Pohatu Marine Reserve Baseline Survey

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CONTENTS

Abstract

Pohatu Marine Reserve, Banks Peninsula, Canterbury was opened on the 4th July 1999. The present study was conducted a period of twelve months after it was opened.

The aims of the present study were to:

- establish a biological data set for Pohatu Marine Reserve and appropriate control sites and to compare densities and sizes of particular species between the reserve and control treatments;
- select sites suitable for ongoing monitoring of the impact of reservation; and
- recommend an appropriate level of sampling, including the size and number of replicates for ongoing monitoring.

This report presents data on the following aspects:

- reef fish presence/absence and densities were collected at eight reserve and six control sites. At each site, fish were counted from within six to ten 60 m^2 quadrats (52 reserve and 39 control).This represented a total area of 5460 m^2;
- the size class of particular fish species were also recorded;
- spiny lobster density, size and sex were collected from six reserve and six control sites. A total of six 120 m^2 quadrats were searched by divers at each site (total area = 8640 m^2);
- paua density data was collected from all sites. Between six to eleven 30 m^2 quadrats were collected at each site (47 reserve and 37 control sites), representing a total area of 2520 m^2; and
- kina density data was collected at all sites. Six to seven 30 m^2 quadrats were sampled at each site. A total of 85 quadrats (48 reserve and 37 control) were collected representing a total area of 2550 m^2.

Habitats

Two distinct hard shore habitat types were recorded from both reserve and control areas. Coralline encrusted rock was the most widespread and common habitat type. It was characterised by a

shallow fringe of brown macroalgae above a widespread subtidal area characterised by little or no brown macroalgae. Deeper areas were colonised by a high percentage cover of crustose coralline alage. The second major habitat type was rock with a high percentage cover of foliose macroalgae.

Fish density

A total of 10 species of reef fish were recorded from underwater diver visual fish transects. Spotty and banded wrasse were recorded from all reserve and control sites. Blue moki were recorded from all control sites, but were only recorded from 63 % of reserve sites. Scarlet wrasse were recorded from 71 % of all sites, but were recorded from a greater percentage of control than reserve sites. Blue cod and southern pigfish were recorded from 50 % of all sites as well as reserve and control sites. Butterfish and girdled wrasse were not recorded from control sites and were only recorded from two of the eight reserve sites. Spotty were significantly more abundant within the pooled control treatment than the reserve treatment. No other significant differences for fish abundance between reserve and control treatments were recorded.

Spiny lobster

Spiny lobsters were recorded from two of the six control sites and three of the six reserve sites. A total of 44 spiny lobster were recorded during the present investigation, 19 from control sites and 25 from reserve sites. The mean size of animals from within the reserve based on diver estimations was 80.4 mm carapace length compared to 91.3 mm from control sites. This difference was not statistically significant. The density of spiny lobster ranged from 0.33 to 3.33 individuals per 120 m^{-2}. Mean density from pooled reserve and pooled control sites was highest from the reserve group, but this difference was not statistically significant.

Black foot paua

Black foot paua density was measured at a total of six reserve and six control sites, while their size (maximum length mm) was investigated at six control and seven reserve sites. A total of 1175 black foot paua were recorded from quadrats during the present investigation, 572 from control sites and 603 from reserve sites. At most sites black foot paua were patchy often being observed in high densities in particular areas at the base of the bedrock wall. The density of black foot paua ranged from 0 to 35.7 individuals per 30 m^{-2}. Mean density from pooled reserve and pooled control sites was highest in the control group, but this difference was not significant. The mean size of animals within the reserve was 111.9 mm length compared to 109.3 mm from control sites. Reserve black foot paua were significantly larger than those recorded from control sites.

Kina

Kina density and size (test diameter mm) were investigated at a total of eight reserve and six control sites. Kina densities were collected from six to seven 30 m^2 quadrats at each site. A total of 85 quadrats (48 in the reserve and 37 at control sites) were sampled during the present study representing a total area of 2550 m^2. Kina were recorded in quadrats at four of the six control sites and two of the eight reserve sites. A total of 24 kina were recorded in quadrats collected during the present investigation, 21 from control sites and 3 from reserve sites. At all sites where kina were recorded they were sparsely distributed. No aggregations of kina were observed. The density of kina ranged from 0 to 1.8 individuals per 30 m^{-2}. Mean density in the pooled control sites was significantly higher than from the reserve group. The mean size of animals from within the reserve was 141.1 mm length compared to 132.9 mm from control sites. No significant difference in the size of kina within the reserve compared to outside the reserve was recorded during the present study.

Statistically significant differences between reserve and control treatments recorded during the present study were:

- Spotty were more abundant within the control treatment;
- Black foot paua were larger within the reserve treatment; and
- Kina were more abundant within the control treatment.

The significantly larger size of black foot paua could be attributed to reservation (i.e. 12 months following reservation).

The presence of both size classes of butterfish (i.e. < 40 cm and > 40 cm length) at two sites within the reserve, although not statistically significant, may also represent a change due to reservation.

As part of any monitoring programme it should be recognised that Pohatu Marine Reserve presents logistical problems related to conducting fieldwork. In particular, water visibility is most often below the level considered suitable for underwater visual fish counts. It is recommended that fish counts be conducted when conditions are favourable rather than at a particular time of the year.

It is recommended that monitoring be conducted in consideration of the following:

- Underwater visual fish counts should be attempted on an annual basis. The number of replicates should be increased at reserve and control sites where butterfish habitat exists. It is probable that butterfish will be one of the key species that will benefit from the Pohatu Marine Reserve.

- Spiny lobster data should be collected annually.
- Black foot paua data should be collected annually. Due to their patchy distribution, the number of replicates where density values are recorded should be increased both inside and outside the reserve.
- Kina data should be collected annually. The number of replicates where kina density values are established should be increased both inside and outside the reserve. The number of kina measured should also be increased both inside and outside the reserve. Where possible a minimum of 40 individuals should be measured at each site.

1.0 INTRODUCTION AND BACKGROUND

Pohatu Marine Reserve is located along the southern coastline of Banks Peninsula east of Akaroa Harbour (Figure 1).

In January 1997, the Canterbury Marine Recreational Fishers Association and the Akaroa Harbour Recreational Fishing Club applied for a marine reserve at Flea Bay (Pohatu). On 4th July 1999 the 215 hectare Pohatu Marine Reserve was opened.

The aims of the present study were to:

- establish a biological data set for Pohatu Marine Reserve and appropriate control sites and to compare densities and sizes of particular species between the reserve and control treatments;
- select sites suitable for monitoring potential changes in relation to retirement from fishing within Pohatu Marine Reserve; and
- establish the appropriate level of sampling (i.e. to define the size and number of replicates appropriate to sample each target species).

The present study occurred 12 months after the formation of the marine reserve. This was the first occasion when water visibility was suitable for underwater fish counts and the weather forecast predicted a relatively long period of stable weather. Sites selected for study were in consideration of the weather and water visibility patterns of the Peninsula(i.e. they were located within the bays and along the outer coast)(Figure 2). Outer coastal areas are subjected to considerable wave action resulting in reduced water visibility. Selection of sites on the outer coast would therefore add further logistical problems during future monitoring fieldwork.

2.0 STUDY AREA AND SAMPLE SITES

Flea Bay is located on the southern coastline of Banks Peninsula (Figure 1). Pohatu Marine Reserve extends over the entire Flea Bay and extends outside the bay along the adjacent outer coastline to the east and west (Figure 2). A total of 5.8 km of coastline has been included within the Pohatu Marine Reserve. This represents 1.9 % of the total coastline of Banks Peninsula (300 km).

Reserve sites selected for study were located along both sides of Flea Bay, while control sites were located on both sides of Otanerito Bay, on the northern shore of Stony Bay and on both sides of outer Akaroa Harbour (Figure 2). Control sites were selected in areas that were comparable to reserve sample sites, in terms of aspect, wave exposure, depth range and habitat.

3.0 MATERIALS AND METHODS

3.1 Underwater visual fish transects

Fish density and the size class of particular species were investigated using underwater visual censusing methods (see Bell 1983, McCormick & Choat 1987, Buxton & Smale 1989, Cole *et al.* 1990, Cole 1994, Cole *et al*. 2000, Davidson 1995, 1997, submitted, in prep.). At all sites, fish were counted from six control and eight reserve sites with between six and ten replicates collected per site. Particular species were placed into size categories (butterfish, blue moki and blue cod). Triplefins, cryptic species and fish that inhabit caves were ignored by divers as reliable counts of these species was not possible using the present methodology. The full list of sites and their grid references have been summarised in Table 1.

At each site, a lead weight attached to the start of the transect line was dropped onto the seafloor. The line automatically reeled off the spool as the diver holding the spool swam away from the lead weight. At a distance of five metres from the lead weight (as indicated by a squeezed metal marker on the line), the diver started counting fish. For each transect each diver estimated a two metre wide by two metre high tunnel that was 30 metres in length.. Transects were sampled within a predetermined depth range within a particular habitat type (i.e. either coralline encrusted rock or foliose macroalgae covered rock). All transects were replicated and undertaken parallel to the shoreline.

Fish transects in the macroalgae habitat were installed immediately above or within the canopy close to its top. In some areas the foliose macroalgae extended up to 3 m distance above the substratum. In Otanerito Bay (Site 1) some transects were installed within a sparse *Macrocystis pyrifera* stand with an under-story of *Carpohyllum flexuosum*. Transects were investigated at a relatively slow, but constant swimming speed that ensured spotty (*Notolabrus celidotus*) and blue cod (*Parapercis colias*) did not overtake divers. All transects were sampled from 5 m to 9 m depth range. Six replicate transects were collected from all sites apart from site 11 where a total of 10 replicates were collected.

The automatic line-spool method enabled divers to sample a pre-determined habitat consistently over the entire transect length. It also minimised count bias due to positive fish behaviour by species such as spotty and blue cod. This method ensured divers sampled the appropriate habitat and depths while collecting data forthree contiguous replicates separated by an appropriate length of "buffer" thereby avoiding problems associated with pseudoreplication.

Blue cod were assigned to three size classes: juvenile (< 10 cm), sub-adult (10 - 30 cm) and adult (>30 cm) length. Blue moki and butterfish were assigned to two size classes (subadult < 40 cm, adult > 40 cm total length). Thirty centimeters for blue cod and 40 cm for butterfish and blue moki represent the legal size limits set by the Ministry of Fisheries for the Canterbury area.

3.2 Spiny lobster size, sex and density

The abundance and size of spiny lobster were recorded from six reserve and six control sites (Table 1). Spiny lobster were counted and their carapace length was estimated within 30 m x 4 m wide transect (n = 6 transects per site). Transect counts were collected from between 7 m to 14 m depth within areas that supported spiny lobster habitat. Spiny lobster habitat was defined as bedrock with crevices or cracks or areas with small, medium and large bounders. Habitats comprising cobbles, pebbles or soft substrata within the depth range were not used for counts. The depth where spiny lobster habitat occurred varied from site to site and transect to transect. Counts were conducted from between 7 m to 14 m depth depending on the location of the appropriate rocky habitat.

At each site, each diver counted three transects (i.e. n = 6 replicates per site). Divers used a dive torch to search holes and to assist with the estimation of spiny lobster size and sex. The same two divers collected all spiny lobster data. These divers had undergone previous training to ensure that sampling variation would be minimised. Plastic rulers were used to estimate lobster size (i.e. carapace length to the nearest 10 cm). Underwater visibility was >2 m horizontal distance during counts, and the transect tape was used to assist estimations of transect width.

3.3 Black foot paua density and size

Black foot paua (*Haliotis iris*) abundance and size were collected from six 30 m x 1 m quadrats sampled haphazardly from within a predetermined depth range (Table 2). Black foot paua size was sampled from six reserve and six control sites, while their density was collected from six control sites and seven reserve sites. All black foot paua samples were collected from bedrock or boulder substrata with or without a foliose macroalgae cover (*C. flexuosum*). All density data were collected from 7 to 10 m depth (Table 2).

All black foot paua located within quadrats were measured (i.e. maximum length). To obtain a sufficiently large sample size, additional individual paua were measured from adjacent areas by divers thoroughly searching within the depth range. Not more than 20 black foot paua were measured from any one patch or cluster of animals in order to avoid any size biases that may have occurred within discrete groups of black foot paua. All individuals were measured *in situ* using callipers to the nearest 5 mm length.

3.4 Kina density and size

Kina (*Evechinus chloroticus*) abundance and size were collected from eight reserve and six control sites between 7 m to 10 m depth (Table 1). Kina density was sampled from six replicates at all but site 1 where seven replicates were sampled. All quadrats were 30 m x 1 m in size and were deployed haphazardly within the predetermined depth range (Table 1). Kina size and density was sampled from bedrock or boulder substrata with or without a cover of foliose macroalgae (*C. flexuosum*).

All kina located within quadrats were measured (maximum test diameter). As kina were relatively rare at all sites, additional kina were measured from adjacent areas by divers thoroughly searching areas within the predetermined depth range. Kina were measured *in situ* using calipers to the nearest 5 mm length.

Table 2 Location of black foot paua sample sites within and outside the Pohatu Marine Reserve.

Site no.	Name	Treat-ment	Habitat	Depth range of size measurements	Depth range of density measurements
1	Otanerito (east)	Control	*Carpophyllum* forest (sparse *Macrocystis*)	7-10 m	7-10 m
2	Otanerito (west)	Control	Bedrock, boulder	7-10 m	7-10 m
3	Stony Bay	Control	Bedrock, boulder	7-10 m	7-10 m
4	Dan Rogers	Control	Sparse *Carpophyllum / Ecklonia*	7-10 m	7-10 m
5	Akaroa (east)	Control	Bedrock, boulder	7-10 m	7-10 m
6	Timutimu Head	Control	Bedrock, boulder	7-10 m	7-10 m
7	Pohatu (north)	Reserve	Bedrock, boulder	7-10 m	7-10 m
8	Pohatu (south)	Reserve	*Carpophyllum* forest	7-10 m	7-10 m
9	Pohatu (north)	Reserve	Bedrock, boulder	7-10 m	7-10 m
10	Pohatu (south)	Reserve	*Carpophyllum* forest	7-10 m	7-10 m
11	Pohatu (north)	Reserve	Bedrock, boulder	7-10 m	7-10 m
12	Pohatu (south)	Reserve	*Carpophyllum* forest	7-10 m	7-10 m
13	Pohatu (north)	Reserve	Bedrock, boulder	NC	NC
14	Pohatu (south)	Reserve	Bedrock, boulder	NC	7-10 m

NC = samples not collected

4.0 RESULTS

This report presents biological data for Pohatu Marine Reserve and adjacent control areas collected during July 2000.

4.1 Habitats

Two distinct hard shore habitat types were recorded during the present investigation from both reserve and control areas.

1. Coralline encrusted rock

Coralline encrusted rock was the most widespread and common habitat type recorded within control and reserve areas. These shores supported a relatively narrow strip of *Durvillaea antarctica* and in more exposed places *D. willana* that extended to approximately <2 m below low water. The subtidal habitat below this zone was dominated by hard substrata clad with little or no foliose brown macroalgae. In some areas isolated plants of *Ecklonia radiata* were observed, but these represented < 2 % cover. These hard substrata were covered in a high percentage cover (i.e. up to 100%) of crustose coralline algae. Dominant invertebrate species in these areas were most often green-lip mussel (*Perna canaliculus*) and sea tulip (*Pyura* sp.), however, their abundance varied b site.

2. Macroalgae clad rock

Macroalgae clad rock was recorded from part of site 1 in Otanerito, from site 4 in Akaroa Harbour and from three of the four sites located along the south-western shoreline of Flea Bay (Figure 1). These rocky substrata supported a relatively narrow strip of *D. antarctica* and in more exposed places *D. willana* that extended to approximately <2 m below low water. The subtidal habitat below this zone was dominated by hard substrata often clad in a high percentage cover of foliose brown macroalgae (i.e. approximately 20 % to 90 % cover). Macroalgae was often dominated by tall stands of wide flapjack (*Carpophyllum flexuosum*). Other species were recorded at particular sites in association with this species (e.g. *Ecklonia radiata, Macrocystis pyrifera, C. maschallocarpum, Lessonia variegata*).

4.2 Fish presence/absence and density

Underwater visual fish count data collected during July 2000 have been presented in Appendix 1. Data were collected from bedrock and boulder substrata either with or without a canopy of foliose macroalgae (Table 1). Water visibility during the study ranged from 3.5 m to 5 m horizontal distance. A total of eight marine reserve and six control sites were sampled during the present study. At each site, fish were counted from within six to ten 60 m^2 quadrats, 52 within the marine reserve and a total of 39 at control sites. A total area of 5460 m^2 was sampled during the present study.

A total of 10 species of reef fish were recorded from transects (Table 3, Appendix 1). Spotty and banded wrasse were recorded from all reserve and control sites (Table 3). Blue moki were recorded from all control sites, but were only recorded at 63 % of reserve sites. A small school of blue moki was recorded from one reserve site (Site 14) and one control site (Site 4). Scarlet wrasse, blue cod and southern pigfish were recorded at a moderate number of sites. Butterfish and girdled wrasse were not recorded from control sites and were recorded from only two of the eight marine reserve sites (Table 3). Tarakihi (*Nemadactylus macropterus*) and trumpeter (*Latris lineata*) were not recorded during the present study, but are a widely distributed reef fish of southern New Zealand and probably occur in the area.

Table 3 Fish species recorded from Pohatu Marine Reserve and control areas.

Species	Percentage of total control sites (n=6)	Percentage of total reserve sites (n=8)	Percentage of total sites (n=14)
Spotty	100 % (6)	100 % (8)	100 % (14)
Banded wrasse	100 % (6)	100 % (8)	100 % (14)
Blue moki	100 % (6)	63 % (5)	79 % (11)
Scarlet wrasse	83 % (5)	63 % (5)	71 % (10)
Blue cod	50 % (3)	50 % (4)	50 % (7)
Southern pigfish	50 % (3)	50 % (4)	50 % (7)
Leatherjacket	33 % (2)	25 % (2)	29 % (4)
Sea perch	17 % (1)	13 % (1)	14 % (2)

Butterfish	0	25 % (2)	14 % (2)
Girdled wrasse	0	25 % (2)	14 % (2)

Mean fish density for pooled reserve pooled control sites has been plotted in Figure 3. No juvenile blue cod (< 100 mm length) or individuals over 300 mm length were recorded in reserve or control sites during the present study (Figure 3, Table 3, Appendix 1). The density of blue cod 100 mm to 300 mm was higher at pooled control sites than marine reserve sites, but this difference was not statistically significant (Table 4). The density of spotty was significantly higher in pooled control sites as compared with reserve sites (Table 4). No other significant differences in the density of fish species or size groups of fish were recorded between pooled reserve and control treatments (Table 4, Figure 3)

Table 4 Mann-Whitney Rank Sum Test comparing numbers of fish recorded from transects collected from control (n = 39) versus reserve (n = 51) sites.

Species	T value	P value	Significance
Blue cod < 10 cm	0	NA	NS
Blue cod 10 – 30 cm	1896	0.3230	NS
Blue cod > 30 cm	0	NA	NS
Spotty	2085	0.0116	Sig.
Banded wrasse	1964	0.1230	NS
Scarlet wrasse	1920	0.2370	NS
Girdled wrasse	1716	0.6351	NS
Blue moki < 40 cm	1927	0.2129	NS
Blue moki > 40 cm	1767	0.9543	NS
Leatherjacket	1864	0.4667	NS
Butterfish < 40 cm	1716	0.6351	NS
Butterfish >40 cm	1696	0.5260	NS
Sea perch	1780	0.9641	NS
Southern pigfish	1827	0.6710	NS

4.3 Jasus edwardsii (crayfish, spiny lobster)

During the present study a total of six reserve and six control sites were investigated. At each site, all cracks and caves within six 120 m^2 quadrats were searched by divers. A total area of 8640 m^2 was sampled during the present study. Spiny lobster size and density data have been presented in Appendix 2 and 3.

Spiny lobsters were recorded from two of the six control sites and three of the six reserve sites. The absence or low numbers of spiny lobster from many areas within and outside of the reserve was primarily due to their absence from many areas or the patchy distribution of suitable habitat at sites 1, 2, 3, 5, 9, 13 and 14. Widespread spiny lobster habitat was recorded from sites 4 and 6 outside the reserve and sites 10 and 12 within the reserve.

A total of 44 spiny lobster were recorded during the present investigation, 19 from control sites and 25 from marine reserve sites (Appendix 2 and 3). The mean size of animals from within the reserve based on diver estimations was 80.4 mm carapace length compared to 91.3 mm from control sites (Figure 4 and 5). This difference between the reserve and control sites was not statistically significant ($T = 502.5$, $P = 0.0774$). The lower mean size value recorded from the pooled reserve treatment was primarily due to one localised area at site 11 where a group of small animals were measured (i.e. eight animals < 65 mm carapace length). The population at both reserve and control sites was dominated by relatively small individuals from 40 mm to 100 mm carapace length (Appendix 3, Figure 4).

The density of spiny lobster ranged from 0.33 to 3.33 individuals per 120 m^{-2} at site 14 and 11 respectively. These sites were located within the reserve (Figure 6, Appendix 2). Mean density from pooled reserve and pooled control sites was highest from the reserve group, but this difference was not statistically significant ($T = 1370.5$, $P = 0.5265$). The variation about the mean was relatively large, particularly at site 11 due to the patchy distribution of spiny lobster.

No pack-horse lobster (*Jasus verreauxi*) were recorded in the present study.

4.4 Black foot paua density and size

Black foot paua density was collected from a total of six reserve and six control sites, while their size (maximum length mm) was investigated from six control and seven reserve sites. Paua densities were collected from between six to eleven 30 m^2 quadrats at each site (47 in the reserve and 37 at control sites). This represented a total area of 2520 m^2. Black foot paua size and density data have been presented in Appendices 4, 5, and 6.

Black foot paua were recorded from five of the six control sites and all of the reserve sites where quadrats were deployed (Appendix 4). A total of 1175 black foot paua were recorded from quadrats collected during the present investigation, 572 from control sites and 603 from reserve sites (Appendix 4). The absence or low numbers of black foot paua from particular sites was not an indication of their absence from the site, rather the sample depth range was set outside the depth range where paua inhabited the shore. This phenomenon occurred at sites 5 and 6. At most sites paua were patchy, often being observed in high densities in particular areas and often at the base of the bedrock wall. Within the macroalgae habitat they were often recorded in low densities often as isolated patches associated with crevices or gullies running down the shore. In order that this patchiness was overcome, long quadrats (i.e. 30 m length) were selected over 1 m^2 quadrats.

The density of black foot paua ranged from 0 to 35.7 individuals per 30 m^{-2} at site 6 and 1 respectively within the control group (Figure 6, Appendix 4). Mean density from pooled reserve and pooled control sites was highest from the control group, but this difference was not statistically significant ($T = 1417$, $P = 0.162$). The variation about the mean was relatively large due to the patchy distribution of black foot paua at most sites.

The mean size of animals from within the reserve was 111.9 mm length compared to 109.3 mm from control sites (Figures 5 and 9). Reserve black foot paua were significantly larger than those recorded from control sites (T = 10128, P = 0.0051). The population at both reserve and control sites was dominated by paua below the Ministry of Fisheries legal size limit (i.e. 125 mm length)(Figure 8).

4.5 Kina density and size

Kina (*Evechinus chloroticus*) density and size (test diameter mm) were investigated at a total of eight reserve and six control sites. Kina densities were collected from six to seven 30 m^2 quadrats at each sample site. A total of 85 quadrats (48 in the reserve and 37 at control sites) were collected during the present study representing a total area of 2550 m^2. Kina size and density data have been presented in Appendices 7, 8, and 9.

Kina were recorded in quadrats from four of the six control sites and two of the eight reserve sites (Appendix 7). A total of 24 kina were recorded in quadrats collected during the present investigation, 21from control sites and 3 from reserve sites (Appendix 7). The reason for the absence or low density of kina particularly from reserve sites remains unknown. At sites where kina were recorded, they were sparsely distributed with no aggregations being observed inside or outside quadrats.

The density of kina ranged from 0 to 1.8 individuals per 30 m^{-2} (Figure 6, Appendix 7). Mean density from pooled reserve and pooled control sites was highest from the control group (Figure 7). This difference was statistically significant (T = 1818, P = 0.0439). The variation about the mean was relatively large due to the absence or low abundance at sample sites.

The mean size of animals from within the reserve was 141.1 mm length compared to 132.9 mm from control sites (Figures 5 and 10). No significant difference in kina size between reserve and control treatments was recorded (T = 299, P = 0.440). The population at both reserve and control sites was dominated by relatively large individuals (Note: there is no legal minimum takeable size for kina – only a daily catch limit of 50 (Iwi are permitted to take an extra 50 kina per boat))(Figure 10).

5.0 DISCUSSION

In recent years a growing base of New Zealand studies have shown change in marine reserves (McCormack and Choat 1987, Cole *et al.* 1990, Creese and Jeffs 1993, Jones *et al.* 1993, McDiarmid and Breen 1993, Cole 1994, Davidson 1997, Cole and Keuskamp 1998, Kelly 1999, Kelly *et al.* 1999, Kelly *et al.* 2000, Davidson submitted, Davidson in prep.). Change has been attributed to retirement from all commercial, recreational and traditional fishing as all New Zealand's marine reserves are no-take.

The present study presents the first set of biological data for the Pohatu Marine Reserve, Banks Peninsula, Canterbury. The aim of the study was to provide a quantitative data set for particular species inside and outside the reserve. The expectation was that these data would be used as a baseline to enable monitoring the area over time and detect changes due to retirement of fishing practices from the reserve.

Due to uncharacteristic weather patterns the water visibility required to reliably conduct underwater visual counts did not occur until 12 months after the opening of the reserve.

Statistically significant differences between reserve and control treatments were recorded during the present study. These were:

- spotty were more abundant within the control treatment;
- black foot paua were larger within the reserve treatment; and
- kina were more abundant within the control treatment.

The presence of both size classes of butterfish at two sites within the reserve, although not statistically significant, may represent a change due to reservation as no butterfish were recorded from control sites that supported comparable habitat.

These differences between reserve and control treatments are discussed in the following sections.

5.1 Reef fish

Davidson (submitted) showed that for Long Island-Kokomohua Marine Reserve, Marlborough Sounds, blue cod size, density and behaviour exhibited dramatic change over an eight year period. At the end of his study, blue cod were over 125 % more abundant within the reserve and on average 80 mm larger than cod sampled at control sites. Davidson (2000) reported large blue cod (> 330 mm) represented 35 % of the population in the reserve compared to < 1 % at control sites. The author also reported that blue cod could be captured using catch, measure and release methodology over 200 % faster from within the reserve compared control sites. The study clearly showed that the exclusion of fishing resulted in a relatively rapid and large scale change for that dominant reef fish.

Most studies that have investigated the impact of reservation on reef fish in New Zealand have adopted traditional diver strip counts to determine fish abundance (e.g. McCormack and Choat 1987, Cole *et al*. 1992, Cole 1994). Willis *et al.* (2000) questioned the reliability of this method and reported that other methods such as baited video stations may be a more reliable method for determining fish abundance. The development of new methods for some species may be an important consideration for present and future marine reserve monitoring studies, especially in areas like Pohatu Marine Reserve where water visibility is most often below the acceptable level for conducting diver visual fish counts.

Despite problems associated with poor water visibility, the present study adopted traditional underwater visual count methodology to calculate reef fish density for the following reasons:

- underwater visual diver count methodology has been widely used in New Zealand and internationally, thereby enabling fish density and presence/absence data for Pohatu Marine Reserve to be compared with other New Zealand and overseas studies;
- alternative methods such as underwater baited video stations, target particular species such as blue cod, but do not sample species that are not attracted to the bait (e.g. butterfish, blue moki); and
- insufficient numbers of blue cod were present in the reserve and control sites to adopt catch, measure and release methodology developed by Bennett and Attwood (1991, 1993) and used in New Zealand by Davidson (1995, 1997, 2000, in prep.) and Willis *et al*. (2000).

In order that marine reserve monitoring studies can be compared around New Zealand, relatively standard methodology should where practicable be adopted. This may not always be easy as the important fish species for any marine reserve will vary throughout the country and the sampling methods appropriate for one species may not be appropriate for another (Willis *et al.* 2000). Similarly, a standard method for blue cod may fail due to the presence of a voracious predator such as snapper that compete for the baited hooks or drive small cod away from the baited video station. Clearly a methodology unique to each fish species and marine reserve location should be developed in order that the impact of protection can be determined and where possible the methods be standardised so that results can be compared nationwide.

Results from the present study showed that a relatively low number of reef fish species in fairly low densities were present at both reserve and control sites compared with other South Island rocky reef areas such as the Abel Tasman (Davidson 1990, 1999), the D'Urville Island, Marlborough Sounds (Davidson and Brown 1994) Long Island, Queen Charlotte Sound (Davidson 1995, 1997, submitted, in prep.) and Paterson Inlet, Stewart Island (Chadderton and Davidson in prep.). Pohatu Marine Reserve and adjacent coast is relatively close to a large city and is probably subjected to considerable fishing pressure. This pressure may account for the relatively low densities of edible species such as blue cod, blue moki and butterfish. For example, no legal size blue cod (i.e. > 300 mm length) were recorded by divers during the present study. The relatively low variety of species recorded during the present study may be a feature of the area. It is likely that more species will be recorded during subsequent marine reserve monitoring events as the area sampled and the number of visits to the reserve and control areas increases.

Spotty was the only species that were recorded in densities statistically different between pooled reserve and pooled control treatments (i.e. higher within the control treatment). Davidson (2000) reported that the density of spotty was consistently higher over an eight year period at control sites compared to sites in Long Island - Kokomohua Marine Reserve. The author stated that this was a feature of the sites and not related to the impact of reservation. This is probably the case for Pohatu Marine Reserve.

The presence of large butterfish (i.e. > 40 cm length) at two reserve sites and their absence from all control sites despite the existence of suitable habitat represents a possible change due to reservation. Butterfish are vulnerable to set netting practices and may therefore be one species that responds well to retirement from fishing in the Pohatu Marine Reserve.

5.2 Spiny lobster

Studies from southern New Zealand suggest that most *Jasus edwardsii* move little with only a proportion of the population undertaking large migrations (McKoy, 1983; Annala and Bycroft, 1993). Spiny lobsters are intensively fished in many areas of New Zealand (Lipcius and Cobb, 1994). As a result of these factors, their abundance and size has been shown to be greater in protected areas than in nearby fished areas (e.g. MacDiarmid and Breen, 1993; Edgar and Barrett, 1999; Kelly *et al.,* 1999, 2000, Davidson *et al.* submitted).

Kelly *et al*. (2000) estimated the increase in population abundance of lobsters in northern marine reserves to be about 9 % per year. Davidson *et al.* (in press) for the Tonga Marine Reserve, Nelson, estimated a 4.4 % per year increase based on two sets of abundance data six years apart. The authors argued that the lower rate of increase for the Tonga Island Marine Reserve might have been due to the isolation from rocky reef areas due to its location within Tasman and Golden Bays.

Results from the present study showed that spiny lobster were larger within the control treatment, but more abundant within the reserve treatment. These small differences were not statistically significant. At particular sites both within and outside the reserve, divers observed considerable spiny lobster habitat. During the present study, animals were either widely distributed or were recorded in distinct patches or congregations. There is therefore potential for an increase in spiny lobster density within the Pohatu Marine Reserve.
No sites were established along the open coastline outside the bays proper. These areas are known to support more spiny lobsters than areas within the bays (A. Hutt, pers. comm.). The greater abundance of spiny lobsters along the outer coast is testified by the number of commercial pots compared to pots set inside the bays (authors pers. obs.). The outer coast was not selected for study for two reasons.

- This area is influenced by regular and at times relatively large wave action. Repeat surveys may therefore not always be possible due to adverse weather and diving conditions.
- Spiny lobsters appear to be patchily distributed in these areas with dense patches or congregations of animals related to habitat quality and availability thereby increasing variability about mean values.

5.3 Black foot paua

Based on results collected during the present study, black foot paua size was significantly greater within the reserve compared to control areas. The difference between pooled mean values was 2.6 mm. This result could be due to reservation as most paua recorded from reserve and control sites were below the legal takeable limit (i.e. < 125 mm length) and may therefore have increased in size due to reservation. It is also prossible that the difference although statistically significant is due to existing differences between control and reserve areas. These differences could be due to variable fishing pressure (i.e. higher in Akaroa Harbour than the Flea Bay) or differences in the environment (e.g. food availability and quality). Sampling of black foot paua sizes in subsequent years should address this issue.

Little data exists for the impact of reservation on black foot paua. In northern New Zealand, paua are relatively uncommon and only grow to sub-legal sizes (R. Cole pers. comm.). A similar pattern has been reported for Tonga Island Marine Reserve by Davidson (1992) who stated they were absent from many sites and where present were restricted to a sublittoral fringe where they were small in size. At the Long Island-Kokomohua Marine Reserve, (Davidson in prep) reported that the density and size of black foot paua increased at some sites and declined at others between two samples separated by six years.

During the present study, black foot paua densities were highest from the pooled control treatment, but this difference was not statistically significant due to the relatively high variability between samples. The mean size of paua was significantly higher from the reserve treatment. This difference may be due to the 12 months of reservation prior to these samples being collected.

Black foot paua were not evenly distributed at most sample sites. At some sites the highest densities of black foot paua were often observed outside the predetermined sample depth range or were most abundant at the base of the bedrock walls. In order to maintain sampling consistency it is therefore important that subsequent monitoring studies continue to sample black foot paua densities using haphazard sampling techniques within the existing sampl depth range.

5.4 Kina

Kina (*Evechinus chloroticus*) were significantly more abundant from the pooled control treatment, while pooled kina size was highest from the reserve treatment. This latter difference was not statistically significant. It is unknown why kina were significantly more abundant from the pooled control group. Kina were absent at many reserve and control sites and where present were uncommon at control sites and rare at reserve sites.

As kina represent a traditional source of food to local Maori, it is probable that densities within the reserve will increase due to retirement of the reserve from fishing.

6.0 ON-GOING MONITORING

Based on results collected during the present study the following points should be considered as options for ongoing monitoring of the Pohatu Marine Reserve.

As part of any biological monitoring programme it should be recognised that Pohatu Marine Reserve presents logistical problems related to conducting field work. In particular, water visibility is below that considered suitable for underwater visual fish counts for most of the year. As fish counts should be conducted when water clarity is favourable, it is unlikely that field-work could be reliably conducted at a particular time each year. Where possible it is recommended that field-work be conducted in late summer-autumn as this period presents the highest probability of clean water and fine periods of weather (A. Hutt, pers. comm.). This time of the year also allows divers to work longer hours during each day in water temperatures that are more comfortable than in winter. In consideration of logistical problems specific to Pohatu Marine Reserve and data generated from other marine reserve studies around New Zealand it is recommended that:

- water conditions permitting, underwater visual fish counts be conducted on an annual basis at five reserve (sites 7, 10, 11, 12 and 14) and five control sites (sites 1, 2, 3, 4 and 6). The number of replicates should be increased from six to 12 at two reserve sites (sites 10 and 12) and one control site (site 1). This would ensure that better data is collected for the relatively rare butterfish. It is probable that butterfish will be one of the key species that will benefit from the Pohatu Marine Reserve. It is recommended that size to the nearest centimeter of particular reef fish species (e.g. blue cod, blue moki, butterfish) be estimated by divers rather than separated into broad size classes;
- spiny lobster size, sex and density data should be collected annually from four reserve (sites 10, 11, 12 and 14) and four control sites (sites 1, 3, 4 and 6). The existing size and number of transects should be adequate to address the impact of protection on this species;
- black foot paua density and size data should be collected annually from four reserve (sites 7, 10, 11 and 12) and four controls (sites 1, 2, 3 and 4). The number of paua density replicates should be increased from six to 10 per site in an attempt to better address the patchiness of their distribution; and
- kina density and size data should be collected annually from four reserve (sites 7,

10, 11, and 14) and four controls (sites 1, 2, 3 and 6). The number of kina density replicates should be increased from six to 10 per site. The number of kina measured should be increased both inside and outside the reserve. As kina are relatively rare at all but site 6, it is recommended that a minimum of 60 kina for pooled control and 60 for pooled reserve sites be attempted.

Table 5 Recommended sites and number of replicates for on-going monitoring of Pohatu Marine Reserve.

Site no.	Name	Treatment	Fish	Spiny lobster	Black foot paua	Kina
1	Otanerito (east)	Control	12	6	10	10
2	Otanerito (west)	Control	6		10	10
3	Stony Bay	Control	6	6	10	10
4	Dan Rogers	Control	6	6	10	
5	Akaroa (east)	Control				
6	Timutimu Head	Control	6	6		10
7	Pohatu (north)	Reserve	6		10	10
8	Pohatu (south)	Reserve				
9	Pohatu (north)	Reserve				
10	Pohatu (south)	Reserve	12	6	10	10
11	Pohatu (north)	Reserve	6	6	10	10
12	Pohatu (south)	Reserve	12	6		
13	Pohatu (north)	Reserve				
14	Pohatu (south)	Reserve	6	6	10	10

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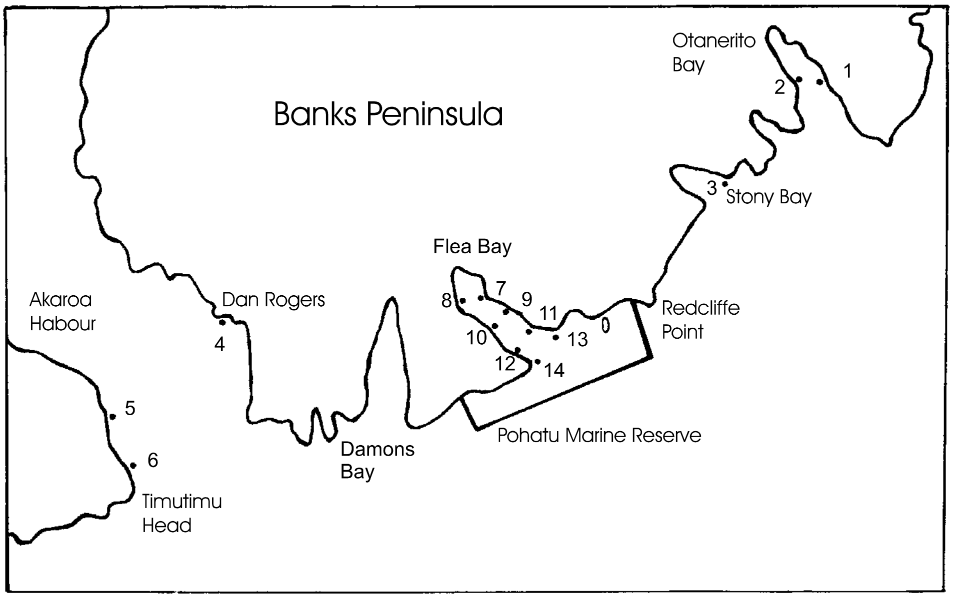

Figure 2 Location of control and marine reserve sample sites, July 2000.

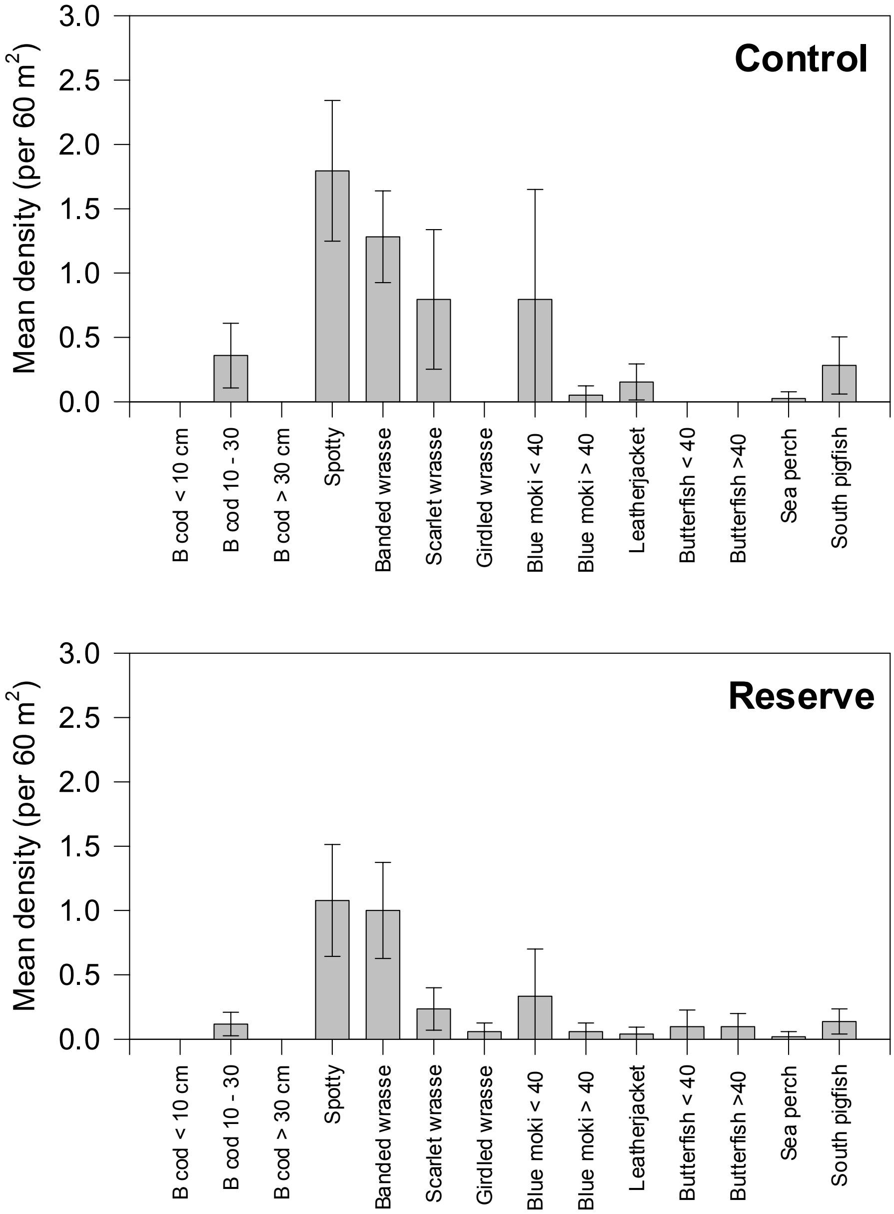

Figure 3 Mean fish density for pooled control (n = 6) and reserve sites (n = 8) during July 2000. Error bars represent 95% confidence intervals.

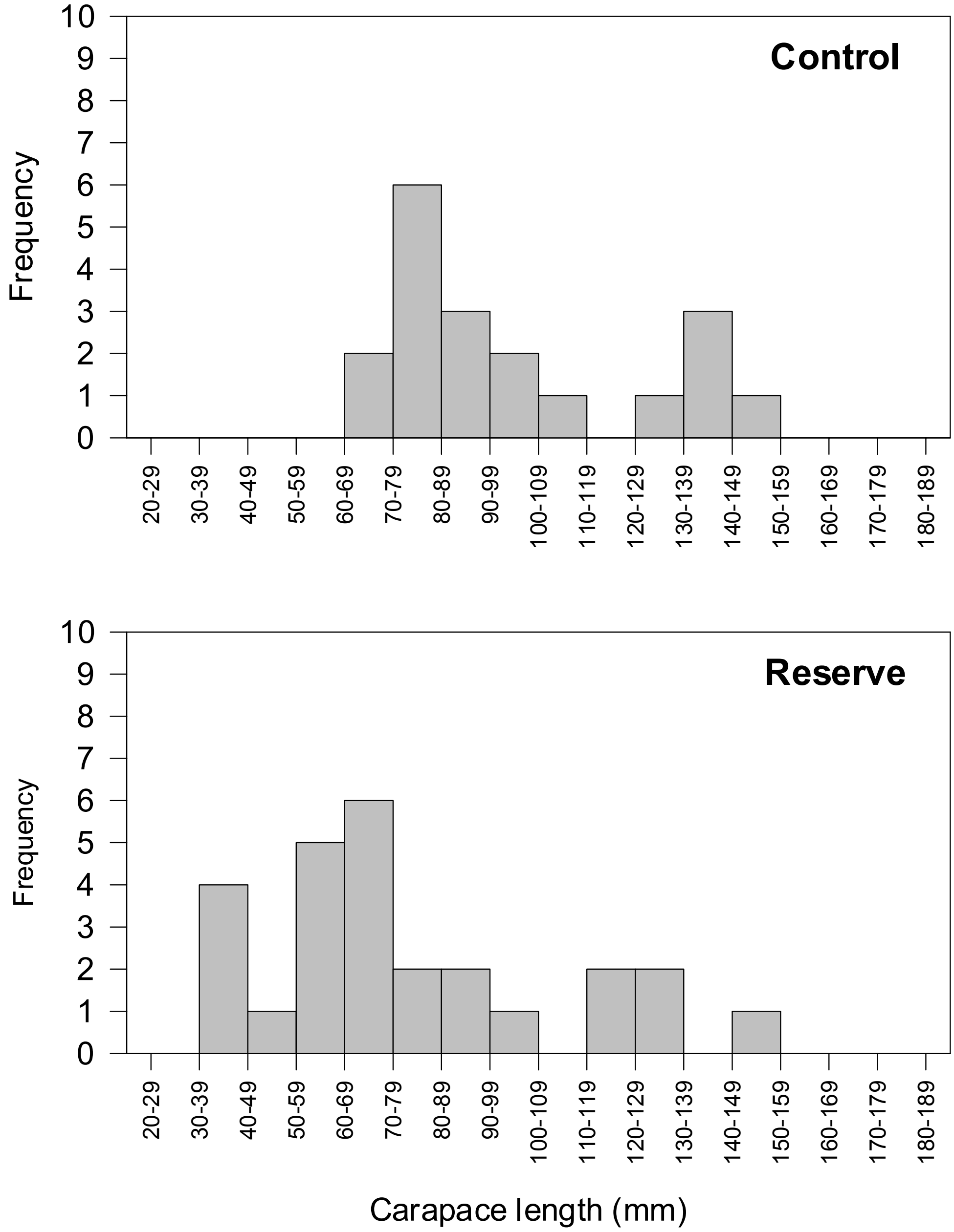

Figure 4 Size frequency of spiny lobster pooled from control and reserve sites during July 2000.

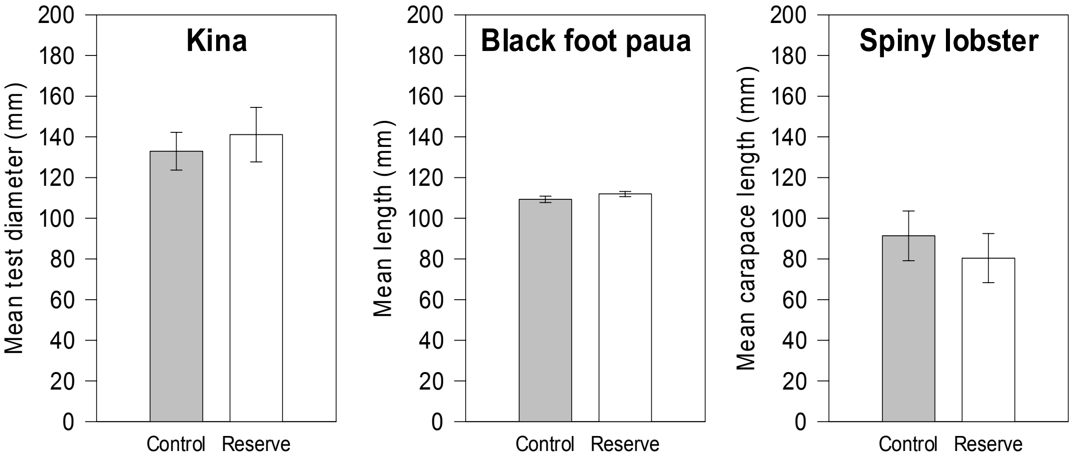

Figure 5 Pooled kina, black foot paua and spiny lobster size from control (shaded) and reserve (open) sites during July 2000. Error bars represent 95% confidence.

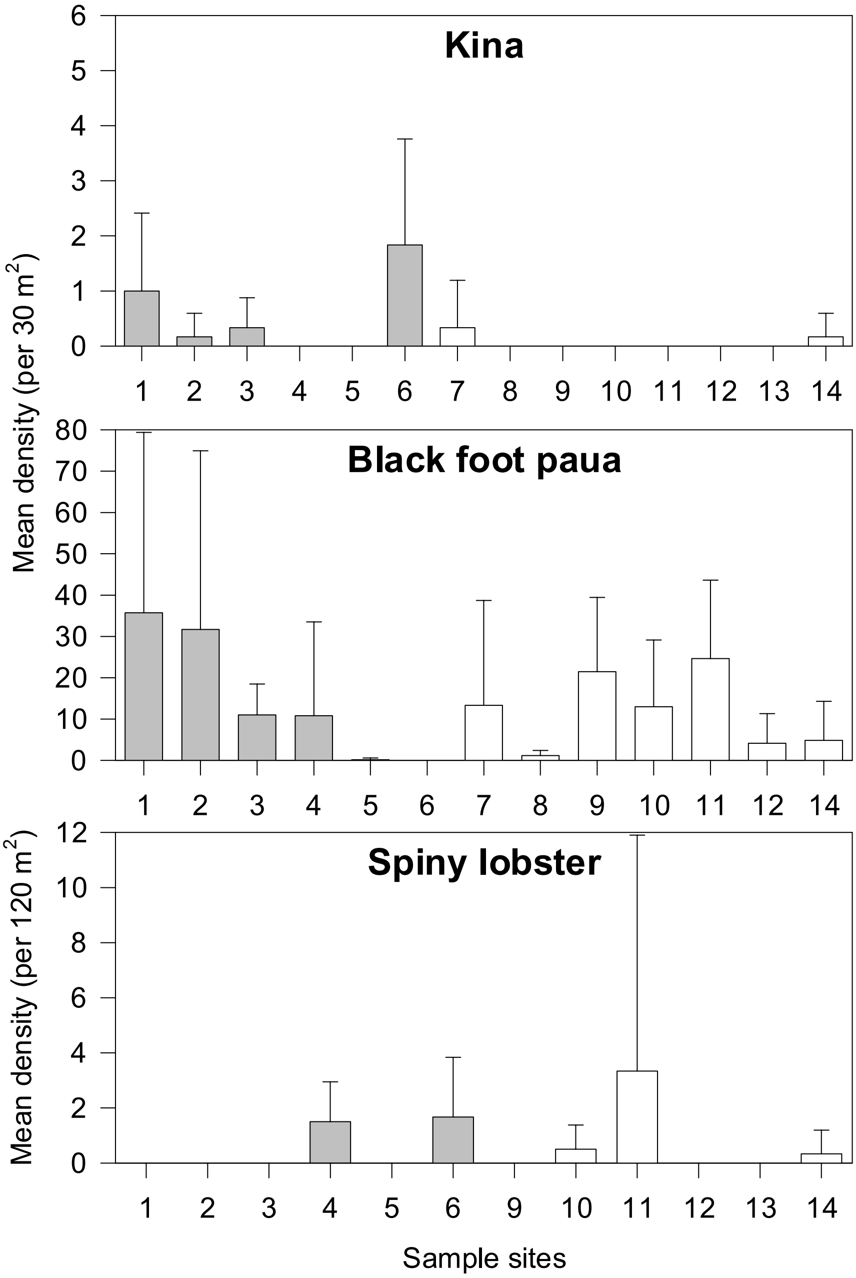

Figure 6 Kina, black foot paua and spiny lobster densities from reserve (open) and control (shaded) sites during July 2000. Error bars represent 95% confidence.

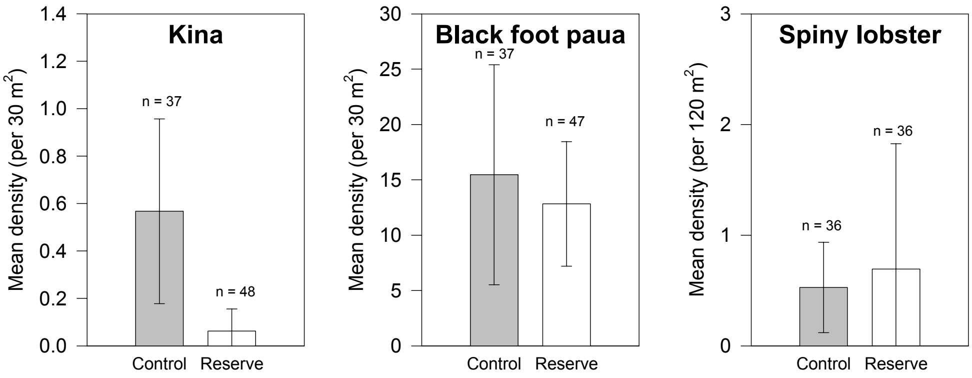

Figure 7 Pooled kina, black foot paua and spiny lobster densities from reserve (open) and control (shaded) sites during July 2000. Error bars represent 95% confidence.

invertrc.spw

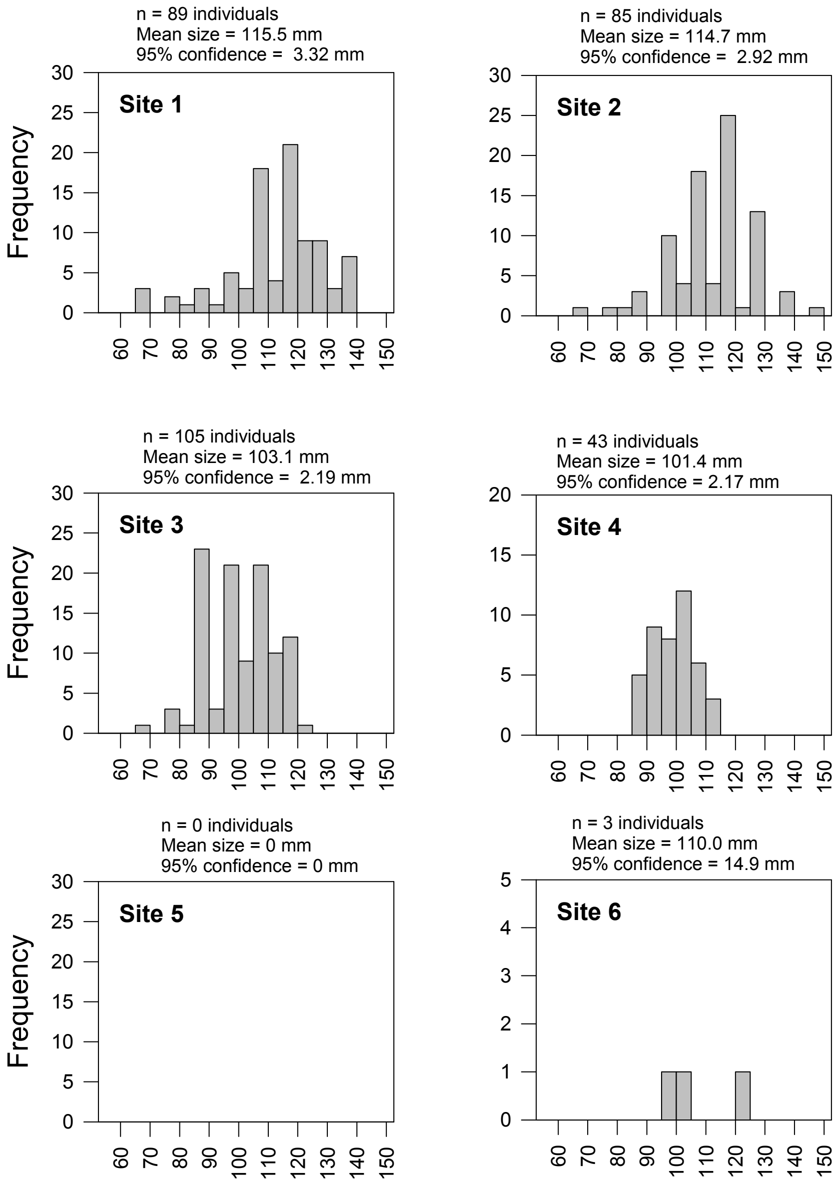

Figure 8 Size frequency for black foot paua collected from control sites during July 2000.

Pauahist.spw

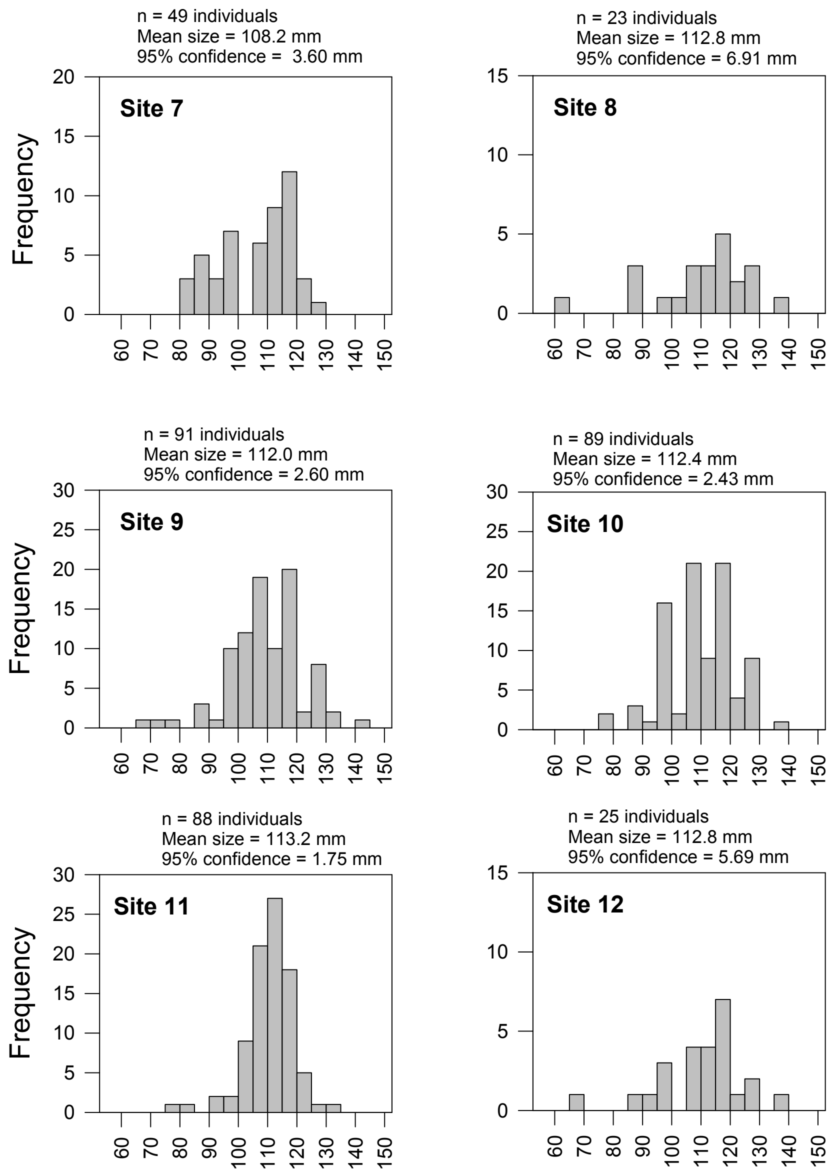

Figure 8 (continued) Size frequency for black foot paua collected from reserve sites during July 2000.

Pauhistb.spw

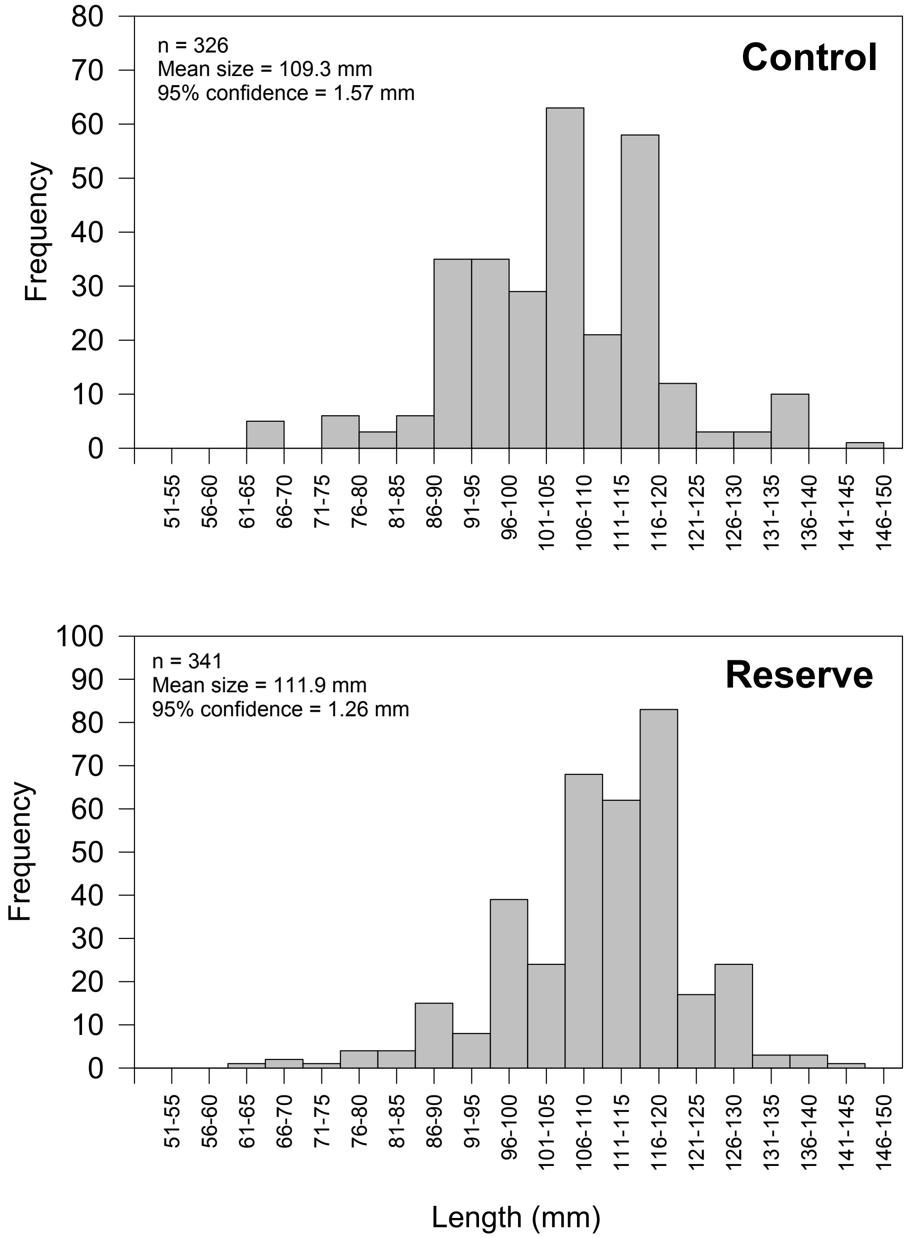

Figure 9 Pooled size frequency for black foot paua collected from reserve (n=6) and control sites (n=6) during July 2000.

Paua1.spw

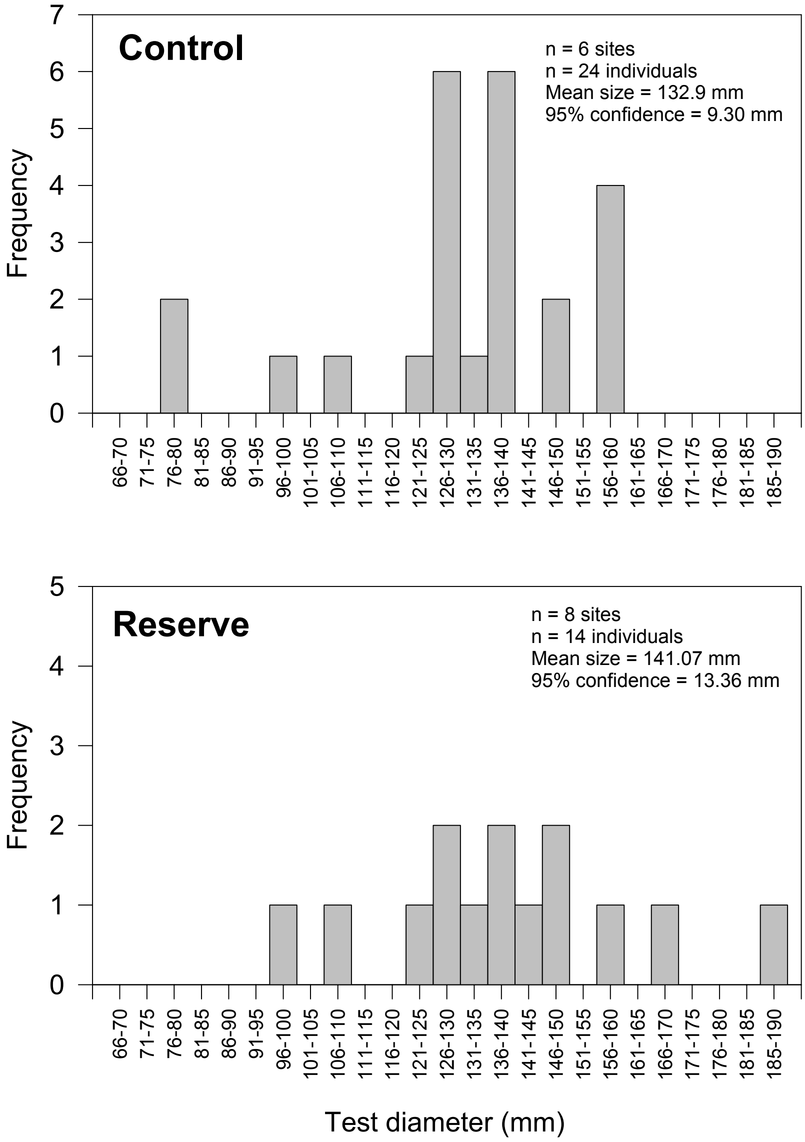

Figure 10 Pooled size frequency for kina collected from reserve (n=8) and control sites (n=6) during July 2000.

Kina1.spw

Table 1 Summary of sample sites within and outside the Pohatu Marine Reserve.

Site no.	Name	Treatment	Habitat	GPS reference July 2000	Species and sample depth (m)			
					Fish	Paua	Kina	Lobster
1	Otanerito (east)	Control	Bedrock, boulder, *Carpophyllum* forest	43° 50 612 S 173° 03 966 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
2	Otanerito (west)	Control	Bedrock, boulder, coralline, sea tulip, mussel community	43° 50 656 S 173° 03 697 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
3	Stony Bay	Control	Bedrock, boulder, coralline, sea tulip, mussel community	43° 51 346 S 173° 02 813 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
4	Dan Rogers	Control	Bedrock, boulder, sparse *Carpophyllum / Ecklonia* forest	43° 52 375 S 172° 57 608 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
5	Akaroa (east)	Control	Bedrock, boulder, coralline, sea tulip, mussel community	43° 53 112 S 172° 56 648 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
6	Timutimu Head	Control	Bedrock, boulder, coralline, sea tulip, mussel community	43° 53 481 S 172° 56 946 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
7	Pohatu (north)	Reserve	Bedrock, boulder, coralline, sea tulip, mussel community	43° 52 283 S 173° 00 531 E	5 - 9 m	7 – 10 m	7 – 10 m	
8	Pohatu (south)	Reserve	Bedrock, boulder, *Carpophyllum* forest	43° 52 357 S 173° 00 344 E	5 - 9 m	7 – 10 m	7 – 10 m	
9	Pohatu (north)	Reserve	Bedrock, boulder, coralline, sea tulip, mussel community	43° 52 386 S 173° 00 739 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
10	Pohatu (south)	Reserve	Bedrock, boulder, *Carpophyllum* forest	43° 52 499 S 173° 00 579 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
11	Pohatu (north)	Reserve	Bedrock, boulder, coralline, sea tulip, mussel community	43° 52 476 S 173° 00 946 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
12	Pohatu (south)	Reserve	Bedrock, boulder, *Carpophyllum* forest	43° 52 729 S 173° 00 825 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
13	Pohatu (north)	Reserve	Bedrock, boulder, coralline, sea tulip, mussel community	43° 52 599 S 173° 01 255 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m
14	Pohatu (south)	Reserve	Bedrock, boulder, coralline, sea tulip, mussel community	43° 52 735 S 173° 01 109 E	5 - 9 m	7 – 10 m	7 – 10 m	7 – 14 m