showed right shifts in their size frequency distributions, with distinct cohorts being recognisable through time. Juvenile kina (<30mm test diameter) have been estimated to grow approximately 10mm per year (Dix 1972) and this appears to be true for all populations surveyed, with each cohort shifting by approximately 10mm. The size frequency distributions for kina suggest that 2000 was a particularly good recruitment year both on the Central Hawke's Bay coast and the Gisborne coast. Echinoid recruitment is known to be highly variable, both spatially and temporally (Dix 1972, Andrew 1988) and it appears that this is the case with the Central Hawke's Bay and Gisborne *Evechinus chloroticus* populations.

The density and mean size of paua was higher within both marine reserves than their respective non-reserve locations, although there was considerable variability in the density estimates. This is likely due to the cryptic nature of the paua and the variation in the availability of boulder and other favoured habitat among channels and among locations.

The recruitment of both paua and kina is dependent primarily on subtidal populations of adults. This and the longevity of larvae of the species will likely have a large influence on the pattern and magnitude of recruitment into the paua and kina populations at the three locations surveyed. For kina, the longevity of larvae is at least 30 days but may be up to 60 days (Andrew 1988). As a consequence of this long larval lifespan, the kina larvae can distribute a great distance from the spawning population and in this case, the larvae produced from locations within each region (i.e. Central Hawke's Bay or Gisborne) can potentially intermix. Thus, recruitment of kina within the marine reserves may not necessarily correlate to the density of spawning, adult kina, particularly if there are significant currents operating in the locality. This means that if there are any changes in the density or population structure of subtidal kina within the marine reserve, this is likely to have an effect on the non-reserve populations, through the "spillover" of kina larvae. Such an effect has been confirmed by recent hydrodynamic modelling (Stephens *et al* 2004, Oldman *et al* 2006).

There are several possible explanations for the lower level of kina recruitment that has taken place within the marine reserves. The intertidal reefs within the reserves and at their respective non-reserve locations are similar in their geology, ecology and in their exposure to wave action. However, there may be particular current patterns that result in fewer larvae settling on the reefs within the reserves. Further scrutiny of hydrodynamic models for the two regions may help elucidate whether this is a factor (Stephens *et al* 2004, Oldman *et al* 2006). A further explanation may be higher levels of predation on the marine reserve kina populations. It has been documented (Freeman *in prep*.) that the marine reserves support higher densities of rock lobster *(Jasus edwardsii)* than non-reserve locations. In addition, rock lobsters within the reserves are significantly larger than those outside the reserves. Rock lobsters are known to be significant predators of kina (Andrew 1988). In particular, large lobsters (>100mm carapace length) are capable of consuming kina of all sizes and lobsters >40mm carapace length can attack juvenile kina (Andrew 1984). It is probable that the higher density of lobsters within the reserves has had a significant impact on the intertidal and subtidal populations of kina.

In contrast to kina, paua have a relatively short larval longevity. Paua larvae generally settle between 3 and 10 days after fertilisation (Tong *et al* 1987, McShane 1992, Moss & Tong 1992) and so have a limited dispersal from the adult population. The recruitment of paua therefore, could be expected to give an indication of the spawning adult population.

However, the low densities of juvenile paua at all locations surveyed in this study, along with the presence of significant populations of adults in the subtidal (pers. obs) suggest that exposure and lack of adequate settlement habitat may be important factors influencing paua recruitment at these locations.

McShane (1993), McShane *et al* (1994a), Annala (1995) and McShane (1995) describe how juveniles are generally absent from exposed coastlines, even when adults are present in deeper water. Schiel *et al* (1995) suggested that an absence of juveniles from some areas where adults were common was due to a lack of an adequate inshore rock / boulder habitat. Sainsbury (1982), Schiel (1992), Shepherd & Breen (1992), Schiel (1993), McShane (1995) and McShane & Naylor (1995) all noted how too much turbulence causes sedimentation or shifts in sand, which in turn can cause significant post-settlement mortality. Many of the channels surveyed in this present study contained large, flat rocks and cobble areas, which is ideal paua habitat. Although paua were found in these areas, they were present in low densities. The exposed nature of the coast, in combination with mobility of sediments is likely to be the reason for the low density of not only juvenile, but adult paua at all three locations. A further possible explanation for the low densities of intertidal paua is the presence of high numbers of kina. Sea urchins have been documented to be capable of “bulldozing” gastropod recruits during their grazing activities (Fletcher 1987). It is possible that the high densities of kina at locations surveyed in this study have had an influence on the recruitment of paua.

The higher abundance of adult paua within the reserves, relative to the non-reserve locations, does suggest some reserve effect on the paua population. It has been suggested (Tegner & Butler 1985) that because larval dispersal is so localised, that replenishment of depleted stocks will occur only slowly, if at all. However, results of this study suggest that recovery of local populations can take place over a relatively short time frame.

There is no published information on the subtidal paua or kina populations at the locations sampled in this survey. In order to establish the mechanisms behind the recruitment patterns observed in the intertidal populations, a survey of the subtidal populations is essential. The subtidal populations of adult kina and paua are the source of larvae for the intertidal and so by studying the distribution and abundance of subtidal populations, we can better understand the patterns observed in the intertidal. The subtidal and intertidal populations of kina and paua will undoubtedly intermix, as a result of factors such as sea conditions, food availability and age of the individuals. A survey of the subtidal populations in conjunction with the intertidal, will help establish how these factors influence the distribution and abundance of paua and kina on the Central Hawke’s Bay and Gisborne coasts.

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