Bay of Islands Lobster Monitoring Programme

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Image cover page "Wallace" the Packhorse Lobster, Deep Water Cove October 2016.

1. Introduction

1.1 MARINE MONITORING

Baseline-monitoring programmes involve the collection of environmental data over a long time frame (Magurran et al., 2010), and although being identified as having limited use when trying to answer specific research questions (Legg & Nagy, 2006), they can be useful in determining natural variation and ecological changes over time.

As marine systems are put under increasing pressure from overfishing, pollution, climate change, invasive species and nutrient run-off, baseline monitoring programmes allow communities to document the ecological status and value of their Rohe Moana with an intrinsic and 'ecosystem goods and services' (benefits derived from ecosystems (Van den Belt & Cole, 2014)) perspective.

Despite well publicised intentions to expand oil and gas operations such as deep sea drilling in New Zealand, the central government should not be relied on to show leadership in regulating industry or being responsible for effective environmental guardianship. This was illustrated by the grounding of the CV Rena, where up-to-date legislation increasing liability for polluters had not been implemented (Marten, 2011) and there was also some deficiencies in pre-impact baseline data on coastal ecosystems from which to gauge impacts. Communities and local government should ensure they have a scientifically robust long-term monitoring programme collecting state-of-the-environment datasets to gauge the effects of impacts and for potential situations arising in which compensation from polluters must be sought.

Monitoring programmes should still be subject to scientific review and ideally they are started before the 'impact' so natural variation can be assessed (Willis, 2013). Regular monitoring may provide other benefits such as detection of marine pest incursions, allowing an eradication effort to be more effective due to a quick response. Marine monitoring projects can also provide a powerful educational tool and good motivation for people to work together and experience their local environment.

Currently there is a need for a monitoring programme of spiny rock lobsters in the Bay of Islands due to current low abundance estimates in fishing areas and to provide supportive data for marine reserve promoters in the local community. There are many factors that influence lobster recruitment and the responses to protection in New Zealand have been variable (D. J. Freeman et al., 2012). Long term datasets can be used to track recruitment pulses so that reserve specific effects are understood more fully. When more resources are available, or patterns are identified that require further investigation, more specific studies can be designed to thoroughly investigate factors.

1.2 BIOLOGY

The spiny rock lobster (*Jasus edswardsii*) and packhorse lobster (*Jasus/Sagmariasus verreauxi)* are found coastally and offshore in New Zealand and South Eastern Australia, with the pack horse lobster having a more limited distribution from east cape to the far north of the North Island. Lobsters are generally nocturnal, foraging at night and spending the daylight hours in refuges formed by rocky reef (leading to patchy distribution throughout areas). Lobsters feed on a wide range of taxon including molluscs, crustaceans, worms, macro algae, echinoderms, sponges, bryozoans, fish with evidence of cannibalism has been observed in some studies (A. B. MacDiarmid, Freeman, & Kelly, 2013).

Sexual dimorphism is exhibited in both species with only females possessing a claw on the rearmost pair of legs and paired pleopods on the abdomen. Males aggregate in spring and separate in summer with females aggregating in winter, with peak mating occurring in May and June (A. B. MacDiarmid et al., 2013). Male lobsters have been found to have size related limits to the amount of female biomass they can fertilise (A. MacDiarmid & Stewart, 2005). Once fertilised, females form aggregations on seaward edges of deep reef and hatch larvae, so beginning a 1-2 year planktonic phase in which larvae will undergo 11 morphological stages while offshore, before swimming inshore to settle in shallow reef (Jeffs & Holland, 2000). Settlement mechanisms are poorly understood, but may involve acoustic and/or chemosensory orientation (Jeffs, Montgomery, & Tindle, 2005).

The spiny rock lobster has been identified as having an important role in shaping ecosystems through trophic interactions (MacDiarmid, Freeman, & Kelly, 2013). This is because it is the most common benthic predator in unfished systems. No-take areas help to investigate the ecological roles of lobsters and the effects fishing has on ecosystems when key species are suppressed to such a point that they are deemed ecologically extinct, as in the case of lobsters in certain areas (A. B. MacDiarmid et al., 2013).

1.3 FISHERY

Rock lobsters are an important species for commercial, customary and recreational fisheries. The Bay of Islands (BOI) commercial *J. edwardsii* fishery is managed as part of Quota Management Area (QMA) CRA1, which starts at the northern entrance of Kaipara Harbour and extends around the North Cape and down the east coast, terminating at Te Ari Point, just South of Mangawhai Heads and with an offshore extent to the Three Kings. Two areas within the BOI are closed to commercial lobster fishing and these are the Te Puna inlet Mataitai and the Rahui at deep water cove (See Fig. 1 for boundaries).

The Total Allowable Commercial Catch (TACC) for CRA1 is set at 131.062 tonnes which is consistently entirely caught (this has a value of $9.4 million, according to the New Zealand Rock Lobster Industry Council). The NZ *S. verreauxi* fishery is managed as a single stock, PHC1 and the TACC for this has been set at 40.3 tonnes since 1993. Unlike other QMAs that use a Catch Per Unit Effort (CPUE) based management procedure, the management of CRA1 relies on a formal stock assessment to inform TACC limits, with the last assessment in 2002. Recent commercial CPUE averages for the statistical area that covers the BOI are 0.5kg per pot lift, and indicate localised depletion when considering it is the lowest (less than 50%) of the five other CRA1 statistical area CPUE values, and that the standardised CRA1 CPUE is 1.678kg per pot lift (Ministry for Primary Industries, 2013).

Recreational fishing for lobsters is common in the BOI with potting and diving the most common methods of harvesting, with fishing activity at its peak during the summer months. A recent access point survey estimated the CRA1 recreational harvest of rock lobster to be 42 tonne for the period 2013–14 with 37 tonnes estimated to be taken from amateur fishers, and the East Northland areas recreational catch at 25 tonnes (Holdsworth, 2014).

1.4 PROJECT AIM

This survey aims to start and establish a long-term monitoring programme for rock lobster in the Bay of Islands using fixed sampling sites, and here we report on the first round of sampling. A set of fixed transects to be resampled over time will be used to record relative lobster abundance and size trends, as possible responses to Rahui protection (and potentially future marine reserve protection) and to investigate variability. Although fixed transect repeated measure monitoring programmes have limitations to the level of inference that can be made from data (Willis, 2013), the resources are not currently available to implement a monitoring programme using a random stratified design to collect abundance estimates.

1.5 STUDY AREA

The area of focus for this programme is the Cape Brett Peninsula in the Eastern Bay of Islands. The BOI is an embayment of 1800 square kilometres, located on the east coast of northern New Zealand. The BOI forms part of the North-eastern biogeographic region and with the East Auckland Current (EAUC) flowing along the coast, the offshore currents influencing the BOI are part of a highly variable hemispheric system (NIWA, 2009). Sea temperature ranges from 14 °C in winter to 21°C in the late summer.

The BOI is made up of a diverse range of marine habitats from estuaries to exposed rocky reef. The focus habitats for this study are the shallow rocky reef systems providing substrate to sponges, bryozoans, ascidians, anemones, encrusting algae and the preferred habitat of the rock lobster.

There has been a steep increase in the local human population, causing rapid changes in land use and strain on marine resources, with over 30 human impacts listed (NIWA, 2009) as threatening the BOI. Sediment deposition, invasive species and fishing pressure are some of the more obvious threats facing the BOI marine ecosystem.

1.6 RAHUI

A Rahui is a temporary restriction of access to a resource, in this case a fishery closure which is set down in law under the Fisheries Act 1996. Since 2012, Maunganui Bay has been closed to all fishing activities other than the gathering of kina (*Evechinus chloroticus* and *Centrostephanus rodgersii*). The two resident hapu, Ngati Kuta and Patukeha have maintained a Rahui in this area due to their concern about the depletion of fish stocks. Anecdotal reports from local dive operators indicate that some illegal fishing does continue within the Rahui.

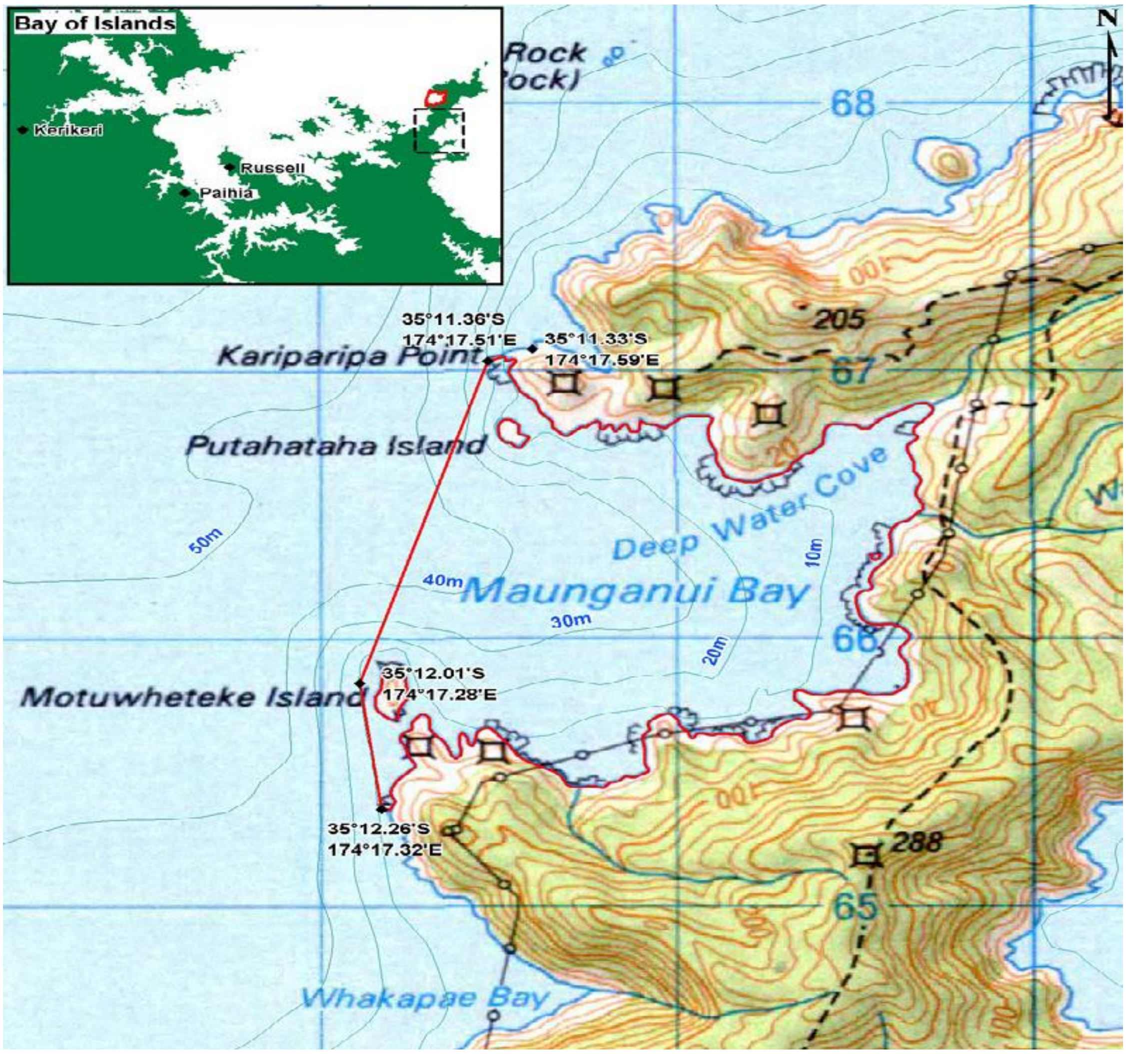


Figure 1: Maunganui Bay Rahui boundaries (red line) of no take area (Image taken from www.Rahui.org.nz)

2. Methodology

This study used an Underwater Visual Census (UVC) technique to collect size and density on two species of rock lobster (*Jasus edwardsii* and *Sagmariasus verreauxi*) at sites within (protected) and outside (control) the Maunganui Bay Rahui. During the first phase of this programme, a total of eight independent permanent transects were established. Four shallow (>12m) sites have been selected for each management type (Rahui and no protection). Site selection criteria are based on having good lobster habitat (boulders, cracks and crevices) and located at the required depth range 3 – 12 metres. The information used to inform site selection was acquired through interviewing Northland Dive Ltd (a local dive operator) and this so provided an invaluable head start to this study. Non-Rahui (control) sites were selected for having similar reef characteristics and exposure levels to the Rahui sites and being located to the north and south of the Rahui.

At each site a 50x10m transect was deployed with the bearing and GPS point at the start of the transect recorded. Natural features were noted to allow the relocation and resampling of the transect over time. In the future marker pins may be installed to aid more accurate resampling of the same area in the future, but for this initial phase the divers used natural features as markers for ‘zero points’ for later surveys. The sites were also selected with the relocation and resampling in mind, and as a result many sites are an isolated section of habitat such as a boulder complex surrounded by sand or bedrock. These shallow boulder reef habitats are easy to relocate in favourable sea conditions.

Once deployed on the waypoint with the 50m tape fixed in position and swum out across habitat, divers carefully moved through lobster habitat systematically searching an area 5m each side of the tape measure (centreline) to locate lobsters. Once located, the lobsters were identified to species level, sex determined (if possible) and carapace length (CL) estimated to the nearest 10mm. Lobster sex was determined through observing sexual dimorphism with the use of a torch to illuminate the back legs or abdomen. The diver would note if the lobsters were solitary or in a den, and if so, the position and characteristics of the den (depth, number of inhabitants, habitat type) were noted, and where practical, photographed.

Habitat data was collected by the diver noting the dominant habitat type at 5m intervals along the transect using habitat classifications (Table 1) adapted from the Cape Rodney and Okakari Point (CROP) and Tawharanui Marine Reserve (TMR) Lobster Monitoring Programme (Haggitt & Freeman, 2014). Other data collected at each site was sea floor depth, sea temperature, underwater visibility and notes on relocation of transect for resampling.

Table 1: Habitat classifications used in survey adapted from CROP/TWR Lobster Monitoring Programme (Haggitt & Freeman, 2014)

Habitat Classification	Code	Complexity	Classification
Large Boulders	LB	Medium - high	>750 mm diameter
Small Boulders	SB	Medium - high	250 mm – 750 mm diameter
Cobbles	C	Medium - low	< 250 mm diameter
Platform reef crevice formed in rock	PRC	High variability in complexity High - medium	Vertical direction
Platform reef ledge	PRL	High variability in complexity. Medium - high	Horizontal direction
Platform reef flats	PRF	Low	Flat platform reef with minimal features.

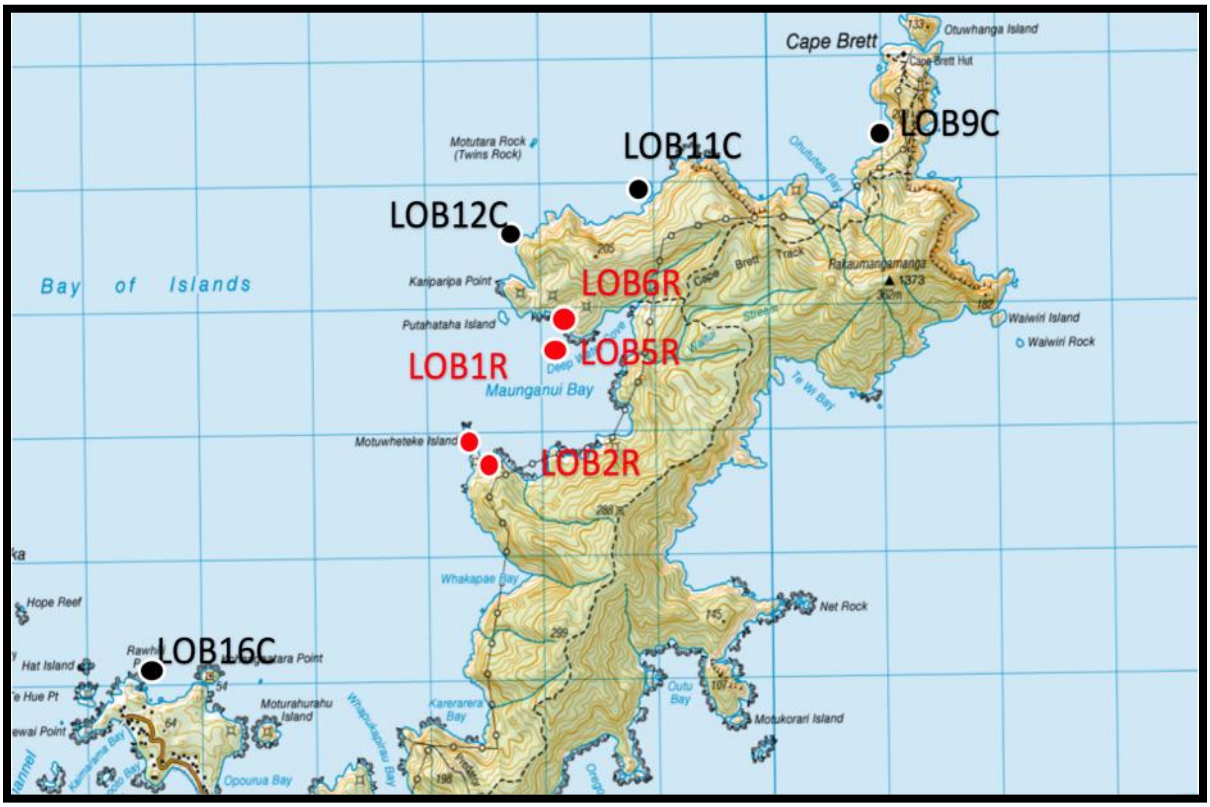


Figure 2: Approximate location of sampled lobster monitoring sites. Map taken from Land Information New Zealand (LINZ).

3. Results

3.1 CARAPACE LENGTH ESTIMATION

This work requires carapace length (CL) estimates to be made in challenging conditions (restricted visibility, low light, size distorting refraction, and obstructed view) to collect lobster size data. In order to quantify diver CL estimation error, actual measured CL data is required. During these survey dives, after a CL estimation was made, the lobster was carefully gathered and the carapace length measured using callipers and recorded. This was completed a total of 17 of the total 148 occasions a lobster was observed (11.4%). The handling of lobsters was only attempted when the diver was confident minimal injury to the lobster would occur. This estimated and measured data was charted on a scatter plot (Fig. 3) and used to quantify diver CL estimation error. In accordance with the CROP study a CL of 95mm is considered legal size (Haggitt & Freeman, 2014).

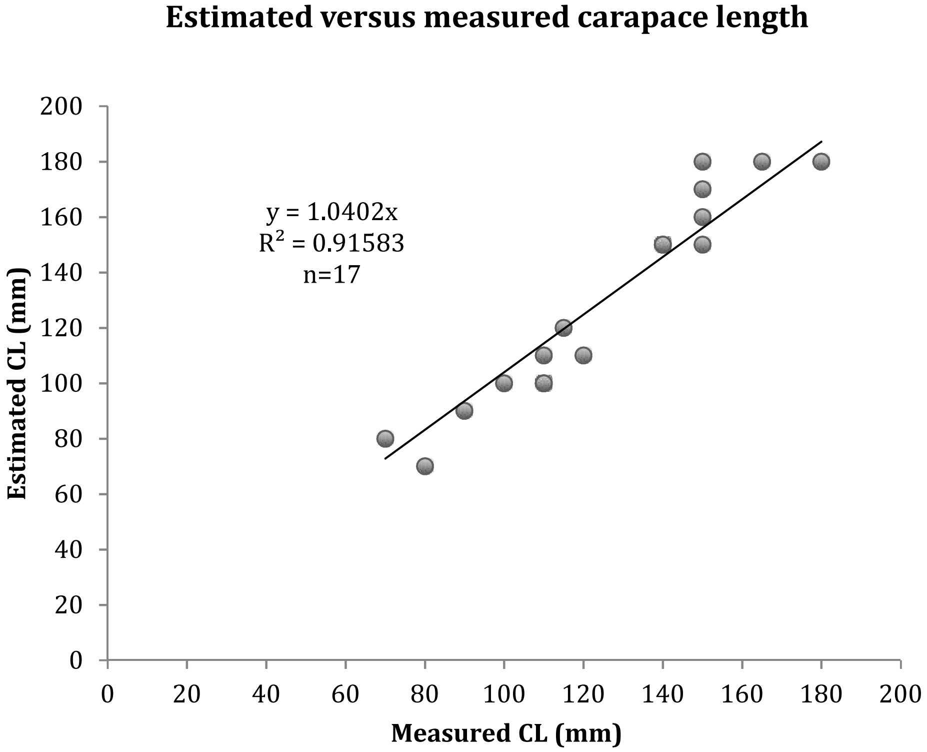


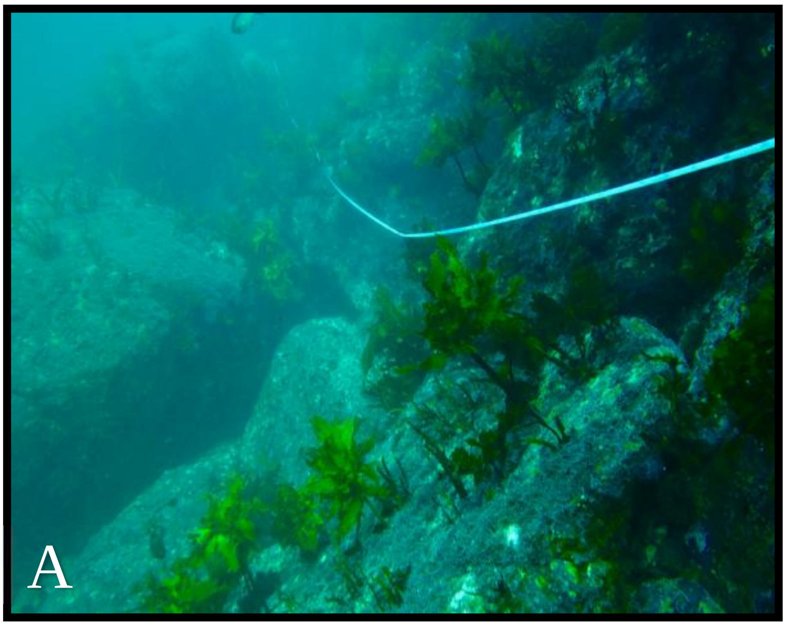
Figure 3: Estimated and actual carapace length from the eight dives

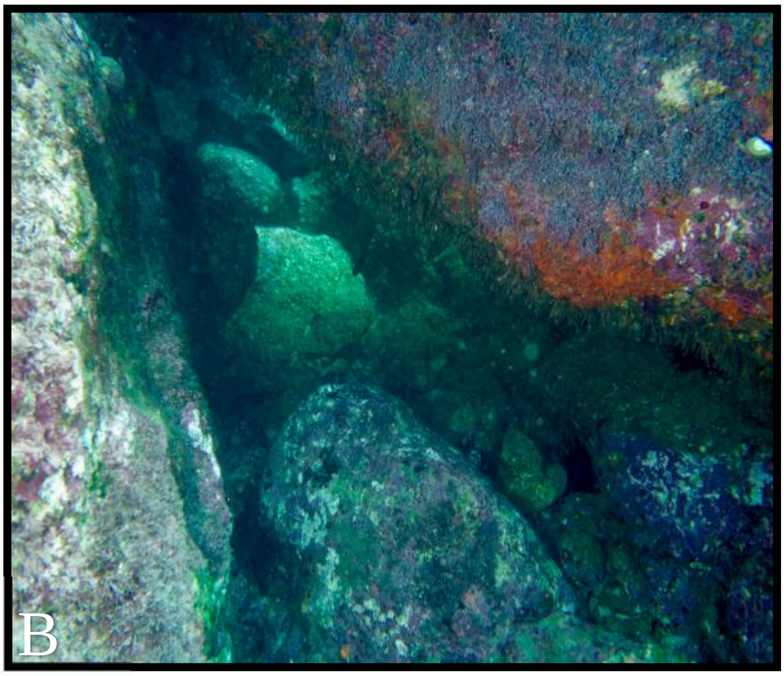
These results show a slight tendency to overestimate by 10-15mm at the larger size classes (150mm CL), and a lower error around the 100mm classes. As sampling is repeated we can expect to see an improvement in CL estimations over time.

3.2 RAHUI SITES

Site ID: LOB1R - *Motuwheteke Island East* **Location:** 35° 12.054'S 174° 17.349'E
Date surveyed 04/06/2016

Situated on the sheltered Eastern side of Motuwheteke Island, habitat of this site consists of shallow large boulder complexes in a valley like depression formed by the shore slope of Motuwheteke Island and the fringing rock platform. The transect runs over large boulders on bedrock (Image A) forming highly complex habitat and two caverns. Due to the complexity of this sites habitat, many encountered lobsters were visually obstructed, so observing of sexual dimorphism could not be carried out safely. The dominant habitat in this transect was large boulders with some areas of platform ledges and flat platform reef. The transect depth ranged from approximately 4 to 7 metres.





A total of 31 *J. edwardsii* were observed on this transect with 64.5% of lobsters observed to be of legal size (>95mm CL) or above. The largest CL length was measured at 150mm and a mean CL of 101.3 ± 8.9mm (($CI_{95\%}$) ($CI_{95\%}$=95% Confidence Interval). Six lobsters were observed being solitary, with the remaining spread over four dens housing groups of 4, 5, 9 and 7 individuals. Two females were observed to be brooding eggs. No *Sagmariasus verreauxi* were observed on this transect.

IMAGE KEY

Image A – Typical habitat of this site (LOB1R), LBC on bedrock platform.

Image B - Typical LBC habitat of this site (LOB1R)

Image C – Grouping of four *J. edwardsii* (LOB1R)

Image D – Large grouping of *J. edwardsii*. This den was too deeply recessed to allow collection of any sex data. There were 9 animals observed in this PRL shelter (LOB1R).

Site ID: LOB2R - *Southwest Cove* **Location:** 35° 12.066'S 174° 17.427'E

Date Sampled 15/06/2016

This site is located at the most southwest point of Maunganui Bay, in the narrow cove just inside the southern headland (Image I). The habitat consists of large and medium sized boulders with patchy *Ecklonia* cover on cobble/sand/broken-shell substratum (Image J). The absence of deep cave recesses allowed more lobsters to be sexed and measured than LOBR1. The transect depth ranges from eight to 16 metres.

Seventeen *J. edwardsii* were observed on this transect with 35% observed to be of legal size or above. The largest *J. edwardsii* CL was measured at 115mm and the largest non-measured CL was estimated to be 150mm. The mean estimated CL was 83.6 ± 21mm ($CI_{95\%}$). Two sub-legal males were observed to be solitary, with the remaining lobsters spread over three dens with one lodging 11 individuals including juveniles (five animals estimated CL<50mm) (Image H), and two other groupings of two individuals each. Sixteen *Sagmariasus verreauxi* were observed on this transect with a mean CL of 159 ± 7mm ($CI_{95\%}$). The largest CL was 180mm (measured). Three dens were observed housing two individuals each, with the other two dens housing five (Image K) and three individuals each.

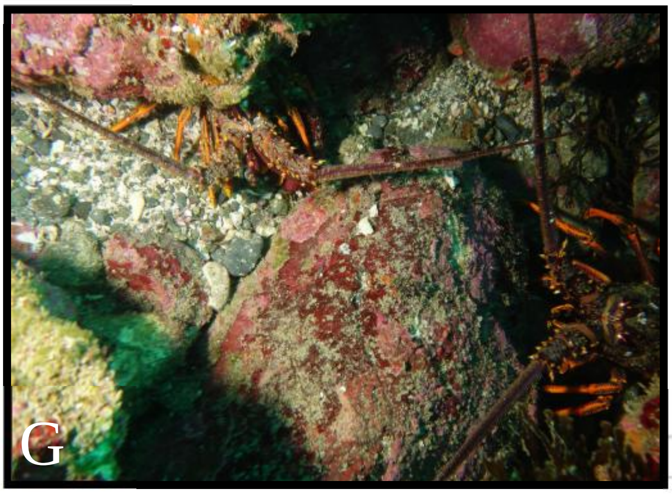


IMAGE KEY

Image E - *S. verreauxi* amongst algae cover

Image F - Solitary legal size *J. edwardsii*

Image G - *J. edwardsii* in small boulder habitat

Image H - Juvenile *J. edwardsii* estimated CL 30mm

IMAGE KEY

Image I – Cove where LOB2R is located

Image J – Typical substratum/habitat of LOB2R

Image K – Grouping of four *S. verreauxi* (LOB2R)

Site ID: LOB5R – *NW edge of White Reef* **Location:** 35° 11.593'S 174°17.903'E

Date sampled 14/06/2016

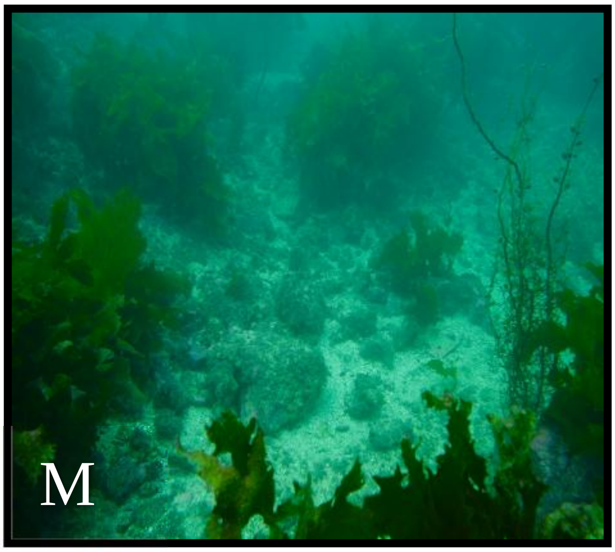
This site is located on the northern edge of 'White reef'. The habitat is made up of medium sized boulders on platform rock substratum with dense *Ecklonia* canopy and *Carpophyllum* coverage. The reef slopes down from a submerged platform (bommie) to coarse sandy bottom of the gut/channel running between the reef and the shore. The transect depth ranges from seven to ten metres depth. This site had the least total number of lobsters observed of the Rahui sites. One individual *J. edwardsii* with an estimated CL of 20mm was observed on this transect. A total of eight *S. verreauxi* grouped in one den were observed on this transect. The den comprised of a deep cave which obstructed the diver from access required to measure or sex the lobsters. The mean estimated CL of this site was 175 ± 14mm ($CI_{95\%}$), with the largest estimated CL of 190mm. It should be noted that it was difficult to get a good view of this den, and so CL estimates may have a higher level of error. There are no images of this site.

Site ID: LOB6R - *Shallow boulder cove* **Location:** 35° 11.481'S 174° 17.865'E

Date sampled 04/06/2016

This site is located in the shallows of the sheltered cove on the northern edge of Maunganui Bay to the west of Deep Water Cove. The habitat consists primarily of boulders on broken shell and sand (Image M) with bedrock with ledges leading up to the shore (Image L).

Thirty-five *J. edwardsii* were observed on this transect with 35% of those observed to be above legal size. The largest measured *J. edwardsii* was 165mm CL and the largest non-measured was estimated to be 150mm CL. The mean estimated CL for this transect was 83.6 ± 13mm ($CI_{95\%}$). Fifteen *J. edwardsii* were observed as being solitary, the highest number of non-grouped individuals on this round of sampling. The two main dens had four and 16 lobsters each (Image N), with the latter being the most densely occupied den observed at all sites. A total of six *S. verreauxi* were observed on this transect with a maximum estimated CL of 150mm, and one measured individual with a CL of 140mm. This site had a mean *S. verreauxi* CL of 140 ± 5mm ($CI_{95\%}$). One *S. verreauxi* was observed solitary with the remaining split between two groups of two and three.



<u>IMAGE KEY</u>

Image L - View to shore from LOB6R waypoint

Image M - Small boulders on shell/sand substratum with patchy *Ecklonia* and *Carpophyllum* (LOB6R)

Image N - Large grouping >10 *J. edwardsii* in LBC habitat (LOB6R)

3.3 CONTROL SITES

Site ID: LOB9C - *North of Ohututea Bay* **Location:** 35° 10.718'S 174° 19.792'E

Date Sampled 05/07/2016

This site is located in the next bay north of Ohututea Bay. The dominant habitat at this site was large boulders on a cobble substrate. The transect was laid over a row of boulders that provide suitable lobster habitat. Several cavernous recesses form part of the shore adjacent to the zero point of the transect.

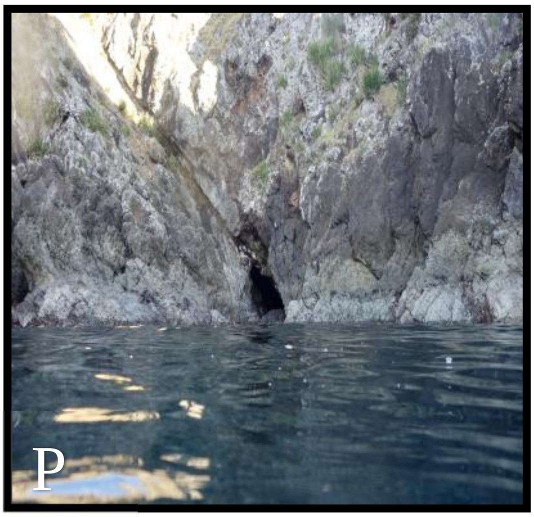
A total of seven *J. edwardsii* were observed on this transect with four being estimated to be over legal size (57%). The mean CL was 101 ± 17mm ($CI_{95\%}$). The largest estimated to be 150mm CL. Four *J. edwardsii* were in the one grouping of this site with the remaining solitary. All of these *J. edwardsii* were located in habitat that did not allow the diver to view or handle the animals, therefore no sex and CL measurements are available for this site. No *S. verreauxi* were observed at this site. There are no photos available for this site.

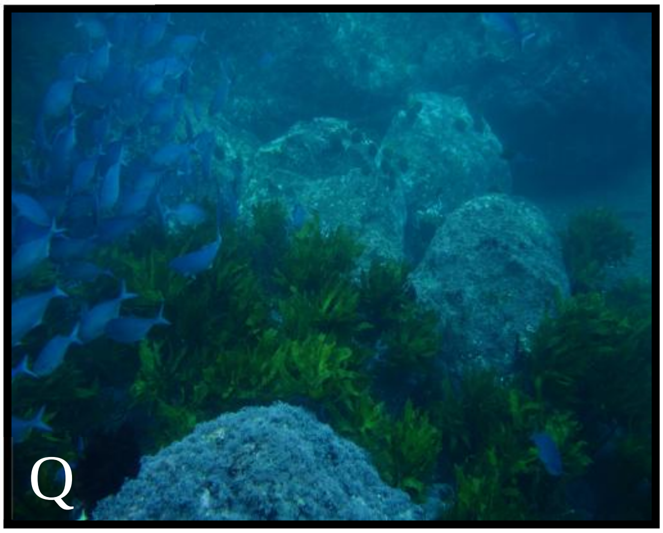
Site ID: LOB11C *Channel behind island* **Location:** 35° 10.986'S 174° 18.402'E

Date Sampled 05/07/2016

This site is in a gut formed by the channel that runs between an island and the mainland, with the transect running along a row of boulders with platform reef either side and a pebble/cobble substratum. The lobster habitat is almost all boulders with *Ecklonia* and *Carpophyllum sp.* cover (Image O and Q).

On this transect a total of six *J. edwardsii* were observed with a mean CL of 81 ± 26 mm ($CI_{95\%}$) with four *J. edwardsii* being estimated as legal (66%). The largest *J. edwardsii* was estimated to have a CL of 110mm. One den had four *J. edwardsii* (Image R) and the other with two. No *S.verreauxi* were observed on this transect.





<u>IMAGE KEY</u>

Image O – LBC habitat of this site (LOB11C)

Image P – View shoreward at waypoint of LOB11C

Image Q – Row of boulders that makes up this sites habitat (LOB11C)

Image R – Four *J. edwardsii* in grouping in PRL habitat (LOB11C)

Site ID: LOB12C *Kariparipa Point* Cove **Location:** 35° 11.093'S 174° 17.719'E
Date sampled 06/07/2016

This site is made up of large boulders and rock structures forming caverns with either a solid rock substratum or large cobble. There is *Ecklonia* and mixed weed cover and encrusting *Coralline* turf. No *J. edwardsii* or *S. verreauxi* were observed on this transect.

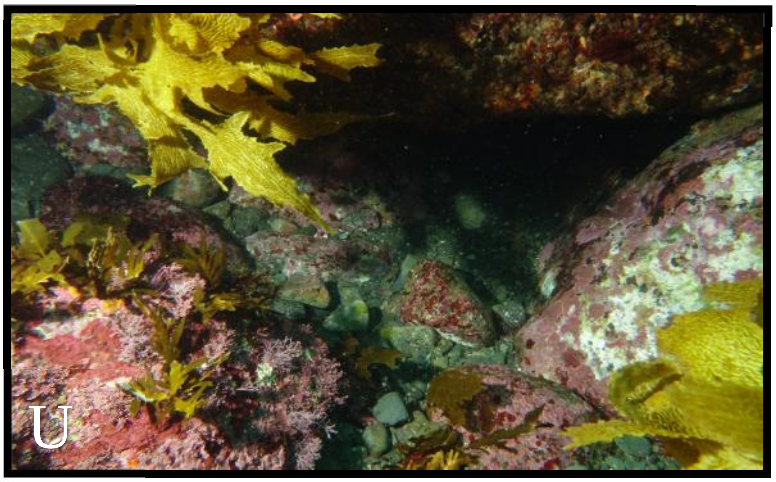


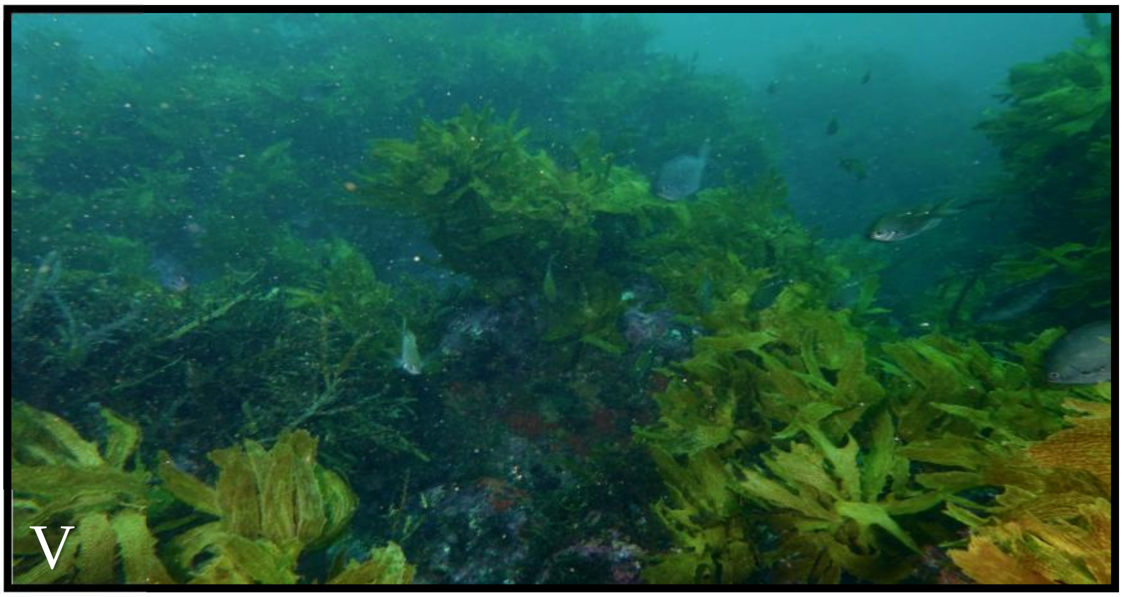
IMAGE KEY

Image S – Boulder that marks start of transect (LOB12C)

Image T – LBC on cobble substrate typical of this site (LOB12C)

Image U – LBC on cobble substrate typical of this site (LOB12C)

Image V – Dense *Ecklonia* cover of this site (LOB12C)



Site ID: LOB16C *Behind Kaimarama Bay* **Location:** 35° 13.116'S 174° 15.461'E

Date sampled 04/07/2016

This site is a narrow cove with a mainly bedrock substratum, with patchily distributed large boulders providing the structural complexity required for habitat. There is low algal cover and the depth ranges from two to eight metres. There are no images of this site due to the low visibility at the time of survey.

A total of 21 *J. edwardsii* were observed on this transect with a mean CL of 68 ± 11 mm ($CI_{95\%}$). The largest *J. edwardsii* measured was 75mm CL and the largest non-measured lobster estimated to have a 130mm CL. There were no solitary *J. edwardsii* observed on this transect, with two large groups of 12 and nine *J. edwardsii*. No *S. verreauxi* were observed in this transect.

3.4 LOBSTER DENSITY

Each species density data was pooled across the four sites in each protection status to compare species densities, and then combined to compare combined species densities (total lobsters of both species). The *J. edwardsii* mean density was higher across the Rahui sites with 21 ± 15.1 ($CI_{95\%}$) lobsters per $500m^{-2}$ compared to 8.5 ± 8.7 ($CI_{95\%}$) lobsters per $500m^{-2}$ for the control sites, however this was not significant when tested (p=0.20, two tailed T-test). Average *S. verreauxi* density across the Rahui sites was 7.5 per $500m^{-2}$, with zero *S. verreauxi* observed during the control site surveys. Combining the density data of both *J. edwardsii* and *S. verreauxi* to compare total lobster density showed the Rahui sites to have a higher mean density 28.5 ± 13.4 ($CI_{95\%}$) compared to control sites 8.5 ± 8.71($CI_{95\%}$).

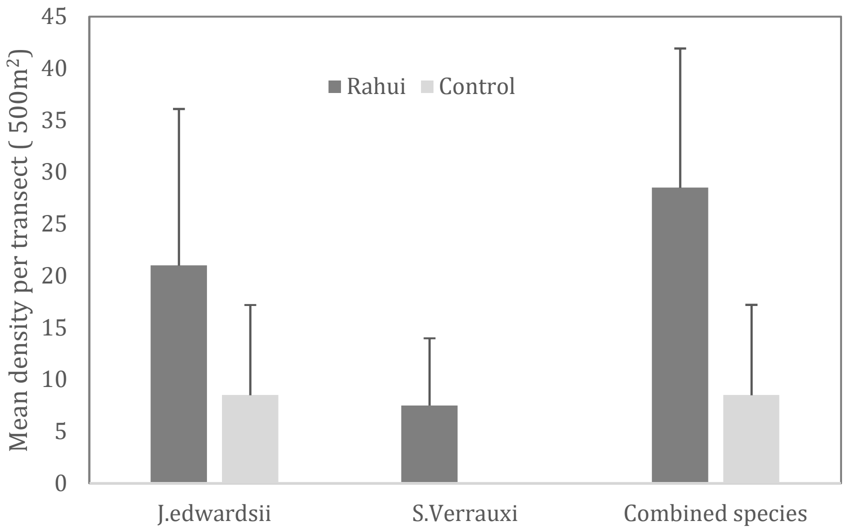


Figure 4: Individual and combined mean species density from pooled control and Rahui site

3.5 CARAPACE LENGTH

Total Rahui (unfished) and control (fished) sites estimated *J. edwardsii* carapace lengths were averaged and compared. The Rahui sites had a higher mean estimated CL of 89.3 ± 8.1mm ($CL_{95\%}$) compared to the control sites with 75.5±10.6mm ($CI_{95\%}$), although this difference was not statistically significant ($p=0.06$).

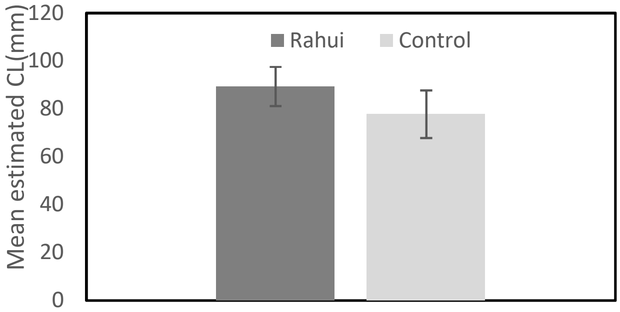


Figure 5: Rahui and Control pooled CL estimates

Carapace length estimates for all sites were pooled for each protection status, and binned and plotted to give frequency distribution. The CL estimates are to the nearest 10mm. The most common CL size class was 100mm in the Rahui site data set and 50mm and 90mm for the control site data set. There was a greater range of CL sizes in the Rahui dataset with 20-180mm, compared to the control dataset with 30-150mm.

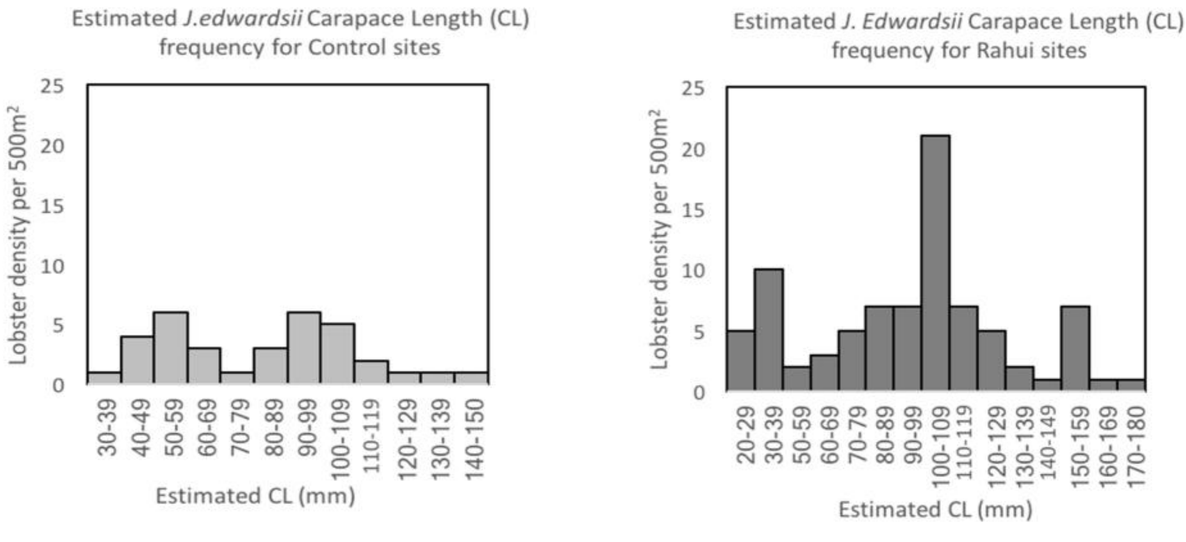


Figure 6: Rahui and Control pooled carapace length size frequency

4. Discussion

The data collected and presented here is the result of the first round of surveys aimed to collect a long-term dataset. Robust inferences about the BOI lobster population and protection effects cannot be obtained due to the low sampling repetition and lack of randomization in the sampling effort. The analysis of this dataset was undertaken simply to look at what could be investigated further when enough data is obtained to reduce the error and detect patterns.

Long term datasets using fixed survey sites for lobster monitoring are still valuable (Shears, Grace, Usmar, Kerr, & Babcock, 2006) and despite only a small amount of data collected on this round of surveying, some useful observations were made despite not being statistically significant. The overall observations that the lobster density and size classes in the Rahui are greater than expected in comparable fished sites is encouraging. These general observations are consistent with common diver opinions of the wider BOI (that it is depleted and that densities in the Rahui are not commonplace in the general BOI). This monitoring programme requires an expansion of the sampling effort and a methodical sampling schedule to verify and track any increases or declines in the future.

Other studies in the northern North Island have found higher densities of lobsters within no take areas, and despite using different methods, it is still thought-provoking to compare lobster density figures. A Reeflife survey project has found significantly higher densities of lobsters when survey data from several no take reserves (CROP, Tawharanui, Whanganui a Hei) are compared to fished sites (D. Freeman & Southwood, 2013). The Reeflife survey densities (when converted to allow comparison) were 15 lobsters per 500m^2 in reserves and three per 500m^2 in fished areas and where lower than this BOI data set, probably due to random not fixed transects being used, but show consistency with the reserve effect of increased lobster density.

The CROP/TWR lobster monitoring programme has reserve densities of 7.6 lobsters per reserve and 1.1 lobsters per 500m^2 for non-reserve areas (Haggitt & Freeman, 2014). The CROP lobster survey had an initial increase in lobster density and then a plateau and decline, however non-reserve densities have remained consistently low at <2 lobsters per 500m^2. The higher densities at the BOI Rahui compared to both of these longer-term studies of protected areas could be attributed to the different sampling (random vs. selected sites), increased lobster habitat in Maunganui Bay, or perhaps the BOI Rahui is in the process of a rapid increase before plateauing out, as has been seen at the CROP reserve.

Data available from monitoring reserves can be useful to fishery and commercial applications. For example, data from the linear modelling of lobsters at four reserves has found rates of population increase of 3.9–9-5% for each year of protection along with an increase in mean size of 1.14mm and increased egg production rates (Kelly, Scott, MacDiarmid, & Babcock, 2000). These kinds of valuable metrics are only available through long term monitoring of protected sites, and could form part of a more holistic system of informing catch limits.

5. Recommendations

- A regular sampling schedule implemented to commence the collection of a long-term dataset.

- Programme expanded to include more sites including deep sites to investigate effects of depth and protection on lobster density in the BOI and give a more robust dataset through repetition.

- This programme could be extended to monitor general trends in lobster population throughout the BOI and Cavalli Islands.

- The Rahui area at Manganui Bay to become incorporated in the existing CROP/TWR lobster monitoring programme through the Department of Conservation (DOC).

- The Ministry of Primary Industries (MPI) to undertake a formal lobster stock assessment of the BOI population to assess the level of suppression due to fishing in light of the statistical area that encompasses the BOI having lowest CPUE figure of the CRA1 area.

- The Rahui boundary area seafloor be surveyed to determine if rocky reef habitat runs from within the Rahui to outside it. This will assess if lobsters from within the Rahui are exposed to fishing during movement.

- Use the Rahui to collect data to assess the protection effect and also the potential to develop the programme to look at changes to the management system due to trophic impacts and kina/algae densities.

- Data sets pre-and post-protection are more valuable and although nothing has been started with lobsters thus far it, will prove valuable to start as soon as possible.

6. Citations

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7. Appendices

See Table 2.

Raw data to be presented on request.

Table 2: Summary data

	Site ID	Date	Sea Temp (C)	Visibility (m)	Depth Range (m)	Habitat Types present	*J. Edwardsii* observed	*J. edwardsii* Males	*J. edwardsii* Females	*J. edwardsii* Unsexed	Number of *S. verreauxi* Observed	*S. verreauxi* Males	*S. verreauxi* Females	*S. verreauxi* Unsexed	Total Lobsters	No. Dens	Photo
Rahui Sites	**LOB1R**	07.06.16	17	5	10-14	LBC, PRL	31	5	4	26	0	-	-	-	31	4	Y
	LOB2R	15.06.16	16	12	4-10	LB, SB	17	4	3	10	16	1	5	10	33	5	Y
	LOB5R	14.06.16	17	5	6-10	LB, PRF, C	1	-	-	1	8	-	-	8	9	1	N
	LOB6R	04.06.16	16	10	4-9	LB, PRF, C, SB	35	5	4	26	6	1	-	5	41	3	Y
Control Sites	**LOB9C**	05.06.16	16	15	3-8	PRF, C	7	-	1	6	0	-	-	-	7	1	N
	LOB11C	5.7.16	16	12	3 - 10	LB, C	6	1	-	5	0	-	-	-	6	1	Y
	LOB12C	6.7.16	16	12	2 - 11	LB, C	0	-	-	-	0	-	-	-	0	0	Y
	LOB16C	5.7.16	16	5	2 - 8	LB, PRF, C	21	2	-	19	0	_	_	-	21	2	N