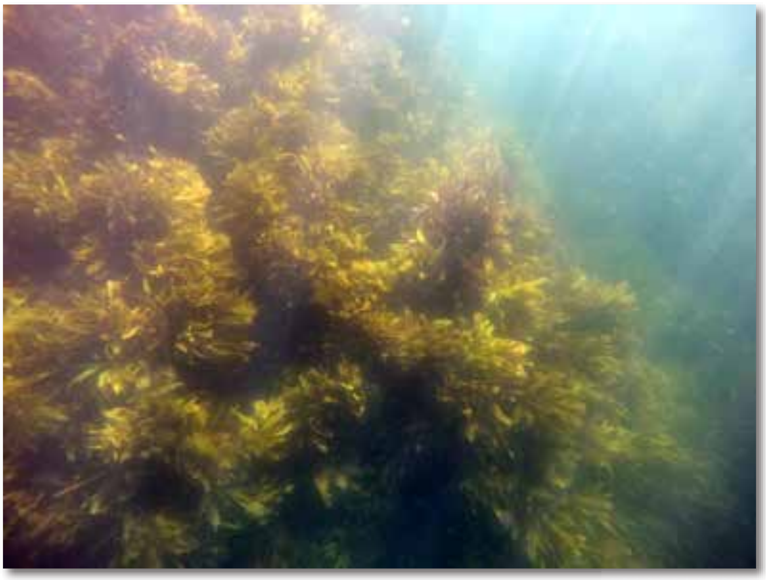
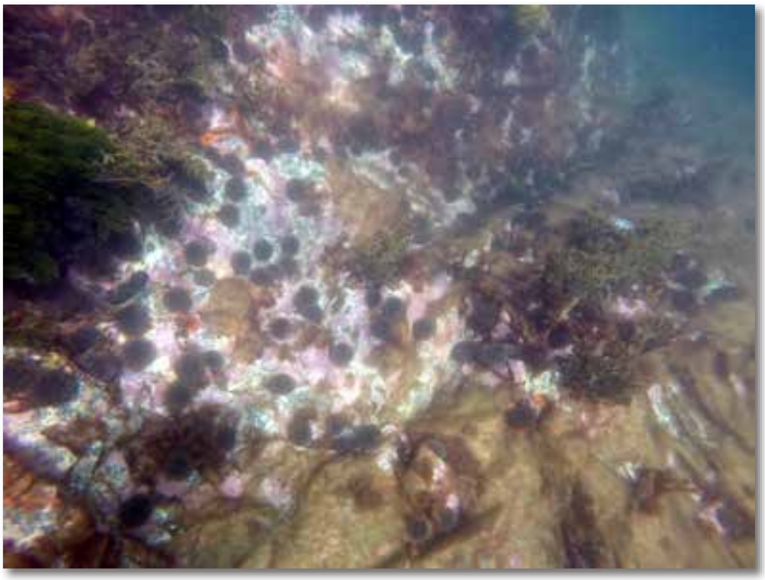
Maitai Bay Rahui Monitoring Preliminary Report and Notes

Vince Kerr, June 2018





Top photo a healthy patch of Ecklonia kelp forest on the W1 transect, bottom photo showing a typical shallow urchin barren on the W1 transect.

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1 Te Kaupapapa

In December 2017 Te Whanau Me Te Rorohuri a Ngati Kahu hapu of the Cape Karikari Peninsula made the decision to establish a no fishing area at Maitai Bay to restore marine life there. After much consideration, this first move was taken under the traditional authority of their hapu and didn't involve the use of the Fisheries Act or Marine Reserves Act and associated partnership arrangements with the Crown and Government Departments. The aims of the hapu were publically stated as:

- bring balance back to our Moana
- restore the depleted areas
- restore Tapu, restore Mana
- implement a sustainability plan for future generations

Figure 1 A map of the Rahui at Maitai Bay

The Mountains to Sea Conservation Trust (MTSCT) based in Northland and home of the Experiencing Marine Reserves Program has an active community support program aimed at helping local communities and hapu to develop conservation actions and restore Kaitiakitanga. The conservation support program is lead by Vince Kerr, a trustee and current chair of the Trust. In 2017 the MTSCT worked in the background to help with some mapping work and supply advice to members of the Rahui committee. Key issues were around design of the boundaries for the initial rahui proposal.

It was decided that the MTSCT would continue to support the Hapu and the Rahui by looking into options for monitoring the restoration associated with the Rahui. A small funding base was obtained by MTSCT to support the beginning of this work reported here in this report.

1.1 Previous Work Relevant to the Rahui project

The Cape Karikari area has very high marine biodiversity values but has not had an extensive survey and monitored work carried out there. Maitai Bay itself despite its status as an iconic spot to visit has also not been well studied. There is useful information on fish community surveys in the general area looking at fish diversity in the Northland context, (Brook, 2002), and comparison of fish abundance at Cape Karikari with Cape Brett, Mimiwhangata and the Poor Knights Island marine reserve using with the baited underwater video method, (BUV), (Buisson, 2009). More general Northland reviews discussing Cape Karikari are a review of marine ecological values of coastal waters, (Morrison, 2005), and a mapping and descriptive study of significant ecological areas, (Kerr, 2016c).

In addition to the site based habitat mapping studies referred to above which mapped urchin barrens, there was an extensive multi-beam based survey of the waters off Cape Karikari (greater than 50m depths) completed in as part of the Oceans 2020 Northland project, (Mitchell, 2010). The Oceans 2020 data and additional survey work sponsored by the Department of Conservation lead to a comprehensive habitat mapping project of the Northland's east coast, (Kerr, 2010). The 2010 map covered the area of Maitai Bay in some detail but did not map urchin barrens. A set of high-quality aerial photos was collected as part of this work (Kerr and Grace collection) that can now be used to map changes to the kelp forest/urchin barren dynamic in the future.

1.1.1 Urchin barrens and degrading shallow reefs a result of prolonged over fishing and their recovery

In northern New Zealand large snapper and crayfish are the main predators of urchins (Shears & Babcock, 2002). In their absence, the population density of urchins can rise to ten-fold of normal densities resulting in the urchins removing large areas of the kelp forest. These areas often become a stable state of drastically reduced productivity and diversity. Shallow kelp forests are connected to the life cycles of many coastal species and their productivity is significant across large distances via species dispersal and 'drift algae' fueling food webs. Maitai Bay has developed urchin barrens over large parts of the shallow reefs, some persisting for decades. A stated goal of the rahui is to restore the life of the rocky reefs. Research in New Zealand on the recovery of algal forests has focused on the Leigh marine reserve where after thirty years of full protection the urchin barren areas,

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extensive in the 1970's reverted to kelp forests. This dramatic change ran in parallel with the predator species re-establishing in the marine reserve. The recovery changes were documented at Leigh via comparing historic habitat maps to recent mapping efforts (Leleu and Remy-Zephir, 2012). Other habitat mapping studies in Northland which have tracked urchin barrens are Doubtless Bay; (Grace and Kerr, 2005), Mimiwhangata; (Kerr and Grace, 2005), Bay of Islands; (Kerr and Grace, 2015), Kerr, 2016a, 2016b), (Booth, 2017, 2015).

Overseas, a similar dynamic of overfishing leading to loss of kelp forests has been reported in virtually every other country with extensive temperate shallow rocky reef and kelp forest habitats (Ling, 2015), (Filbe and Wernberg 2015) and (Filbe and Scheibling, 2018). In New South Wales and Tasmania, the impact of intense fishing and establishment of urchin barrens has been extensively documented including significant adverse ecological impacts and impacts to commercial reef dwelling species like paua.

2 Methods

In this first summer of the Rahui, the Rahui committee had only limited time to detail and establish a monitoring program as part of their ongoing Kaitiakitanga program. There was a great deal of effort put into various communication challenges, signage, erection of Pou and other activities associated with the launch of the Rahui which continued on through the summer. The MTSCT team also had limited resources for this first season of monitoring work. In this context, it was decided to begin some work around habitat mapping, and trialling a timed swim approach to fish monitoring for the shallow reefs. Areas were selected which were typically the most severely affected by long-term urchin barrens and loss of the kelp forests.

2.1 Fish monitoring – timed swim

A method of timed swim fish counts was proposed for the shallow reef areas of Maitai Bay. With this method, a single diver on snorkel swims slowly and as quietly as possible along a permanent mapped route for 15 minutes. The diver records the species and number of fish seen along the way that within a 6 m distance from the diver. Sizes were recorded for snapper, red moki, and butterfish. These three species were selected on the basis that they are ideal indicator species to show recovery following the no fishing ban. Having the ability to analyse the size classes of these species will allow for biomass calculations (total weight) to be done. This will show recruitment progress during the recovery process; in the form of more small fish showing up and over time more large fish accumulating on the reefs. One of the benefits of the timed swim method is that it is relatively easy to learn for competent divers and avoids the cost and logistical complications of using scuba. Maps of the timed swims established are shown in the Results section along with the results for ease of understanding.

Snapper length estimates were converted to wet weight biomass using the equation;

$W = aL^b$ where W is weight(g), L is length, a is 7.194×10^{-5} and b is 2.793 (Taylor & Willis 1998).

The timed swim method has not been used to any extent previously in New Zealand, but it is commonly used in coral reef fish community monitoring. An example of the use of this method is detailed in a report by the author from a survey of the remote Phoenix Islands of the Central Pacific, (Kerr, 2006).

2.1.1 Comparison with other no-take reserves

In our discussions around the Rahui and monitoring, the questions of what will restoration look like, how long will it take emerged as key questions. We decided that one way to explore these questions is to have a way of comparing the results of our timed swim fish counts to similar results from established reserves. We decided to complete the first set of timed transect counts at Motukaroro Marine Reserve in Whangarei Harbor and at the Leigh Marine Reserve near Warkworth. Neither of these reserves is a perfect match in terms of habitat for Maitai Bay with Leigh being more similar but we decided this could be useful. This first survey is reported on in the result section below.

2.2 Habitat Monitoring

One of the most effective ways of tracking the health of algal forests and the persistence and spread of urchin barrens is via accurate mapping of the shallow reef habitats. Information from a variety of methods listed below can be brought together with mapping software systems to construct a habitat map detailing the extent of reefs, urchin barrens and different types of algal forests. With current methods, the accuracy of the mapping can get down to just a few meters. A list of techniques commonly used is:

- aerial photos
- drone photos
- drop video and photos
- diver transects
- side scan sonar surveys

In working with this mapping approach in some cases it is possible to compare the present condition with the past to track for example the spread of urchin barrens over time. This can be possible if good quality aerial photos can be located for the areas of interest. In a habitat mapping project at

Mimiwhangata (Kerr & Grace, 2005), good aerial photos of the shallow reefs were sourced to show the extent of the algal forests in the 1950'. The 1950 photos showed virtually full coverage of the reefs with a lush forest of kelp contrasting with the current condition of extensive urchin barrens. Importantly these habitats can be reassessed at points in the future to show the recovery of kelp forest areas following a period of no-take protection. An excellent example of this approach was recently completed at the Leigh Marine Reserve where historic habitat maps several decades old were compared with recent surveys and habitat maps to show almost complete recovery of the kelp forests in the reserves but still extensive urchin barren condition outside the boundaries of the reserve (Leleu, Remy-Zephir, 2002).

The science team at MSCT has done a lot of this work and has the use of side scan imagery equipment on the Kerr & Associates boat. In order to get ready to complete a full-scale detailed habitat map of the Rahui area, our team started collection of side-scan imagery data this summer and available aerial photography resources are currently being sourced and assembled in a GIS project to support a full mapping effort in future.

3 Results

3.1 Timed swim results

Eight transects were established on the shallow reefs of Maitai Bay and sampled twice in the 2018 summer/autumn (February and early June). To offer us a way to compare results with more established reserves we also created 3 transects at Motukaroro Marine Reserve near the entrance to Whangarei Harbour and 3 transects at the Leigh Marine Reserve. These 'reference' transects were sampled only once in June this year.

Maps, (Figures 1-6) of the transects have been created in a GIS program to assist in future work. The timed swim transects were all done using a dive watch to record 15 min periods of swimming and recording of data. Once mapped on the GIS software it was possible to measure the estimated length of the transects. All of the transects were similar distances at between 300-350m. Results of this initial survey follow for each location.

3.1.1 Maitai Bay

All eight transects established had extensive urchin barrens, the shallower transects had urchins grazing hard right up into the shallow mixed weed zone and even to the edge of the intertidal zone. On the shallowest transects, W2, W2, M1 and M4 the urchin barrens appeared to have been present for a very long term and extended to a sand edge with virtually no *Ecklonia* kelp present. The sand or gravel boundary with the reef was at between 4 and 10m for these shallowest of the reefs. An overview map is presented in Figure 2.

On the deeper of the transects, O1, O2, M2 and M3 there was a large (and deeper) belt of shallow mixed weed and in most cases, there was at least a narrow band of *Ecklonia* kelp starting at the deeper end of the reef typically at about 10-12 m. There were also patches of *Ecklonia* present along the transects as well, usually associated with the rugged terrain of gullies, big boulders and guts. In some areas of these outer transects, the reefs extended out beyond 12-15m in depth where typically *Ecklonia* forest was apparently healthy.

Figure 2 Aerial photo of Maitai Bay showing the 8 transects established for shallow reef timed swims, photo: Grace and Kerr 2005

Figures 3 and 4 show a finer scale view of the transects in the two areas selected for this first trial survey. At this scale, these aerial photos taken in 2005 clearly show the extent of the shallow portions of the reefs down to 12-15m and also the extent of the shallow mixed weed kelp zone occurring just below the intertidal line. The bare looking areas seen as greyish looking in these photos are urchin barren areas. The dark band of *Ecklonia* at the bottom edge of the reef in most areas is what remains of the *Ecklonia* kelp forest that would have once covered the entire reef below the shallow mixed weed band. From our observations made during this survey, the status or extent of the urchin barrens currently is similar to that shown in these 2005 photographs taken at 1,500m altitude.

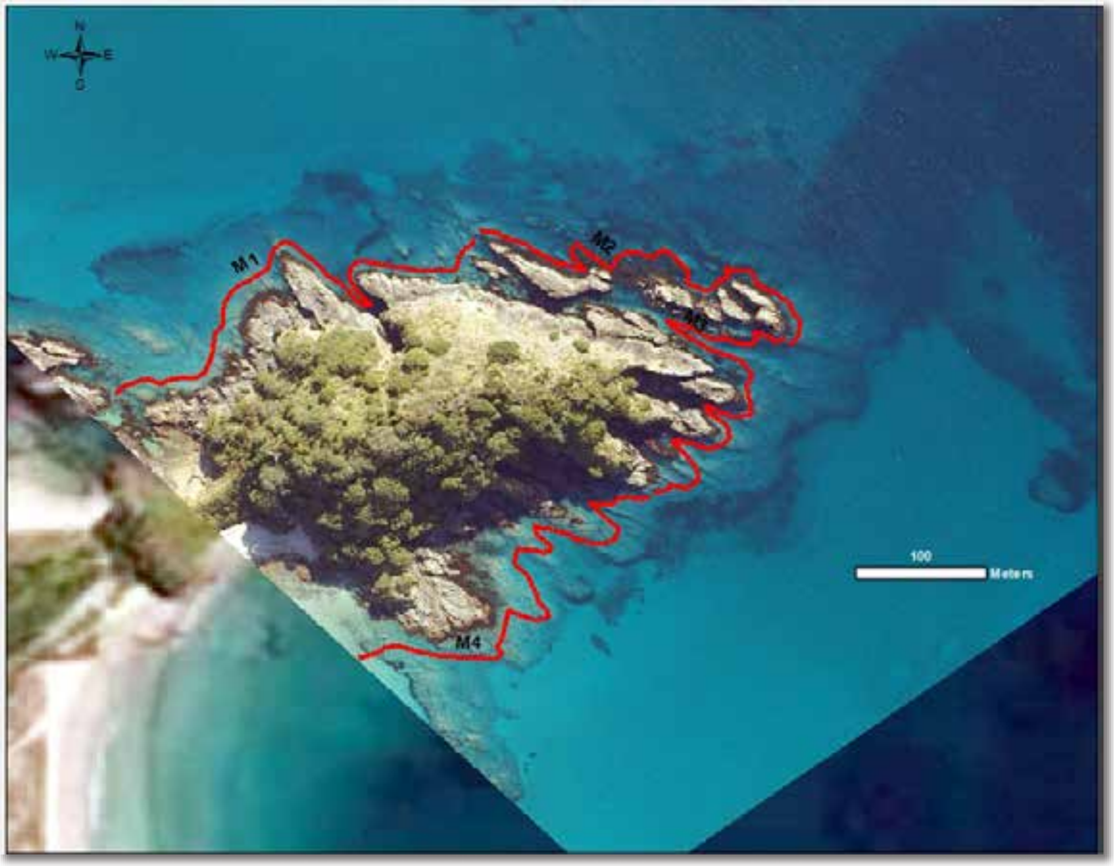

Figure 3 An aerial photo of the peninsula in the centre of Maitai Bay where four transects were established for timed swims, photo Grace and Kerr 2005

Figure 4 An aerial photo of the Waikura and Omahuri areas at the north entrance to Maitai Bay showing the four transects established there for timed swims, photo Grace and Kerr 2005

Table 1 shows the results of counts for snapper, red moki and butterfish. For these three species sizes were estimated and recorded, tabulated here in size classes. On some of the shallower transects, good numbers of juvenile snapper were recorded suggesting that the inner parts of Maitai Bay are an important summer nursery area for snapper. There were very few above legal size snapper seen. For all surveys, only two large snapper were seen.

Small counts of medium-sized red moki were recorded on all transects but no small fish were recorded in the survey. This suggests there could be poor recruitment of young red moki to the urchin barren areas. There were no large red moki recorded which is typical of areas where spearfishing has been common.

Only one butterfish was recorded across all transects which is a concern but not unexpected as butterfish are specialized kelp feeders and often are absent in urchin barrens in addition to being a prized species of spearfishers.

Table 1 Maitai Bay timed swim counts and sizes recorded for snapper, red moki and butterfish

	snapper (cm)						red moki (cm)					butterfish (cm)				
Transect	Total	1-10	11-24	25-39	40-59	60+	Total	1-15	16-29	30-50	50+	Total	1-10	11-24	25-39	40+
m1	10	6	3	1			0					0				
m1	66	63	1	2			1			1		0				
m2	3	1	2				0					0				
m2	2		1	1			5		1	4		1			1	
m3	3	1	1			1	3		2	1		0				
m3	3	2	1				2		2			0				
m4	41	23	18				2		1	1		0				
m4	1					1	1			1		0				
o1	4	2	2				2			2		0				
o1	4		2	2			5			5		0				
o2	6	3	3				1			1		0				
o2	2			2			3			3		0				
w1	8	3	5				1			1		0				
w1	11	9	1	1			3			2	1	0				
w2	5	3	2				1			1		0				
w2	25	21	4				3			3		0				

Table 2 below lists the counts of all fish species other than snapper, red moki and butterfish. Across all transects, there were 26 species recorded. It could be argued this is a reasonable count for a fished shallow rocky reef in the region from a method only involving observation from the surface.

Parore was the most consistently common species occurring in some pretty good numbers, spotty also fit into this group. Both of these species are not preferred fish of fisherman and are generalized grazers and scavengers that seem to be able to persist in urchin barren dominated reefs. Leatherjackets were also seen in small numbers especially in the deeper areas cruising over the reefs. The second list of species made up of blue mao mao, sweep and demoiselles are schooling plankton feeders which typically congregate around areas of stronger currents typical of the more exposed areas. Numbers were not high and in virtually all cases the fish were small in size. The third group of fish are what we might call classic reef-dependent species like hewihewi, marblefish, the wrass species, goatfish, porae, pigfish, moray eels and black angelfish. These species were seen but infrequently and only in small numbers. They could all be described as being strongly associated with kelp forests normally and are thus adversely affected by the urchin barrens. Another group of fish consisting of kahawai, trevally, kingfish, piper and the rays are normally pelagic meaning moving about between open ocean and reef areas, though at times some of these species do take up short or long-term residence on reefs.

Table 2 Maitai Bay timed swim counts for all species other than snapper, red moki and butterfish

Transect	parore	spotty	banded wrass	sandagger wrass	blue maomao	sweep	demoiselle	leather jacket	kingfish	kahawai	trevelly	marbelfishh	black angelfish	hewihewi	pigfish	silver drummer	slender roughy	swimming blennie	shortailed ray	eagle ray	puffer	porae	goatfish	piper	yellow moray
m1	17	4		2		46			2			0					40					1	2		
m1	20	15						3									50			1			8		
m2	13		1		62	40		7	2					2		3								15	
m2	71	5	3		31			7				1		1		8				1	1				
m3	10				203			3			100			2		1					1				
m3	6	4	1		31			4				1		1		6	15	80			1				1
m4	13	4				25		1															1		
m4	47	7	1					2						3				110							
o1	8	1	2		200		100	3				1							1						
o1	39	1		3	1			5	2			3				2									
o2	15				100	5	55	3				1	4		2										
o2	14	1		2			18	1				1				7									
w1	8	8	2		30		2	6		8															
w1	17	2		1				11						1			30			1	1				
w2	13	5	5					5									20	30							
w2	16	8		1				6						2							1				

3.1.2 Leigh Marine Reserve

Three transects were established at Leigh in the shallow reefs surrounding Goat Island and adjacent shoreline. An effort was made to select reefs with similar topography and exposure to our transects in Maitai Bay. The one significant difference is these shallow reefs are nearly free of urchin barrens although in the shallowest parts of these transects there are some significant areas of algal turf habitat. The Leigh Reserve has had no fishing for over thirty years resulting in the kelp forest recovering fully where once there were extensive urchin barrens.

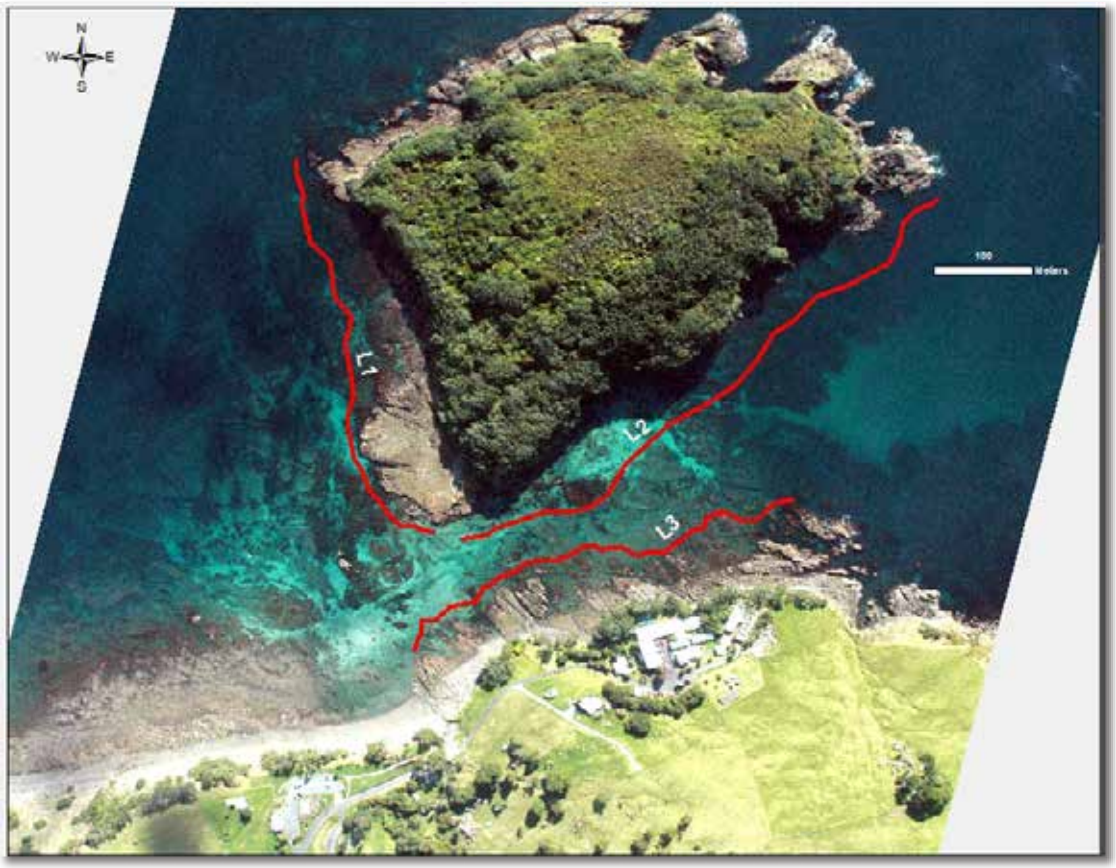

Figure 5 An aerial photo showing the 3 transects reported on in this report. Photo by Roger Grace (2006)

Table 3 below shows the counts and sizes for snapper, red moki and butterfish. Significantly in the Leigh Reserve snapper appear in good numbers in all size classes. This is an important result in two ways. One it shows what would be a more ‘natural state’ age and abundance picture for this important reef species, which include good numbers of very large fish. Secondly, this result indicates that the timed swim method used here is capable of producing reasonable or useful counts for this key species. Below a further analysis of the size classes and biomass of snapper is presented in graphic form. Red moki numbers were quite low compared to what was expected but did include a number of large individuals. The zero counts for butterfish was likewise a surprise as previous surveys using various methods and many hours of observation show healthy numbers of butterfish in the reserve including many large fish.

Table 3 Leigh Marine Reserve timed swim counts and sizes recorded for snapper, red moki and butterfish

	snapper (cm)						red moki (cm)					butterfish (cm)				
Transect	Total	1-10	11-24	25-39	40-59	60+	Total	1-15	16-29	30-50	50+	Total	1-10	11-24	25-39	40+
L1	16		2	6	5	3	6			4	2	0				
L2	50	16	1	22	6	5	2			1	1	0				
L3	23	10	1	5	4	3	22		2	18	2	1				1

Table 4 lists the counts for fish species other than snapper, red moki and butterfish. Overall the numbers of fish counted and the overall diversity recorded was surprisingly low compared to what is known and observed of the reef species on the reefs at Leigh. This raises questions about how effective the timed swim method is for areas such as this densely covered in a kelp forest. The blue mao mao schools seen were significant and were primarily composed of fully grown adult fish not seen at Maitai Bay.

Table 4 Leigh Marine Reserve timed swim counts for all species other than snapper, red moki and butterfish

Transect	parore	spotty	banded wrass	blue maomao	sweep	leather jacket	kahawai	marbelfishh	silver drummer	shortailed ray	piper	koheru
L1	54	3		181	13	1	6		6		20	200
L2	12	7	1		1	5	10	1	1			
L3	20	10	1			2			2	1		

3.1.3 Motukaroro Marine Reserve

Figure 6 shows the map of the three transects established on the shore of the Motukaroro Marine Reserve. These transects only cover the shallow shore of the reserve. Typically the reefs along this shore are bouldery with patches of sand and gravel interspersed with rocky reef areas. They are quite shallow running down to coarse sands and gravels at between 4-12 meters. The kelp forest here is generally healthy and dense, and there are substantial areas of *Carpophyllum flexulosum* mixed with the *Ecklonia radiata*. There are no large urchin barrens on this shoreline. There are some deeper reefs further offshore and an extensive reef surrounds Motukaroro Island which on its southwestern end runs down to 30m depth.

Motukaroro is not an ideal 'reference' site for Maitai Bay because it is part of a large estuarine system albeit relatively close to the mouth of Whangarei Harbour and oceanic influences. At Motukaroro communities are quite specialized to the high silt environment of the estuary and strong tidal currents associated with the harbour. Having said this there are some similarities in terms of the shallow reefs making this comparison at least worth testing.

Figure 6 Aerial photo showing the transect location, red are the transects reported on in this report, yellow transects were timed swims conducted by EMR coordinators with high school students, done as 5 min timed swims.

Surprisingly very few snapper were recorded, no juvenile snapper and no large snapper. Higher snapper counts might be expected since the reserve has now been established for 7 years. Interestingly sightings of juvenile snapper in these areas are common and regular during the summer months which suggests that these fish are moving around and were missed on this once only survey. Repeats of this survey method can shed some light on this question.

Red moki numbers were also low and butterfish counts were zero. In both cases, we would have expected the counts to be higher based on our observations on these reefs. This raises the question of how effective the timed swim method is for counting these species that commonly are swimming down in the kelp or quickly seek cover down amongst the kelp at the first sign of any disturbance. The kelp forests at Motukaroro are quite dense making an observation of some of the reef species difficult.

Table 5 Motukaroro Marine Reserve timed swim counts and sizes recorded for snapper, red moki and butterfish

	snapper (cm)						red moki (cm)					butterfish (cm)				
Transect	Total	1-10	11-24	25-39	40-59	60+	Total	1-15	16-29	30-50	50+	Total	1-10	11-24	25-39	40+
mot1	0						1	1				0				
mot2	0						0					0				
mot3	3			3			0					0				

For the species other than snapper, red moki and butterfish, the results for parore and spotty are impressive as expected, however, the diversity and counts of the other reef fish were overall disappointing, and do not match up particularly well with what is regularly observed on this shoreline.

Table 6 Motukaroro Marine Reserve timed swim counts for all species other than snapper, red moki and butterfish

parore	spotty	banded wrass	blue maomao	leather jacket	kingfish	kahawai	hewihewi	shortailed ray	goatfish
151	70	1				1		1	1
255	64		4	1			1		1
116	42				2	11			20

3.1.4 Snapper counts, size class and biomass calculations

Figures 7-9 show a comparison of the three survey areas looking at snapper specifically. Average counts per transect are displayed in graphic form as are the calculated biomass (combined weight) for each size class across the three survey areas.

The graphs tell the dramatic story that in the Leigh Reserve there is a significant population of snapper consisting of all size classes from juvenile to the very large old individuals. When these numbers of snapper are expressed in terms of biomass you can see just how dramatic the difference is between a restored population (Leigh) and a heavily fished population (Maitai Bay).

The cause of the low counts at the Motukaroro Reserve at this point is not completely understood.

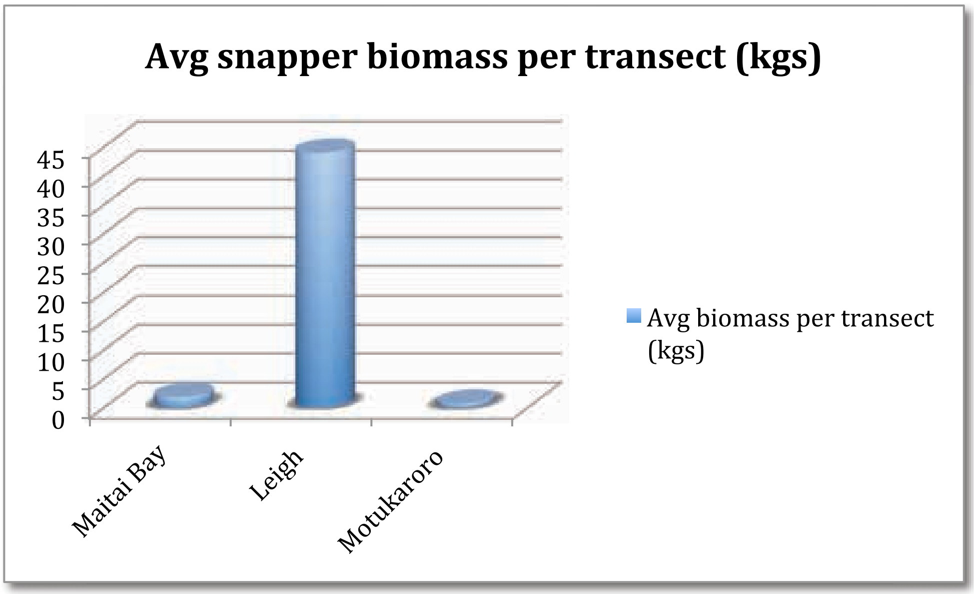

Figure 7 Comparison of the average biomass of snapper per transect in the three areas surveyed

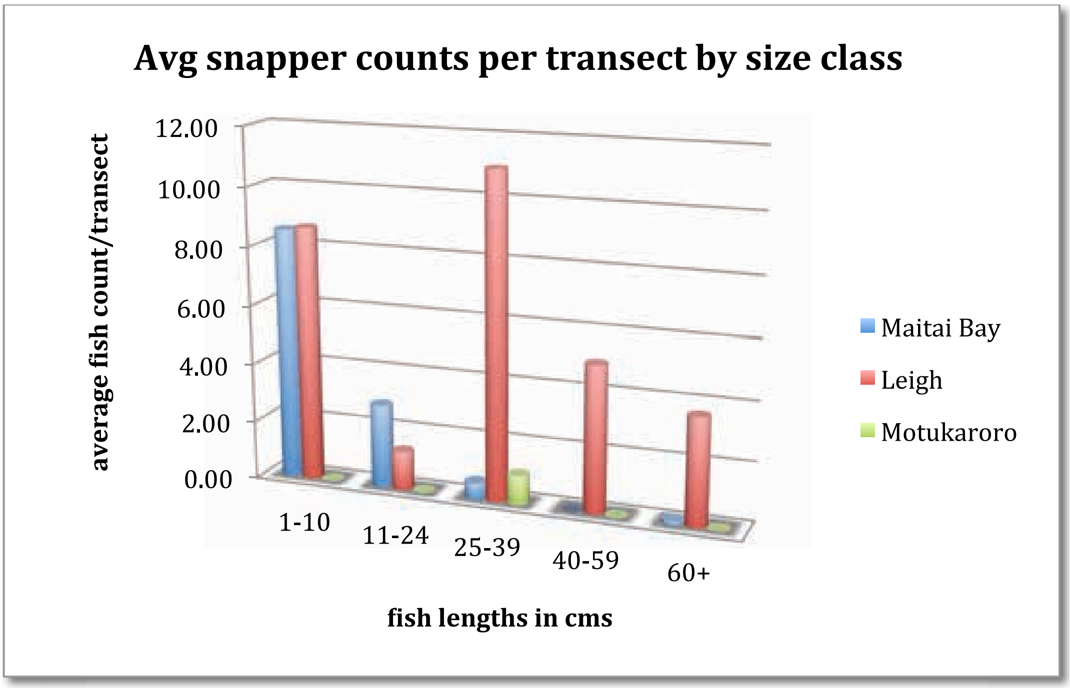

Figure 8 Comparison of the average biomass of snapper per transect broken down by the snapper size classes in the three areas surveyed

3.1.5 Diversity and abundance counts

Tables 7-9 below list summarised data covering the average total number of fish recorded per transect (abundance) and the number of species per transect recorded (diversity).

With the very small number of surveys undertaken it is probably not possible to draw any conclusions from comparison of these abundance and diversity average counts. Also there are questions arising over how effective the method is for the more cryptic of the reef species often found down in amongst the kelp and thus hard to count from swimming above the kelp.

In comparing Leigh to Maitai Bay however, the overall count is much higher 226 compared with 140 respectively and as we saw with the biomass calculation the impact of larger fish and higher counts results in very large overall differences in these communities.

Table 7 Maitai Bay time swim surveys: the total number of fish counted, number of species counted (fish diversity), notes on visibility, survey diver, and range in reef depth

Transect	No of fish counted	No of species	Diver	Date	Viz (m)	Reef depth
m1	124	9	vk	2/24	8-12	3-15+
m1	164	8	vk	5/10	6-8	3-15+
m2	148	10	vk	2/24	8-12	15+
m2	137	13	vk	5/10	6-8	15+
m3	326	9	vk	2/24	8-12	5-15+
m3	156	14	vk	5/10	6-8	8-15+
m4	87	7	vk	2/24	8-12	8-3
m4	172	8	vk	5/10	6-8	8-3
o1	322	10	vk	2/25	8-12	6-8
o1	65	10	wr	4/23	8-12	6-8
o2	192	10	vk	2/25	8-12	6-12
o2	49	9	wr	4/23	8-12	6-12
w1	73	9	vk	2/25	8-12	10-15+
w1	78	10	vk	4/23	8-12	10-15+
w2	84	8	vk	2/25	8-12	15+
w2	62	8	vk	4/23	8-12	15+
Average	**140**	**9.5**				

Table 8 Leigh Marine Reserve: time swim surveys: the total number of fish counted, number of species counted (fish diversity), notes on visibility, survey diver, and range in reef depth

Transect	No of fish counted	No of species	Diver	Date	Viz (m)	Reef depth
L1	506	11	vk	5/10	6-10	6-12+
L2	90	10	vk	5/10	6-10	6-12+
L3	82	9	vk	5/10	6-10	4-8
Average	**226**	**10.0**				

Table 9 Motukaroro Marine Reserve: timed swim surveys: the total number of fish counted, number of species counted (fish diversity), notes on visibility, survey diver, and range in reef depth

Transect	No of fish counted	No of species	Diver	Date	Viz (m)	Reef depth
mot1	226	7	vk	5/9	5	4
mot2	326	6	vk	5/9	5	4-12
mot3	194	6	vk	5/9	5	5-8
Average	**249**	**6.3**				

3.2 Habitat mapping and side scan sonar

Figures 10 & 11 are screenshots of some of the sonar data collected this summer. This sonar track view is shown here to illustrate some differences between the deeper reefs of the exposed coast and the shallow reef areas surveyed in the timed swim surveys.

The screenshots are taken from a viewer function of the software mapping program, *Reef Master*. In this view, the scene on the far right is a map view of the track following by the boat and the boat symbol shows the current boat position corresponding to the two other sonar images shown. The centre image is called a downscan that shows a vertical view trailing out behind the boat from the bottom to the surface. The way it is displayed it is as if you were looking at it from out from the side of the boat path under water. The far left view is the side scan image which shows the bottom contour and other information trailing out behind the boat looking from the top (under the boat) to bottom where boat has been. The side scan image is showing a 3D like view of the bottom structure extending out to each side about 25 meters from either side of the boat track. The darker centre area of the image is the vertical water column.

The middle images are particularly useful for seeing fish schools and also kelp forest cover on the bottom can be clearly seen. In Figure 10 you can see a lighter layer above the reef surface this is *Ecklonia* forest standing approximately 1m high, at a depth 15 m. There is no sign of urchin barrens here. Also, visible hovering over the bottom in mid-water at 7m depth is a fish school. This sounder is quite accurate in the way it portrays the fish images and they are to scale. In this school, most of the fish are at least .5m long maybe bigger and have a snapper like shape although other species like trevally are a possibility.

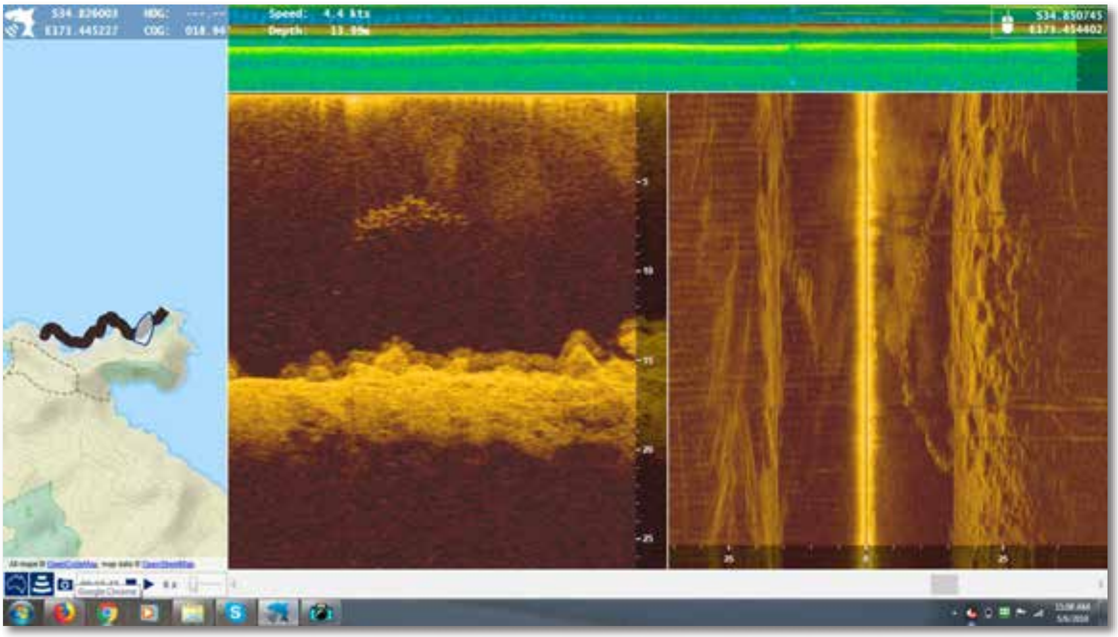

Figure 10 Sonar imagery from the deeper reef habitats of the exposed coast near the southeastern boundary of the Rahui area

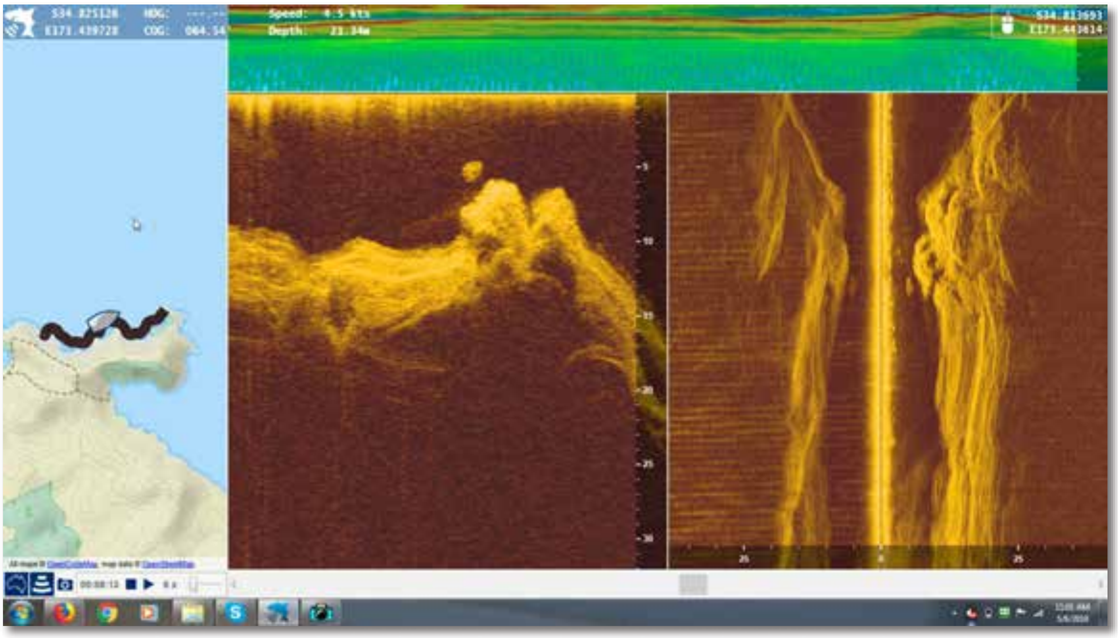

Figure 11 Sonar imagery from the deeper reef habitats of the exposed coast near the southeastern boundary of the Rahui area

In Figure 11 a smaller stand of algal forest can be seen covering the reef and a dense school of fish clearly seen hovering over a small pinnacle rock which reaches up to 7 m depth from a reef to the left at 10 m depth and a drop off under the boat at 20 m. The fish are likely one of the plankton-feeding species, blue mao mao or demoiselles or could possibly be baitfish.

Sonar surveys of both of the outer exposed coasts of the Rahui area were recorded and showed a reef community consistent with these two examples in Figures 10 & 11. The southeastern side is steeper in slope and we are uncertain how much of the shallow part of the reef is in urchin barrens. The northwestern exposed coast is gentler sloping and does have some extensive areas of urchin barrens as indicated in the aerial photographs, (see Figure 4). In both cases in the deeper zone beyond 12m we typically say good *Ecklonia* forest cover and frequently we say fish or fish schools of various sizes showing on the sonar contrasting with the more barren condition of the inner Bay. All data from the sonar recordings are archived for further mapping efforts.

4 Discussion

4.1 Revisiting goals for the Rahui and monitoring

In this first year of monitoring our time and resources were severely limited, it is fair to say that in all projects like this it takes time to be clear on shaping goals, directions for future management etc. Restoration of marine life following prolong heavy fishing is a complex process and as we have seen at our marine reserves in New Zealand can be a process that takes decades. When you consider the key ecological role of large fish like snapper and crayfish on our shallow reefs and the time it takes (some 20 years) to grow to a large size it is clear this is not a quick process. Along with this long-term view are many challenging questions about reserves, how big, where, where to put boundaries and how to gain support from the community etc. Monitoring and studying the restoration process along the way can help to answer some of these questions and provide valuable learning for everyone involved. We decided this first year to make a start with the timed swim method. With this method, local people can potentially collect information on shallow reefs. The urchin barrens dominating there are the most degraded of the habitats in the Rahui and most visible and accessible to people. Also with the sonar surveys, we have done and establishing the GIS project and base maps, we are ready to collectively plan and gather our resources for more ambitious projects in the years to come if that is the direction the hapu wish to pursue.

Data collected from this first season can be viewed as a general indication of what is going on particularly with the species that are effectively observed with this method such as snapper, parore, spotty, and blue maomao. However, the timed swim method requires more repetitions and observations to paint a more accurate picture as many of the fish are moving around the reef area and also between the shallow reef and deeper reef areas making any ‘one-off count’ somewhat unreliable.

4.2 Strengths and weaknesses of the timed swim method

The timed swim method has some very important advantages and strengths but as in all fish monitoring methods also some glaring weaknesses.

Strengths

1. The technique can be mastered by anyone who is keen to learn and is a competent snorkeler having appropriate gear, which is minimal. This means that many people can potentially be involved and 'experiencing' the marine life and learning from the restoration process.
2. Maitai Bay has consistently clear water by Northland standards which aids observations
3. For reef-associated fish species that are readily seen on the shallow part of the reef, this method potentially can deliver useful relative abundance or qualitative information if sufficient replications are completed in each sampling season. Examples of this group of fish are snapper, parore, spotty, blue mao mao, sweep, other plankton-eating species and the second group of pelagic species like kahawai, kingfish and trevally.
4. This method allows the surveyor to become intimately familiar with each transect and thus able to make a variety of worthwhile observations over time on changes taking place.

Weaknesses

1. The third group of reef-associated fish are more kelp forest dependent and typical are down in the kelp or hiding in the kelp and thus not reliably counted with this method.
2. When urchin barrens are extensive as they are in the inner areas of Maitai Bay many fish species are simply not present because they are dependent on the kelp forest, thus this monitoring is only looking at a very diminished reef community.
3. The method is useful only for the shallowest part of the reef from 0-8m effectively. This introduces a number of difficulties and challenges to the usefulness of the data. Topography, slope depth and exposure (wave energy) profoundly affect the make-up of reef and fish communities. Even over a 300m transect, these factors can change a great deal, resulting in the method working well for part of the reef, but missing a lot fish further along the transect.
4. Differences in fish behaviour make it difficult to know which species are in fact being reliably represented in the counts on any given day. For example, if red moki are concentrating on the deeper areas of the reef (>8m) they will be missed with this method.

4.3 The importance and value of snapper monitoring

Snapper are the most significant predator on our shallow reefs. We know that the ecological roles of snapper change as they grow and mature. When in their 'natural' state our shallow reefs have snapper of all sizes with the reefs providing protection for juveniles as well as a great variety of food that various sizes of snapper can exploit. It makes sense that snapper as the main predator on the reef would have a crucial ecological role in controlling urchin populations associated with healthy kelp forests. It could be considered useful to have a monitoring method that focuses only on snapper due to this central role they play on the reef. Fortunately, the timed swim method on the shallow reefs appears to be working quite effectively. Snapper of all size classes were observed at the various sites. The method has the significant advantage that the diver can swim quietly and slowly without the loud noise associated with scuba gear that is known to warn and scare snapper. Based on the limited amount of surveys completed our suggestion is that this method is efficient and worth pursuing on the shallow reefs for snapper monitoring.

4.4 Suggestions for additional monitoring projects

Over the coming months, we anticipate some robust discussion on the future directions of monitoring at Maitai Bay. There are a number of key decisions to make around who will be involved, how to fund, what partners to work with, what objectives/goals to focus on etc. Beyond all these 'big picture' challenges, there is the task of detailing what monitoring is possible and what projects will deliver the best results relative to the goals.

We would like here to list some suggestions for further study and consideration by the kaitiaki group: (Note This is a big list, it is provided here to open up discussion on what is possible etc.)

1. The timed (snorkel) swim is worth continuing on the established transects and areas on the western side of the bay could be considered. It would be good to complete as many replicates as possible in the summer months.
2. Timed swim transects on scuba for the deeper reefs could be trialled next summer, alternatively traditional permanent transects could be established (scuba) for reef fish counts.
3. Consider establishing a camera-based fish monitoring for reef fish with the focus on predator species, i.e. snapper. A simple 'baited underwater video system' (BUV) could be used. This system would involve getting the gear together and learning to use it, boat time and time to process the video that involves following a standard methodology for accurate counting. One advantage of this method is that there is good historical data from reserves and other fished areas to compare our results to.
4. Consider adding a 'reef fish diversity' method to the monitoring mix. This method would need to be scuba based and could utilise a roving diver technique or a fixed transect approach. Essentially in this method the survey diver is carefully searching a given area, including cracks and guts and under the kelp canopy, recording all species seen across the reef depth profile for a given time an/or area covered. What this would give us is a truer picture of all the species living on each area of reef and we would be able to measure over time how this changed as part of the restoration process and recovery of the kelp forests.
5. Crayfish monitoring would be a very worthwhile addition and could be done by carrying out regular counts at a specific high quality hole or den areas or on permanent transects located

on good crayfish habitat. Crayfish would be a good indicator species for the recovery of the area. They play a key role in controlling kina numbers and the recovery of the kelp forests.

6. Complete a detailed habitat map of the Rahui area with special focus on accurately mapping urchin barrens. This would allow for the recovery of the kelp forests to be measured over time and would assist planning and interpretation of the monitoring program. A long-term series of habitat maps are an important tool supporting the design of management areas and boundaries. They also provide a way for the community to 'see' what is out there under the water and the changes going on.
7. Consider a basic descriptive study of the deep areas of reef in the offshore area of the Rahui at depths beyond 30m where reef habitats change from kelp forests to sponge gardens and encrusting invertebrate dominated communities. The survey could be done with a drop camera and video equipment. High-quality photography could be used to construct a description of these valuable reef habitats and what lives there.
8. Consider reaching out to interested and supportive partners like the Universities who could be interested in building research projects or student projects around any of the monitoring objectives listed above. This strategy could greatly extend the learning and information developed at minimal cost to the hapu.
9. Consider adding 'reference sites' outside the Rahui area to further develop understanding of the restoration process going on inside the Rahui area.

5 Acknowledgements

We firstly would like to acknowledge the efforts and vision of the kaitiaki group of the Haititaimarangai Marae at Cape Karikari for getting the project underway. The Hapu are reviving their kaitiaki role at a time when many local marine environments are in long-term decline and Government Departments have all but walked away for their responsibilities to these places and their biodiversity. Your kaitiaki group has boldly begun work on a local approach. The Rahui has the potential to restore one of our most precious marine habitats, the shallow rocky reefs. That this is happening at Maitai Bay is also significant as this is one of Northland's most iconic bays. I consider it a privilege to work there. You have my highest praise and respect for how you have positively engaged your community in beginning this restoration process. I would also like to thank the Mountains to Sea Conservation Trust Team for their support at all times for my efforts in this project. On the ground and out on the water Whetu Rutene has been there supporting the work of the Kaitiaki group. A huge thanks Whetu.

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