Rahui Monitoring Report, Maitai Bay, Cape Karikari

August 2019

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Kaitiaki leader Whetu Rutene counting crayfish

Te Whanau Moana me Te Rorohuri Rahui committee members and the Pou the Hapu erected at Maitai Bay

For: Te Whanau Moana me Te Rorohuri

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Key Words: urchin barrens, marine reserves, rahui, kaitiaki, kaitiakitanga, habitat maps, snapper, crayfish, Maitai Bay, Cape Karikari

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Summary

Monitoring work at the Maitai Bay was carried out over the summer months of 2019. A team supported by the Mountains to Sea Conservation Trust carried out habitat mapping work, fish diversity and abundance monitoring. Three complementary methods have now been established to characterise the reef fish community and create a baseline for which to compare results in further years. The goals are to support learning about the benefits of the Rahui and track the ecological restoration.

Results of timed swim surveys showed encouraging signs in the Rahui area. A large number of small-size snapper showed up this summer (2019). It is too soon to know if the Rahui has influenced this change, but it will be interesting to follow the progress of this large cohort of small snapper in the Bay in the summer of 2020 and following years. There was also a large increase in sandagger wrasse in the 2019 summer compared to the previous year. Other species mostly showed small increases in numbers. There were 17,550 fish counted on 45 timed swim surveys carried out on 13 transects. Snapper made up 1,522 of the total count, indicating that this species is important on these reefs. Each timed swim transect involves a slow swim over the shallow reef for 15 minutes and covers roughly of the reef shoreline.

Observations from fish diversity dives and the baited underwater video survey were generally consistent with the timed swim results and showed small snapper present in all areas of the Bay. Overall there was a small gain in overall diversity compared with a smaller survey effort completed in 2018. The observed changes described in this report will need to be tracked for several years to ensure results are analytically sound. While it is tempting to conclude that these positive results are an effect of the Rahui, at this stage these changes could be a result of natural variations.

We expect positive changes to accelerate as the restoration of the kelp forests become significant. The initial comparison we have made with Leigh Marine Reserve indicates that full restoration of the shallow reefs at Maitai Bay will result in large gains, such as snapper biomass increasing five-fold on current levels and the current count of reef fish diversity extending from 45 species across all our surveys to around 100 species.

In this report we discuss the importance of studying the processes of restoration associated with Rahui and the implications this has on decision-making for the hapu. Recommendations are made for how to expand the kaitiaki role to support the Rahui and economic opportunities associated with the restoration.

Introduction and kaupapa

In December 2017 Te Whanau Moana 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. This move was taken, after much consideration, under the traditional authority of their hapu. It was decided neither to use the temporary closure regulations under Fisheries or Marine Reserves Acts, nor 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

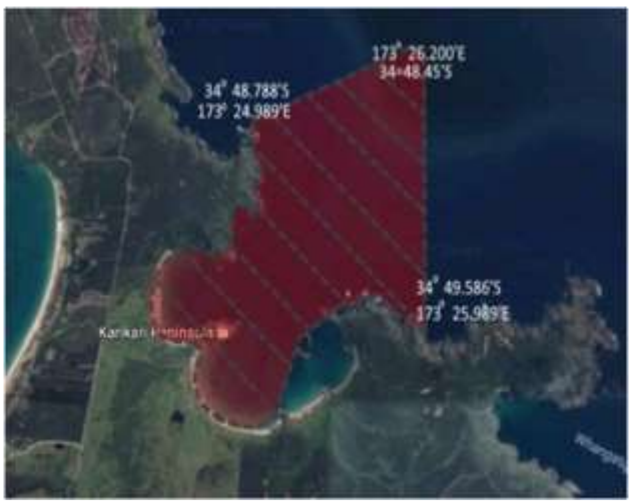

Figure 1 A map of the Rahui at Maitai Bay

The Northland-based Mountains to Sea Conservation Trust (MTSCT), home of the Experiencing Marine Reserves Programme, has an active community support programme aimed at helping local communities and hapu to develop conservation actions and restore Kaitiakitanga. The conservation support programme is led by Trustee Vince Kerr. In 2017 the MTSCT helped the Matai Bay Rahui committee with some mapping work and advice, including recommended boundary design for the initial Rahui proposal.

In 2018 it was decided that the MTSCT would continue to work with the hapu 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 monitoring effort. The 2018 baseline monitoring results were presented to the hapu in a technical report (Kerr 2018), outlining methods adopted for the study and results. The initial monitoring work completed in 2018 established a useful baseline condition for the Rahui to enable us to track restoration of the species and habitat over time. The timed-swim method proved to be effective for the project. It provided an opportunity to compare Maitai Bay shallow-reef fish abundances directly with the successful and long-established Leigh Marine Reserve and thus provide a picture of what the restoration under a full no-take regime can achieve. Preliminary work included locating crayfish monitoring sites and some habitat mapping work (Kerr, 2018). Recommendations were offered to guide development of the monitoring effort to support the future Rahui management decisions.

1 Methods

1.1 Timed swim shallow rocky reefs

The timed-swim method used for the first summer survey is a worthwhile part of a long-term monitoring strategy. Refer to (Kerr 2018) for 2018 summer survey results and a discussion of method strengths and weaknesses. The method is particularly useful for the Maitai Bay project because:

- there are large areas of shallow reef in the Maitai Bay Rahui area
- there are many days of good or ideal conditions for using this method, which are good visibility greater than 4m-6m and calm sea conditions
- the method is easily mastered by anyone who is keen to learn and has good free-diving skills
- while the method is not comprehensive in terms of the full range of shallow reef species, it has shown to be good for snapper and other key indicator species. Thus it is useful as a long-term measure of relative abundance, community composition and age class
- the method is relatively low-cost and can generate a large dataset based on many observations which overcomes some of the disadvantages of other fish monitoring methods that have less replication in time
- the divers spend considerable time in the water observing the reef communities over several months, learning the reef environment.

Basic 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 are within a 6m distance from the diver. Sizes are recorded for snapper, red moki, and butterfish. These three species were selected because they are ideal indicator species to show recovery following the fishing ban. The ability to analyse the size classes of these species allows for biomass calculations (total weight). This will show recruitment progress during the recovery process, in the form of the presence of more small fish and, over time, more large fish accumulating on the reefs.

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).

Transect locations selected for the 2018 survey were considered representative of the shallow reefs in the Rahui. Four additional transects were added for the 2019 survey, located in the south-eastern corner of the Bay - which has been left as a 'local fishing area'. The transects were extended to observe the differences between this fished area and the Rahui area through time. An additional aim of the timed swim work for 2019 was to provide opportunities for more divers to participate and increase the number of repeat surveys over the course of the summer period. Maps of the timed swim transects are shown in Figure 5 in the Results section.

1.2 Fish diversity survey

Work in 2018 demonstrated to us that although the timed swim method is useful in the shallow reef situation, it has limitations. For some species, such as snapper, it does well as a relative abundance measure. Other species that are more cryptic and spend time roaming around the reef and down inside the kelp can be easily missed by the timed swim method. To better complete the picture of the reef fish community we have included a 'fish diversity' survey method, and a baited underwater video method described in the next section. The diversity dive method attempts to observe as many species as possible at a site. The diver swims over the reef searching for and recording all fish species present. The dive is planned to cover all depth zones and habitats, evenly covering as large an area as possible on one tank of air. A specific attempt is made to observe the more cryptic species down in amongst the cracks and crevices of the reef substrate and underneath the kelp canopy. The full list of species observed becomes a measure of the total reef fish diversity for that location. This method is not commonly used in New Zealand, but it is common and well-documented in coral reef fish community studies. An example of this work and references supporting the method can be found in the series of rapid assessment biodiversity surveys such as those carried out by Conservation International which the author has participated in at New Caledonia (McKenna et al., 2009).

In the 2019 survey five sites were selected for being representative of the shallow reef habitats for the fish diversity survey sites. Maps of the five sites are shown in Figures 12 and 13 in the Results section.

1.3 Baited underwater video

A simple baited underwater video (BUV) system has been used to monitor reef fish populations in northeastern New Zealand for the two decades (Willis and Babcock 2000a). Valuable information has been collected on the abundance and size distribution of the snapper *Pagrus auratus* inside and outside marine reserves in this region, including: Poor Knights Islands; Cape Brett, Cape Karikari; North Cape; Mimiwhangata Marine Park; and Mokihinau Islands (Buisson 2009). Other coastal marine reserves also have important BUV datasets: Leigh Marine Reserve, Tawharanui and Hahei Marine Reserves (Willis et al. 2003) and Motukaroro Island as part of the Whangarei Harbour Marine Reserve (Kerr & Grace 2007).

Baited underwater video sampling involves dropping a video camera attached to a frame (Figure 1) into the water and filming fish, as they are attracted to a bait pot. At each sampling location the BUV apparatus is submerged for a thirty-minute sampling period. Bait pots are filled with approximately 100g of chopped pilchards.

Figure 2 The baited underwater video (BUV) apparatus with Gopro camera mounted at the top of the frame facing down

1.3.1 Site selection

Twenty-five sites were located for the BUV survey. The selection of the sites was designed to provide enough data from two basic habitat zones 'sheltered coast' sites in Maitai Bay itself, and exposed coast sites within the greater Rahui area. These two groups were paired with sites located in sheltered coasts and exposed coast area outside the Rahui. This arrangement over time will allow us to compare results between the sheltered and exposed areas and between inside and outside the Rahui. See Figure 3 below.

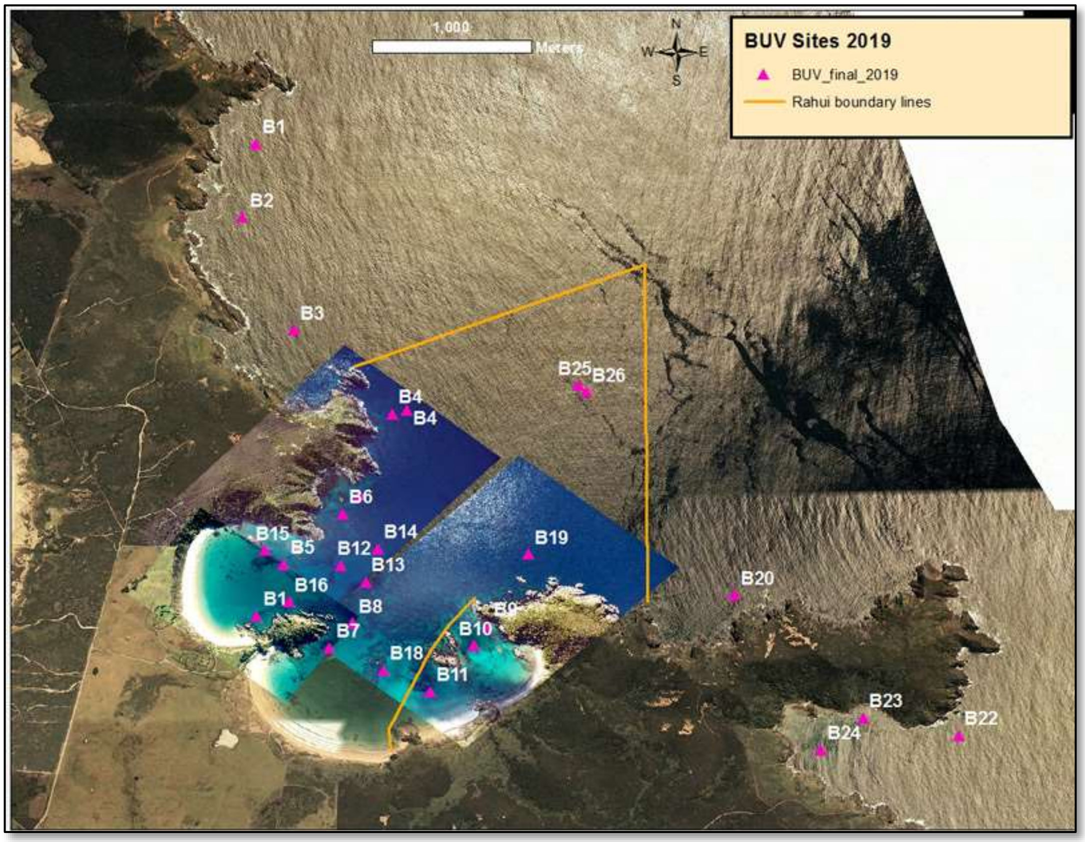

Figure 3 Map of BUV sites 2019 survey

Each sample location generated a minimum of 30 minutes of video. The analysis protocol used is described in Willis and Babcock (1998). For each sample location, the video was examined for the maximum number of each fish species recorded in a frame over the 30-minute period. Individual fish lengths for snapper were measured in still frames of the video sequence and calibrated against a scale bar of known length and a bait container of known length within the baited video's field of view (Figure 4). Care was taken to accurately measure fish length: fish were only measured when they were at the same level as a calibration point of known length, usually the bait container. Initial analysis of species diversity, and mean length data and biomass for snapper is presented in the results section of this report.

 

Figure 4 Examples of BUV video footage, left sit B9 and right site B25, see location map below

1.4 Habitat mapping project

The goal for the habitat-mapping project set for this summer was to fill gaps in habitat information and data to inform a 'baseline' fine-scale habitat map of the entire Rahui area. Summer 2018 survey efforts, using side-scan sonar equipment, filled some information gaps by accurately mapping the shallow reefs and shallow patch reef areas. In the deeper areas outside the Bay, mapping of reef extent, patch reefs and description of soft sediment habitat types required more survey effort. A survey was designed to run a grid of side-scan sonar tracks to cover the outer areas of the Rahui, beyond 25m depth zone, including the area around the pinnacle, which rises from 40m depths offshore. At the same time a representative matrix of drop video sites were designed to collect visual ground-truthing data for the side-scan sonar effort. The aim of this work was to accurately map the outward reef edges and patch reefs offshore in the Rahui and characterise the soft sediment habitat types within the range of fine sands to shelly and gravelly substrates.

2 Results

Fish species in this report are referred to by their common name; their scientific name and family appear in a full list of the species observed across all the survey methods used (see Appendix 1).

2.1 Timed swim shallow rocky reefs

Surveys of the 13 established transects were completed in the summer months between January and May 2019. The number of surveys on each transect varied between two and five repeats. Four divers were trained and used in the survey this year (Vince Kerr, MTSCT biologist, Oliver Bone, MTSCT biologist, Isabel Kraus, MTSCT EMR coordinator, Whetu Rutene, Kaitiaki).

A number of other people, at various snorkel days, were taken through a 'learning experience' on the training transect near the campground carpark to help establish a uniform method of swimming speed, recording etc. The method is easily mastered if the surveyor has reasonable fish identification skills and good free-diving skills.

The location and layout of the 13 transects is illustrated in the map Figure 5 below.

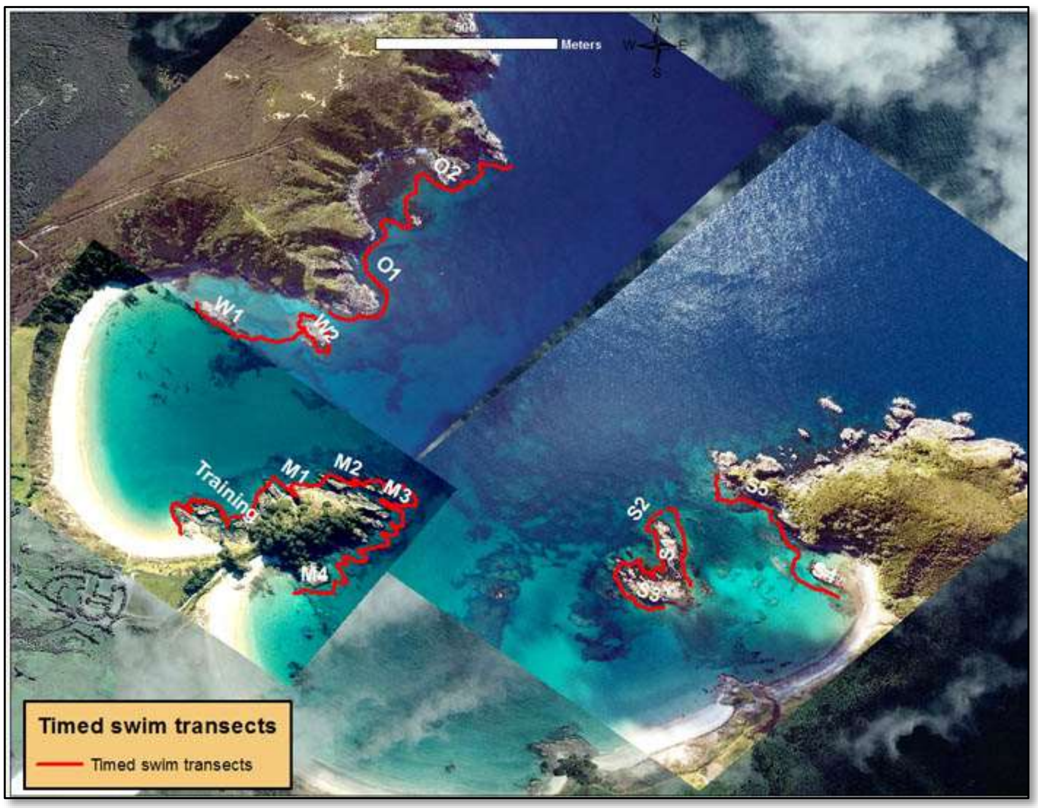

Figure 5 Map of the 13 timed swim transects, and one 'training' transect in the southeast corner of the North Bay by the campground car park. Note: the dark areas in this aerial view are shallow rocky reefs. The visibility of the reefs extends to about 15-20 m in these images. The grayish colored part of the reefs shown here are primarily bare rock and are referred to as urchin or kina barrens. The darker patches are kelp forest habitat.

In total there were 45 transect surveys completed. Summary information is shown in Tables 1 and 2 below. One of the strong points of this type of survey is that it allows for a lot of observation time slowly swimming over the shallow reef. This summer these observations extended over a period of five months. In our survey approximately 45 hours were spent counting the fish. In total 17,550 fish were counted over the whole survey effort. The average diversity count (number of species) for a transect was 10.4 species. The lowest count was 5 species and highest was 20 species. The low count came from transect M4, which is also the area worst affected by kina barrens. The highest count occurred on transect O2 which is a more exposed site. O2 has smaller kina barren areas and a larger, deeper zone of reef with areas of healthy *Ecklonia radiata*, large brown kelp forest.

A comparison of the summary information for the survey between the 2018 and 2019 surveys, shows an increase in the average number of fish counted on the transects. They rose from 140 in 2018 to 340 in 2019. Diversity, however, only increased slightly from 9.5 species/transect to 10.4 species/transect. Changes to the kelp forest and key species are key ecological indicators that will inform us, in time, of the impact of the Rahui. From just the first two years of results it is difficult to know whether changes are a result of the Rahui and removal of fishing pressure, or whether these changes are caused by some other natural yearly variation, such as recruitment success of young fish, or some other factor. That said, this substantial increase in total fish counts suggests something important is happening. We explore this question further when we look at our other results.

Table 1 Summary of results from the timed swim monitoring for 2018 and 2019

Timed swim results summary	**2019**	**2018**
Number of transects in survey	13	8
Number of transects surveyed	45	16
Hours surveying	15	4
Total number of fish counted	17,550	2,239
Average number of fish counted/transect	**352**	**140**
Diversity avg no of species/transect	10.4	9.5
Highest diversity no of species/transect	20	14
Lowest diversity no of species/transet	5	7

Table 2 Summary information from each transect surveyed using the timed swim method

Transect	No of fish counted	No of species	Diver	Date	Swim start time	Tide	Viz (M)
M1	83	9	vk	17/1	1050	1102L	8
M1	65	8	wr	5/3	1220	0837H	6
M1	237	7	vk	10/4	1430	1120H	10
M1	434	11	ik	27/4	1420	0802L	10
M2	256	12	vk	17/1	1105	1102L	8
M2	54	5	wr	5/3	1237	0837H	6
M2	460	9	vk	10/4	1500	1120H	10
M2	223	12	ik	27/4	1450	0802L	10
M3	110	12	vk	17/1	1122	1102L	8
M3	50	5	wr	5/3	1340	0837H	6
M3	156	10	ob	10/4	1333	1120H	10
M3	621	11	ob	14/4	1055	0856L	15
M3	246	12	ik	27/4	1515	0802L	10
M4	43	6	vk	17/1	1142	1102L	8
M4	24	5	wr	5/3	1343	0837H	6
M4	505	11	ob	10/4	1430	1120H	10
M4	885	13	ob	14/4	1030	0856L	15
M4	189	9	ik	27/4	1540	0802L	10
O1	318	9	vk	6/3	0845	0918H	10
O1	640	15	ob	10/4	1126	1120H	10
O1	942	15	ob	14/4	1230	0856L	15
O2	137	13	vk	6/3	0910	0918H	10
O2	511	12	ob	10/4	1153	1120H	10
O2	1479	20	ob	14/4	1300	0856L	15
S1	53	4	vk	5/3	1220	0837H	6
S1	112	13	vk	10/4	1259	1120H	10
S1	247	13	ob	15/4	1530	1000L	15
S2	846	9	wr	5/3	1237	0837H	6
S2	547	10	vk	10/4	1317	1120H	10
S2	393	14	ob	15/4	1540	1000L	15
S3	53	6	vk	5/3	1340	0837H	6
S3	362	7	vk	10/4	1340	1120H	10
S3	489	13	ob	15/4	1615	1000L	15
S4	74	8	wr	5/3	1343	0837H	6
S4	508	13	ob	10/4	1259	1120H	10
S4	271	10	vk	15/4	1530	1000L	15
S5	21	7	wr	5/3	1408	0837H	6
S5	734	15	ob	10/4	1317	1120H	10
S5	1211	14	vk	15/4	1555	1000L	15
W1	181	7	vk	6/3	0808	0918H	10
W1	608	13	vk	10/4	1126	1120H	10
W1	181	12	ob	14/4	1340	0856L	15
W2	75	10	vk	6/3	0823	0918H	10
W2	59	7	vk	10/4	1153	1120H	10
W2	172	14	ob	14/4	1330	0856L	15
Average	**352**	**10.4**					

2.1.1 Overall fish community results

As previously mentioned, it is difficult to measure changes in fish communities and habitats as part of the Rahui's restoration in just one or two years. Many of the reef fish species which are missing, or observed in very low numbers, or only seen as very small fish, take time to recruit to the reef or to grow to a mature age. In many cases these changes only happen when the kelp forest habitat is recovering as many reef fish species are dependent on the kelp forest for shelter or food sources.

On most transects we observed higher fish numbers over all, but not generally increases in the numbers of new species or large fish present. A notable exception was the sandagger wrass, which was much more commonly seen. Most of this increase in numbers was comprised of young fish.

Sandagger wrasse is a subtropical reef resident species common in the Northland waters in more exposed areas and offshore islands. Sandagger wrasse are at times targeted by spear fishers and are one species we would expect to become abundant as part of the recovery process. In the 2018 survey we averaged a count 0.56 sandagger wrasses per transect. In the 2019 survey the count rose to an average of 4.62 fish across all transects. The highest 2019 count on one transect was 34 fish, most were juveniles.

Another notable result was a large increase in piper. In 2018 very few were seen in the survey whereas in 2019 they were common. It is not possible to know if this increase is due to the Rahui, but it will be interesting to see if the trend of increased numbers of piper continues.

Red moki, butterfish and snapper have been selected as species for which we collect size class information. In this year's results there were small changes to numbers and sizes of butterfish and red moki, but changes were not large enough to support any type of analysis or conclusions about the progress of the restoration process. Both species are dependent on the kelp forest habitat. Both are mainly grazers, so we would not expect large increases in these species until the return of the kelp forest. Snapper, however, are extremely versatile feeders and mainly predators of invertebrates or small fish. Snapper will vary their feeding strategies, spending short periods of time on the reefs or near to the reefs along with time as school fish in deeper waters or becoming fully residential on the reefs and loyal to a home territory. These behaviors can change over time in terms of the fish's age and size, seasons and results of fishing pressure. In this summer's survey we found large increases in snapper observed in the small size classes but not in larger fish.

There are two useful ways to look at the survey results for snapper. We can simply look at the number of fish counted divided up into the different size classes, shown in Figure 6 below. The second way of viewing the data is to look at the biomass or weight of the fish in each size class, which can be calculated via a mathematical equation that allows us to estimate the weight of a fish based on its size. This view of the data is shown in Figures 7 below. Note: For timed swim surveys Maitai Bay in summer 2018 n = 16, Maitai Bay in summer 2019 n = 45, Leigh Marine Reserve in summer 2018 n = 3. We did not re-survey the Leigh Marine Reserve this summer.

The graph below of this year's survey result shows a dramatic increase in one of the size classes of young fish 11-24 cms in length. This represents an impressive number of fish that have made their way on to the reef. Increases in this size class of snapper showed up on nearly all transects. It will be fascinating to monitor this group of fish over time. Will they stay and become reef resident, will they all go off and become school fish? The expectation is that some will become resident which we would be able to see in next year's survey, as these fish will be growing fast and move into the next size class. Another exciting aspect of this young age class showing up in such large numbers is that while these fish would not be able to eat large kina they certainly do eat small kina, meaning that they will start to fulfill their ecological role on the reefs in controlling the numbers of small kina in the system, thus aiding the restoration process.

There are only small differences between the 2018 and 2019 survey results for the smallest age class (less than 10 cm). This is also the case for large sizes greater than 40cm in length. As fish numbers increase on the reef and as habitat (kelp forests) restore, we expect this trend to reverse and more large fish will regularly visit and become residential. The size class 25-39 cm in length is showing an increase in 2019 but it is hard to say if this is significant. If this trend continues it will mark a solid beginning to the restoration process as these larger fish will start to effectively control kina to below the levels required to allow the kelp community to re-establish. It is worth noting that the big increase we are anticipating in the legal and above-size would quickly be knocked back if even a light-to-moderate level of fishing resumed.

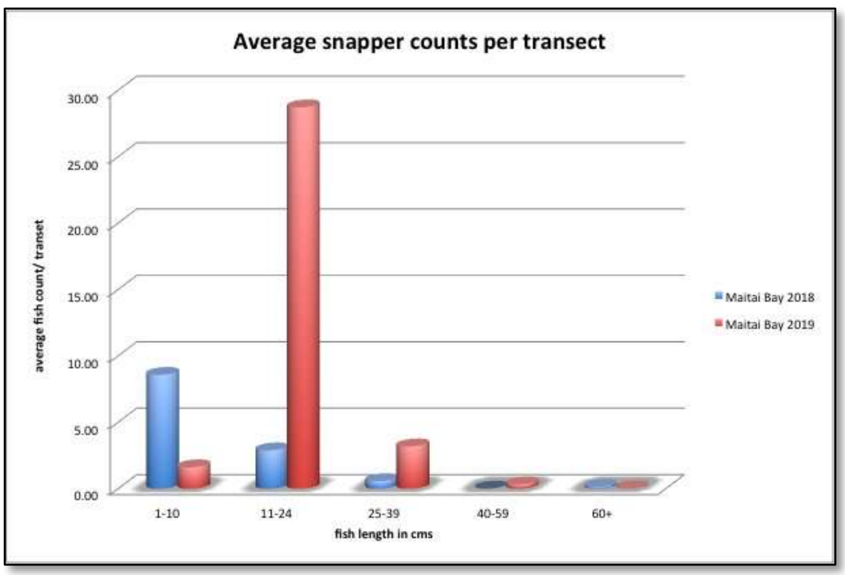

Figure 6 Average snapper counts displayed grouped in size classes for both 2018 and 2019 survey results

2.1.2 Snapper biomass

Looking at fish abundance as calculated in weight or biomass terms is extremely useful to help construct an ecological or functional picture of what these figures mean. A fish's weight does not increase in a linear manner; the increase in weight is disproportional to increase in length. Instead it increases exponentially. As a result, a fish that doubles in length is not twice as big. It is much heavier than that and it consumes far more than twice as much food. On top of this the large fish can turn to different feeding strategies because it can catch and eat larger prey. In other words, as fish grow in size their ecological role changes. This is especially true of snapper and is crucially important to the health of shallow reefs because snapper is such a dominant predator.

In Figure 7 below, a comparison of 2018 and 2019 average snapper biomass in kilograms is shown for each size class group. The pattern is roughly similar to the count data but with some notable exceptions. The group of small fish (11-24 cms) present in large numbers contributes a good proportion of the overall biomass. In the larger size classes it is worth noting that even the relatively small number of fish counted are contributing significantly to the total biomass. This is an example of how important these large fish are on the reef.

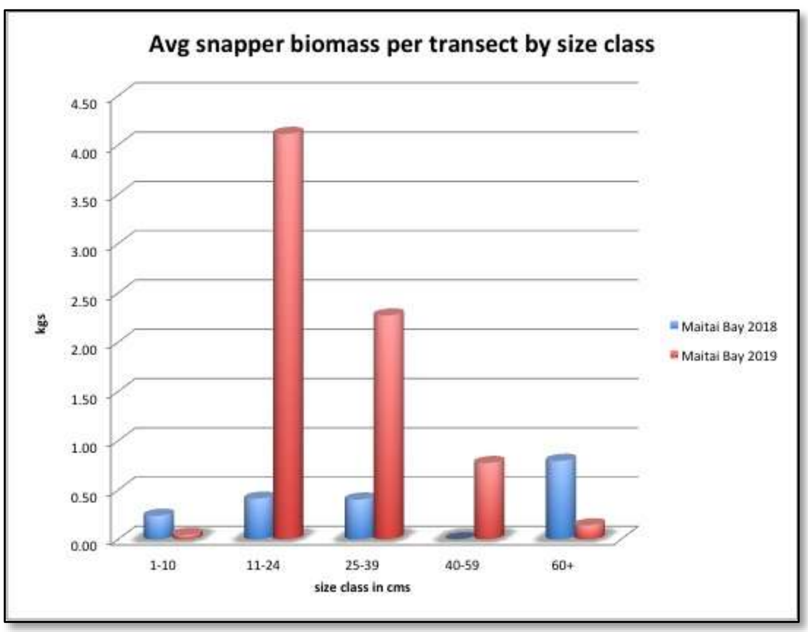

Figure 7 Average snapper biomass per transect shown in size class groups for the 2018 and 2019 surveys.

2.1.3 Comparison of timed swim results between the Maitai Bay Rahui and the Leigh Marine Reserve

In our discussions about the Rahui and monitoring, key questions are "what will restoration look like?", and "how long will it take?". We decided that one way to explore these questions is to compare the results of our timed swim fish counts to similar results from established reserves which have experienced recovery of their kelp forests habitats and have a more natural reef fish community.

We completed the first set of timed transect counts at Motukaroro Marine Reserve in Whangarei Harbour and at the Leigh Marine Reserve near Warkworth in summer 2018. Neither of these reserves is a perfect match in terms of habitat for Maitai Bay, with Leigh being the more similar, but we decided it could still provide useful comparisons. In the graphs in Figures 8 – 10 below we look at the changes in snapper numbers we counted between 2018 and 2019 when compared to results at Leigh. A description and aerial view of the Leigh transects are shown in our 2018 summer monitoring report (Kerr 2018). The Leigh timed swims were not repeated this year as we decided to focus all resource on the work at Maitai Bay. The comparison with results from the Motukaroro marine reserve are not continued here because the shallow reefs of Motukaroro, as an inner harbour site, are unique and not ideally suited to comparison with Maitai Bay whereas Leigh has similar exposure and reef communities.

In comparing the Maitai Bay snapper results to those of Leigh it is useful to look separately at the small fish groups and the large fish groups. In the small fish sizes of 11-24 cm the large recruitment of small fish at Maitai Bay is reflected in much larger numbers than what is seen at the Leigh Marine Reserve. This is an impressive result and suggests that Maitai Bay is an outstanding 'nursery' area for young snapper. In the large size classes the difference at Leigh is notable, with good numbers of large fish seen regularly on the transects. At Maitai Bay they are rarely observed. This makes is a major ecological difference due to the importance of these large snapper as predators resident on these reefs.

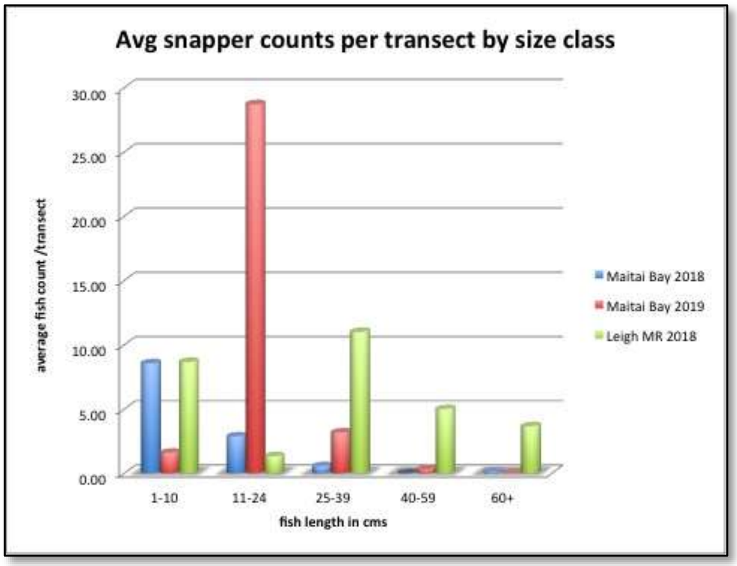

Figure 8 Average snapper counts per transect shown in size class groups comparing survey data from Maitai Bay summer 2018 and 2019 and Leigh Marine Reserve, summer 2018

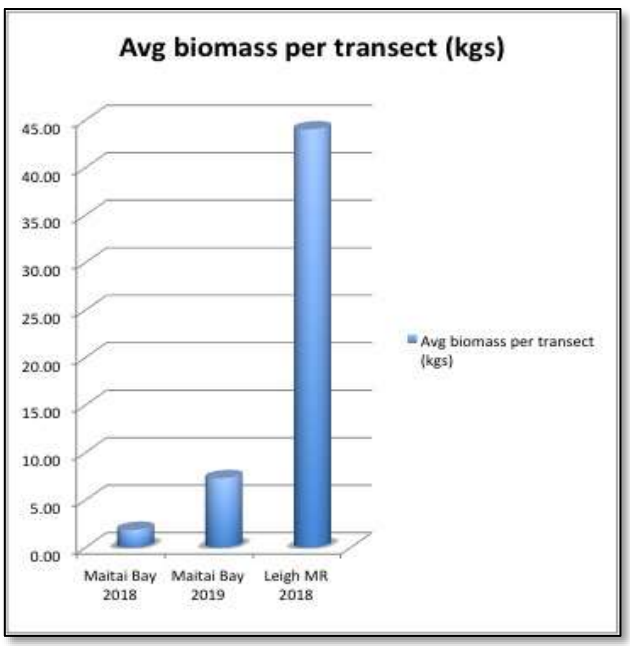

Figure 9 A comparison of the average biomass of snapper counts between timed swim surveys. at Maitai Bay summer 2018, summer 2019 and at the Leigh marine reserve summer 2018. In this graph biomass calculations for all the size classes are combined.

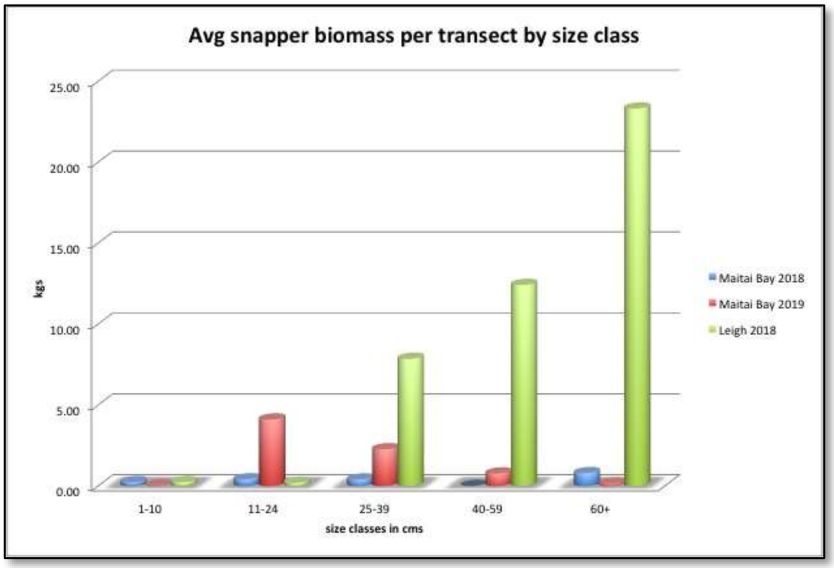

Figure 10 Average snapper biomass per transect shown in size class groups comparing survey data from Maitai Bay summer 2018 and 2019 and Leigh Marine Reserve, summer 2018.

2.2 Baited underwater video

2.2.1 Abundance and diversity measures

Tables 2 below shows a summary of the counts for all species combined and the MAXsna value for the 25 sites surveyed. MAXsna is the maximum snapper that are observed at one time in the video frame during the total 30 minutes of the drop. The tables break up the results into sheltered and non-sheltered sites. Overall results show low numbers of species (diversity), but a moderate number of snapper counted when compared to other 'fished' sites where similar surveys have been done in Northland. An interesting observation of this data is that exposed sites overall have more fish species and a higher total count as compared to the sheltered coast sites. As the restoration advances within the Rahui this will be an significant comparison to watch. The present difference could be explained by two important distinctions between these habitats. At Maitai Bay the sheltered coasts sites in the Bay itself are the most degraded of the reefs in the Rahui in terms of long-term loss of kelp forest. Also the exposed coast reefs are more complex in terms of depth zones, topography and effects of wave energy and currents. The complexity and much greater areas of healthy kelp forests typical of the exposed coast would be expected to support higher fish diversity and abundance.

Sites with maximum and minimum counts overall are highlighted in the tables of for total species counts, diversity and MAXsna. These sites are evenly spread around the survey area with most of the high counts on the exposed sites and the minimum counts in both zones.

Table 2 Sheltered coast sites species counts per BUV site. Diversity is the total number of fish species counted per BUV drop and MAXsna is the maximum number of snapper counted at one time in the 30 minutes of video. Sites are marked 'in' for inside the Rahui and 'out' for outside the Rahui. Sites that had the lowest counts are highlighted in red (minimum), and blue for (maximum).

Site	**All species count**	**Diversity**	**MAXsna**
B5 in	5.0	2.0	4.0
B7 in	10.0	3.0	8.0
B8 in	5.0	2.0	4.0
B12 in	15.0	1.0	15.0
B13 in	2.0	2.0	1.0
B14 in	9.0	4.0	3.0
B15 in	8.0	2.0	7.0
B16 in	**1.0**	**1.0**	**1.0**
B17 in	**30.0**	**5.0**	13.0
B18 in	5.0	1.0	5.0
B9 out	25.0	4.0	**19.0**
B10 out	18.0	2.0	17.0
B11 out	4.0	1.0	4.0
Mean	**10.5**	**2.3**	**7.8**
Mean 95% Confidence Level	4.9	0.7	3.4

Table 3 Exposed coast sites species counts per BUV site. Sites are marked 'in' for inside the Rahui and 'out' for outside the Rahui. Sites that had lowest counts are highlighted in red (minimum), and blue for (maximum). The highest diversity site was B25 which offshore at the pinnacle with 10 species. The lowest diversity sites were B20 and B24 both outside the Rahui area.

Site	**All species count**	**Diversity**	**MAXsna**
B4 in	14.0	4.0	8.0
B6 in	27.0	6.0	18.0
B19 in	**13.0**	8.0	6.0
B25 in	32.0	**10.0**	10.0
B26 in	**13.0**	4.0	7.0
B1 out	14.0	7.0	6.0
B2 out	26.0	4.0	7.0
B3 out	23.0	8.0	8.0
B20 out	18.0	**3.0**	**0.0**
B22 out	**60.0**	9.0	11.0
B23 out	26.0	5.0	**20.0**
B24 out	15.0	**3.0**	12.0
Mean	**23.4**	**5.9**	**9.4**
Mean 95% Confidence Level	7.5	1.4	3.1

Looking at all the BUV results, the total numbers of fish species that appeared on the BUV video footage was 24. Snapper were the predominant species in the survey, they were present in all but one site. The total number of snapper counted for all sites was 214. The next two most abundant species were two spot demoiselle and bigeye at 55 and 48 respectively. Next in abundance were leatherjacket 21, pigfish and yellow moray eel at 18. The remainder of the species were recorded in small numbers less than 10 across all sites. The full results of the survey are presented in Appendix 4.

2.2.2 Analysis of snapper results

In Table 4 below the snapper results are explored in more detail. MAXsna count means were similar for sheltered and exposed coasts, at 8 and 9 respectively. Across all sites the mean length was consistently around 20-21mm. Mean biomass of individual snapper was 270 grams for sheltered sites and 286 grams for exposed sites. These numbers indicate that the small age class of snapper of around 20cm in length were present across nearly all the sites. The mean biomass of snapper for the 25 sites was 2.6 Kgs/BUV drop.

Table 4 Snapper maximum counts and biomass calculations grouped in sheltered and exposed coasts

Snapper Max count and biomass data	Sheltered coast sites n = 13	Exposed coast sites n = 12
max count	19	20
min count	1	0
mean count	8	9
mean length (mm)	21	20
mean biomass (g)	270	286
mean total biomass/site (Kgs)	1.7	2.6
total biomass all sites (25) = 54 Kgs		

We look at the sizes of fish as well as the numbers present because as the fish grow, or as larger fish visit or take up residence in the Rahui, they affect the whole system in various ways. Larger fish become the main predator on the reef for invertebrates as well as small fish. Snapper's ecological significance on the reef is increased by the fact that they are long-lived and can grow quite large. As these larger fish become prominent on the reef they carry out a completely different role as a predator. Specifically, large snapper can easily crush a large kina in their mouth, whereas a 20cm long snapper cannot do this but can feed on small kina.

Snapper are relatively fast-growing fish and tend to have fish in each year class which are of slightly different sizes. Typically, in each age class there are fish which were born in the spring and others that are born later in the summer. These two groups are noticeably different in size through the first several years of their lives. In the first year of their life snapper grow rapidly and reach a size of around 10cm. In the second year onwards, growth is not as fast and slows dramatically in winter. A year two fish is typically between 10cm and 20cm. Thereon, they are adding 10-15cm of length per year (Francis, 1994). The biomass calculations show as length grows, weight or biomass increases at a much greater rate. As numbers of larger fish on the reef grow the biomass of snapper grows rapidly along with their ecological impact as a predator. BUV is an effective tool for measuring the relative abundance of these and other carnivorous species and provides a simple way to track this important aspect of the restoration process.

2.2.3 Comparison between Maitai Bay and Leigh Marine Reserve

In Table 5 below we can look at how our initial BUV results for snapper compares to other Northland surveys. Our results are comparable to other fished sites like Mimiwhangata, Cape Brett and the Mokihinau Islands. Also our results are similar to the DOC BUV survey that was done at Moturoa and Motutapu Islands (Cape Karikari) in 2009. The 2009 survey results show slightly higher MAXsna counts and mean fish size than our current result at Maitai Bay.

Table 5 BUV results from various Northland locations showing the comparison between sites protected from fishing as marine reserves versus fished locations. *References for this comparison of BUV results: Cape Brett (Kerr, 2016), Poor Knights Marine Reserve, Cape Brett, Cape Karikari and Mimiwhangata (Buisson, 2009), Leigh Marine Reserve (Willis, 2003).*

Area	**year(s) of sampling (summer)**	**typicial mean MAXsna**	**typical mean of snapper length (cm)**	**typical mean total snapper biomas per BUV site (kgs)**
Maitai Bay Rahui	2019	9	21	2
Fish Forever Cape Brett BUV	2016	10	23	4
Leigh Marine Reserve	1997-99	14	30	17
Poor Knights Marine Reserve DOC BUV	2001-2009	17	35	24
Cape Brett DOC BUV	2001-2009	7	21	3
Mokohinau Islands DOC BUV	2001-2009	6	23	2
North Cape DOC BUV	2009	9	19	2
Cape Karikari DOC BUV	2009	17	23	3
Mimihwangata DOC BUV	2002 2002 2009	4-7	25	3

In Figure 11 below we focus on comparing our current snapper results to the results from the BUV surveys at the Leigh Marine Reserve where, at the time of the survey, all fishing had been prevented for over twenty years and kelp forests had restored from extensive urchin barrens to almost a complete absence of urchin barrens. In all three measures the results are significantly better for Leigh. While the increase in mean MAXsna counts per BUV drop do not look that large, what is happening is that many of the larger number of fish are much bigger fish which results in a larger difference in the figures for mean snapper length. The real crunch of this comparison is in the mean biomass per BUV drop figures. In our survey, where small snapper make up the majority of the fish population, the mean biomass per BUV drop is 2 kgs for Maitai Bay compared to 17 kgs for the Leigh Marine Reserve. Referring back to Table 5, you can see that the same figure for Poor Knights Islands is 24Kgs.

The importance of these results is that, these comparison show us that no-take reserves have a dramatic effect on restoring fish abundance to more natural levels, and indicate what is a more natural age and size structure of the population. These data sets also allow us an opportunity to accurately track the progress of a restoration project, like the Maitai Bay Rahui. In turn, this provides a window for us to view the ecological relationships between snapper, as the dominant predator, and the larger shallow reef community.

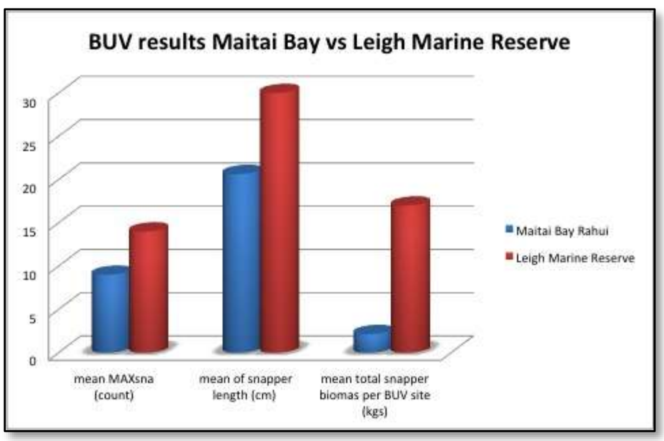

Figure 11 Comparison of BUV results between Maitai Bay and Leigh Marine Reserve (*see references listed in Table 5*)

2.3 Reef fish diversity survey

Five sites were chosen for fish diversity dives. The sites and the approximate path the diver swam while recording fish species is shown in Figures 12 and 13. The idea of the diversity survey is that time is spent closely looking for all the species of fish that live on a given reef. Much more time is spent in a particular area than on the timed swims. The deeper habitats down to the reef's edge are also carefully looked at extending down to 24 meters depth depending on the site.

Figure 12 Map showing the three fish diversity survey sites in the Waikura and Merita areas of Maitai Bay

Figure 13 Map showing the two fish diversity survey sites at located near Blue Maomao Point at the southeast end of Maitai Bay

Table 6 below shows the results of the fish diversity dives for the five sites. The number of species observed ranges from 18 to 23. The area around Blue Maomao Point had the highest diversity and stood out as one of the special areas of the shallow rocky reefs in the Rahui. At Blue Maomao point there are areas of quite rough terrain with large cracks, crevices, rocks and pinnacles. There is a noticeable current present around the Point itself where blue mao mao and two spot demoiselle tend to congregate in large numbers, probably making use of upwellings and eddies occurring there, which assist their plankton feeding. The lowest fish diversity site was Merita 4 or M4 on the Figure 12 map.

Table 6 Species counts for the five fish diversity survey sites

Diversity site name	**Species count**
Waikura 2	18
Merita 4	15
Blu Maomao Pt	22
Swim through south coast	23
Merita Point	20

The total number of species found across all the survey effort was 45. A complete list of these species has been compiled in Appendix 1. As the restoration of habitats and fish communities develops this number could climb upwards as high as 100 species. The total number of fish species observed at the Leigh Marine Reserve stood at 90 in 1981 (Thompson). In a comprehensive study of rocky reef fish surveys by Fred Brook (2002), Cape Karikari is regarded as one of the best (most diverse) examples of shallow reef fish communities ranking alongside areas like Cape Brett, Bream Head and Poor Knights Islands. In a study of the habitats and reef communities of the outer islands in the Bay of Islands the total count of species recorded for the whole study was 54 species (Kerr and Grace, 2015).

Table 7 Fish diversity in the form of total species counts from the all surveys

Survey	**Species count**
timed swims combined	33
diversity dives	40
BUV	24
drop video	11
All surveys combined	**45**

2.4 Gallery

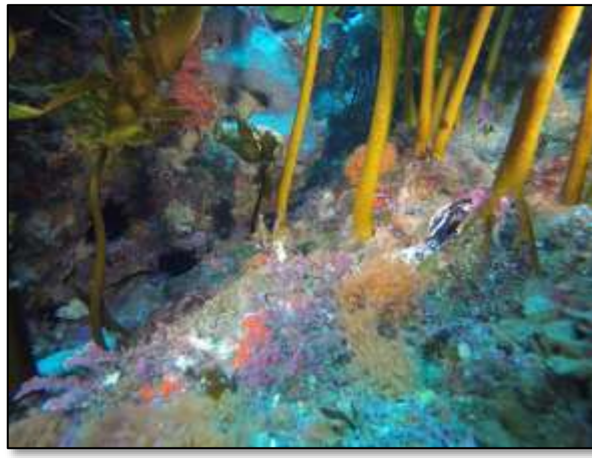

Figure 14 (left) A school of blue maomao often seen at Blue Maomao Point, (right) a view of the rich and diverse encrusting invertebrate community growing under a healthy kelp forest canopy

Figure 15 Examples of reef dwelling fish that are dependent on healthy kelp forest for their browsing lifestyle, (left) a banded wrasse hovers in the shallow mixed weed zone, (right) a red moki seen here moving between urchin barren areas and patches of remaining kelp

 

Figure 16 (left) Kaitiaki diver Whetu Rutene swims over a large urchin barren area near the campground carpark followed by a small snapper and a male sandagger wrasse (rainbow markings), (right) a large gathering of juvenile sandagger wrasse with a school of parore in the distance and a blue maomao at the top of the image

 

Figure 17 (left) An example of an extensive urchin barren with an active kina feeding front grazing up into the shallow mixed weed zone, (right) a contrasting view of a degraded long standing urchin barren on the right side located near the campground carpark contrasted with a thriving healthy kelp forest seen on the exposed coast out from Blue Maomao Pt where there are no urchin barrens other than small isolated patches

2.5 Crayfish monitoring

A formal crayfish monitoring system was not established this summer, although it would be valuable to the overall monitoring program and contribute to our understanding of the restoration process.

We carried out a number of training dives on key crayfish sites (divers Vince Kerr and kaitiaki Whetu Rutene). On these dives we focused on two things 1) practicing estimating and recording sizes and 2) scoping potential high-quality sites for selection as ongoing monitoring sites. Discussions about how we will approach the crayfish monitoring continue. In the meantime, there is very good local knowledge of crayfish abundance and where quality dens are located. We have decided to work further on the challenge of incorporating local knowledge and traditional knowledge with science methods, rather than rush a solution. Crayfish numbers in the Rahui are at quite low levels and are expected to slowly build over time to much higher levels.

Figure 18 A lone crayfish occupying a large high quality den near Blue Maomao Pt

2.6 Habitat mapping project

Combinations of side-scan recordings and drop-camera sampling were carried out in May. The data points in Figure 19 below are points along the side scan tracks where we recorded data in real time corresponding to our interpretation of the bottom substrate. At each location where we observed a change in the bottom habitat, we created a waypoint and made a note. Classification of the bottom types used was high profile reef (greater than 3-5m in height of reef structures), reef, sand, gravel and patch reef. In addition to the notes and data collected on the water. All the sonar tracks have been recorded and archived and can be examined in detail to support the habitat mapping task.

Drop-cam survey sites were located around the offshore pinnacle at a range of depth zones spread evenly across the survey area. Along the exposed mainland coast in three locations transects were completed on the reef profile from 10 m depth out to deeper waters where the reef ended on soft sediment. The purpose of these drop-cam transects was to determine the lower depth limit of the *Ecklonia radiata* kelp forest. These deeper reef habitats change from kelp forest to sponge dominated invertebrate communities at depths which vary in relation to local water clarity conditions. At a given depth there is not enough light to support the kelp species and the reefs become dominated by filter feeding sponges and other encrusting filter feeding invertebrates. At Cape Karikari the depth of this habitat change is at about 30m.

The collection of habitat information is now sufficient to take the next step; to bring all the data together in a GIS project and draw a fine-scale habitat map. This work is now planned for next year. The fine-scale habitat map will assist the project in a range of ways. The map and descriptions of the habitats is an effective way to generate interest in the Rahui and appreciation of the natural values of the Rahui. It is also very useful for planning and evaluating any marine work. Most importantly in the longer term it will enable us to measure the restoration of the shallow kelp forests.

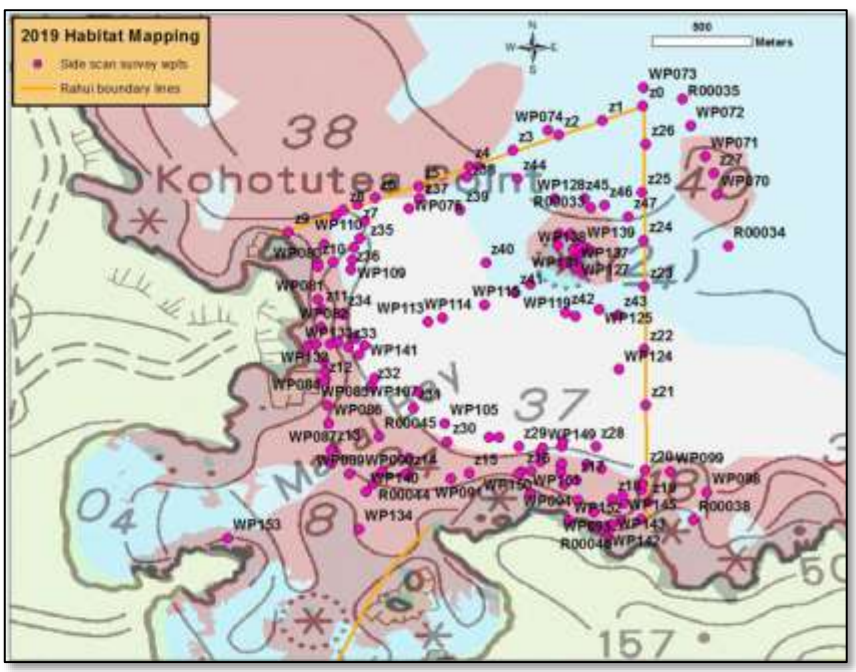

Figure 19 Map showing the information points from the side-scan sonar and drop-video survey work completed in the summer 2019 survey. Z points are targets for the side scan sonar lines; WP points are information points for the side-scan interpretation and drop camera sites. R00 points are start points for side-scan sonar recordings files.

3 Discussion

Maitai Bay, the adjacent exposed coast and offshore area ranks nationally as a marine environment. It is a special place to the people of New Zealand and the many overseas visitors who come to the area. To the tangata moana, Te Whanau Moana me Te Rorohuri this area is a taonga and they carry with them a very great responsibility to care for this place and all who visit. This responsibility is so great that we suggest there should be national support of what they are striving to achieve. Our work with the monitoring programme is a small part of this support. We hope that the information coming from the program, and the chance to learn new skills and ways of thinking about the marine communities, will be helpful.

Use of traditional rahui across the Pacific varies widely but there is always a carefully considered local process that defines the action, the purpose, and an understanding of the timeframe that is appropriate. In virtually all cases the purpose relates to restoration of spiritual and/or biological values. Normally the concept in English would be described as to restore the life of this place. There is a danger though that lost in an English translation is the full and rich understanding and language around how Polynesian cultures would think or talk about 'life' in Maitai Bay. Of course, in western culture there are also rich and deep understandings of what life or living systems are. Our purpose for raising this is to emphasise the context of this Rahui and thus our monitoring program. We are adapting science tools informed by local knowledge and matauranga maori wherever we can. We are attempting to provide a window on to what is happening out in the water. All this work is potentially valuable, but in the end it must be applied in a decision-making process, and that is our main goal: to assist the hapu and community in making decisions in kaitiakitanga for Maitai Bay and the rohe.

A key decision looming for the hapu and the community is the timeframe for the Rahui, which requires understanding and clarity on the purpose. Is the Rahui a short-term measure which aims to restore some species so that some sort of fishing can resume? Or is there a longer-term goal of restoration of the habitats and a fuller, or more natural, abundance of the species that once lived and flourished here? This decision sits alongside many local views of what is best for Maitai Bay, not least of which is "where do people fish and why at those locations"? How do we balance this need against the growing need to have Kohanga areas along the coast for restoration and the need to have places where all people can experience and enjoy marine life in its natural state? Where can our children learn about life in the sea?

Our monitoring work has been specifically focused on the restoration goal and how this story will unfold at Maitai Bay. We have put together a reasonable picture of what the reef and fish communities look like after decades of heavy fishing. Clearly there are degraded habitats and a greatly reduced fish community. The value of the monitoring effort going forward is that we will be able to clearly track the changes that take place as a result of the Rahui. Every indication is that the changes will be dramatic and significant, but not fast as these communities take time to recover. Realistically restoring these shallow reef systems should be viewed as a generational project. A really large snapper or crayfish takes 20 years to grow, and they are a key part of these shallow reef communities.

The Mountains to Sea Conservation Trust looks forward to continuing to work with the hapu on this project. We are keen to test our approach within the setting of matauranga maori and the mahi of kaitiakitanga. These learnings along the way will help with the urgent job of making decisions for the greater Rohe area. Our experience out in the water - seeing new fish species, more fish, larger fish showing up on the reefs each year when for so many years we have watched things get worse - is a thrill. We would love to see this experience shared far and wide.

3.1 Challenges in interpreting results of this study

The Ocean does not give up its secrets easily.

Surveying fish communities is a challenge. There have been many studies illustrating the weaknesses of popular methods used, and the limitations of what people describe is happening from casual observations.

In this year's work on the water we expanded our effort of last year and are building a data set and observations which describe the fish community, creating a start point of the Rahui. Even with several survey observations spread over four months of summer there is always a problem of accurately recording the changes that are happening over this time in response to ocean conditions and variations in seasons. We are using three complementary methods to measure fish abundance and diversity. We deliberately did this because no one method is free of failings. All fish species behave differently, they respond to environmental conditions differently, so that collectively there is no ideal method. Some fish are diver-shy and some fish follow divers, and these behaviors are not necessarily constant in time. One approach to improving what we can learn from the work is to simply do more observations across time and space.

A simple rule is the more you look, the more you will see, and this is a strength of the timed swim approach: it can create the opportunity to observe the fish and habitat across large spatial areas and be repeated often. This advantage to a degree offsets the limitation of the simple snorkel-based approach. In future years we can expand the number of times we do the timed swims.

The BUV system we have established is comprehensive and has been designed to cover variations in habitats as well as make a comparison between inside and outside the Rahui which, over time, will be a very important test of what the Rahui is achieving. The BUV results will also be directly comparable to a number of other places around the country where this method is regularly used. The timed swim transects have been extended to cover the unprotected southeast corner of the Bay. We are not sure if, over time, we will have a clear result from this but it is worth testing. The spatial area of the unprotected southeast corner is small, which means that there could be considerable movement across the boundary between the Rahui and the southeast corner where fish can be taken. This will be affected as well by how much fishing takes place there. For now, at least we have begun to observe changes there.

As we accumulate more data over the years, we will begin to have the ability to ask and answer the questions around whether or not changes measured can be put down to the Rahui. Current observed changes between 2018 and this year can not yet be properly tested statistically; in other words, we can't say whether they are the result of some natural variation that has nothing to do with the Rahui or that the Rahui is having this effect. Specifically increases in the snapper numbers and the sandagger wrasse that we have recorded falls into this category. It is tempting to think that this large change has occurred because of the Rahui, but there is also a chance it is down to special circumstances such as a strong breeding recruitment event for these two species. Further down the track we can test these changes by comparing to a longer-term record for these species and examine results from surveying at sites both inside and outside the Rahui. The system we are building is designed to do just this.

3.2 Looking at the ecological restorations goal

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. For this to happen the natural balance of predators on the reef needs to be returned. 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 which were extensive in the 1970s reverted back 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 and kelp forest decline are Doubtless Bay; (Grace and Kerr, 2005), Mimiwhangata; (Kerr and Grace, 2005), Bay of Islands; (Kerr and Grace, 2015, and Kerr, 2016a, 2016b), (Booth, 2017, 2015) and a Northland east coast scale analysis (Kerr and Grace, 2018).

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.

With the urchin barren story in mind, what we see in Maitai Bay is clearly a seriously degraded reef community. It is hard to overstate the importance of shallow reef kelp forest because there are so many species that use this habitat for shelter, protection, food or a place to hunt for their food. While there may be many benefits derived from the Rahui we suggest that recovery of the shallow kelp forest could be a key goal for the Rahui and an effective measure of 'good health' for Maitai Bay.

3.3 Possibilities for the monitoring and kaitiakitanga

The responsibility of looking after the Rahui is a big one, and in the first instance an important goal is winning support for the project from the whole community. It is vital that everyone observes the 'no fishing' rule. During the restoration process each positive step is a building block that encourages more to happen, more fish to settle on the reef, more kelp forest returning etc. In the early stages of this process, even very small amounts of fishing can have quite serious adverse effects on the progression of recovery. For this reason, the proactive kaitiaki work, such as doing the beach, campground and boat ramp talks with people, is important and ideally would be done daily in the busiest times. In addition, an on-water presence would be well worthwhile to check that people are not fishing and to further drive home the positive restoration messages and demonstrate that this is indeed a serious project supported by the community. In the summer season many recreational fishing boats visit the area coming from other boat ramp locations.

Last summer was very busy, with large numbers of people visiting Maitai Bay. There is no reason to expect this trend of increasing visitors and school groups will not continue. On several occasions our science crew found boats fishing in the Rahui area. In each case we approached the people and asked them not to fish in the Rahui and explained about the Rahui. Usually these people were not local, with most saying they did not know about the Rahui. Tourists also constantly approached us on the beach as we were launching our boat. They were universally interested in what we were doing and what the Rahui was. We recommend that a kaitiaki presence would be worthwhile, and it is our opinion that there are funders out there who would be keen to support this role. Beyond the initial job of looking after the Rahui, there is scope to explore opportunities in the area of adventure tourism, and ecotourism. There appears to be great interest in the Rahui and the increase in marine life and this is sure to keep growing. This significant interest could be channeled into activities like guided snorkel trips, glass-bottom boat trips, nature-based cultural tours, youth programs, extensions of school programs to name a few. Again, because of the special nature of the place and the strong conservation purpose of the Rahui, we suggest all these opportunities could be successful and would grow from strength to strength. At Maitai Bay there is the added potential of providing visitors with a cultural experience and context of the Rahui and history of the hapu and place. The experience from marine reserves around the world and in New Zealand is that people are strongly drawn to places where marine life has been restored.

3.4 Recommendations for the monitoring process going forward

Building on the good start made in the first two years, we would like to recommend the following for consideration for the project going forward:

The suite of timed swims, fish diversity dives, and BUV offers a versatile combination of methods to track reef fish communities. With the timed swim method there could be more divers trained and more dives completed; the more the better for this method. For the fish diversity dives it would be good to establish more sites, covering more habitats. There is an opportunity now to examine our three fish monitoring methods against a context of Matariki and local knowledge to refine questions around when to survey and what we could learn from that.

It would be ideal to each year also do the timed swim counts on the transects established at the Leigh Marine Reserve in 2018 (Kerr). Over time this comparison would be especially interesting and valuable as a test of the restoration success from the Rahui.

From next year we could also turn our attention to the recovery process of the shallow kelp forest, this can be done on the large scale by completing the habitat mapping now well advanced with the collection of data in the last two years. This would give us a map of the urchin barrens that we could compare directly with maps produced in the future. Mapping could also be done on smaller scale at monitoring sites established. Fine-scale projects could be started where we track changes in the urchin abundance, size and condition which parallels observations maori have always made of kina on their local reefs. Kelp recovery could also be measured with transect studies in representative sites. This would provide a useful way to track the restoration process. There are a number of methodologies that can be adapted for this work, each of which could be looked at in conjunction with matauranga maori to see how we could add to the interest and effectiveness of what we are aiming to achieve.

It would be very useful to begin some sort of crayfish monitoring in the Rahui and surrounding area. Crayfish along with snapper are key species on the reef. Their return to an abundant state is directly connected with the recovery of the kelp forests. There are established methods for doing crayfish survey, however in the case of this study there is considerable hands-on knowledge of the crayfish in the area which needs to be used as part of the approach taken. More work on developing a local approach to the crayfish monitoring would be valuable. A local approach could also be developed that could be used to assist monitoring and decision making in other areas of the Rohe.

4 Acknowledgements

The kaitiaki group of the Haititaimarangai Marae at Cape Karikari are to be commended for the vision and commitment behind the Rahui project. It is working and there is strong community support. Already the benefits are flowing as the numbers of our children, local community and visitors enjoying Maitai Bay and the Rahui grows. It is our hope that the Hapu are proud of the progress towards reviving their kaitiaki role and to see positive changes happening in the Bay. Our team consider it a privilege to work with you and be part of this kaupapa. I would also like to thank the entire 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 ongoing thanks to you Whetu. Lastly I would like to sincerely thank our funders for this past year, Foundation North and the Pacific Conservation and Development Fund, your support is appreciated and vital to the project.

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6 Appendix 1 Reef fish diversity species list

Family, *Genus, species,* (common name)

Aplodactylidae
Aplodactylus meandratus (marblefish)

Cheilodactylidae
Cheilodactylus spectabilis (red moki)
Cheilodactylus ephippium (painted moki)
Cheilodactylus douglasi (porae)

Chironemidae
Chironemus marmoratus (kelpfish/hiwihiwi)

Dasyatidae
Dasyatis brevicaudata (short-tailed stingray)

Diodontidae
Allomycterus jaculiferus (porcupine fish)

Arripidae
Arripis trutta (kahawai)

Berycidae
Centroberyx affinis (golden snapper)
Hoplostethus elongatus (slender roughy)

Carangidae
Caranx lutescens (trevally)
Decapterus koheru (koheru)
Seriola lalandi (kingfish)
Trachurus novaezelandiae (jack mackerel)

Hemiramphidae
Hyporhamphus ihi (Piper)

Kyphosidae
Kyphosus sydneyanus (silver drummer)
Girella tricuspidata (parore)

Labridae
Bodianus unimaculatus (red pigfish)
Coris sandageri (sandagers wrasse)
Notolabrus celidotus (spotty)
Notolabrus fucicola (banded wrasse)
Pseudolabrus miles (scarlet wrasse)
Pseudolabrus miles (scarlet wrasse)
Pseudolabrus luculentus (orange wrasse)

Monacanthidae
Parika scaber (leatherjacket)

Mullidae
Parupeneus fraterculus (black-spot goatfish, sub- tropical)
Upeneichthys porosus (red mullet/goatfish)

Muraenidae
Gymnothorax prionodon (mottled moray)
Gymnnothorax nubilus (mottled moray)
Gymnothorax prasinus (yellow moray eel)

Myliobatidae
Myliobatus tenuicaudatus (eagle ray)

Odacidae
Coridodax pullus (butterfish)

Pinguipedidae
Parapercis colias (blue cod)

Pempheridae
Pempheris adspersus (bigeye)

Pomacentridae
Parma alboscapularis (black angelfish)
Chromis dispilis (two spot demoiselle)

Scorpidae
Scorpis lineolatus (sweep)
Scorpis violaceus (blue maomao)

Serranidae
Caesioperca lepidoptera (butterfly perch)
Hypoplectrodes sp. (half banded perch)

Sparidae
Pagrus auratus (snapper)

Tetraodontidae
Canthigaster callisterna (sharp nosed puffer)

Tripterygiidae
Obliquichithys maryannae (oblique swimming blenny)
Tripterygion sp.
Several triplefin species observed but not individually identified

Zeidae
Zeus japonicus (john dory)

7 Appendix 2 Timed swim count and size data for snapper, red moki and butterfish

			snapper (cm)					red moki (cm)					butterfish (cm)				
Date	**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+**
1/17	M1	52	20	27	4	1		3			3		0				
5/3	M1	34	12	19		3		1				1	0				
4/10	M1	113		104	8	1		1			1		0				
4/27	M1	171	15	154	2			2			2		0				
1/17	M2	4		3	1			2			2		0				
5/3	M2	21		20	1			0					0				
4/10	M2	47		47				4			4		0				
4/27	M2	38		37	1			7		6	1		0				
1/17	M3	16		15	1			3			3		0				
5/3	M3	20		1	19			0					0				
4/10	M3	68		63	4	1		0					0				
4/14	M3	45	1	34	10			3		1	2		0				
4/27	M3	19		17	2			3			3		0				
1/17	M4	18	10	5	2	1		0					0				
5/3	M4	7		6	1			0					0				
4/10	M4	139		136	3			5		1	4		0				
4/14	M4	16		16				3		1	2		0				
4/27	M4	95	10	85				1			1		0				
6/3	O1	3			1	1	1	5			5		0				
4/10	O1	18		11	7			9		2	7		3		1	2	
4/14	O1	16		8	8			6		2	4		0				
6/3	O2	2		1	1			5			5		1			1	
4/10	O2	24		22	2			11			11		0				
4/14	O2	41		22	16	3		6			6		0				
5/3	S1	29		24	5			0					0				
4/10	S1	13		10	3			2			2		1			1	
4/15	S1	36		36				9	1		8		1			1	
5/3	S2	11		10	1			4			4		0				
4/10	S2	7	1	4	2			4			4		0				
4/15	S2	3		1	2			8		1	7		1			1	
5/3	S3	26		25		1		5			3	2	0				
4/10	S3	31		30	1			1			1		0				
4/15	S3	38		36	2			6		2	4		1				1
5/3	S4	14		13	1			3		1	2		0				
4/10	S4	109	2	89	18			2			2		0				
4/15	S4	11		6	5			1			1		0				
5/3	S5	6		5		1		0					0				
4/10	S5	35		32	3			2	1		1		0				
4/15	S5	26		26				5			5		0				
6/3	W1	19		18	1			5			5		0				
4/10	W1	37		37				3			3		0				
4/14	W1	10		10				2		1	1		0				
6/3	W2	8		7	1			8		1	7		0				
4/10	W2	22	1	16	4	1		4			4		0				
4/14	W2	4		4				1		1			0				
Total Counts		**1522**	**72**	**1292**	**143**	**14**	**1**	**155**	**2**	**20**	**130**	**3**	**8**	**0**	**1**	**6**	**1**

8 Appendix 3 Timed swim count data other species (not snapper, red moki and butterfish)

Date	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	koheru	triplefin	bigeye	john dory
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	28	29	30
1/17	M1	4	3		2			3	13						2									1						
5/3	M1	1	10		2			4	10						3															
4/10	M1	10	2						10															1	100					
4/27	M1	89	4	1	2	3	5		10															7					140	
1/17	M2	31	1	1	1	46	133	12	13						4		8													
5/3	M2	19			5				8						1															
4/10	M2	33	1	2		10	340		20		3																			
4/27	M2	30	9	4	15				15		13						6				1							5	80	
1/17	M3	17	8	2	2	22			3		32				2		2							1						
5/3	M3	6	2																				2					20		
4/10	M3	30	11	1	3		1		9				2		1														30	
4/14	M3	115	6	2	24		84		8				2						132										200	
4/27	M3	132	1	1		15			15		8		1				5											6	40	
1/17	M4	2	11	1				10							1															
5/3	M4	6	2					8	1																					
4/10	M4	25	13		1				3							1								8	300			9		1
4/14	M4	7	5		5				4					1						40			7		700		14	13	70	
4/27	M4	55	10					1	2															4				6	15	
6/3	O1	30	6	1			40	230							1		2													
4/10	O1	125	5		3	43	185	220	19	1			5				2			1		1								
4/14	O1	30	4	4	1	5	280	220	19				1	5			1		250										100	
6/3	O2	37	1		3	4	10	70	1				1		1		1													
4/10	O2	33		1	9	53	30	40	8				1			1			300											
4/14	O2	61	15	2	4	302	310	385	7	2			1	5	1	1	3		300	2			1						30	
5/3	S1	21	1						2																					
4/10	S1	14	3	1		10	2	50	12				2			1							1							
4/15	S1	4	7	3	6		2	65	12				1				1												100	
5/3	S2	40	1		17	502		170						1											100					
4/10	S2	12	2		3	6		250	5		8														250					
4/15	S2	53	4	2	10		1	15	4		1						1								220				70	
5/3	S3	19	1					1	1																					

4/10	S3	23						93	13																1	200					
4/15	S3			2	2		30	56	17											1				3	130			3	200	
5/3	S4	50	3	1							1				1									1						
4/10	S4	35	19	1	8		3		2		1													1	140			1	186	
4/15	S4	21	4		1				1		50					1				1					180					
5/3	S5	7	3	1					2						1									1						
4/10	S5	27	13	1	34	50		380	15		20			1					100					6	40				10	
4/15	S5	25	1	1	15	215		120	1					2							1			1	790				8	
6/3	W1	26	2						3		125													1						
4/10	W1	20	5	2	7				11		17		2		1	1								2					500	
4/14	W1	49			1			25	15		5					1						1		7				5	60	
6/3	W2	22	11	3	5	8			8				1				1													
4/10	W2	15	3	2	2				11																					
4/14	W2	14	6	3	15		2	55	7				1						10					1				3	50	
Totals		1425	219	46	208	1294	1458	2483	340	3	284	0	21	15	20	7	33	0	1092	45	2	2	11	47	3150	0	14	71	1889	1

9 Appendix 4 Results of BUV survey

code 1	code 2	Site	Snapper	Trevally	Goatfish	Leatherjacket	Blue cod	Pigfish	Porae	Scarlet Wrasse	John Dory	Red moki	Orange wrasse	grey moray	Yellow moray	Eagle ray	Sandagers wrasse	Mottled moray	Butterfly perch	Demoiselle	Sweep	Bigeye	Silver drummer	Blue maomao	Marble fish	Koheru		Total
in	exposed	B4	8					2							3			1										14
in	exposed	B6	18		1	1					1				2					4								27
in	exposed	B19	6				1	1		1							1			1			1	1				13
in	exposed	B25	10		2	3	2	2	1	1									2	4				5				32
in	exposed	B26	7			4		1							1													13
in	sheltered	B5	4												1													5
in	sheltered	B7	8			1									1													10
in	sheltered	B8	4													1												5
in	sheltered	B12	15																									15
in	sheltered	B13	1			1																						2
in	sheltered	B14	3			1		1													4							9
in	sheltered	B15	7			1																						8
in	sheltered	B16	1																									1
in	sheltered	B17	13			1		1							2					13								30
in	sheltered	B18	5																									5
out	exposed	B1	6			1		2				1		1	2					1								14
out	exposed	B2	7					1							1					17								26
out	exposed	B3	8					2	1			1			1						1	8	1					23
out	exposed	B20	0					2							2					14								18
out	exposed	B22	11					2				1	1		2					1		40		1	1			60
out	exposed	B23	20	2		2		1									1											26
out	exposed	B24	12	1		2																						15
out	sheltered	B9	19		1	2																				3		25
out	sheltered	B10	17			1																						18
out	sheltered	B11	4																									4