Motukaroro Island, Whangarei Marine Reserve UVC Reef Fish and Crayfish Monitoring 2012

Vince Kerr[1], Joe Moretti[2]

For the Department of Conservation, Northland Conservancy, Whangarei April 2012

A legal size red crayfish at 24m southwest corner of Motukaroro Island reef

[1]**Vince Kerr**
Kerr & Associates
176 Dip Rd, RD6,
Whangarei, 0176, NZ.
Phone: 09 435 1518
Email: vincek@igrin.co.nz

[2]**Joe Moretti**
Bay of Plenty Polytechnic
022 636 7607

Keywords Motukaroro, crayfish monitoring, underwater visual census, reef fish monitoring, community monitoring

Table of Contents

Client Brief

- Repeat the programme established in 2006-7 for monitoring crayfish and reef fish at Motukaroro Island in the Whangarei Harbour using the underwater visual count (UVC) method for abundance survey as described by Kerr & Grace (2007a).
- Provide a project report which includes results and discussion of the baseline fish and crayfish abundance monitoring. Additional and/or alternative methods of monitoring to be explored and discussed.

Executive Summary

Abundance data for fish and crayfish populations were collected in order to support the study of changes to the ecology of the site arising from the introduction of the marine reserve designation at Motukaroro in 2006.

Underwater Visual Count (UVC) data for recreationally targeted fish showed low numbers in and outside the marine reserve. For snapper only sub-legal sized fish were present inside and outside the reserve. Crayfish were found in small numbers and were all sub-legal size. Only a small proportion of transects had crayfish present, which is typical for heavily fished areas. It was not possible to identify a significant trend in abundance change between the reserve and fished reference sites. Recommendations are made for future options for this survey at Motukaroro. The potential to encourage and develop community monitoring for this popular marine reserve is also discussed.

The Motukaroro marine reserve has become a popular and well used recreational and marine educational site. While the particular nature of the reserve and its very small size makes rigorous scientific monitoring somewhat problematic, there is still an expectation that long term results in species abundances will be measurable with the methods used. In addition to this scientific approach we can expect a growing interest from the community to engage in their own ways of ‘monitoring’ the changes occurring in the reserve. A local approach to monitoring would need to be appropriate for their interests and capabilities. It is suggested that as a priority the Department should work with this local interest and support the community in developing and owning a locally based program.

Introduction

The marine reserve located around Motukaroro Island was established and gazetted in October 2007 as part of the Whangarei Harbor marine reserve. The reserve covers just over 25 hectares, near the entrance to Whangarei Harbour, and is characterized by shallow rocky reefs dropping on to soft sediments. Strong tidal currents affect much of the Reserve as it is on the northern side of the narrow entrance channel to the Harbour.

Baseline fish monitoring using baited underwater video (BUV), underwater visual counts, (UVC) and detailed marine habitat mapping was carried out in 2007, and reported in reports by Kerr and Grace (2007a, 2007b) respectively. The reports reviewed previous work and described the methods used for both BUV, UVC and habitat mapping.

This report follows on from the Kerr and Grace (2007a, 2007b) reports. The focus of this work was to carry out underwater visual counts (UVC) monitoring for fish and crayfish. It was decided that the priority for this year's work was the monitoring of crayfish in the reserve as anecdotal reports (K. Jones & W. Farrelly) and observations by the author suggested that recovery of crayfish in the reserve had begun. In the current survey the 2007 UVC transects and methods were repeated to record both reef fish and crayfish abundance.

Alternatives to the current approach of crayfish monitoring were also explored. These options are discussed in the report.

This year it was decided that BUV would not be used. This was due to cost constraints and limitations with the methodology set up in 2007 as reported on in (Kerr & Grace, 2007a). The limitations to the method established relate to the UVC reef fish methodology as well as the BUV method, but since we were swimming all the transects for the crayfish counts we decided to record the UVC fish counts for further evaluation.

Methods

Underwater visual counts (UVC) reef fish and crayfish monitoring

The UVC transect sites established in 2007, (Kerr & Grace 2007a) were located via recorded GPS position of the zero point. In the 2007 survey three sites inside the marine reserve, and three sites outside established. The sites and zero points of the transects are shown in Figures 1-4 below and navigation and site description details are listed in Appendix 2. At each site four replicate transects were worked for both reef fish and crayfish (rock lobster). At each site a transect line was laid in the direction of the compass bearing recorded in 2007.

In the current survey two new transects were added inside the reserve. These transects are labeled G1 and G2 in the survey maps Fig. 1 & Fig. 2. There are now fourteen transects in the reserve and 12 reference transects outside the reserve. The additional transects G1 and G2 were added to try to include another potential crayfish habitat site in the reserve and to have one of the transect areas in a regular snorkeling spot. A third consideration was the aim to match up habitats within the reserve with habitats outside. G1 and G2 are very similar to transects E1-4.

Figure 1. UVC fish and crayfish monitoring sites in and around Motukaroro Island marine reserve (site details included in Appendix 2)

Figure 2. UVC fish and crayfish monitoring sites located inside the Motukaroro Island marine reserve (site details included in Appendix 2)

Figure 3. UVC fish and crayfish monitoring sites inside the Motukaroro Island marine reserve (D1-4), and fished reference sites adjacent and to the east of the reserve boundary (E 1-4).

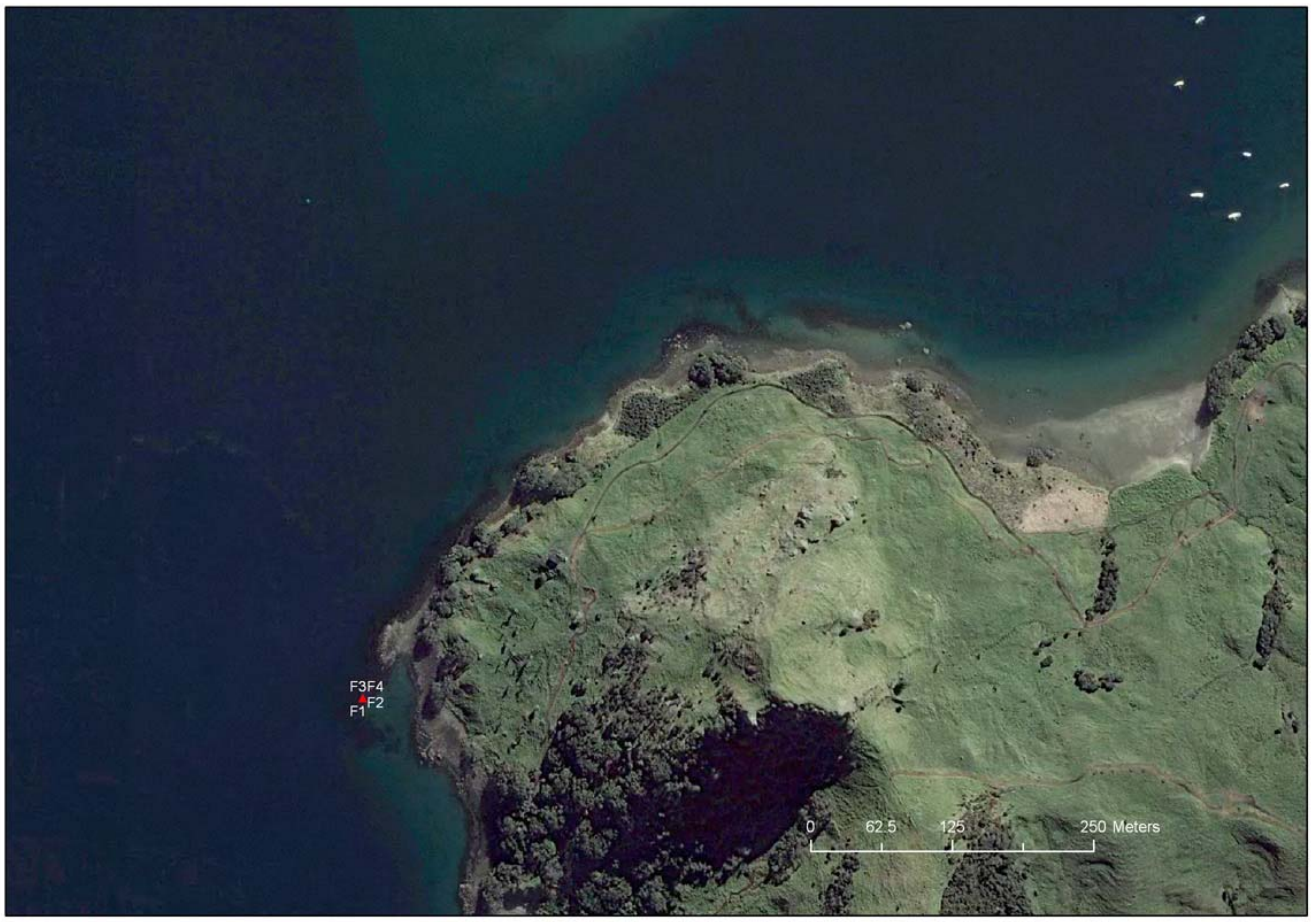

Figure 4. UVC fish and crayfish fished reference monitoring sites at Home Point down harbour from the Motukaroro Island marine reserve (F1-4).

For clarity the method used by the survey divers is repeated here from the previous report (2007a): Two divers proceeded to the anchor, and tied off the zero end of a 30-metre tape either to the anchor or to a kelp plant or rock nearby. Each diver then headed off in a predetermined direction running out the tape to the 5 metre mark before beginning the fish count. This was to minimise any affect of the anchor and tying-off activity on fish behavior. At the 5 metre mark the diver began identifying and counting fish seen within a 5-metre diameter tunnel immediately in front and ahead. Fish were noted down as tally marks, or if a larger group was seen an estimate of the number in the school, against a fish list on a pre-prepared underwater data sheet. In many cases the length of fish was also recorded, usually to the nearest 5cm. The diver continued to move slowly forward trying to avoid stopping during this process, until reaching the end of the tape at 30 metres. The diver then tied off the tape reel to a kelp plant or rock and proceeded to carry out the crayfish survey. On completion of the crayfish transect the reel was wound up and another fish transect begun. In some cases this was from the same zero point, so that four transects radiated out from the anchor. In other cases where the reef was more linear in shape, and radiating transects would not “fit” in the available reef space, the zero point for the next two transects was shifted along the reef about 60 metres or a little more, so that four transects could be counted along the narrow reef structure. The area covered by each transect was 25 x 5 metres, or 125 square metres.

Crayfish survey

The crayfish survey was started at the 30-metre end of the tape already tied off after the fish count described above. The diver commenced working back toward the zero end of the tape working within a 2.5 metre wide strip adjacent to one side of the tape. The presence of a short dense forest of kelp at most of the sites necessitated a laborious process of burrowing through the kelp in a zig-zag pattern along the transect, carefully searching under the kelp and around all rocks in order not to miss any crayfish or holes in which they could hide.

Once back at the 5-metre mark, the diver then proceeded along the other side of the tape working a zig-zag search pattern within a 2.5 metre strip as before out to the 30-metre mark. The tape was then wound back to zero and another fish/crayfish transect commenced.

Crayfish seen were counted and their carapace width estimated to the nearest 5mm interval, by comparison with a measured scale marked along the top of the data recording sheet. The area covered by each transect was the same as for the fish survey, that is 25 x 5 metres or 125 square metres.

Results

Crayfish survey (UVC)

No green or packhorse crayfish (Sagmasarius verreauxi) were seen during this survey.

Counts and size estimates of red crayfish (Jasus edwardsii or red rock lobster) on each transect are presented below in Table 1.

Site and replicate	A1	A2	A3	A4	B1	B2	B3	B4	C1	C2	C3	C4	D1	D2	D3	D4	G1	G2	E1	E2	E3	E4	F1	F2	F3	F4
Red crayfish #																										
Sublegal shell width (mm)																										
10																										
15																										
20																					1					
25																										
30																					6					1
35																										
40								1						1							5					1
45																		1	1							
50																					2					
55																										
Legal shell width (mm)																										
60																										
70																										
80																										
90																										
100																										
110																										
120																										
130																										
140																										
150																										
Total sublegal size	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0	1	1	0	14	0	0	0	0	2

Table 1. UVC Crayfish counts and size data. Note: Reserve sites shaded grey and arranged from left to right in west to east position.

All red crayfish seen were of a sub-legal size.

Sub-legal size crayfish appeared on three transects inside and three transects outside the marine reserve. A total of three crayfish occurred on transects inside the reserve, and seventeen on reference transects. Sizes were between 20 and 50 mm carapace width.

Zero counts occurred on 11 of 14 transects inside the reserve, and 9 of 12 transects at reference sites.

A comparison of the crayfish counts from 2007 and the current counts is illustrated in Fig. 5 below.

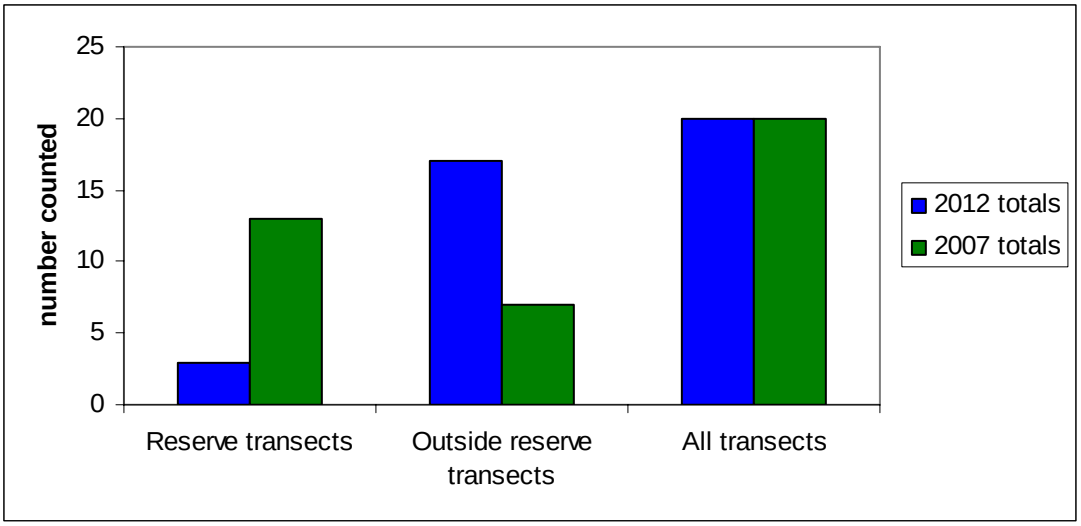

Figure 5. Crayfish total count inside and outside the reserve

Looking at the pattern of the results between the two periods it appears that there is a reverse in the difference between inside and outside of the reserve. The 2007 survey found more animals in the reserve and the opposite was observed in the current survey. Interestingly the total number of animals counted was similar between the two years. In interpreting these results we need to take into account that there are still low numbers of crayfish overall and that 20 of 26 transects had zero counts. When we view the data with standard error calculations the error bars clearly show that there is insufficient data to make any conclusion about any change over time in the numbers of crayfish inside and outside the reserve. The crayfish counts are too low to make any kind of statistical analysis possible. The graph in Fig. 6 below illustrates the relationship between the means of inside and outside transect counts to the standard error calculated. In comparing year to year, or the inside to outside, any change in variation observed falls easily within the standard error of each data group. As a result we have to conclude that the differences observed between inside and outside the reserve, and between the surveys, are not as yet significant or cannot be detected with our method.

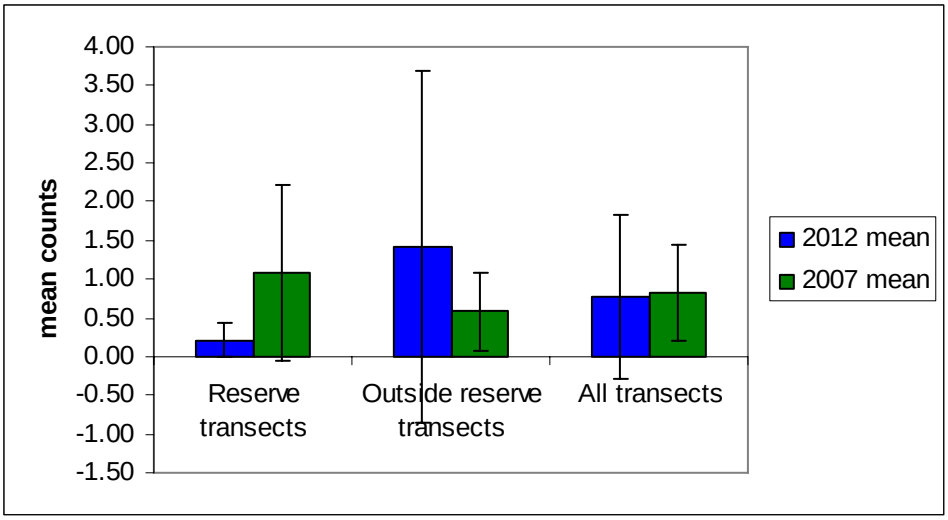

Figure 6. Mean crayfish counts comparing inside and outside of reserve, 2007 and 2012 surveys. Error bars are standard error for the mean of each group of transects.

Underwater Visual Counts (UVC) fish survey

Fish Counts

All 26 transects had fish numbers recorded as per the methodology established in 2007. The full data is presented in Appendix 1.

In general the results of this survey were similar to the previous 2007 survey. Like in 2007 this year's survey showed considerable variations. On most transects six species were frequently observed in reasonable numbers and were distributed more or less equally between reserve and reference sites, with considerable variation in actual counts. These species include goatfish, jack mackerel, parore, spotty and snapper. Spotty, the most abundant fish in the area, reached numbers of 300 to 400 on individual transects, both inside and outside the reserve. For this analysis juvenile spotty is included with the adult tally. Table 2 and Fig. 7 below show these results in graphic form. Based on the standard error (95% confidence levels), calculated for these species it is reasonable to conclude that spotty densities were similar between the reserve and reference sites. For the other species it is not possible to reliably infer a conclusion because of the high variability across the transects as demonstrated by the high standard error values that are exceeding mean values. It possible that there are similar densities for these species overall in and outside the reserve, but our data based on the limited number of replicates does not statistically support this conclusion.

Fish	2012 Reserve transects mean	2007 Reserve transects mean	2012 Reference transects mean	2007 Reference transects mean	2012 Reserve transects standard error	2012 Reference transects standard error	2007 Reserve transects standard error	2007 Reference transects standard error
goatfish	6.50	13.58	6.75	19.25	4.77	3.50	8.22	13.27
jack mackerel	0.00	29.17	8.33	20.83	na	14.52	27.53	21.64
parore	11.14	7.58	17.50	8.00	4.74	6.62	4.82	4.21
spotty	59.50	98.00	98.42	83.25	27.64	36.38	62.83	64.13
sweep	0.00	7.00	17.17	30.50	na	15.84	11.30	26.29
Snapper	7.36	1.33	4.50	1.33	14.89	6.67	2.86	4.80

Table 2. Comparison of 2012 and 2007 mean UVC fish counts inside vs. outside the reserve, (six most abundant fish species). Standard error is indicated for each group of transects

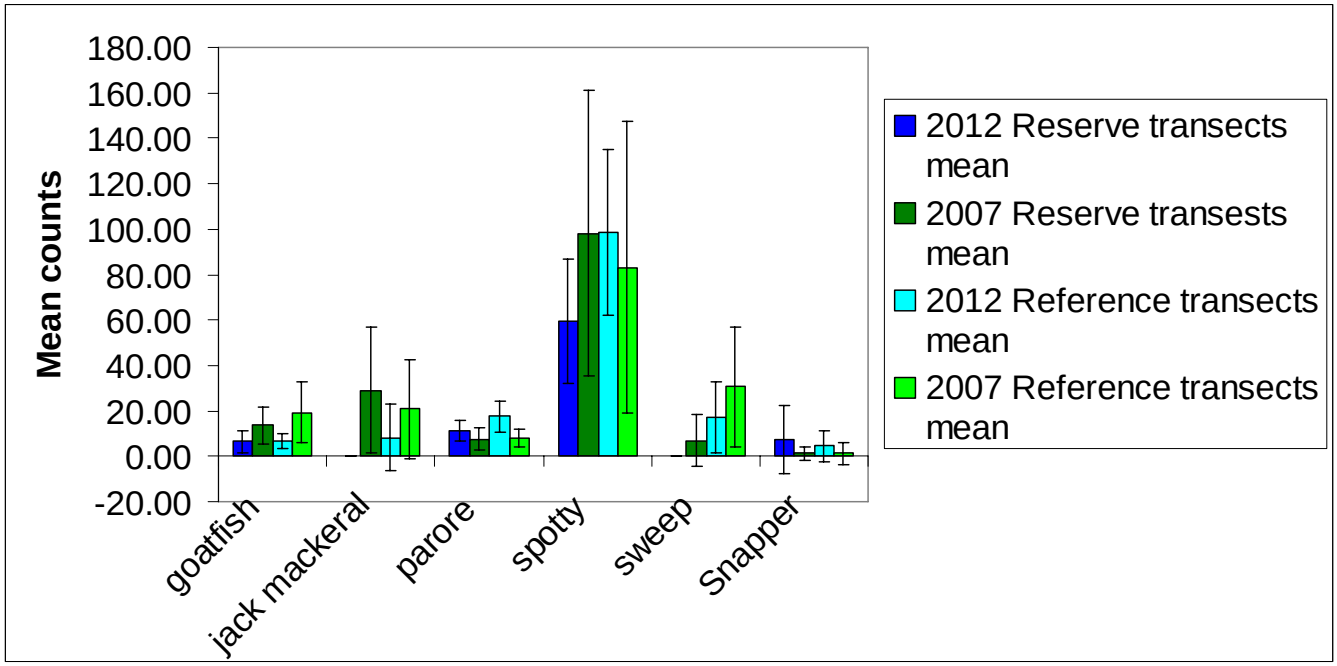

Figure 7. Comparison of 2012 and 2007 mean UVC fish counts inside vs. outside the Reserve. Standard error is indicated for each group of transects.

All the other species were either found infrequently on transects or only in very small numbers. For these species the data does not support statistical comparison between reserve densities and reference site densities or change over time.
Red moki, an important reef fish in the area, occurred in small numbers at several sites both within and outside the marine reserve. The results for the current survey generally followed the pattern of the previous survey for this species.

On a number of transects the presence of juvenile snapper was noticeable with a maximum of 68 being seen on D3. Our impression in the field was that we were seeing a lot more juvenile snapper in this 2012

survey. In total 157 snapper were counted in 2012 versus 32 in 2007. However when the mean counts for snapper across the transects are examined the error bars exceed the mean values for the transects. Although the results indicate that the juvenile snapper numbers are greater in the 2012 survey our data cannot support this conclusion. While it was encouraging to encounter a large sized shoal of juvenile snapper swimming over the transect this observation was subject to chance as these shoals of young fish are mobile which can skew the overall result.

For each species a total count across all transects was calculated as in 2007. This information is presented below in Table 3 and Fig. 8.

Species	2012 Total count reserve transects	2007 Total count reserve transects	2012 Total count reference transects	2007 Total count reference transects
Banded wrasse	17	5	12	9
Blue maomao	0	13	0	80
Butterfish	0	2	6	1
Butterfly perch	0	0	2	2
Conger eel	0	0	0	0
Demoiselle	0	0	15	1
Eagle ray	0	0	1	0
Goatfish	91	163	81	231
Jack mackerel	0	350	100	250
John dory	1	0	0	3
Kahawai	1	0	100	1
Kelpfish	1	0	0	3
Kingfish	2	0	1	0
Koheru	101	3	2	70
Leatherjacket	12	1	5	7
Black pipefish	1	0	0	0
Parore	156	91	210	96
Piper	0	0	0	0
Red moki	18	10	15	19
Scarlet wrasse	0	1	0	0
Short-tail stingray	1	0	0	0
Silver drummer	0	0	0	1
Snapper	103	16	54	16
Spotty	833	1,176	1,181	999
Sweep	0	84	206	366
Dragon horse	0	0	2	0

Table 3. Total fish counts for each species across reserve and reference transects with comparisons to 2007 survey counts.

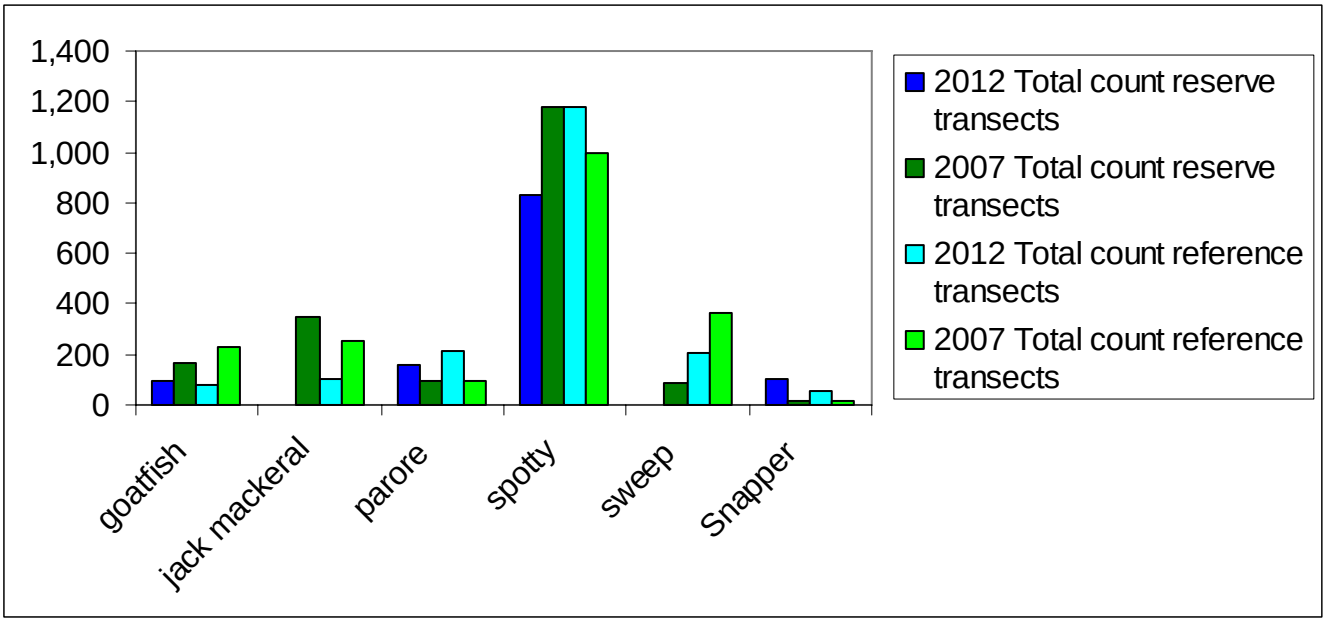

Figure 8. Total fish counts for reserve and reference transects with comparisons to 2007 survey counts (six most abundant species).

Considering the limitations of the data set, the variation we see in the Fig. 8 graph can be a reflection of the sampling variation rather than depicting any trend change in time or between reserve and reference transect sites. The relative high numbers of spottys compared to any other species is worth noting. For our analysis juvenile spotty counts have been combined with adult spotty counts. The numbers of juvenile, mid-size and full grown fish clearly demonstrate that both reserve and reference sites are important nursery areas and adult habitat for this species. This should be taken as an indication that these areas are significant nurseries for many reef and reef associated fish species.

Discussion

Limitations of this study

The 2007 monitoring report (Kerr & Grace) provides a detailed discussion of the specific problems associated with monitoring a site like the Motukaroro Island reserve, the methods used, and the design of the transect sites. The Motukaroro Reserve has the compounding challenges of strong tidal currents, the variations created by its harbour entrance location, estuarine and oceanic influences all working together, and its very small size. The 2007 survey included the use of the Baited Underwater Video Method (BUV) which wasn't repeated in this year's work. Recommendations to address some of these difficulties suggested in the 2007 report remain relevant to monitoring approaches used in future for this site.

The results of this survey for UVC suggest that BUV monitoring would have added little information this year due to the fact that we are not yet seeing large scale trend changes in fish abundances in the reserve. But the caution here is that we must remember that the BUV system is useful for avoiding the one serious problem that all UVC monitoring has, which is the disturbance divers cause and the subsequent reaction in fish behavior. Some species are sensitive to this disturbance and stay away from

the diver transects while the counts are being made. BUV does not have this problem and therefore should always be considered as a paired method with UVC if it is used. Medium and large snapper are one important example of a species that is effectively monitored with BUV and poorly monitored with the UVC technique.

One additional site with two transects, G1 & G2, (see Fig. 1) was added to the program for this year's survey. This site was chosen to (1) add to the potential statistical power of the results, and (2) provide a better match-up of sites in and out of the reserve. From both a fish and crayfish perspective the results of adding these new transects didn't alter the overall analysis this year. In the future when there are hopefully larger trend changes and an increase in abundance within the reserve, these additional transects and potentially other additional transects will contribute to a more reliable monitoring result.

UVC crayfish survey

Legal sized red crayfish were not found on reserve or reference site transects. Variation between years and between inside and outside of reserve sub-legal crayfish counts fall within the sampling error overall. The conclusion is that with our current method, we are not yet seeing a significant restoration or increase of crayfish numbers in the reserve. This result is not necessarily unexpected. Generally speaking recruitment of crayfish on the Northland coast is known to be somewhat erratic and light compared to other regions of New Zealand. This pattern has appeared in the few long term studies we have for the Northland coast, (Shears et.al 2007, Kerr and Grace 2007). There is also the possibility as well that crayfish numbers are increasing in the reserve but our sites are not yet showing this trend change. Diver observations are suggesting that this is indeed the case. The author has had several dives in the last year down on the deeper sections (24m) of the Motukaroro Island reef and counted and photographed crayfish of legal size in groups of up 10 individuals in high quality 'lairs' which exist there. This observation is supported by another local diver who has logged many dives at Motukaroro over many years, (pers. com. Warren Farrelly). In addition the divers working for the *Experiencing Marine Reserves Program* have started to report sightings of crayfish in the shallows where they snorkel regularly, (pers. com. Samara Nichols). Taken together these are encouraging signs.

In the future, if crayfish numbers increase in the reserve as expected, they will spread out from the higher quality habitats and from deeper sites to more shallow sites. If this is the case, then over time we would expect to be able to detect a trend change with our existing transects and method. If there is a big recruitment year for crayfish in Northland we would expect to see a significant increase in the juvenile crayfish numbers in the subsequent years. Roughly speaking we might expect these recruitment pulses to happen once in every five to seven years.

UVC fish survey

As depicted in the results section no clear trend change is apparent for the reef fish species monitored in the reserve. This result is somewhat surprising because diver reports suggest an increase in fish numbers in the reserve. These anecdotal reports do have to be taken with some caution as they can represent one off sightings of a large number of fish moving through an area or visiting an area temporarily. Having said this, there is potential to gain valuable information from divers who regularly use the area. One important advantage they bring to the monitoring effort is that they observe the reserve many times across the year and across different conditions. This is very hard and costly to achieve with a formal scientific monitoring program. This potential is discussed further in the next section.

Community Based Monitoring at Motukaroro

Snorkelling at the Motukaroro Reserve is now well established and regularly occurring. There are also scuba divers using the area. Within this group of divers there are some quite capable and experienced divers including the co-ordinators and assistants that work for the *Experiencing Marine Reserves Program* at the site. There is also interest and possibilities with other educational institutes like NorthTec, the University of Auckland and AUT. While it may be hard for any of these groups to maintain a rigorous scientific program they could collect valuable information, particularly where they could do repeated observations of an area.

Some suggestions of methods that could be encouraged and developed are:

- Recorded timed swims – simple fish and crayfish counts observed while swimming at a given pace for a set time, preferably repeated for a specific location. There would be separate snorkelling and scuba sites.
- Recorded fish counts at key spots. There are certain areas where good numbers of fish are often seen while snorkelling and diving and these could be identified and monitored.
- Observation of key crayfish habitats at specific sites. There are a number of good shallow water rock overhangs that are within the normal snorkelling area. Other shallow water sites could be found and added and regularly monitored.
- For scuba divers some deep crayfish lairs could be identified and regularly visited and counted.

Recommendations

1) The formal monitoring of the Motukaroro Island Reserve with the system described in 2007 and repeated in this survey could now be considered a long term monitoring approach. The monitoring that we are doing is suitable for detecting significant trend changes in key species abundance between the reserve and reference areas outside the reserve. Generally speaking we can expect these changes to occur over a time period of 5-10 years or even longer. Therefore a monitoring interval of 3-5 years is suggested as appropriate for a long term program. Yearly monitoring would be better but is not essential if the purpose is to identify long term changes. It is worth pointing out that as this monitoring becomes long term and represents a significant time series of data, trend changes in species abundance will become easier to detect in a statistical sense if the numbers of animals are increasing. The longer a survey of this type runs the more likely it is that significant changes can be detected.

2) In reference to previous recommendations on the methods and layout of monitoring sites, there is still scope for additional sites to be added to the system. Some of the sites could be further developed with depth stratification by adding additional transects at different depth levels. Also a system underwater marking of zero points could be worth investigating, however this would result in increased costs for establishing and maintaining markers. It is not clear is if this work would result in improving data quality.

3) Work could be done to locate and describe some of the high quality crayfish habitats and lairs in deeper parts of the reserve, and a system of monitoring counts could be devised for some of these areas to measure change over time. A caution here is that navigation and accurate location of sites in these

areas of the reserve are difficult due to often low visibility and strong current. The times that a diver can work in these areas is limited to ebb tide periods and thus any work of this kind would be expensive and challenging in terms of diver costs. For new and additional monitoring sites such as suggested above we would not have the same time series base line data to use for assessment of change over time. Having said this though, we need to keep in perspective that the reserve is still in the early phase of changes that could be expected with the establishment of the reserve. Over time changes would be expected to be detected with the approach above. It could also be argued that the highest quality habitat for crayfish is the one we should be most interested in monitoring.

4) There is scope for development of community based monitoring in the Motukaroro. Simple methods such as the ones identified above if done regularly can provide valuable information and become a focal point of interest for the community interested in the progress of the reserve. There is great potential to engage schools and the greater community in this activity via the sharing or publishing of results and photographs on some sort of web platform or 'news' media.

Acknowledgements

Diane Kerr assisted with proof reading. Keith Hawkins and Leon Candy, Department of Conservation for providing advice and assistance in support of this work.

This work was funded by the Department of Conservation, Northland Conservancy.

References

Biosecurity New Zealand. 2005 Marine Pest Guide. Series of information cards on potential invasive marine species. Biosecurity New Zealand, 2005.

Denny, C.M., Babcock, R.C., 2004. Do partial marine reserves protect reef fish assemblages? *Biological Conservation* 116, 119–129.

Kerr, V.C. and Grace, R.V. 2007 Progress report: Motukaroro Island baseline marine investigations, BUV fish monitoring, subtidal and intertidal habitat mapping 2007. For Department of Conservation, Northland Conservancy June 2007.

Kerr, V.C., Grace, R.V., 2007a. Motukaroro Island baseline marine investigations: BUV fish monitoring 2007, UVC fish and crayfish monitoring 2007, and brief assessment of invasive marine species. For the Department of Conservation, Northland Conservancy, Whangarei, December 2007.

Kerr, V.C., Grace, R.V., 2007b. Subtidal and intertidal habitat mapping of Motukaroro Island 2007. For the Department of Conservation, Northland Conservancy, Whangarei, June 2007.

Kerr, V.C. and Grace, R.V. 2007c UVC fish and crayfish survey of 32 sites (320 transects) from Mokau to Whananaki, including Mimiwhangata Marine Park, April 2007. Data held by Department of Conservation, Northland Conservancy.

Morrison, M., 2005. An information review of the natural marine features and ecology of Northland. NIWA client report for Department of Conservation, May 2005. 162p.

Shears, N.T., Grace, R.V., Usmar, N.R., Kerr, V.C., Babcock, R.C., 2007. Long-term trends in lobster populations in a partially protected vs. no-take Marine Park. *Biological Conservation* 132, 222 –231.

Appendices

Appendix 1. UVC Reef Fish Counts 2012 Survey

Year	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
Transect	**A1**	**A2**	**A3**	**A4**	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**	**D1**	**D2**	**D3**	**D4**	**G1**	**G2**	**E1**	**E2**	**E3**	**E4**	**F1**	**F2**	**F3**	**F4**
Species																										
Banded wrasse	1	1	1	1	2	3		3		5				3				1		1			2	1	2	2
Black angelfish																										
Blue maomao																										
Butterfish																					1		3		2	
Butterfly perch			1	1																						
Conger eel																										
Demoiselle																							5	10		
Eagleray																						1				
Goatfish	16	4	2	12			2	4	3			2	13	14	7	1	30	15	3	17	13	12		2		
Jack mackerel	55	5																		40						
John dory													1													
Kahawai			100									1														
Kelpfish					1																					
Kingfish											2													1		
Koheru										1								100						2		
Leatherjacket		1	3		1					8	2	1														1
Black pipefish							1																			
Marblefish																										
Parore	24	23	15	32	8	19	6	17	6	20	26	27	2	15		4	3	3	8	2	3	30	17	12	7	37
Piper																										
Red moki	1		1	1				1	1	6		1		2			5	2	3		6	1				2
Scarlet wrasse																										
Shorttail stingray										1																
Silver drummer																										
Snapper	5		30	14									17	8	68	10				5						
Spotty	9	8	6	3	10	40	6		6	4	7	4	8	9	3	1	1	4	14	12	4	18	2		8	2
spotty juv.	55	30	50	100			20	100	200	65	50	100	60	55	50	20	2	8	60	50	50	50	250	200	100	100
Sweep																			85	30	2	30		19		40
dragon horse		2																								
No. of spp.	8	8	10	8	5	3	5	5	5	8	5	7	6	7	4	5	5	7	6	8	7	7	6	8	5	7
Total number of fish counted	166	74	209	164	22	62	35	125	216	110	87	136	101	106	128	36	41	133	173	157	79	142	279	247	119	184

Appendix 2. UVC Transect Site Information

(a) **Reserve sites**

Site and replicate	**B1**	**B2**	**B3**	**B4**	**C1**	**C2**	**C3**	**C4**	**D1**	**D2**	**D3**	**D4**
Direction from zero	WSW	ENE	WSW	ENE	NNW	NE	SE	S	NE	E	SE	S
Depth at zero	4.5	4.5	5	5	6	6.5	6.5	6.5	6.9	6.9	7	7
Depth at 30m	5	5	6	6	12	11.2	9.8	3	6.6	6	8	8.5
Habitat at zero	eck	eck	eck	eck	eck	eck	eck	eck	sand	sand	sand	sand
Habitat at 30m	eck	eck	eck	eck	eck	sand	eck	eck	eck/sand	eck/sand	eck/sand	sand
Sampling date	30.1.12	30.1.12	30.1.12	30.1.12	31.1.2012	31.1.2012	31.1.2012	31.1.2012	1.2.12	1.2.12	1.2.12	1.2.12
Approximate time	1415	1445	1415	1445	1130	1130	1215	1215	1400	1430	1400	1430
Tide state	falling high	falling high	falling high	falling high	rising high	rising high	rising high	rising high	high	high	high	high
Current	mod	strong	mod	strong	nil	nil	slight	slight	slight	slight	slight	sight
Visibility (metres)	4	4	4	4	5	4	4	5	4	4	4	4
Observer	J.Moretti	J.Moretti	V.Kerr	V.Kerr	V.Kerr	J.Moretti	J.Moretti	V.Kerr	J.Moretti	J.Moretti	V.Kerr	V.Kerr

(b) **New Reserve transects Established**

Site and replicate	**G1**	**G2**
Direction from zero	SE	NW
Depth at zero	11	11
Depth at 30m	15	8.5
Habitat at zero	eck	eck
Habitat at 30m	eck	eck
Sampling date	18.3.12	18.3.12
Approximate time	1600	1640
Tide state	near high	high
Current	slight	slight
Visibility (metres)	4	4
Observer	V.Kerr	V.Kerr

(c)**Reference sites**

Site and replicate	**A1**	**A2**	**A3**	**A4**	**E1**	**E2**	**E3**	**E4**	**F1**	**F2**	**F3**	**F4**
Direction from zero	WNW	NNW	ENE	E	NNW	SSE	W	NNE	NNW	NE	SW	SE
Depth at zero	7.6	7.6	8.7	8.7	7.8	7.8	8.4	8.4	4	4	3	3
Depth at 30m	8	5.1	8	9.5	3.4	9	8	8	3	2	4	4
Habitat at zero	eck/sand	eck/sand	eck/sand	eck/sand	eck/sand	eck/sand	eck/sand	eck/sand	eck	eck	eck	eck
Habitat at 30m	eck	eck/sand	eck/sand	eck/sand	C.flex	eck	eck/sand	eck	eck	eck	eck	eck
Sampling date	31.1.2012	31.1.2012	31.1.2012	31.1.2012	1.2.12	1.2.12	1.2.12	1.2.12	30.1.12	30.1.12	30.1.12	30.1.12
Approximate time	1400	1445	1400	1445	1500	1600	1500	1600	1153	1330	1153	1330
Tide state	high	high falling	high	high falling	high falling	high falling	high falling	high falling	before HW	after HW	before HW	after HW
Current	slight	strong	slight	strong	mod	strong	mod	strong	nil	slight	nil	slight
Visibility (metres)	4	4	4	4	4	4	4	4	4	4	4	4
Observer	J.Moretti	J.Moretti	V.Kerr	V.Kerr	J.Moretti	J.Moretti	V.Kerr	V.Kerr	J.Moretti	J.Moretti	V.Kerr	V.Kerr

Appendix 3 UVC Navigation Data

Transect zero point	Latitude	Longitude
B1	-35.830575	174.497367
B2	-35.830575	174.49737
B3	-35.830475	174.498075
B4	-35.830475	174.498075
C1	-35.830033	174.498697
C2	-35.830033	174.498697
C3	-35.830033	174.498697
C4	-35.830033	174.498697
D1	-35.8307	174.504278
D2	-35.8307	174.504278
D3	-35.8307	174.504278
D4	-35.8307	174.504278
G1	-35.831133	174.501833
G2	-35.831133	174.501833
A1	-35.828648	174.496587
A2	-35.828648	174.496587
A3	-35.828648	174.496587
A4	-35.828648	174.496587
E1	-35.829415	174.512728
E2	-35.829415	174.512728
E3	-35.829702	174.513387
E4	-35.829702	174.513387
F1	-35.851417	174.524327
F2	-35.851417	174.524327
F3	-35.851417	174.524327
F4	-35.851417	174.524327