# Cape Rodney to Okakari Point Marine Reserve Lobster Monitoring Programme: 2004 Survey


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**Summary**

Between 1995 and 2001, *Jasus edwardsii* abundance within the Cape Rodney to Okakari Point Marine Reserve declined by approximately 80%. Since then, abundance has increased steadily at a mean annual rate of ~ 50 % per year. The increase is driven by strong recruitment, ongrowth, and the relatively high survival of juveniles entering the adult population. In contrast, no significant change in the unprotected lobster population was recorded over the same period.

In 2004, overall lobster abundance within the reserve was the highest recorded (15.5 lobsters per $500m^2 \pm 2.6$ s.e.) since the inception of the annual monitoring programme in 2000, and was approximately 15 times higher than in unprotected (control) sites. Using the relative difference in lobster abundance and assuming that:

- lobster populations of the 6 unprotected sites surveyed are representative of the general Leigh coastline, and
- habitat within the reserve is representative of the wider area,

then the 5 km long Cape Rodney to Okakari Point Marine Reserve contains the equivalent number of lobsters from 75 km of fished, Leigh coastline.

For most surveys there were positive linear relationships between sub-legal and legal-sized lobsters. Given that the habitats found in reserve and non-reserve sites are similar, this suggests that the presence of larger lobsters may influence the survival and/or retention of smaller lobsters. However, large numbers of small juveniles led to a decrease in the mean size of protected lobsters between 2001-2004, concurrent with a slight decrease in large (> 170 mm) legal-sized lobsters in the 2004 sample. The recent reduction in large lobsters from the reserve population may reflect fishing activity on the reserve boundary.

The lower abundance and smaller size of lobsters that is characteristic of unprotected sites reflects sustained fishing pressure in the Leigh area. This is particularly evident in the progressive decline of legal-sized lobsters since 2000. Moreover, it is unlikely that lobster abundance will increase markedly in fished areas in the near future unless fishing effort is reduced, or the recruitment of juveniles increases markedly.

**Keywords:** Cape Rodney to Okakari Point Marine Reserve, Leigh, Lobster, *Jasus edwardsii*, Recruitment

## Introduction

The spiny rock lobster (*Jasus edwardsii*) is an ideal species to use in exploring and promoting the benefits of marine reserves. *Jasus edwardsii* is one of the few species known to respond positively to protection in New Zealand (Cole *et al.* 1990, MacDiarmid and Breen 1993, Kelly *et al.* 2000). They have significant cultural and economic value, giving them wide public appeal and are a conspicuous and important component of the subtidal reef community. *Jasus edwardsii* are high level predators that consume a wide variety of prey including echinoids, molluscs, bivalves and crustaceans, and in turn are prey for a suite of species including octopus and a variety of fish. Recent evidence also suggests that predation by *J. edwardsii* plays a major role in structuring subtidal reef communities (Babcock *et al.* 1999, Shears and Babcock 2002, Shears and Babcock 2003).

The Cape Rodney to Okakari Point (CROP) Marine Reserve (commonly known as the Leigh Marine Reserve) is New Zealand's oldest and best known marine reserve. Prior to 2000, the only information on the state of the CROP Marine Reserve lobster population was obtained from ad hoc surveys conducted to examine specific research questions (Cole *et al*. 1990, MacDiarmid 1991, MacDiarmid and Breen 1993, Kelly *et al*. 2000, Kelly unpublished data). These surveys occurred infrequently and could not be used as a reliable means of monitoring the reserve lobster population. The Department of Conservation therefore established a formal monitoring programme for *J. edwardsii* in May 2000. The Cape Rodney to Okakari Point Marine Reserve Lobster Monitoring Programme provides the department with information on the current status of the protected lobster population, monitors trends in population parameters through time and is capable of alerting reserve managers to potential problems with the lobster population.

This report details the results of the fifth lobster survey of the CROP Marine Reserve and unprotected control sites under this programme. The methods used were standardised with those developed during previous surveys of the CROP Marine Reserve and at least 4 other protected areas, to allow broader scale generalisations about the effects of protection on lobster populations. Data from the 2000 - 2004 surveys are compared with similar data collected at Leigh in 1995 (see Babcock *et al*. 1999).

The objectives of CROP Marine Reserve Lobster Monitoring Programme are to:

- Determine the current population status of *J. edwardsii* within the CROP Marine Reserve.

- Compare lobster size and abundance within the CROP Marine Reserve with unprotected control sites.

- Compare trends in CROP Marine Reserve lobster population through time.

**Methods**

The methods used in the Cape Rodney to Okakari Point Marine Reserve Lobster Monitoring Programme were developed during previous lobster surveys of at least five New Zealand marine protected areas (CROP, Cathedral Cove, Tuhua, Tawharanui Marine Park, and Te Angiangi).

Lobster surveys of the CROP Marine Reserve were carried out in 1995 and from 2000 to 2004. The 1995 survey included, 2 shallow (0 - 10 m) and 2 deep (>10 - 20 m) sites within the marine reserve, and 2 shallow and 2 deep unprotected control sites. Since 2000, an extra deep and shallow site has been surveyed inside and outside the marine reserve (Fig. 1). A total of three shallow and three deep sites in the reserve and control areas was considered the minimum required to meet the objectives of the program. It was chosen because:

- Previous surveys (Kelly unpublished data) indicated that the design had sufficient power to detect differences between reserve and non-reserve locations and would provide reliable estimates of lobster population parameters.
- The CROP Marine Reserve Monitoring Program could be combined with the Cathedral Cove Marine Reserve Monitoring Program to allow a cost effective means of increasing the level of replication and generality of the survey.
- The design was consistent with previous surveys and therefore allowed direct comparisons to be made with a historic data set.
- An ongoing monitoring program is more likely to be maintained if costs were minimised.

In order to eliminate seasonal effects and allow direct comparisons between surveys, monitoring is conducted in May, which coincides with *Jasus edwardsii's* mating season. Several criteria were used in site selection:

- Sites within the reserve were randomly selected from five potential shallow and deep sites.
- The control sites at Kawau were haphazardly selected from a number of possible sites in the Leigh area. Selection occurred prior to the survey with no knowledge of lobster abundance or population structure in the areas concerned.

- A maximum depth limit of 20 m was set to ensure repetitive, multi-day diving could be conducted safely.
- The sites contained reefs with suitable shelters for lobsters.
- The extra sites added in 2000 were randomly selected from a list of three protected and three unprotected sites.

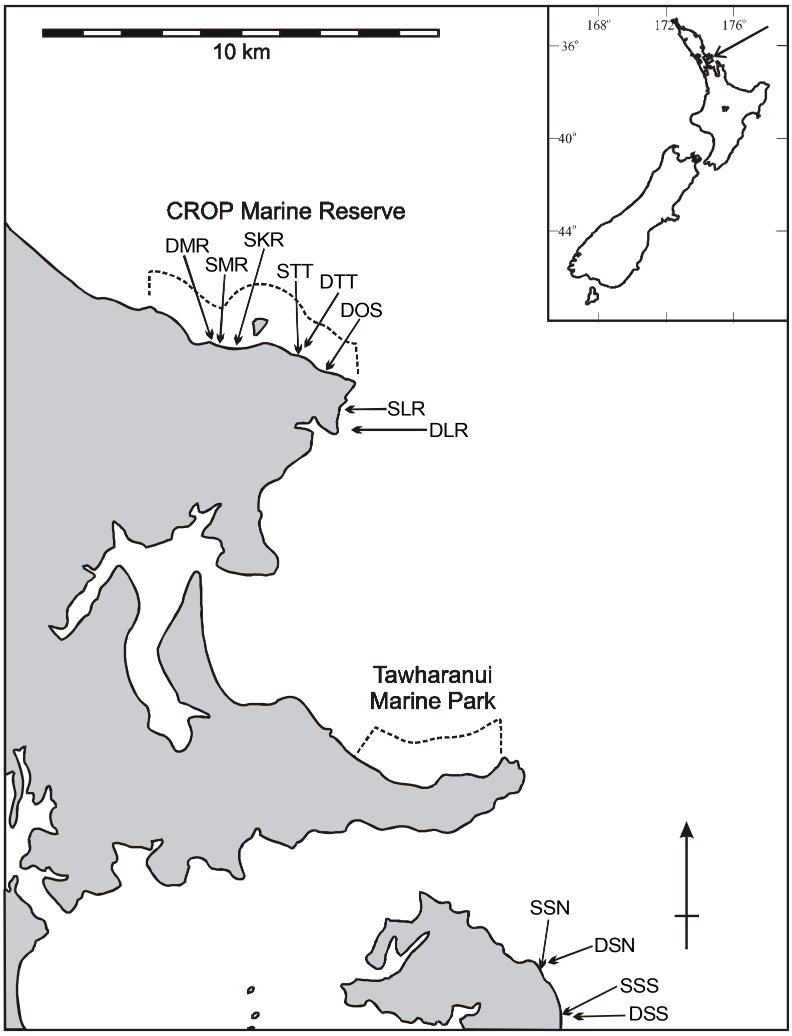
Five, 50 m x 10 m, haphazardly placed transects were sampled within all sites. Haphazard sampling was used to ensure inter-annual samples were independent, allow data to be analysed with ANOVA techniques (which require independent samples), and provide an unbiased representation of each site (Creese and Kingsford 1989). Fixed transects were considered for the programme, but were disregarded because of the disadvantages associated with their use (see Creese and Kingsford 1998):

- They would not provide a representative sample of site populations;
- Comparisons among sites and times could not be examined using simple statistical techniques that require independent samples, such as ANOVA;
- There is uncertainty about the validity of using fixed transects in repeated measures analyses.

The size, and where possible, sex of lobsters within each transect were determined by visual estimation. The choice of the 50 m x 10 m transect and replication level was based on a pilot study conducted by MacDiarmid (1991) who compared the precision of 3 different transect sizes, 10 m x 10 m (n = 20), 25 m x 10 m (n = 8) and 50 m x 10 m (n = 4), each covering a total area of 2000 $m^2$. All transects provided a similar level of precision. Fifty by ten meter transects were chosen for this programme because they permitted at least one transect to be completed per dive in areas of high lobster abundance and they limited the number of zero counts in areas of low lobster abundance. However, the replication level was increased from four (MacDiarmid 1991) to five transects per site, covering a total area of 2500 $m^2$.

Sex was determined using the dimorphic characteristics of male and female lobsters. Torches were used to aid in the sexing of lobsters and to ensure that lobsters in deep holes were not missed. All divers were required to estimate carapace length (C.L.) to within an average of 10 mm. This level of accuracy was achieved through a series of training and calibration dives where the size of individual lobsters was estimated, after which each lobster was caught by hand and measured with vernier callipers to obtain a true length measurement (Fig. 2). An analysis of covariance (ANCOVA) could not detect any significant difference between the size estimation ability of the two censors used in the survey (P = 0.690). In northern New Zealand the minimum legal size limit for *J. edwardsii* occurs between 95 mm and 100 mm C.L. For the purpose of this report lobsters ≥ 95 mm were therefore considered to be legal.

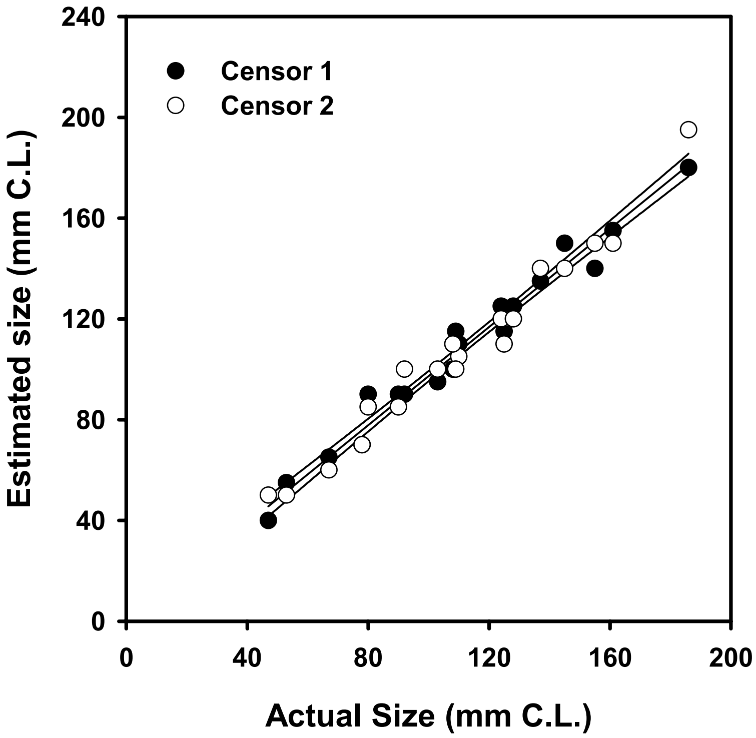
**Fig. 1** Map of the protected and unprotected sites included in the survey. The site names have been abbreviated with the first letter indicating the depth (S – 0 m -10 m, D - >10 m – 20 m). Site abbreviations are as follows: DMR – Deep Martins Reef, SMR – Shallow Martins Reef, SKR – Shallow Knot Rock, STT – Shallow Table Top, DTT – Deep Table Top, DOS – Deep One Spot, SLR – Shallow Leigh Reef, DLR – Deep Leigh Reef, SSN – Shallow Slater North, DSN – Deep Slater North, SSS – Shallow Slater South, DSS – Deep Slater South.




Abundance data is presented graphically. To test for differences between surveys and reserve and non-reserve sites, data were analysed with a repeated measures generalised linear mixed model using the SAS macro GLIMMIX (Littell *et al.* 1996). The model was backfitted to a Poisson distribution and an autoregressive error structure [AR(1)] was used to account for repeated measures. In addition, ordinary least squares linear regression and correlation were used to examine changes in lobster abundance between 2001 and 2004 and the relationship between legal and sub-legal lobsters. Size data is presented graphically and lobster sizes from protected and unprotected sites in

2004 were pooled and analysed with a 2-tailed *t*-test. All statistical analyses were carried out using SAS® (1999).

**Fig. 2** Size calibration data from the three censors conducting the 2003 survey of Cape Rodney to Okakari Point Marine Reserve. Size estimates were made without the handling individual lobsters. Actual sizes were determined by capturing the lobsters and measuring with vernier callipers after the size estimates were made. The least squares regression line for the pooled estimates (± 95% confidence intervals) is also given.




## Results

### *Lobster abundance*

In 2004, spiny lobster abundance within the Cape Rodney to Okakari Point Marine Reserve was the highest recorded since the programme began in 2000 (Fig. 3). A total of 467 *Jasus edwardsii* were counted in the reserve, whereas 32 were counted in non-reserve areas. Mean lobster abundance pooled for all reserve sites was approximately 15 lobsters per 500 $m^2$, which is 38 % of the figure recorded in 1995. Within the reserve, the increase in lobster abundance between 2003-2004 occurred at all sites irrespective of depth (Fig. 4.), with Knot Rock (shallow) and One Spot (deep) having almost 2-fold increases relative to the previous year (Fig. 4). In contrast, mean lobster abundance at non-reserve sites in 2004 showed no obvious overall trend, being similar to previous surveys at around 1 lobster per $500m^2$ and ~ 10 % of 1995 levels (Fig's 3 & 4).

Within the reserve, abundance increased linearly between 2001 and 2004 (Fig. 5). The increase was statistically different from zero ($P < 0.05$, $r^2 = 0.97$), with the rate of increase equivalent to around 50 % per annum. No significant relationship was detected between lobster abundance and time for non-reserve populations ($P = 0.388$, $r^2 = 0.37$). Further analysis of temporal data (2000-2004) using a repeated measures mixed model detected a significant difference in abundance between reserve and non-reserve sites (status) ($P < 0.001$). There was no significant difference among surveys (years) ($P = 0.650$) and no significant interaction was detected between status and year ($P = 0.845$).

***Lobster sex and size***

Consistent with previous surveys, the mean size of lobsters was significantly higher inside the CROP reserve than outside ($P < 0.001$ – 2-tailed *t*-test) (Fig. 6). This difference reflects a higher proportion of legal-sized lobsters within the protected population. Seventy percent of the lobsters that were estimated for size (n = 286) were of legal size (i.e., ≥ 95 mm C.L.) inside the marine reserve compared to 46 % (n = 12) outside. Despite this difference, the mean size of lobsters has consistantly decreased in both reserve and non-reserve populations since 2000 (Fig. 6) due to increases in the number of sub-legal lobsters and loss of larger lobsters from the population.

Size frequency histograms and abundance plots (Fig's 7 & 8) indicate that recruitment has been reasonably good over the last three years, with a strong pulse occurring in 2004 (Fig. 7). A slightly lower frequency of large lobsters > 170 mm C.L., potentially related to fishing activity, also contributed to the reduction in the mean size of protected lobsters in 2004. Similarly, sporadic small-scale recruitment events and the persistent decline of legal-sized lobsters (Fig's 7 & 8) appear to be responsible for a decline in the mean size of unprotected lobster. Analysis of temporal data suggested that sub-legal and legal lobster abundance within the reserve were positively associated (Fig. 9), although the strength of the relationship was variable.

The sex ratio of lobsters within the reserve population remains consistent with previous surveys (2002-2003), i.e., male and female lobsters occur in similar numbers. In 2004 there was a slight shift in bias from females to males in the non-reserve population (Fig. 10), although, the biological significance of this change should be viewed with caution given the low number of lobsters that were sexed (n = 13).

**Fig. 3** Mean abundance (per 500$m^2$) of *Jasus edwardsii* (± s.e.) pooled from sites inside and outside the CROP Marine Reserve in 1995 and 2000 to 2004.

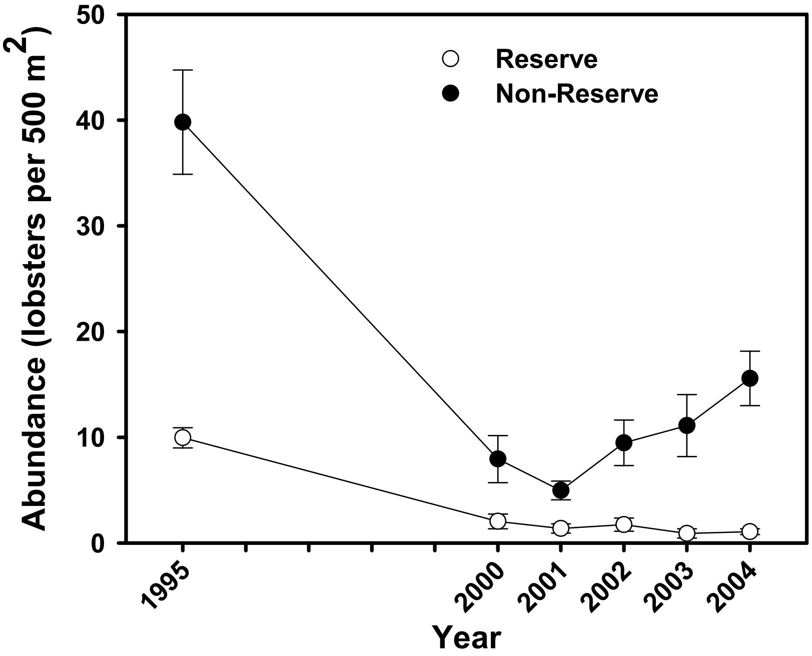



**Fig. 4** Mean abundance of *Jasus edwardsii* (± s.e.) recorded during lobster surveys of the Cape Rodney to Okakari Point Marine Reserve and unprotected control sites. Sites marked * were not surveyed in 1995. Refer to Fig. 1 for the location and abbreviations of each site.

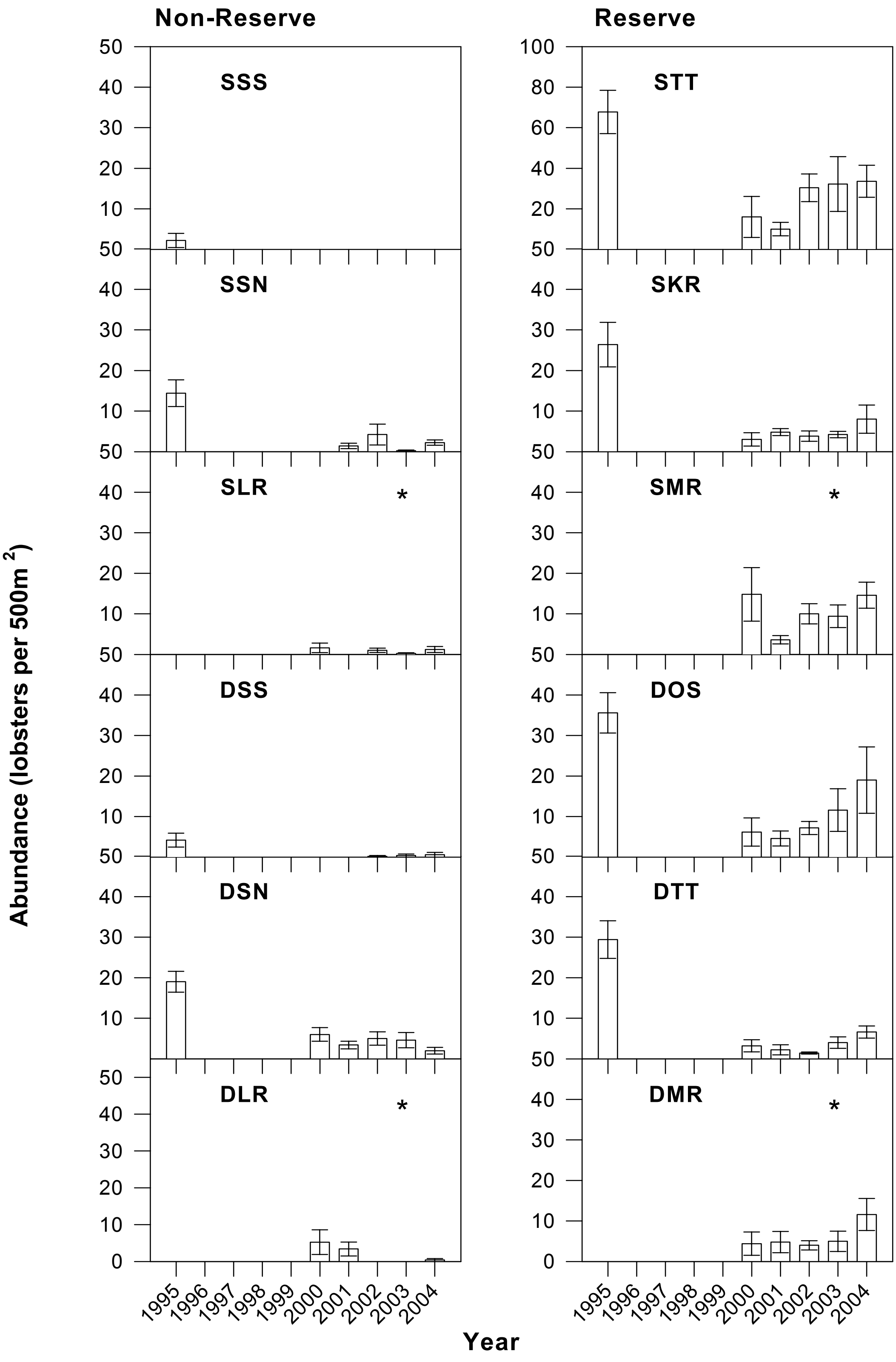



**Fig. 5** Relationship between mean abundance (per 500 m$^2$ ± s.e.) and time (year) for *Jasus edwardsii* within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control areas from 2001 to 2004. Lines represent best-fit linear regressions.

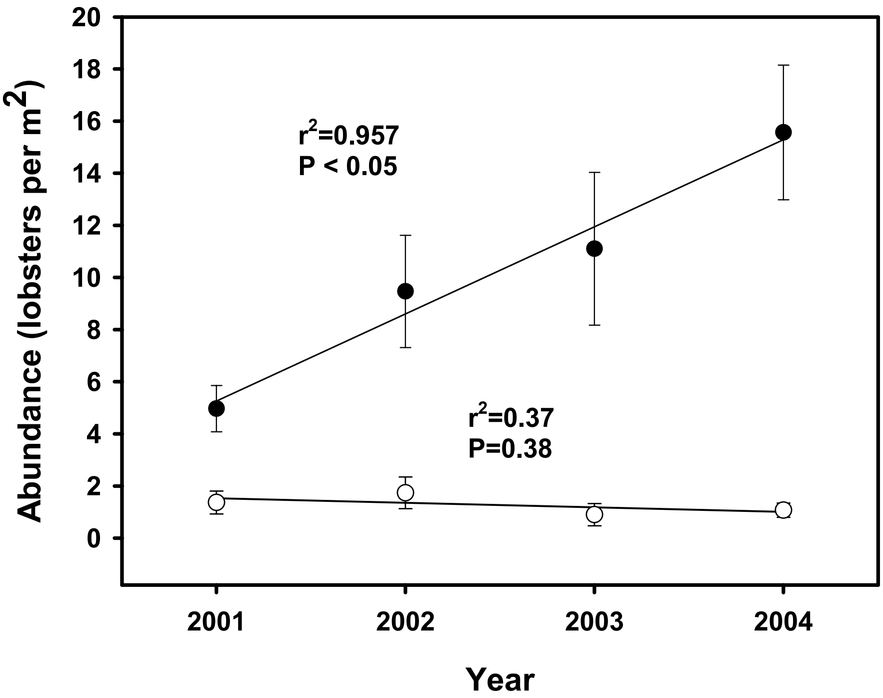



**Fig. 6** Changes in the mean size of *Jasus edwardsii* (± 95 % C.I.) within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2004.

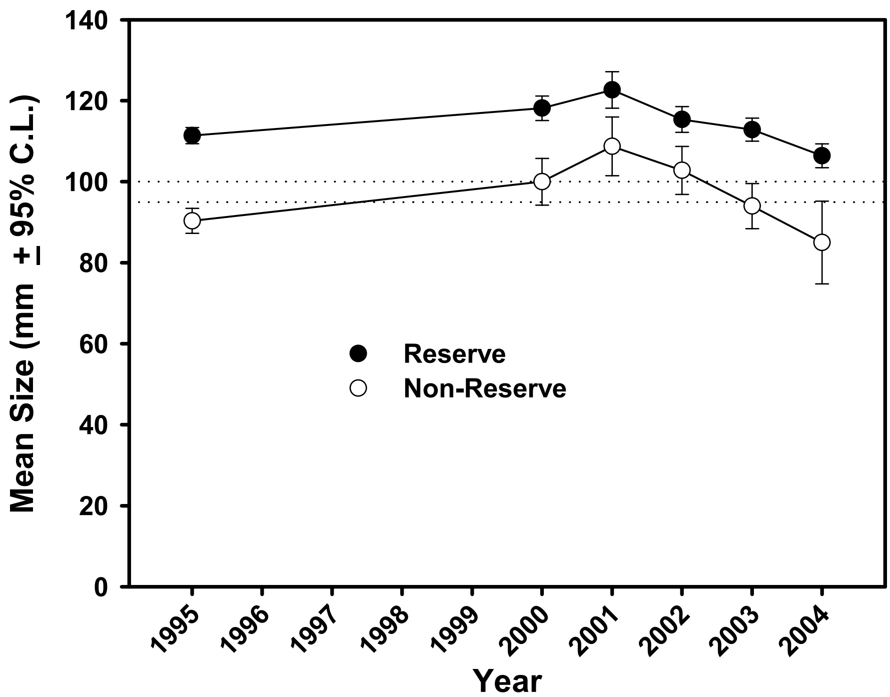



**Fig. 7**
Size

frequency histograms of *Jasus edwardsii* from the Cape Rodney to Okakari Point Marine Reserve and non-reserve control areas from 2000 to 2004. The dashed line denotes the division between legal and sub-legal lobsters.

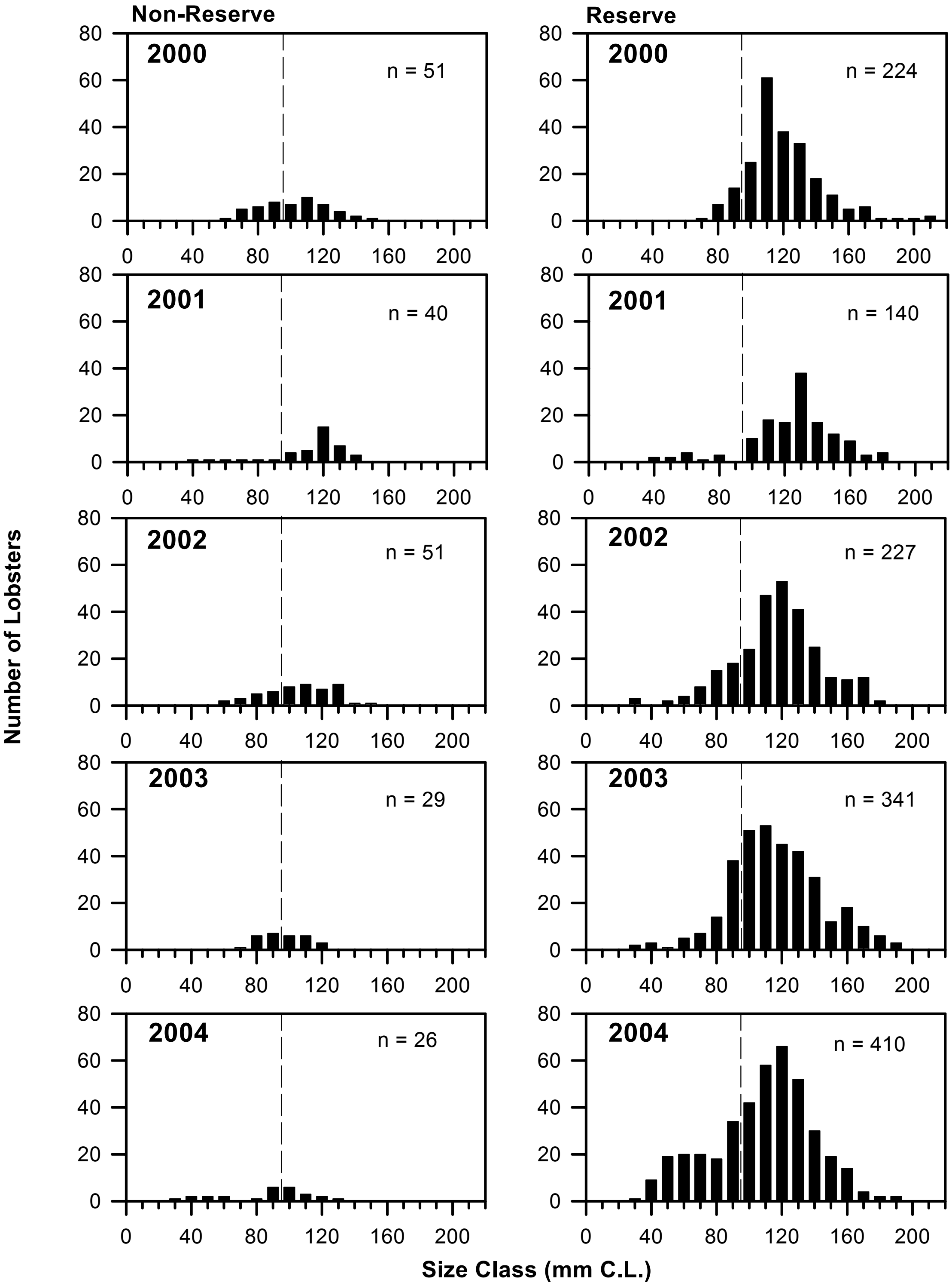



**Fig. 8** Mean abundance (± s.e.) of juvenile (carapace length < 95 mm) and legal *Jasus edwardsii* (carapace length ≥ 95 mm) within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2004. Note: *y* axis scale differs between plots.

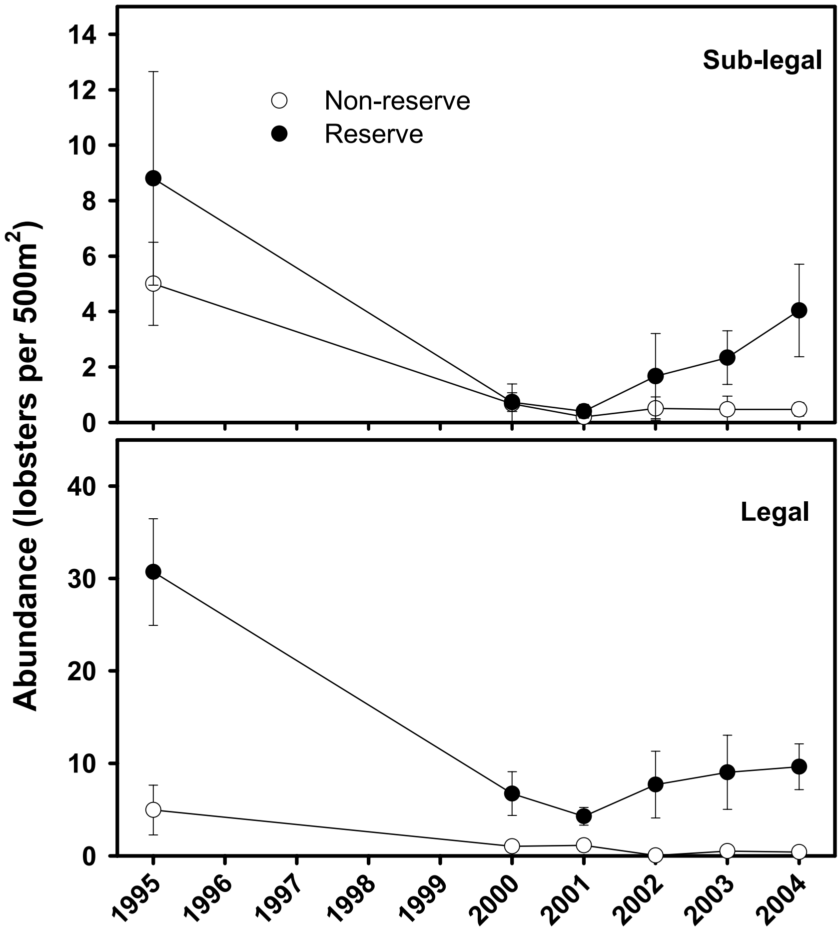



**Fig. 9** Relationship between legal and sub-legal *Jasus edwardsii* abundance for individual transects surveyed within the cape Rodney to Okakari Point Marine Reserve between 1995-2004. Note: Only transects in which both adults and juveniles co-occurred have been analysed. A plot for 2001 has not been included due to a lack of any relationship between legal and sub-legal lobsters.

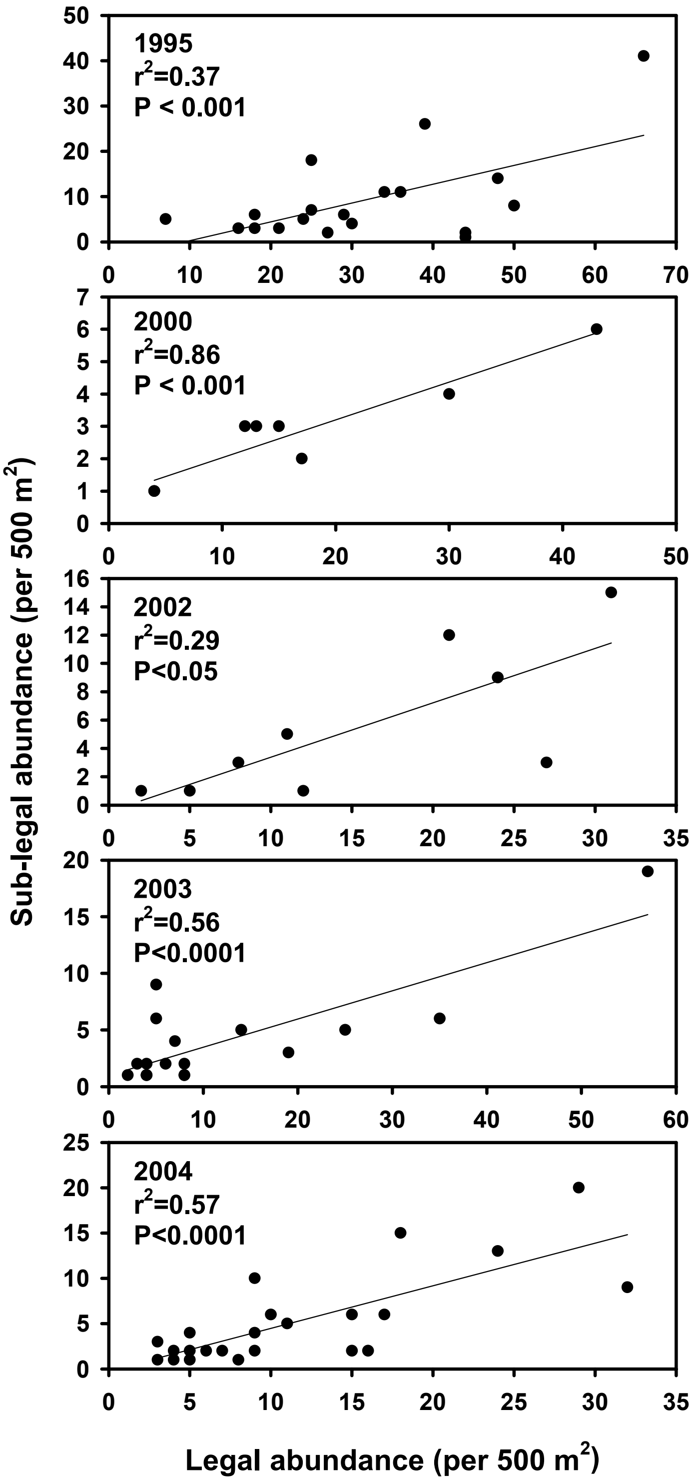
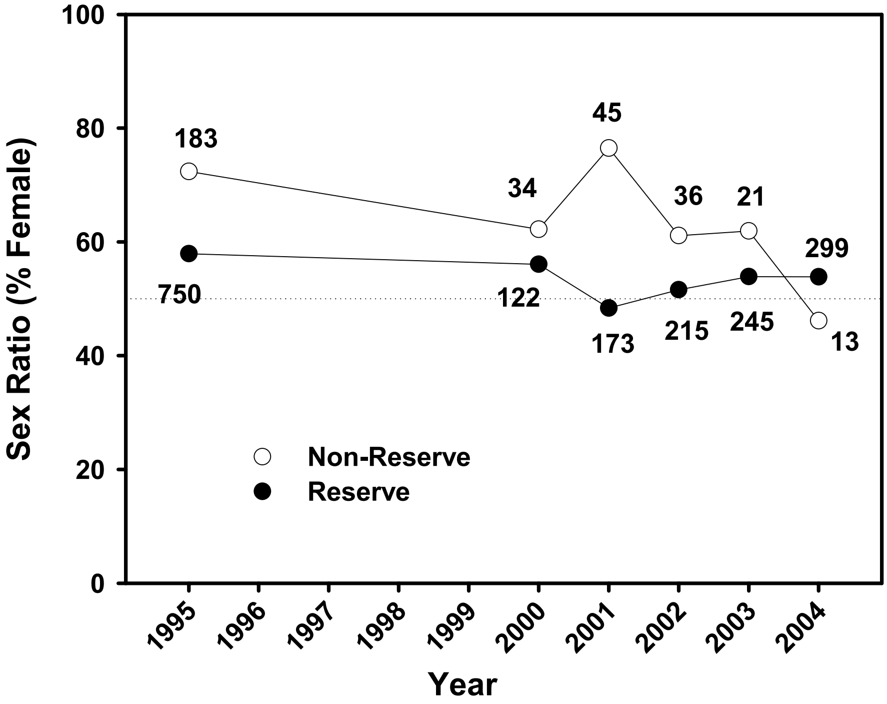



**Fig. 10** Sex ratios (% female) of lobsters within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2004. Sample sizes for the estimates are given.




**Discussion**

The lobster population of the Cape Rodney to Okakari Point Marine Reserve is steadily recovering from a major decline in abundance between 1995 and 2001. Population increases are being driven by recruitment, the ongrowth of juveniles and subsequent increases in the number of legal sized lobsters. The most recent survey recorded increases at all sites within the reserve, whereas in previous surveys, recovery was patchier with large increases occurring at only one or two sites. Relatively weak recruitment pulses have also occurred in non-reserve areas, although unprotected lobster abundance remains at very low levels. For the larger size classes this is most likely attributable to fishing activity, which has increased in the area over recent years (Dave Fisher personal communication in 2003), and is noticeable in the progressive decline of legal-sized lobsters in the fished population since 2000.

The reason for the low number of recruits in unprotected sites is unknown. Recruitment strength in the CROP and Cathedral Cove marine reserves tends to be correlated, which suggests that recruitment events in northeastern New Zealand occur on the scale of 10s – 100s of km. Habitats differ little between the reserve and non-reserve sites surveyed at Leigh, so habitat related differences are unlikely to explain the difference in juvenile abundance. Furthermore, similar patterns have been recorded inside and outside the Cathedral Cove Marine Reserve, Tonga Island marine reserve (Davidson *et al.* 2002) and in Tasmanian marine reserves (Edgar and Barrett 1999). The positive linear relationship between legal and sub-legal lobster abundance within the marine reserve, which was apparent for most surveys, provides some evidence that smaller lobsters may prefer to settle and/or aggregate in areas where large lobsters are abundant. Alternatively, greater numbers of lobsters settling in low abundance areas may be lost to predation, due to a lack of mutual protection provided by conspecifics (Butler *et al.* 1999).

Due to seasonal offshore movements of *J. edwardsii* associated with moulting, reproduction and feeding, the reserve population is also vulnerable to fishing at various times of the year (Kelly 2001). The slight decline of large lobsters (> 170mm C.L.) within the reserve population in the current survey may be related to fishing activity concentrated at the reserve boundary and/or in areas where *J. edwardsii* aggregate (Kelly and MacDairmid 2003).

Using the relative difference in lobster abundance between reserve and non-reserve areas and assuming lobster populations of the 6 unprotected sites surveyed are representative of the general Leigh coastline, and habitat within the reserve is representative of the wider area, then the 5 km long Cape Rodney to Okakari Point Marine Reserve contains the equivalent number of lobsters from 75 km of fished coastline. This clearly illustrates the effectiveness of reserve protection, but it is also raises management concerns, because the temptation to poach lobsters from the reserve is likely to increase as the disparity between reserve and non-reserve populations increases.

**Recommendations**

- Annual monitoring of the CROP Marine Reserve should continue over consecutive years to:

1) Determine the natural variability in the resident lobster population.
2) Detect shifts in the size and abundance that cannot be attributed to natural variability.
3) Determine recovery dynamics and the frequency of recruitment pulses within sample populations.

- The methodologies used in the Cape Rodney to Okakari Point Marine Reserve Lobster Monitoring Programme are allowing the objectives to be met and should be retained in future surveys to ensure consistency and permit direct comparisons with other studies. The addition of Tawharanui Marine Park into the monitoring programme would also provide worthwhile information on lobster population changes in a nearby protected area and enhance spatial resolution. This data, together with that from the Cathedral Cove Marine Reserve would be invaluable for interpreting changes in the Cape Rodney to Okakari Point Marine Reserve lobster population.

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