Cape Rodney to Okakari Point Lobster Monitoring Programme: May 2006 Survey

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Cape Rodney to Okakari Point Lobster Monitoring Programme: April/May 2006 Survey

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SUMMARY

In 2006 the spiny lobster *Jasus edwardsii* within the Cape Rodney to Okakari Point Marine Reserve was 10 times greater than non-reserve (unprotected) control populations. Legal-sized lobsters were 11 times greater than non-reserve populations and mean lobster size was 50 mm greater than non-reserve populations. While the current abundance of 16.1 lobsters $500m^{-2} \pm 3.5$ (SE) is the highest recorded since the sampling programme was initiated in 2000, lobster abundance has still not recovered to 1995 levels following the broad-scale decline between 1995-2000 remaining ~ 2.5 times lower than 1995 levels. Nevertheless, using the relative difference in lobster abundance between reserve and non-reserve areas 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 in 2006 contains the equivalent number of lobsters from 60 km of fished, Leigh coastline.

To evaluate potential reserve-related effects in non-reserve populations the 2006 survey differed form previous surveys (2000-2004) with the addition of two extra control sites within the adjacent Leigh coastline close to the reserve and one extra control site at Kawau Island (approximately 12 km south from the reserve). Despite higher abundances of sub-legal lobsters at sites close to reserve, this difference was not statistically significant from sites at Kawau Island. Mean lobster size was also similar between unprotected areas.

The lower abundance and smaller size of lobsters, 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 and lack of legal-sized lobsters at Kempts Beach, one of the new non-reserve survey sites where sub-legal lobsters were abundant. 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: CROP Marine Reserve, rock lobster, *Jasus edwardsii*, abundance.

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1 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, Edgar and Barrett 1998, Kelly *et al.* 2000, Davidson *et al.* 2002, Shears *et al. in press*). *Jasus edwardsii* 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. 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.

Between 1995 and the inception of the monitoring programme in 2000, *Jasus edwardsii* within CROP and the adjacent Leigh coastline declined from 40 lobsters per 500 m^2 to about 5 lobsters per 500 m^2. Previous surveys between 2000 and 2004 have quantified the recovery of *J. edwardsii* relative to unprotected sites. This report details the results of the sixth 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 - 2006 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.

2 METHODS

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

Previously, lobster surveys of the CROP Marine Reserve have been 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. 2.1). 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 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 are minimised.

For the 2006 survey, three extra shallow and deep control sites were added to the survey design (Fig 2.1), with a focus on comparing lobster populations in unprotected sites close to and far from the marine reserve boundary. The rational for increasing the number of non-reserve sites was to assess lobster size and abundance at control sites close to the reserve boundary in relation to control sites further away from the reserve, to assess the potential influence of the reserve on nearby non-reserve areas.

In order to eliminate seasonal effects and allow direct comparisons between other 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 were haphazardly selected from a number of possible sites in the 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 three extra control sites added in 2006 were randomly selected from a list of five unprotected sites.

Within all sites, five 50 m x 10 m haphazardly placed transects were sampled. 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 (see Creese and Kingsford 1998).

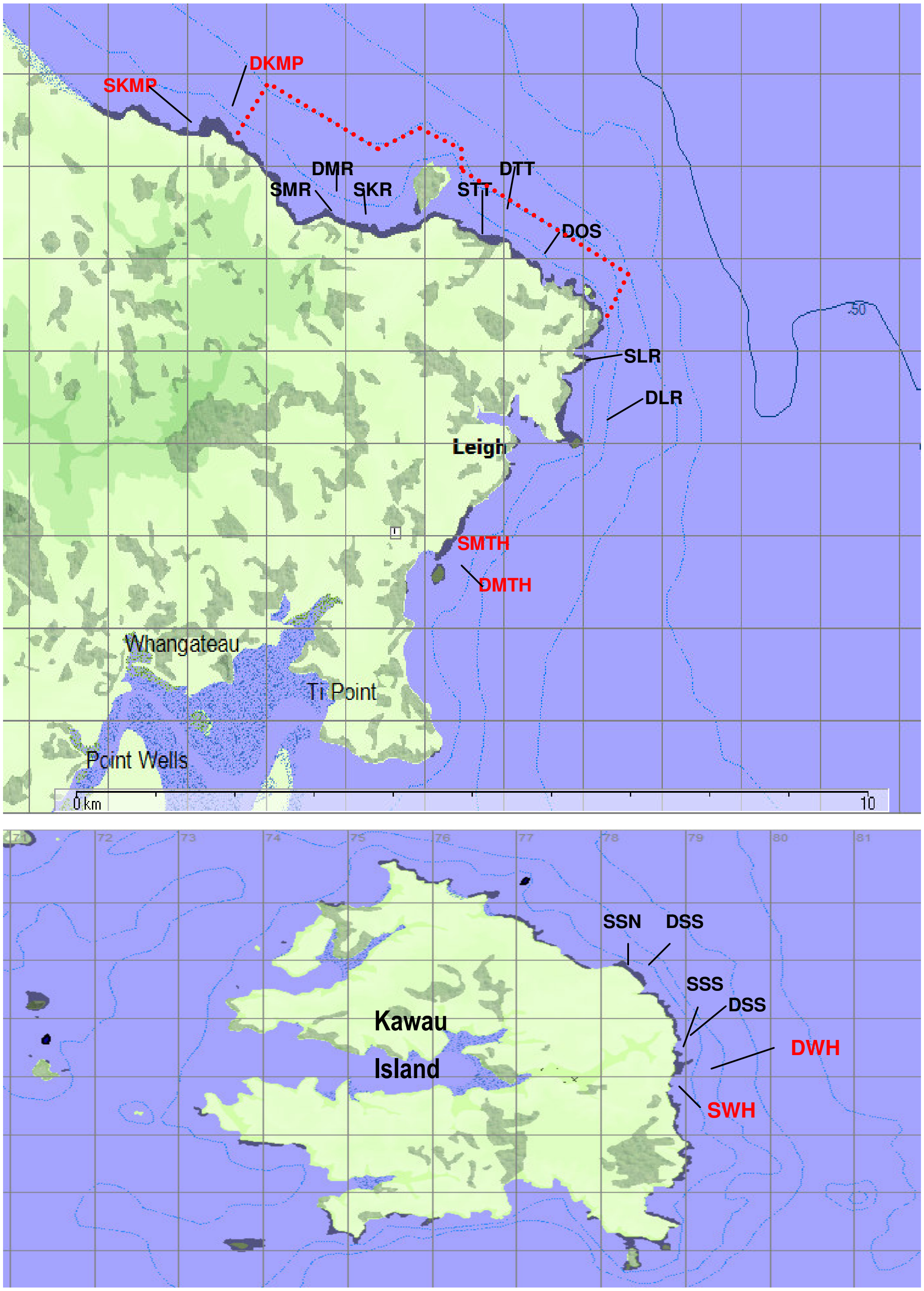

Figure 2.1 Map of the protected and unprotected sites included in the survey. The site names have been abbreviated with the first letter indicating the depth (S – 0 m -10 m, D - >10 m – 20 m). Site abbreviations are as follows: SKMP – Shallow Kempts Beach, DKMP – Deep Kempts Beach, DMR – Deep Martins 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, SMTH – Shallow Matheson Bay, DMTH – Deep Matheson Bay, SSN – Shallow Slater North, DSN – Deep Slater North, SSS – Shallow Slater South, DSS – Deep Slater South, DWH – Deep Wells Hill, SWH – Shallow Wells Hill. New sites added to the 2006 survey in control area are in red font.

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 to within an average of 10 mm. This level of accuracy was achieved through a series of 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. 2.2). An analysis of covariance (ANCOVA) could not detect any significant difference between the size estimation ability of the three censors used in the survey, i.e., the slope was not significantly different from 1 ($P = 0.585$) and the y intercept did not differ significantly from 0. 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 and thus susceptible to fishing.

Data analysis

Abundance and size data is presented graphically. To investigate statistical differences in lobster counts between the three status types (reserve, Leigh non-reserve and Kawau Island non-reserve) data pooled across sites (2006 data only) were analysed with ANOVA. Prior to formal analysis, data were tested for normality and homogeneity of variances with a Shapiro-Wilk W test and residual plots. One-way ANOVA on the log x+1 transformed counts was employed, with the factor *status* treated as fixed. Where significant differences were detected Tukey-Kramer multiple comparison tests were used to determine differences between means.

As the long-term data set violated assumptions of traditional ANOVA[1], generalised linear modeling (McCullagh and Nelder 1989) was used to analyse abundance data from 2000-2006. To test for differences in abundance 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, as measurements were likely to be most similar between sampling dates closer in time and because variances between sampling dates were heterogeneous.

Habitats

To document habitat types among survey areas, a remote video survey of each area was conducted over the course of the survey. The video survey used a Splashcam® underwater camera unit connected to Sony® digital videocassette recorder (GV-D800E) on the surface. A series of video drops were made within each survey area. So that individual stations could be identified upon playback, the video drop number was written on a whiteboard and videoed before deployment. The camera was then hand-lowered to the seabed from the boat. Once the camera had reached the seabed, recording commenced and a GPS mark was immediately taken. Each location was videoed for a minimum of 60 seconds.

Video surveys were edited into 10 second sequences with Ulead® video software. The coordinates of each drop were then used to create points on a geo-registered map within

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[1] Residual plots of count data showed numerous outliers whereas Shapiro-Wilk *W*-tests for normality of errors and Levene's test for homogeneity of variances were significant in many cases. Appropriate transformations (Zar 1999) failed to ameliorate these problems.

the mapping program TUMONZ®. Surveyed areas were then grouped into habitat types using the classification system described in Shears *et al.* (2004). A video map was then created by 'hyperlinking' each point to its corresponding video clip. This enabled the video footage of a certain point to be observed by running the program TUMONZ® and then clicking on the specific symbol on the map of the study area. The interactive CD-ROM, which is located in a pocket in the back cover of this report, should be consulted for information on habitat types at each site.

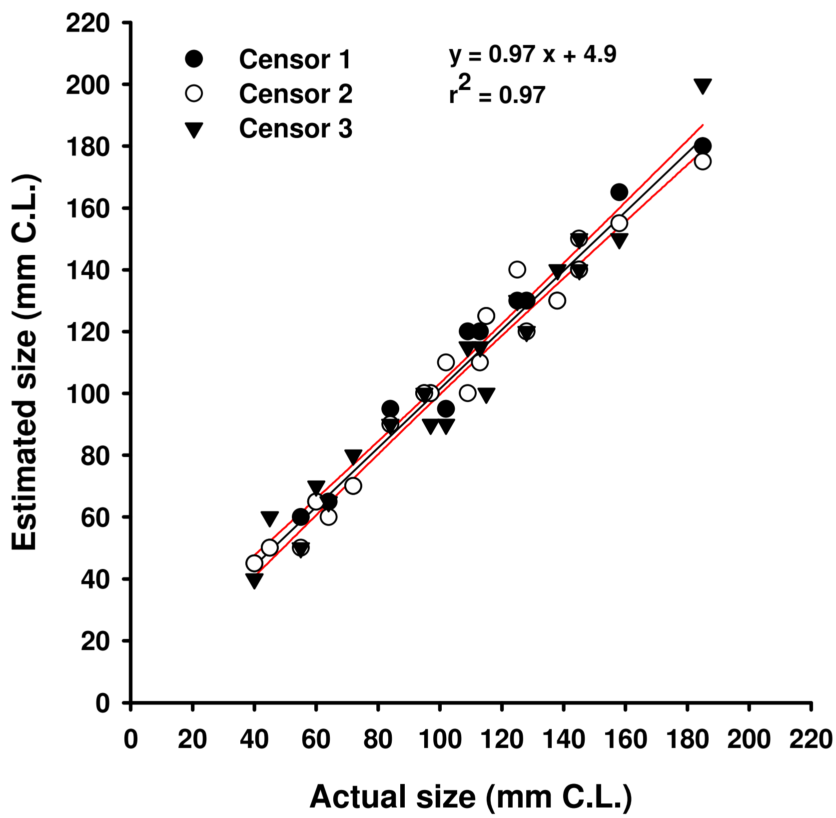

Figure 2.2 Size calibration data from the three censors conducting the 2006 survey of CROP. Size estimates were made without handling individual lobsters. Actual sizes were determined by capturing the lobsters and measuring with vernier calipers after the size estimates were made. The least squares regression line for the pooled estimates (± 95% confidence intervals *in red*) is also given.

Urchin tests

Jasus edwardsii is a significant predator of the urchin *Evechinus chloroticus* (Shears and Babcock 2002). In order to begin to assess urchin predation on urchins, urchin tests with distinct fractures attributable to lobster predation (refer to Fig. 2.3) that occurred next to lobsters or within lobster holes along each transect were counted.

Figure 2.3 Urchin tests showing distinct key-hole fractures, characteristic of lobster predation. Photo courtesy of N. Shears.

3 RESULTS

Jasus edwardsii abundance

A total of 483 lobsters were counted within the CROP Marine Reserve compared to 99 lobsters at control sites. The abundance of *Jasus edwardsii* (pooled across depths) within the Leigh Marine Reserve in 2006 was approximately 10 times higher than non-reserve areas surveyed and the highest abundance recorded since the initiation of the CROP sampling programme in 2000 (Fig. 3.1). While the current density represents a slight increase in abundance from 2004 levels, lobster abundance remains ~ 2.5 times lower than 1995 levels. In non-reserve sites, the overall abundance of lobsters remains low and ~ 6 times lower than *J. edwardsii* abundance in non-reserve sites in 1995.

While lobster abundance in reserve sites was substantially higher than non-reserve sites, lobster abundance among the two non-reserve areas was generally higher in non-reserve areas in Leigh relative to Kawau Island (Fig. 3.2). ANOVA of the 2006 data pooled across sites and depths among the three status types indicated a statistically significant difference with respect to status ($F_{2,31}$ 11.07 $P < 000.1$), however, a Tukey-Kramer Multiple Comparison Test indicated that while reserve counts were statistically different from non-reserve areas, non-reserve counts in Leigh were not significantly different from non-reserve counts in Kawau Island.

Mirroring previous surveys, *J. edwardsii* displayed high spatial variation among sites and depths in 2006 (Fig. 3.3). At a site specific level within the reserve, lobsters were found in their highest numbers in shallow sites e.g., Table Top shallow (STT – 44.8 lobsters 500 m^{-2} ± 6.3 (SE)) and Knot Rock (KR – 15.2 lobsters 500 m^{-2} ± 5.0 (SE)), whereas deeper sites generally had lower abundances (Fig. 3.3). At STT and KR lobster abundance has increased relative to 2004 levels, whereas the other reserve sites were generally of similar abundance to 2004 levels. The exception to this was Outer Martins Reef (deep), which had the lowest abundance of lobsters since the initiation of the sampling programme and was ~ 5 times lower than 2004 abundance – 2.0 lobsters 500 m^{-2} ± 1.5 (SE). Within reserve sites, lobsters were often found in aggregations with largest nests occurring at SST and KR, but were also solitary, the latter being more common at deep sites. Largest nests occurred at SST and KR. Of particular note was the behaviour of large males at STT, which were routinely seen in the open away from shelters and were particularly aggressive towards surveyors.

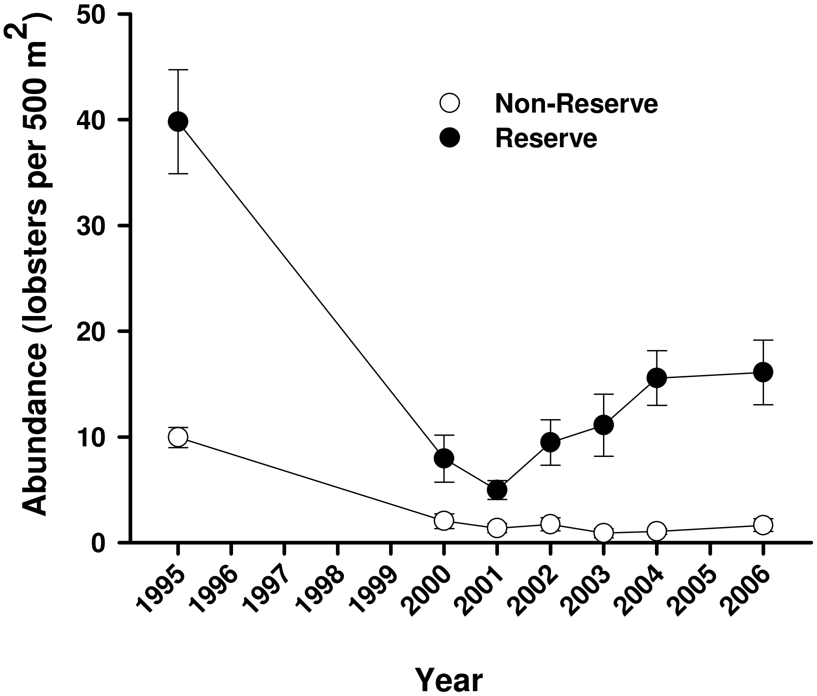

Figure 3.1 Mean abundance of *Jasus edwardsii* (± SE) pooled from sites inside and outside the CROP Marine Reserve in 1995 and 2000 to 2006. Note: non-reserve sites in 2006 include three additional shallow and deep-water sites.

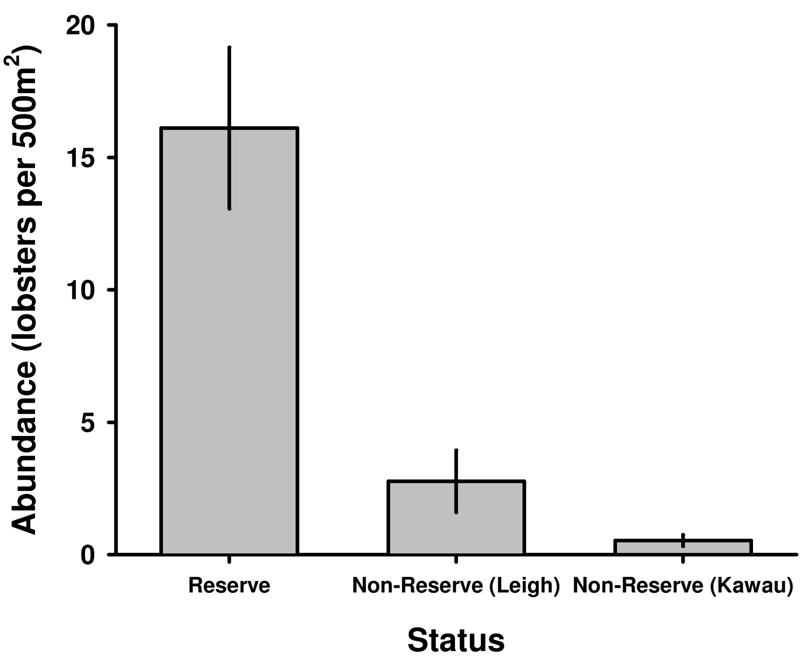

Figure 3.2 Comparison of *Jasus edwardsii* abundance within CROP reserve and Leigh and Kawau Island non-reserve areas in 2006. Data are mean values ± SE.

For the most-part, non-reserve sites had very low lobster abundance, a trend consistent with previous surveys. Despite affording good habitat for lobsters (Refer to Table 3.2), no lobsters were found at Matheson Bay (Shallow or Deep), however, at Kempts Beach (shallow) immediately north of the Okakari Point reserve boundary, *J. edwardsii* were present at ~ 13 lobsters per 500 m^2 and these were predominantly sub-legal. Non-reserve sites at Kawau Island, including the new site Wells Hill, were characterised by low lobster abundance, i.e., < 1 lobster per 500m^2 (Fig. 3.3).

Statistical analysis of the historical dataset (2000-2006 excluding new sites) using mixed model analysis indicated statistically significant differences in lobster abundance between status (reserve and non-reserve) ($P < 0.001$), although the factor time (years) was not statistically significant ($P = 0.650$). There was however, a significant year × status interaction ($P < 0.001$), which we interpret as being due to the abundance of lobsters changing at very different rates through time between reserve and non-reserve sample populations, i.e., lobsters in the reserve have increased substantially relative to non-reserve populations through time (Fig. 3.1).

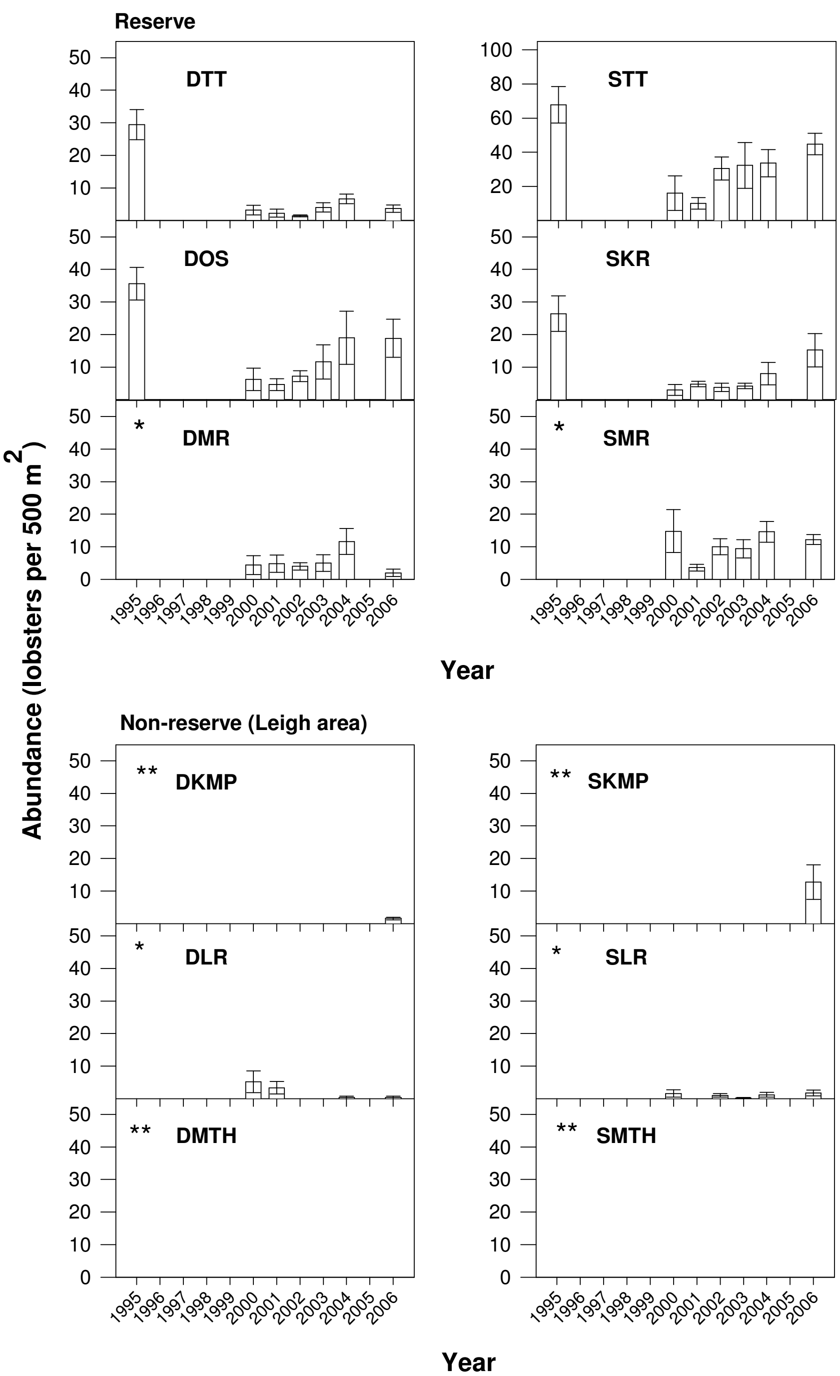

Figure 3.3 Mean abundance of *Jasus edwardsii* (± SE) recorded during lobster surveys of the Cape Rodney to Okakari Point Marine Reserve and unprotected control sites. Sites marked with * were not surveyed in 1995, whereas sites marked with ** were new to the survey in 2006. Refer to Figure 1.1 for the location and abbreviations of each site.

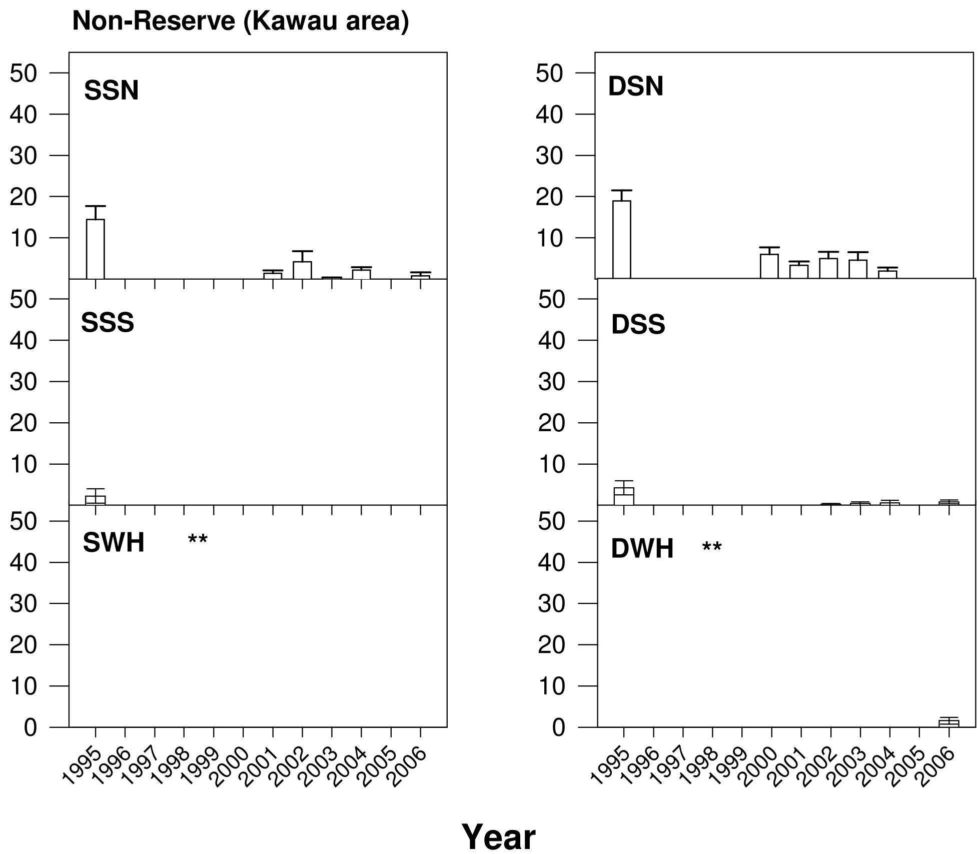

Figure 3.3 ***continued*** Mean abundance of *Jasus edwardsii* (± SE) recorded during lobster surveys of the Cape Rodney to Okakari Point Marine Reserve and unprotected control sites. Sites marked with * were not surveyed in 1995, whereas sites marked with ** were new to the survey in 2006. Refer to Figure 1.1 for the location and abbreviations of each site.

Lobster sex and size

The mean size of lobsters was ~ 50 mm greater inside the CROP reserve than in unprotected areas and this difference was statistically significant ($P < 0.001$ – 2-tailed *t*-test) (Fig. 3.4), reflecting a higher proportion of legal-sized lobsters within the protected population (Fig's 3.5, 3.6, 3.7). Moreover, mean lobster size within CROP reserve was similar to the 2000 size estimates being ~ 10 mm greater than in 2004 (Fig. 3.4). Eighty percent of the lobsters whose size was estimated inside the marine reserve ($n = 350$) were of legal size (i.e., ≥ 95 mm C.L.) compared to 17 % ($n = 15$) outside.

The mean size of lobsters in non-reserve populations since 2000 (Fig. 3.4) has steadily declined through time and in 2006 was 69.7 mm ± 4.9 (95% CI). The decline is largely due to the loss of larger lobsters from the sample population, but also due to increased abundance of sub-legal lobsters. For example, the decline in size between 2004 and 2006 is largely due to the high number of sub-legal lobsters counted and sized at the new Kempts Beach site relative to previous years. There was no difference in the mean lobster size between non-reserve sites at Leigh and Kawau Island (Fig 3.5).

Size frequency distributions for both non-reserve and reserve areas are presented in Fig. 3.6. CROP reserve size frequency data suggests continued growth of the adult population following distinct recruitment pulses in 2002 and 2004. Conversely, while small-scale recruitment has been evident in non-reserve populations (2000 and 2004), this has not transpired into an increase in the number of legal-sized lobsters – trends reflective of a fished population.

Within the reserve population, the abundance of legal-sized lobsters has increased in a linear fashion since 2001, whereas non-reserve sites remain at very low levels (Fig 3.7). Consequently, legal-sized lobsters are 11 times more abundant than non-reserve legal-sized lobsters. Sub-legal lobsters were lower in the reserve in 2006 relative to 2004, whereas in the non-reserve areas sub-legal lobsters were higher than previous years, predominantly due to the inclusion of the shallow Kempts Beach site.

The sex ratio of lobsters within the reserve population remains consistent with previous surveys (2002-2004), i.e., male and female lobsters occur in similar numbers within the reserve with a slight bias towards females. In non-reserve areas, the population has been slightly biased towards males and similar to 2004 levels, although the biological significance of this pattern should be interpreted with caution given the low number of lobsters that were sexed ($n = 23$), largely through the difficulty of accurately sexing small lobsters, i.e., < 60 mm C.L.

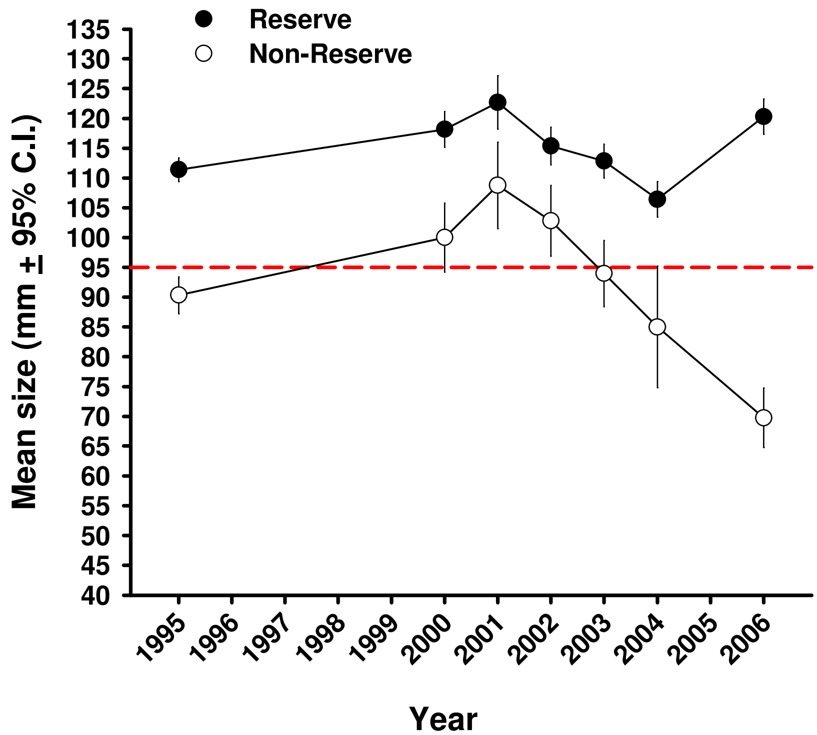

Figure 3.4 Changes in the mean size of *Jasus edwardsii* (± 95 % C.I.) within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2006. Note: non-reserve sites in 2006 include three additional shallow and deep-water sites.

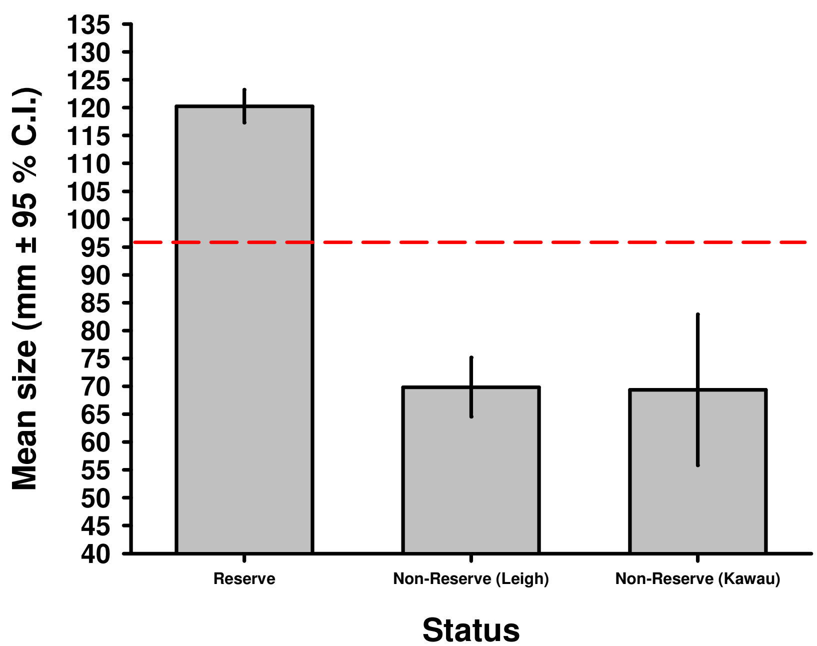

Figure 3.5 Comparison of *Jasus edwardsii* size within CROP reserve and Leigh and Kawau Island non-reserve areas in 2006. Data are mean values.

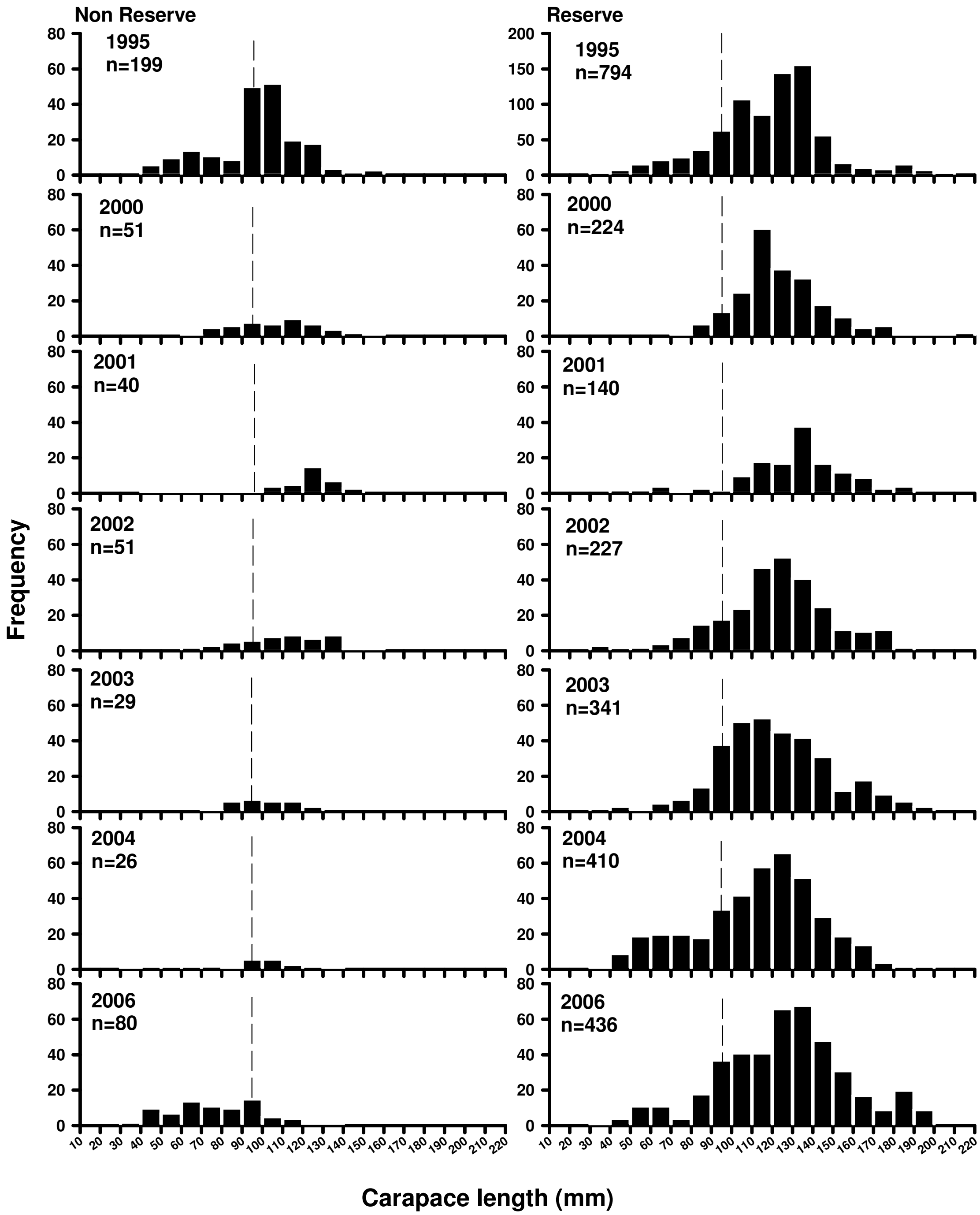

Figure 3.6 Size frequency histograms of *Jasus edwardsii* from the Cape Rodney to Okakari Point Marine Reserve and non-reserve control areas from 2000 to 2006. The dashed line denotes the division between legal and sub-legal lobsters. Note: non-reserve sites in 2006 include three additional shallow and deep-water sites.

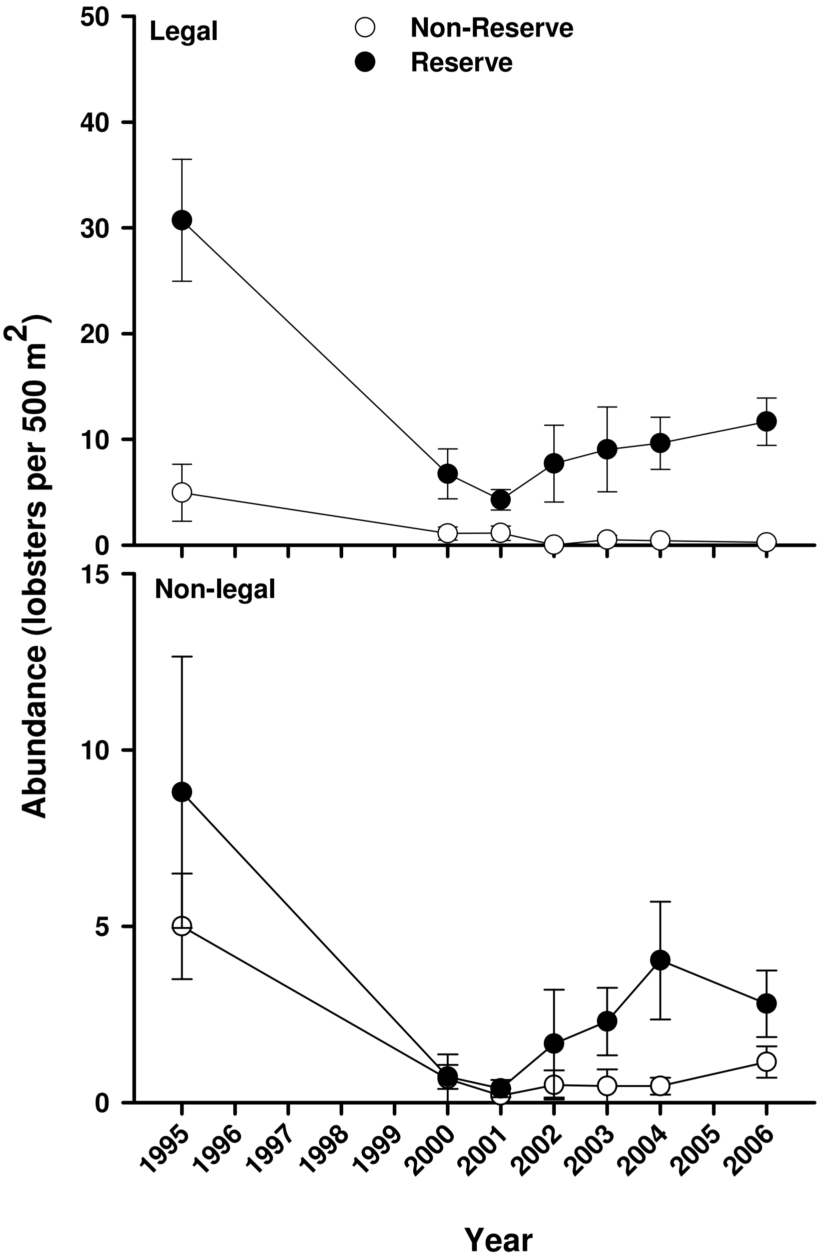

Figure 3.7 Mean abundance (± SE) of legal (carapace length ≥ 95 mm) and sub-legal (carapace length < 95 mm) *Jasus edwardsii* within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2006. Note: non-reserve sites in 2006 include three additional shallow and deep-water sites and the *y* axis scale differs between plots.

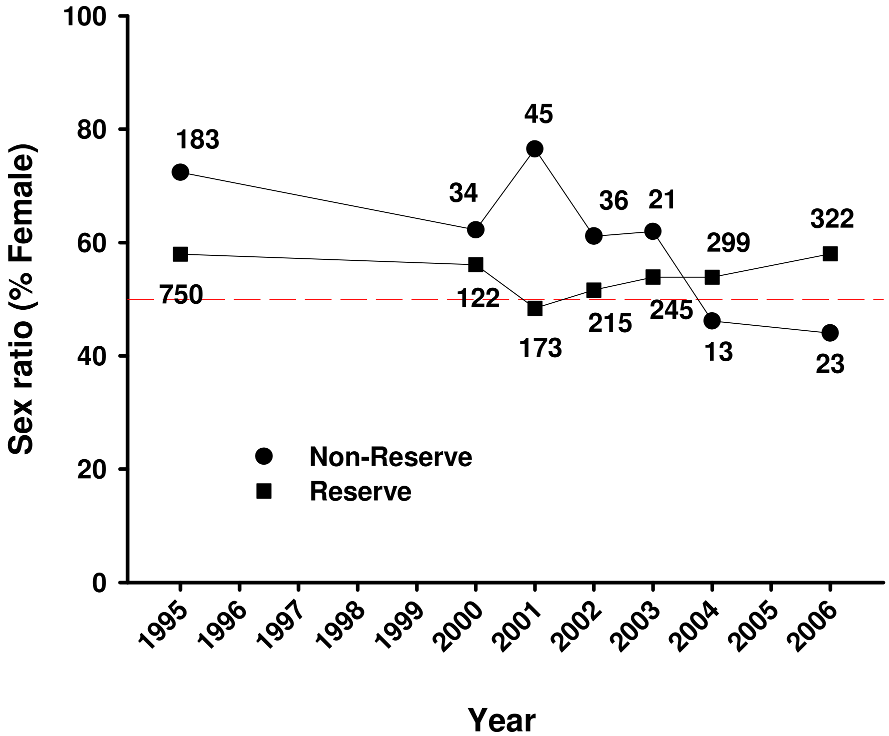

Figure 3.8 Sex ratios (% female) of lobsters within the Cape Rodney to Okakari Point Marine Reserve and non-reserve control sites between 1995 and 2004. Sample sizes for the estimates are given.

Urchin tests

A low number of urchin tests with visible lobster predation fractures were observed at all shallow reserve sites and at Kempts Beach the only non-reserve site to have any evidence of lobster predation (Table 3.1). Three of the tests at Table Top shallow were fresh, having guard spines still attached.

Table 3.1 Number of urchin tests encountered (pooled across transects) at each site.

Site	**Shallow**	**Deep**	**Site**	**Shallow**	**Deep**
Reserve			**Non-reserve**		
Table Top	8	–	Kempts Beach	1	–
Knot Rock	2	N/a	Leigh Reef	–	–
Martins Reef	1	–	Matheson Bay	–	–
One Spot	N/a	–	Slater Point North	–	–
			Slater Point South	–	–
			Wells Hill	–	–

Habitats

A description of dominant habitat types, based on remote video surveys, in presented in Table 3.2; also refer to CD-ROM.

All monitoring sites contained rocky reef habitats that would afford shelter to lobsters and ranged from boulder reef complexes to sandstone and greywacke reef platforms characterised by ledges and deep undercuts. Shallow reefal habitat in reserve areas generally contained mixed algal habitats and low urchin densities, whereas *Ecklonia radiata* was the dominant alga on deeper reef areas. In non-reserve sites, shallow reef habitats contained mosaics alternating between urchin barrens and mixed algae and deep reefs > 10 m generally characterised by *E. radiata* forest.

Table 3.2 Habitat types within reserve and non-reserve sites sampled.

Reserve

Site	Depth	Habitat
Shallow Table Top	2-5 m	Boulder complexes intermixed with patches of loose gravel. Mixed algal habitat comprised of *Carpophyllum maschalocarpum*, *Ecklonia radiata* and turfing reds including *Pterocladia* spp and *Osmundaria colensoi*. Lobsters found under boulders and in the open, often in very shallow water.
Deep Table Top	18-20 m	Low-lying platform reef characterised by deep undercut ledges. Reef interdispersed with sand-flats. Low density *Ecklonia radiata*, with sponges common on sandflats. Lobsters often found under boulders and in the open.
Shallow Martins	3-8 m	Boulder habitat and platform reef intermixed with loose gravel patches. Generally mixed algal habitat comprised of *Carpophyllum maschalocarpum*, with *Ecklonia radiata* dominant > 5m depth. Lobsters found under boulders and in reef crevices.
Deep Martins	15 m	Platform reef typified by deep cuts and ledges. Reef terminates in sand at about 15 m. Deep undercuts common on the reef sand interface. *Ecklonia radiata* abundant. Lobsters generally found under ledges, particularly on the reef-sand interface.
Shallow Knot Rock	3-5 m	Platform reef typified by deep cuts and ledges. *Ecklonia radiata* forest common at 8m, whereas mixed algae predominates on reef < 3 m depth Lobsters generally found under boulders and deep ledges.
Deep One-Spot	12-16 m	Boulder habitat and platform reef intermixed with loose gravel patches. *Ecklonia radiata* dominant. Lobsters found under boulders and in reef crevices.

Table 3.2 ***continued*** Habitat types within non-reserve sites sampled.

Non-reserve

Site	**Depth**	**Habitat**
Shallow Kempts Beach	5-10 m	Medium-sized boulder habitat terminating in sand at ~ 10 m depth. Lobsters found in small holes among boulders
Deep Kempts Beach	12-15 m	Low-lying platform reef characterised by undercut ledges. Reef interdispersed with sand-flats. Low density *Ecklonia radiata*, sponges common on sandflats. Lobsters found in small holes.
Shallow Leigh Reef	5-8 m	Mix of boulders and greywacke platform reef with deep ledges. Extensive urchin barrens between 3-5 m give way to *Ecklonia* forest at depths > 6 m. Urchin grazing fronts observed at 5 m.
Deep Leigh Reef	15-18 m	Extensive platform reef and boulder areas terminate in sand at ~ 18 m depth. *Ecklonia radiata* extensive on reef surfaces
Shallow Matheson Bay	3-8 m	Platform reef typified by deep cuts and ledges. *Ecklonia* radiata common at 8m, whereas mixed algae predominates on reef < 3 m depth.
Deep Matheson Bay	10-15 m	Platform reef typified by deep cuts and ledges. *Ecklonia radiata* common at 10 m, whereas sponge flats occur at depths > 18 m.
Shallow Slater North	5-8 m	Mix of small boulders and greywacke platform reef. Extensive urchin barrens between 3-5 m, with mixed algal complexes dominant on boulder tops.
Deep Slater North	15-20 m	Large boulder reef terminating in sand at ~ 18 m. *Ecklonia radiata* abundant throughout.
Shallow Slater South	3-8 m	Boulder complexes intermixed with patches of loose gravel. Mixed algal habitat comprised of *Carpophyllum maschalocarpum* and *Ecklonia radiata*.
Deep Slater South	15-20 m	Large boulder reef terminating in sand at ~ 18 m. *Ecklonia radiata* abundant throughout.
Shallow Wells Hill	5-8 m	Platform reef typified by deep cuts and ledges.
Deep Wells Hill	12- 15 m	Large boulder reef terminating in sand at ~ 15 m. *Ecklonia radiata* abundant throughout.

4 DISCUSSION

The 2006 CROP Marine Reserve survey is the sixth lobster survey since the inception of the programme in 2000. Following the decline in lobster abundance between 1995 and 2000, a reasonably steady increase in lobster abundance has occurred, largely driven by recruitment, subsequent growth of recruits and retention of adult lobsters. However, the current survey suggests that population growth, in terms of abundance, has decreased over the last 2 years, with any increase largely due to two sites having very high abundances of legal-sized lobsters (STT and SKR). Data on growth of lobster populations through time in protected areas is somewhat limited (Shears *et al.* in press), therefore continued monitoring of CROP will provide invaluable information on whether the reserve population will reach that of 1995 levels.

Despite lower population growth between 2004 and 2006, lobster density still remains significantly higher within CROP reserve than adjacent unprotected areas**.** Using this relative difference in lobster abundance between reserve and non-reserve areas and assuming lobster populations of the 9 unprotected sites surveyed are representative of the general Leigh coastline, and habitat within the reserve is representative of the wider area, which the habitat survey suggests, then the 5 km long Cape Rodney to Okakari Point Marine Reserve contains the equivalent number of lobsters from 60 km of fished coastline. This difference 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.

Of particular note was the high abundance of sub-legal lobsters within the boulder bank habitat in shallow water at Kempts Beach shallow. This area has traditionally been recognised as having high abundances of juvenile lobsters (N. Shears personal communication in 2006). As this site is continually potted throughout the year (personal observation) the lack of legal lobsters is likely due to fishing activity around this area.

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), which may be influencing the recovery of the reserve population. In past years we have suggested that declines of large lobsters (> 170mm C.L.) within the reserve population may be related to fishing activity concentrated at the reserve boundary and/or in areas where *J. edwardsii* aggregate (Kelly and MacDiarmid 2003).

The 2006 survey differed slightly from previous lobster surveys by the inclusion of additional non-reserve sites, i.e., two new sites in the Leigh area (Kempts Beach and Matheson Bay) and one new site at Kawau Island (Wells Hill). The rational for increasing the number of non-reserve sites was to evaluate lobster size and abundance at control sites closer to the reserve boundary in relation to control sites further away from the reserve boundary, to begin to investigate the potential for assessing likely spill-over effects manifest in population abundances. While differences in abundance were not statistically different between control sites, there was some evidence to suggest that lobster abundance was higher closer to the reserve. Determining weather this difference is in fact due to reserve related influences such as spill-over effects is fraught with uncertainty as it requires information on movement rates relative to reserve boundaries, measurements of fishing pressure and long-term data sets on lobster abundance (Davidson *et al.* 2002).

One advantage of increasing the number of reserve sites in and around Leigh and Kawau Island is that in future years Tawharanui Marine Park could be easily incorporated into the monitoring design at minimal cost. Despite using different methodologies, Shears *et al*. (in press) recorded legal-sized lobster as being eleven times more abundant and biomass 25 times higher than adjacent non-protected coastline within Tawharanui Marine Park.

In four of the shallow-water sites surveyed urchin tests attributable to lobster predation were evident, indicative of predation on near-by urchin populations, as revealed by

Shears and Babcock (2002). Predation of this nature has been attributed as spearheading habitat change within north-eastern New Zealand marine reserves relative to unprotected areas. Lobster distribution is highly dependent on habitat characteristics (Childress & Hernkind 1997) and within CROP reserve there has been a substantial decline in *Evechinus chloroticus* and an increase in *Ecklonia* and fucalean algae in shallow depths since 1994 (Shears and Babcock 2003). All sites surveyed in this study could be considered good quality lobster habitat (Kelly 1999, Davidson *et al.* 2002) therefore habitat changes are unlikely to have significantly influenced lobster abundance. However, at this stage it is unclear how sustained low urchin densities may influence lobster abundance and/or whether lobsters are resource limited within CROP reserve.

Biological monitoring of CROP reserve, in tandem with lobster surveys would be worthwhile to assess habitat changes relative to lobster abundance through space and time and to begin to explore questions such as resource availability. An assessment of current fishing pressure on the CROP reserve boundary and wider Leigh coastline would also be of value in addressing recovery of the CROP reserve lobster population.

5 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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7 APPENDIX

2006 Cape Rodney to Okakari Point Marine Reserve Lobster Survey Data

Site	Size	Sex	Transect	Status	Recorder
DOS	150	m	1	Reserve	Tim
DOS	90	f	1	Reserve	Tim
DOS	100	f	1	Reserve	Tim
DOS	120	f	1	Reserve	Tim
DOS	100	f	1	Reserve	Tim
DOS	u	u	1	Reserve	Tim
DOS	140	f	1	Reserve	Tim
DOS	125	m	1	Reserve	Tim
DOS	155	f	1	Reserve	Tim
DOS	130	f	1	Reserve	Tim
DOS	135	f	1	Reserve	Tim
DOS	120	f	1	Reserve	Tim
DOS	135	m	1	Reserve	Tim
DOS	u	f	1	Reserve	Tim
DOS	u	f	1	Reserve	Tim
DOS	125	f	2	Reserve	Tim
DOS	180	m	2	Reserve	Tim
DOS	110	u	2	Reserve	Tim
DOS	120	f	2	Reserve	Tim
DOS	130	f	2	Reserve	Tim
DOS	140	f	2	Reserve	Tim
DOS	110	f	2	Reserve	Tim
DOS	130	m	2	Reserve	Tim
DOS	120	f	2	Reserve	Tim
DOS	60	u	2	Reserve	Tim
DOS	40	u	2	Reserve	Tim
DOS	50	u	2	Reserve	Tim
DOS	50	u	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim
DOS	110	m	2	Reserve	Tim
DOS	130	f	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim
DOS	100	u	2	Reserve	Tim
DOS	120	u	2	Reserve	Tim
DOS	95	f	2	Reserve	Tim
DOS	200	m	2	Reserve	Tim
DOS	180	m	2	Reserve	Tim
DOS	140	f	2	Reserve	Tim
DOS	150	f	2	Reserve	Tim
DOS	95	f	2	Reserve	Tim
DOS	90	u	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim
DOS	u	u	2	Reserve	Tim

DOS	150	m	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	150	m	3	Reserve	Tim
DOS	130	f	3	Reserve	Tim
DOS	140	f	3	Reserve	Tim
DOS	100	m	3	Reserve	Tim
DOS	100	u	3	Reserve	Tim
DOS	90	u	3	Reserve	Tim
DOS	95	u	3	Reserve	Tim
DOS	100	u	3	Reserve	Tim
DOS	130	f	3	Reserve	Tim
DOS	125	f	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	110	f	3	Reserve	Tim
DOS	120	f	3	Reserve	Tim
DOS	80	f	3	Reserve	Tim
DOS	60	u	3	Reserve	Tim
DOS	60	u	3	Reserve	Tim
DOS	75	u	3	Reserve	Tim
DOS	90	u	3	Reserve	Tim
DOS	90	u	3	Reserve	Tim
DOS	100	u	3	Reserve	Tim
DOS	110	u	3	Reserve	Tim
DOS	110	u	3	Reserve	Tim
DOS	100	u	3	Reserve	Tim
DOS	100	u	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	u	u	3	Reserve	Tim
DOS	115	u	3	Reserve	Tim
DOS	95	u	3	Reserve	Tim
DOS	85	u	3	Reserve	Tim
DOS	160	m	3	Reserve	Tim
DOS	120	f	3	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	u	u	4	Reserve	Tim
DOS	120	f	5	Reserve	Tim
DOS	125	f	5	Reserve	Tim
DOS	140	m	5	Reserve	Tim
DOS	115	u	5	Reserve	Tim
DOS	110	u	5	Reserve	Tim
DOS	u	u	5	Reserve	Tim
DOS	u	u	5	Reserve	Tim
DOS	u	u	5	Reserve	Tim
STT	110	f	1	Reserve	Nick

STT	110	f	1	Reserve	Nick
STT	115	m	1	Reserve	Nick
STT	85	f	1	Reserve	Nick
STT	100	f	1	Reserve	Nick
STT	105	m	1	Reserve	Nick
STT	125	m	1	Reserve	Nick
STT	90	m	1	Reserve	Nick
STT	90	m	1	Reserve	Nick
STT	90	f	1	Reserve	Nick
STT	105	u	1	Reserve	Nick
STT	105	f	1	Reserve	Nick
STT	110	f	1	Reserve	Nick
STT	115	f	1	Reserve	Nick
STT	80	f	1	Reserve	Nick
STT	125	f	1	Reserve	Nick
STT	120	u	1	Reserve	Nick
STT	120	u	1	Reserve	Nick
STT	120	u	1	Reserve	Nick
STT	75	u	1	Reserve	Nick
STT	85	u	1	Reserve	Nick
STT	75	u	1	Reserve	Nick
STT	75	u	1	Reserve	Nick
STT	85	m	1	Reserve	Nick
STT	100	u	1	Reserve	Nick
STT	50		1	Reserve	Nick
STT	85		1	Reserve	Nick
STT	30		1	Reserve	Nick
STT	35		1	Reserve	Nick
STT	85	m	1	Reserve	Nick
STT	105	m	1	Reserve	Nick
STT	110	f	1	Reserve	Nick
STT	85	m	1	Reserve	Nick
STT	105	m	1	Reserve	Nick
STT	110	f	1	Reserve	Nick
STT	150	m	1	Reserve	Nick
STT	120	f	1	Reserve	Nick
STT	105	m	1	Reserve	Nick
STT	180	m	1	Reserve	Nick
STT	90	m	1	Reserve	Nick
STT	140	m	1	Reserve	Nick
STT	125	f	1	Reserve	Nick
STT	110	f	1	Reserve	Nick
STT	100	m	1	Reserve	Nick
STT	115	f	1	Reserve	Nick
STT	150	m	1	Reserve	Nick
STT	120	m	1	Reserve	Nick
STT	100	f	1	Reserve	Tim
STT	115	m	1	Reserve	Tim
STT	105	f	1	Reserve	Tim
STT	125	m	2	Reserve	Tim

STT	120	f	2	Reserve	Tim
STT	90	f	2	Reserve	Tim
STT	50	f	2	Reserve	Tim
STT	110	m	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	140	m	2	Reserve	Tim
STT	130	f	2	Reserve	Tim
STT	145	f	2	Reserve	Tim
STT	40	u	2	Reserve	Tim
STT	50	u	2	Reserve	Tim
STT	50	u	2	Reserve	Tim
STT	40	u	2	Reserve	Tim
STT	120	f	2	Reserve	Tim
STT	110	f	2	Reserve	Tim
STT	160	m	2	Reserve	Tim
STT	120	f	2	Reserve	Tim
STT	95		2	Reserve	Tim
STT	100		2	Reserve	Tim
STT	90		2	Reserve	Tim
STT	90		2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	150	m	2	Reserve	Tim
STT	160	m	2	Reserve	Tim
STT	140	m	2	Reserve	Tim
STT	135	f	2	Reserve	Tim
STT	80	u	2	Reserve	Tim
STT	80	f	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	140	f	2	Reserve	Tim
STT	130	f	2	Reserve	Tim
STT	200	m	2	Reserve	Tim
STT	150	f	2	Reserve	Tim
STT	205	m	2	Reserve	Tim
STT	140	f	2	Reserve	Tim
STT	145	f	2	Reserve	Tim
STT	130	f	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	200	m	2	Reserve	Tim
STT	140	u	2	Reserve	Tim
STT	125	u	2	Reserve	Tim
STT	200	m	2	Reserve	Tim
STT	160	m	2	Reserve	Tim
STT	170	m	2	Reserve	Tim
STT	120	f	2	Reserve	Tim
STT	95	u	2	Reserve	Tim
STT	90	u	2	Reserve	Tim

STT	85	u	2	Reserve	Tim
STT	80	u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	120	u	2	Reserve	Tim
STT	135	u	2	Reserve	Tim
STT	60	u	2	Reserve	Tim
STT	50	u	2	Reserve	Tim
STT		u	2	Reserve	Tim
STT	60	u	2	Reserve	Tim
STT	60	u	2	Reserve	Tim
STT	60	u	2	Reserve	Tim
STT	75	u	2	Reserve	Tim
STT	140	u	2	Reserve	Tim
STT	150	m	2	Reserve	Tim
STT	135	f	2	Reserve	Tim
STT	120	f	2	Reserve	Tim
STT	100	u	2	Reserve	Tim
STT	70	u	2	Reserve	Tim
STT	70	u	2	Reserve	Tim
STT	70	u	2	Reserve	Tim
STT	220	m	3	Reserve	Tim
STT	150	f	3	Reserve	Tim
STT	110	f	3	Reserve	Tim
STT	90	f	3	Reserve	Tim
STT	110	m	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	160	f	3	Reserve	Tim
STT	180	f	3	Reserve	Tim
STT	95	m	3	Reserve	Tim
STT	90	f	3	Reserve	Tim
STT	85	f	3	Reserve	Tim
STT	80	u	3	Reserve	Tim
STT	75	u	3	Reserve	Tim
STT	60	u	3	Reserve	Tim
STT	60	u	3	Reserve	Tim
STT	120	u	3	Reserve	Tim
STT	120	u	3	Reserve	Tim
STT	210	m	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	120	u	3	Reserve	Tim
STT	140	u	3	Reserve	Tim
STT	225	m	3	Reserve	Tim

STT	140	f	3	Reserve	Tim
STT	120	f	3	Reserve	Tim
STT	130	m	3	Reserve	Tim
STT	150	m	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	125	u	3	Reserve	Tim
STT	130	u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	120	f	3	Reserve	Tim
STT	115	f	3	Reserve	Tim
STT	110	f	3	Reserve	Tim
STT	230	m	3	Reserve	Tim
STT	200	m	3	Reserve	Tim
STT	210	m	3	Reserve	Tim
STT	160	f	3	Reserve	Tim
STT	135	f	3	Reserve	Tim
STT	125	f	3	Reserve	Tim
STT	120	f	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	95	m	3	Reserve	Tim
STT	90	m	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	130	f	3	Reserve	Tim
STT	95	f	3	Reserve	Tim
STT	90	f	3	Reserve	Tim
STT	95	f	3	Reserve	Tim
STT	120	f	3	Reserve	Tim
STT	165	m	3	Reserve	Tim
STT	125	f	3	Reserve	Tim
STT	140	m	3	Reserve	Tim
STT	125	m	3	Reserve	Tim
STT	130	m	3	Reserve	Tim
STT	180	m	3	Reserve	Tim
STT	135	f	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT		u	3	Reserve	Tim
STT	120	f	3	Reserve	Tim
STT	140	m	3	Reserve	Tim
STT	200	m	4	Reserve	Tim
STT	145	m	4	Reserve	Tim
STT	120	f	4	Reserve	Tim
STT	90	f	4	Reserve	Tim
STT	95	f	4	Reserve	Tim
STT	110	m	4	Reserve	Tim
STT	125	m	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT	135	f	4	Reserve	Tim
STT	120	f	4	Reserve	Tim

STT	240	m	4	Reserve	Tim
STT	125	f	4	Reserve	Tim
STT	110	m	4	Reserve	Tim
STT	125	f	4	Reserve	Tim
STT	110	f	4	Reserve	Tim
STT	120	m	4	Reserve	Tim
STT	115	m	4	Reserve	Tim
STT	120	m	4	Reserve	Tim
STT	110	m	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT	125	u	4	Reserve	Tim
STT	130	u	4	Reserve	Tim
STT	145	u	4	Reserve	Tim
STT	150	u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT	125	f	4	Reserve	Tim
STT	120	f	4	Reserve	Tim
STT	110	f	4	Reserve	Tim
STT	125	f	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT		u	4	Reserve	Tim
STT	125	f	5	Reserve	Nick
STT	150	m	5	Reserve	Nick
STT	140	m	5	Reserve	Nick
STT	125	f	5	Reserve	Nick
STT	125	m	5	Reserve	Nick
STT	150	f	5	Reserve	Nick
STT	140	f	5	Reserve	Nick
STT	135	m	5	Reserve	Nick
STT	190	m	5	Reserve	Nick
STT	140	f	5	Reserve	Nick
STT	110	f	5	Reserve	Nick
STT		u	5	Reserve	Nick
STT	95	u	5	Reserve	Nick
STT	100	u	5	Reserve	Nick
STT	90	u	5	Reserve	Nick
STT	125	u	5	Reserve	Nick
STT	120	u	5	Reserve	Nick
STT	130	u	5	Reserve	Nick
STT	125	u	5	Reserve	Nick
STT		u	5	Reserve	Nick
STT		u	5	Reserve	Nick

STT		u	5	Reserve	Nick
STT	165	m	5	Reserve	Nick
STT	130	f	5	Reserve	Nick
STT	80	m	5	Reserve	Nick
STT	70	m	5	Reserve	Nick
STT	125	f	5	Reserve	Nick
STT	135	f	5	Reserve	Nick
STT	170	m	5	Reserve	Nick
STT	90	f	5	Reserve	Nick
STT	90	f	5	Reserve	Nick
STT	90	f	5	Reserve	Nick
STT	110	m	5	Reserve	Nick
STT	105	m	5	Reserve	Nick
STT	120	f	5	Reserve	Nick
STT	125	f	5	Reserve	Nick
STT	120	f	5	Reserve	Nick
STT	160	m	5	Reserve	Nick
STT	150	m	5	Reserve	Nick
DTT	0	0	1	Reserve	Caroline
DTT	100	f	2	Reserve	Caroline
DTT	55	f	2	Reserve	Caroline
DTT	90	f	2	Reserve	Caroline
DTT	110	u	2	Reserve	Caroline
DTT	120	f	2	Reserve	Caroline
DTT	80	f	2	Reserve	Caroline
DTT	135	m	3	Reserve	Caroline
DTT	160	m	4	Reserve	Tim
DTT	140	m	4	Reserve	Tim
DTT	180	m	4	Reserve	Tim
DTT	u	u	4	Reserve	Tim
DTT	135	u	5	Reserve	Tim
DTT	120	u	5	Reserve	Tim
DTT	u	u	5	Reserve	Tim
DTT	u	u	5	Reserve	Tim
DTT	110	f	5	Reserve	Tim
DTT	100	f	5	Reserve	Tim
SMR	120	m	1	R	Tim
SMR	115	f	1	R	Tim
SMR	u	u	1	R	Tim
SMR	u	u	1	R	Tim
SMR	120	m	1	R	Tim
SMR	110	f	1	R	Tim
SMR	u	u	1	R	Tim
SMR	125	f	1	R	Tim
SMR	130	f	1	R	Tim
SMR	100	u	1	R	Tim
SMR	90	u	1	R	Tim
SMR	115	f	1	R	Tim
SMR	120	m	1	R	Tim
SMR	125	f	2	R	Tim

SMR	140	f	2	R	Tim
SMR	160	m	2	R	Tim
SMR	125	f	2	R	Tim
SMR	u	u	2	R	Tim
SMR	180	m	2	R	Tim
SMR	140	f	2	R	Tim
SMR	120	u	2	R	Tim
SMR	100	m	2	R	Tim
SMR	100	u	2	R	Tim
SMR	130	m	3	R	Tim
SMR	125	f	3	R	Tim
SMR	100	f	3	R	Tim
SMR	95	f	3	R	Tim
SMR	120	m	3	R	Tim
SMR	150	m	3	R	Tim
SMR	130	f	3	R	Tim
SMR	110	f	3	R	Tim
SMR	100	f	3	R	Tim
SMR	90	f	3	R	Tim
SMR	210	m	3	R	Tim
SMR	100	f	3	R	Tim
SMR	145	m	3	R	Tim
SMR	120	f	4	R	Tim
SMR	130	f	4	R	Tim
SMR	150	m	4	R	Tim
SMR	170	m	4	R	Tim
SMR	170	m	4	R	Tim
SMR	130	f	4	R	Tim
SMR	110	f	4	R	Tim
SMR	80	f	4	R	Tim
SMR	60	u	5	R	Tim
SMR	50	u	5	R	Tim
SMR	75	u	5	R	Tim
SMR	50	u	5	R	Tim
SMR	120	f	5	R	Tim
SMR	125	f	5	R	Tim
SMR	140	m	5	R	Tim
SMR	110	f	5	R	Tim
SMR	100	f	5	R	Tim
SMR	125	f	5	R	Tim
SMR	120	f	5	R	Tim
SMR	150	m	5	R	Tim
SMR	u	u	5	R	Tim
SMR	85	f	5	R	Tim
SMR	80	u	5	R	Tim
SMR	90	m	5	R	Tim
SMR	110	f	5	R	Tim
DMR			1	R	Tim
DMR	160	m	2	R	Tim
DMR	125	m	2	R	Tim

DMR	140	f	2	R	Tim
DMR	140	m	2	R	Tim
DMR	100	f	2	R	Tim
DMR	165	m	2	R	Tim
DMR	160	m	3	R	Tim
DMR	120	m	3	R	Tim
DMR	130	m	3	R	Caroline
DMR	80	f	4	R	Caroline
DMR			5	R	Tim
KRS	100	f	1	Reserve	Tim
KRS	150	m	2	Reserve	Caroline
KRS	130	m	2	Reserve	Caroline
KRS	u	u	2	Reserve	Caroline
KRS	u	u	2	Reserve	Caroline
KRS	125		2	Reserve	Caroline
KRS	120		2	Reserve	Caroline
KRS	130		2	Reserve	Caroline
KRS	135	f	2	Reserve	Caroline
KRS	120		2	Reserve	Caroline
KRS	220	m	2	Reserve	Caroline
KRS	135	f	2	Reserve	Caroline
KRS	125	f	2	Reserve	Caroline
KRS	120	f	2	Reserve	Caroline
KRS	50	u	2	Reserve	Caroline
KRS	130	f	2	Reserve	Caroline
KRS	145	f	2	Reserve	Caroline
KRS	90	f	2	Reserve	Caroline
KRS	125	f	2	Reserve	Caroline
KRS	u	u	3	Reserve	Tim
KRS	150	u	3	Reserve	Tim
KRS	120	u	3	Reserve	Tim
KRS	u	u	3	Reserve	Tim
KRS	u	u	3	Reserve	Tim
KRS	u	u	3	Reserve	Tim
KRS	u	u	3	Reserve	Tim
KRS	145	m	3	Reserve	Tim
KRS	150	m	4	Reserve	Tim
KRS	130	f	4	Reserve	Tim
KRS	200	m	4	Reserve	Tim
KRS	160	m	4	Reserve	Tim
KRS	150	f	4	Reserve	Tim
KRS	140	f	4	Reserve	Tim
KRS	160	m	4	Reserve	Tim
KRS	135	f	4	Reserve	Tim
KRS	140	f	4	Reserve	Tim
KRS	130	f	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	170	m	4	Reserve	Tim

KRS	180	m	4	Reserve	Tim
KRS	120	m	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	140	u	4	Reserve	Tim
KRS	125	u	4	Reserve	Tim
KRS	120	u	4	Reserve	Tim
KRS	125	u	4	Reserve	Tim
KRS	140	u	4	Reserve	Tim
KRS	120	u	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	130	u	4	Reserve	Tim
KRS	u	u	4	Reserve	Tim
KRS	140	f	4	Reserve	Tim
KRS	160	m	4	Reserve	Tim
KRS	135	f	4	Reserve	Tim
KRS	180	m	4	Reserve	Tim
KRS	135	f	4	Reserve	Tim
KRS	175	m	5	Reserve	Tim
KRS	130	f	5	Reserve	Tim
KRS	120	f	5	Reserve	Tim
KRS	110	m	5	Reserve	Tim
KRS	125	f	5	Reserve	Tim
KRS	u	u	5	Reserve	Tim
KRS	150	m	5	Reserve	Tim
KRS	135	f	5	Reserve	Tim
KRS	160	m	5	Reserve	Tim
KRS	50	u	5	Reserve	Tim
KRS	180	m	5	Reserve	Tim
KRS	185	m	5	Reserve	Tim
KRS	145	f	5	Reserve	Tim
KRS	170	m	5	Reserve	Tim
KRS	100	f	5	Reserve	Tim
KRS	120	f	5	Reserve	Tim
KRS	155	m	5	Reserve	Tim
KRS	120	f	5	Reserve	Tim

Site	**Size**	**Sex**	**Transect**	**Status**	**Recorder**
SLR	95	u	1	NR	Tim
SLR	85	f	2	NR	Tim
SLR	90	m	3	NR	Tim
SLR	90	f	3	NR	Tim
SLR	95	f	3	NR	Tim
SLR	90	m	3	NR	Tim
SLR	105	f	3	NR	Tim
SLR			4	NR	Tim
SLR	80	u	5	NR	Tim
DLR			1	NR	Caroline
DLR			2	NR	Caroline
DLR			3	NR	Tim
DLR	80	m	4	NR	Tim

DLR	90	m	4	NR	Tim
DLR			5	NR	Tim
DKMP	95	m	1	NR	Tim
DKMP	105	m	1	NR	Tim
DKMP	110	m	2	NR	Tim
DKMP	115	f	2	NR	Tim
DKMP		u	2	NR	Tim
DKMP		u	3	NR	Tim
DKMP		u	4	NR	Tim
DKMP	90	u	5	NR	Tim
SKMP	80	m	1	NR	Tim
SKMP	90	m	1	NR	Tim
SKMP	85	m	1	NR	Tim
SKMP	70	u	1	NR	Tim
SKMP	70	u	1	NR	Tim
SKMP	90	m	2	NR	Tim
SKMP		u	2	NR	Tim
SKMP	60	u	2	NR	Tim
SKMP	70	u	2	NR	Tim
SKMP	60	u	2	NR	Tim
SKMP	70	u	2	NR	Tim
SKMP	70	m	2	NR	Tim
SKMP	50	u	2	NR	Tim
SKMP	40	u	2	NR	Tim
SKMP	70	u	2	NR	Tim
SKMP	40	u	2	NR	Tim
SKMP		u	2	NR	Tim
SKMP	50	u	2	NR	Tim
SKMP	60	u	3	NR	Tim
SKMP	60	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	70	u	3	NR	Tim
SKMP	40	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	70	u	3	NR	Tim
SKMP	80	u	3	NR	Tim
SKMP	90	u	3	NR	Tim
SKMP	90	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	60	u	3	NR	Tim
SKMP	85	f	3	NR	Tim
SKMP	90	u	3	NR	Tim
SKMP	80	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	40	u	3	NR	Tim
SKMP	40	u	3	NR	Tim
SKMP	50	u	3	NR	Tim
SKMP	40	u	3	NR	Tim
SKMP	60	f	3	NR	Tim

SKMP	30	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	35	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	60	u	3	NR	Tim
SKMP		u	3	NR	Tim
SKMP	55	u	3	NR	Tim
SKMP	40	u	3	NR	Tim
SKMP	80	u	4	NR	Tim
SKMP	95	f	4	NR	Tim
SKMP	60	u	4	NR	Tim
SKMP	30	u	4	NR	Tim
SKMP	75	f	4	NR	Tim
SKMP	95	m	4	NR	Tim
SKMP		u	4	NR	Tim
SKMP	45	u	4	NR	Tim
SKMP	50	u	4	NR	Tim
SKMP	40	u	4	NR	Tim
SKMP	40	u	4	NR	Tim
SKMP	50	u	4	NR	Tim
SKMP	75	f	4	NR	Tim
SKMP		u	4	NR	Tim
SKMP		u	4	NR	Tim
SKMP			5	NR	Nick
DMTH			1	NR	Tim
DMTH			2	NR	Tim
DMTH			3	NR	Tim
DMTH			4	NR	Tim
DMTH			5	NR	Tim
SMTH			1	NR	Tim
SMTH			2	NR	Tim
SMTH			3	NR	Tim
SMTH			4	NR	Tim
SMTH			5	NR	Tim

Site	Size	Sex	Transect	Status	Recorder
DWH	90	u	1	NR	Tim
DWH	60	u	1	NR	Tim
DWH	75	u	1	NR	Tim
DWH			2	NR	Tim
DWH	65	u	3	NR	Caroline
DWH	125	m	3	NR	Caroline
DWH	110	f	3	NR	Caroline
DWH	70	u	3	NR	Caroline
DWH			4	NR	Caroline
DWH			5	NR	Tim
SWH			1	NR	Tim
SWH			2	NR	Tim
SWH			3	NR	Tim

SWH			4	NR	Tim
SWH			5	NR	Tim
SSN			1	NR	Tim
SSN			2	NR	Tim
SSN			3	NR	Caroline
SSN			4	NR	Caroline
SSN	65	u	5	NR	Tim
SSN	60	m	5	NR	Tim
SSN	55	u	5	NR	Tim
SSN	90	f	5	NR	Tim
DSN			1	NR	Tim
DSN			2	NR	Tim
DSN			3	NR	Tim
DSN			4	NR	Tim
DSN			5	NR	Tim
DSS	75	u	1	NR	Tim
DSS	60	u	1	NR	Tim
DSS			2	NR	Tim
DSS			3	NR	Caroline
DSS			4	NR	Caroline
DSS	50	u	5	NR	Tim
DSS	60	u	5	NR	Tim
ISS			1	NR	Caroline
ISS			2	NR	Caroline
ISS			3	NR	Tim
ISS			4	NR	Tim
ISS			5	NR	Tim