

Te Tatauranga Ataata Raro Wai ā-Mounu mō ngā
Taupori Ika ki Rākaumangamanga (Cape Brett), Te
Pewhairangi | Baited underwater video survey of
fish populations in Rakaumangamanga (Cape
Brett), Bay of Islands

2025

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1. Tīmatanga kōrero | Introduction

Background

Fishing has reduced the abundance of some of our most valued cultural, recreational and commercial species, and altered the age, size, and gender structure of fish populations. Some fishing methods, such as trawling and dredging have also damaged features on the seabed and some techniques have resulted in the bycatch of other species, like birds and dolphins. The populations of two of our most important cultural, recreational, and commercial fish species - snapper/tāmure and crayfish/kōura are now a fraction of their pre-fished state. The overall spawning biomass of tāmure in east Northland is estimated to be 38% of its unfished levels while the spawning biomass of crayfish is just 37% of unfished levels (Mckenzie *et al.* 2024; Fisheries New Zealand 2023).

One of the most well documented impact of fishing on coastal ecosystems is the expansion of kina/urchin barrens. The decrease in the populations of tāmure and kōura, has limited the ability of these species to control kina populations. Native kina are important grazers of our kelp forests, but when their population is allowed to grow unchecked due to the absence of large predators, they can completely strip a reef of kelp creating what is referred to as a kina barren. Recent research has shown that kina barrens covered 30% of shallow reefs in fished areas, compared to < 2% in marine reserves, and estimated that as much as 30 km² of kina barrens exist in Northeastern Aotearoa (which includes Northland to the Hauraki Gulf) (Kerr *et al.* 2024). This is consistent with earlier analysis in the Bay of Islands, which showed that kelp forests visible in early aerial images (1940-70s) have been depleted and that by 2009, kina barrens covered 47% of rocky shores (Booth 2017).

Marine protection in Northland

The creation of marine reserves and marine protected areas is a mechanism to protect local fish population from fishing pressure. Marine reserves have been attributed with an increase in abundance of popular fish species within the protected area, overflow effects to adjacent unprotected areas, and indirect changes to the marine habitats within the protected area. In New Zealand's first marine reserve, Cape Rodney - Okakari Point marine reserve, the return of large tāmure and cray fish has controlled kina populations allowing kelp forest to regenerate (Babcock *et al.* 1999).

In Northland, the early establishment of a marine reserve at the Poor Knights Islands in 1981 (1,890ha), was followed by two small reserves in Whangārei Harbour in 2006 (236ha), collectively covering 0.2% of Northland's coastal waters (territorial sea). Other small areas of Northland had partial or temporary protection from fishing pressure including Mimiwhangata marine park, which had rules limiting recreational fishing (e.g. one hook per line, no sinkers, one craypot) and a ban on commercial fishing, and Maunganui Bay in the Bay of Islands, which was placed under a temporary rāhui in 2010 under s.186 of the Fisheries Act by local hapū Ngāti Kuta and Patukeha ki Te Rawhiti, and rolled over every two years until 13 October 2024.

More recently, following the notification of the Proposed Regional Plan for Northland in 2017, an appeal to the Environment Court was lodged seeking restrictions on all commercial and recreational fishing between Maunganui Bay and Ōpōurua (Oke) Bay and around Mimiwhangata Peninsula, and commercial fishing restrictions around Rākaumangamanga (Cape Brett), on the basis that the significant ecological values of these areas had been severely impacted by fishing.

In May 2023, the Environment Court released its final decision on new marine protection rules for Mimiwhangata and Rākaumangamanga. The court decision directed Northland Regional Council to implement new rules, restricting fishing in three areas via the Proposed Regional Plan for Northland.

The rules created two new Rāhui Tapu (no-take, except kina) areas around Mimiwhangata Peninsula and between Oke Bay and Maunganui Bay in the Bay of Islands. In a third area around Rākaumangamanga/Cape Brett peninsula harvesting of fish using seining and bottom trawling methods is prohibited (Figure 1).

Education and enforcement of the Rāhui Tapu areas

Annual communications plans have been developed with input from hapū representatives since 2024 covering public awareness, education and engagement activities for both Rāhui Tapu. Education and communication of the Rāhui Tapu rules has included: signage at boat ramps; pamphlets; posters at community events; social media campaigns; local radio advertisements, magazine, newsletter and newspaper advertisements; community events; Councils' website; and engagement with marinas and boat charters.

On-water education and enforcement has also occurred in the Rākaumangamanga Rāhui Tapu focussing on high use times i.e. weekends, and public and summer holidays. Between October 2023 and June 2024 there was an education only focus – 147 vessels were approached and informed about the marine protection rules, with 75 people witnessed fishing or diving. Formal enforcement of the rules commenced in late 2024. Between October 2024 and June 2025 a total of 63 on-water surveillance trips were undertaken in the Rākaumangamanga Rāhui Tapu. During this period, 268 vessels were approached and informed about the rules; one infringement notice and 31 directions notices were issued to individuals witnessed fishing; and an abatement notice was issued to a commercial operator who was found to have engaged gear within the Rāhui.

Monitoring the impact of the Rāhui Tapu areas

Monitoring the response of the marine environment in the new protected areas is vital if we are to understand if the new rules are sufficient to revive the mauri (health) of the areas. Northland Regional Council has committed to working with local hapū to undertake monitoring of the Rāhui Tapu areas, with an initial focus on monitoring the abundance and size of kōura and tāmure, and the extent of kina/urchin barrens.

Baited remote underwater video systems (BRUV), comprising a waterproof camera system, frame and a bait canister to attract fish, have been used to survey fish abundance and biodiversity in New Zealand since 2000 (Willis & Babcock 2000). In Rākaumangamanga, BRUV surveys have previously been conducted by the Department of Conservation (Buisson 2009) and by Kerr (2016) on behalf of Bay of Islands Maritime Park Inc (Fish Forever). More recently, Smith (2025) undertook a stereo BRUV survey of 42 sites along Rākaumangamanga for Northland Regional Council. A stereo BRUV uses two forward facing convergent cameras, which can be calibrated to enable accurate length measurements of fish. The forward facing stereo BRUV survey captures a horizontal view and a larger area of the water column compared to a downward BRUV, which captures a smaller area directly below the camera, so the results of Smith's survey cannot be directly related to the earlier downward BRUV surveys by Buisson (2009) and Kerr (2016).

In 2025, Northland Regional Council, together with kaitiaki from Ngāti Kuta and Patukeha of Te Rāwhiti aimed to replicate the most recent survey undertaken by Kerr in 2016. The purpose of the

survey is to provide baseline data on fish biodiversity and snapper/tāmure abundance and biomass in the newly established Rāhui Tapu areas, which can be used to assess the impact of the new rules restricting fishing in the Proposed Regional Plan.

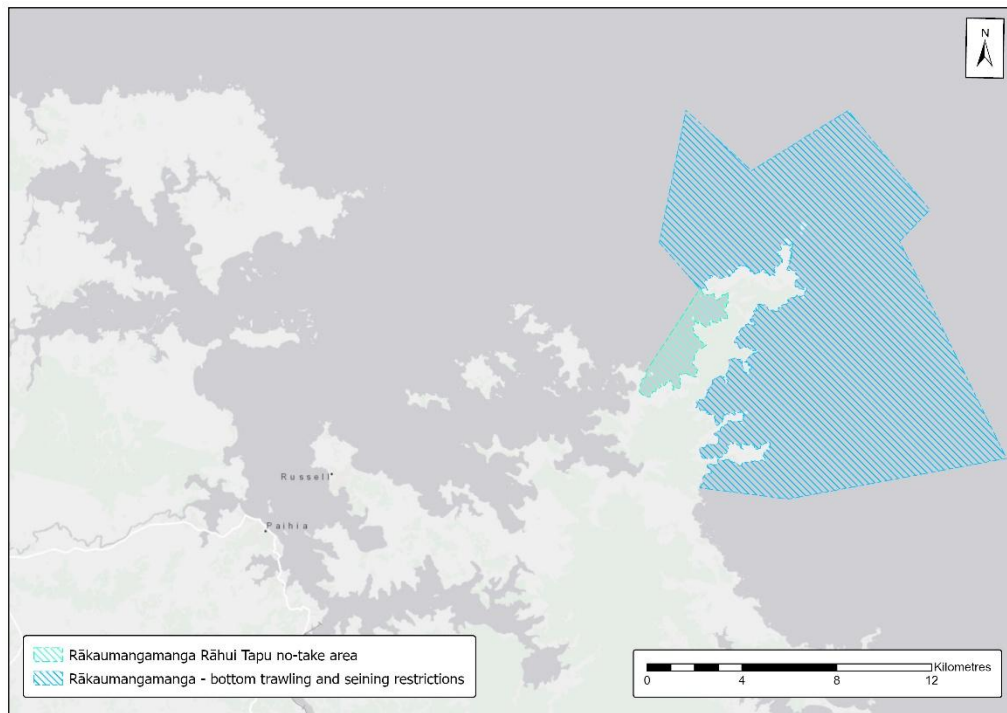


Figure 1. Te Hā o Tangaroa protection areas at Rākaumangamanga (Cape Brett).

2. Ngā pēwheatanga | | Methods

Sampling sites

The sampling plan involved surveying the 30 sites sampled by Kerr in 2016 (Figure 2 and Appendix 1). The sites are located in three areas with different levels of historical protection (Figure 2): Nine sites are located between Oke Bay and Motuwheke Island, where new fishing restrictions were introduced in 2023, prohibiting recreational and commercial fishing (Rāhui Tapu 2023); Ten sites are located in Maunganui Bay, which is also subject to new rules restricting commercial and recreational fishing, but had been subject to an earlier rāhui, restricting fishing since 2010 (Rāhui Tapu 2010). A further 11 sites are located beyond Maunganui Bay, between Kariparipa Point and Otuwhanga Island, where new rules restrict seining and bottom trawling fishing methods, but allow for recreational fishing (Restricted 2023).

The fieldwork was undertaken on 7 and 14 of May 2025 with a total of 29 deployments made over the two days. One site - 948 (in the Rāhui Tapu 2023 area) could not be surveyed due to time constraints.

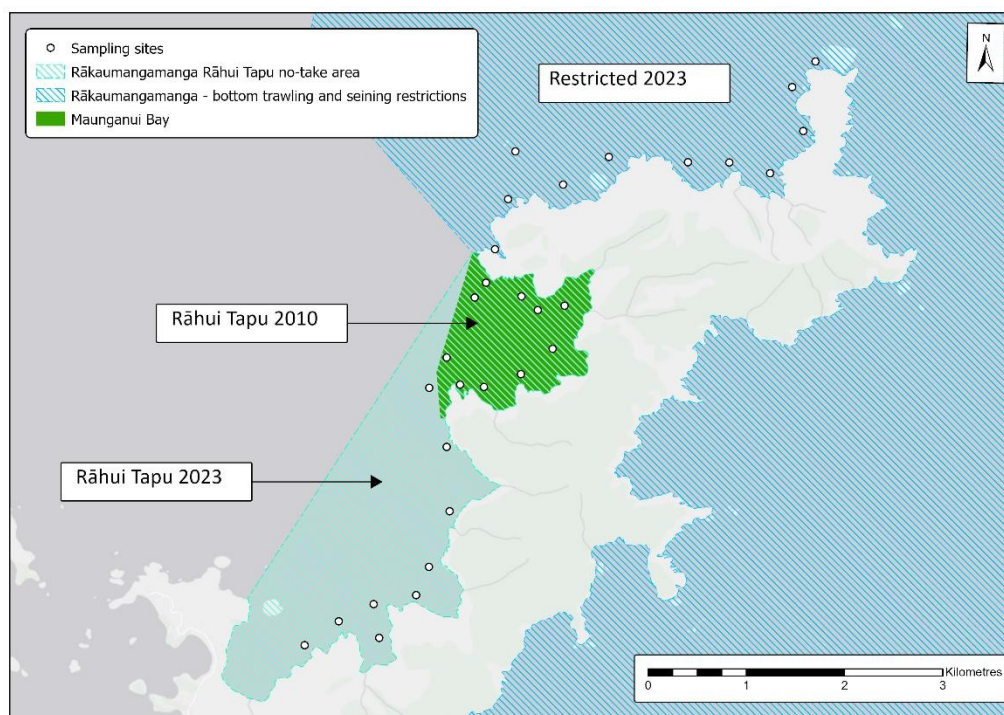


Figure 2. Sample sites along Rākaumangamanga, surveyed in May 2025.

Sampling methods

The BRUV equipment and methods used in this survey were similar to those used by the Department of Conservation (Buisson 2009) and Kerr (2016). The method involves dropping a BRUV unit onto the seabed for thirty minutes to video fish that are attracted to the bait canister. The BRUV unit comprises an aluminium frame, with a scale bar, a GoPro HERO 12 video camera in waterproof housings, lights, and a bait canister (Figure 3). The units were attached by a rope to a surface marker buoy and deployed from a 6.7m Surtees, using 1 kg of fresh chopped pilchards for bait. The images from the GoPro HERO 12 camera, resulted in a field of vision (sampling unit) of approximately 1.870m² (1870mm by 1000mm).

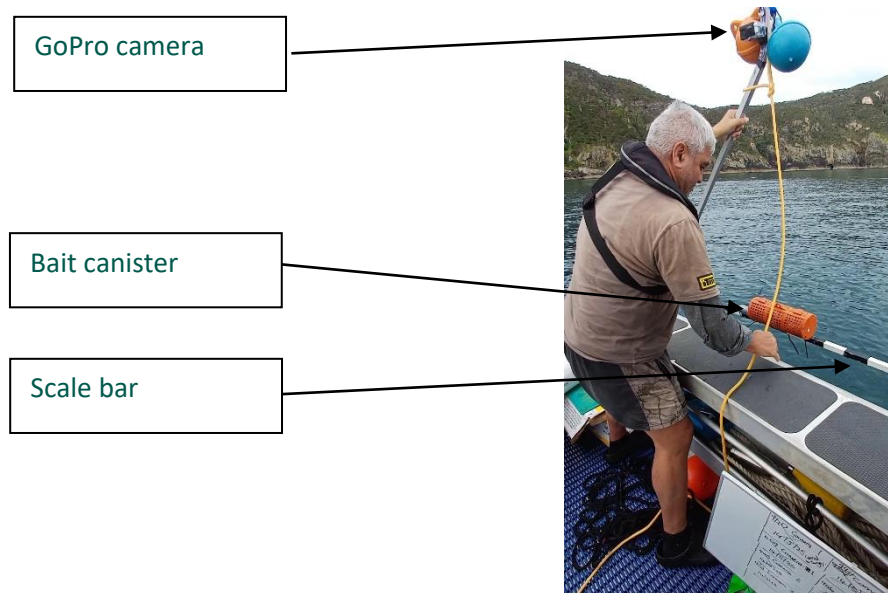


Figure 3. Downward DRUV unit used in current survey of Rākaumangamanga.

Video analysis

The videos were initially analysed in VideoLan Client (VLC) to determine the quality of each deployment. Deployments were classified as ‘good’, ‘ok’ and ‘bad’. ‘Good’ deployments were high quality images without any obstructions. ‘Ok’ deployments typically had some kelp obstructing a small portion of the video (sampling unit). Deployments were classified as ‘bad’ if the gear was located on the reef edge (obscuring half of the video or the sampling unit), if the gear was not sitting stably on the seabed, or if the image was obstructed by kelp (Appendix 4).

All ‘good’ and ‘ok’ deployments were analysed for fish diversity, the maximum snapper/tāmure count (MaxN snapper), and maximum snapper/tāmure biomass (MaxN snapper/tāmure biomass). The maximum tāmure count is defined as the maximum number of tāmure observed in a single frame during the first 30 minutes of recorded footage. Individuals are counted and included in the MaxN if any part of the fish is in the video frame (i.e. just the head or tail). Once the highest maximum tāmure count had been identified, suitable still frames of each fish were selected for length measurement. These still frames were then uploaded to Photoblique v2.0.122 for length measurements.

In Photoblique, the spatial scale of each image was set using the scale bar on the BRUV frame. Each tāmure was then numbered and the fork length of each fish measured. The best frame was selected for each individual tāmure, with care taken only to measure tāmure, when they were on the same plane as the scale bar on the BRUV unit used to set the spatial scale. If a fish was pointing up or down or at a different depth to the scale bar the lateral line won’t be in the same plane as the scale bar and the length measurement will not be accurate. A small number of fish that were not on the same plane as the scale bar at any point in the video were not measured and some individuals that never fully entered the video frame were also not measured.

The tāmure length measurements made in Photoblique were then exported as a csv and used to estimate the biomass of tāmure, using the length weight relationship for East Northland calculated by Walsh *et al.* (2022).

$$W = aL^b$$

Where W is the weight (g), L is the length (cm), a is 0.0349 and b is 2.8701.

On occasions when the length of all individuals from the MaxN count could not be accurately measured, the total biomass was estimated by dividing the measured biomass by the number of individuals measured and multiplying by the total number of tāmure in the MaxN to account for the unmeasured fish.

Data analysis

MaxN snapper/tāmure and MaxN biomass, are presented on maps of Rākaumangamanga, with proportional circles representing the values for each site. The species richness, MaxN snapper/tāmure and MaxN biomass data for the three sampling areas (Rāhui Tapu 2010; Rāhui Tapu 2023; & Restricted 2023) are also presented in box plots. The box displays the interquartile range (middle 50% of the data) with the middle line indicating the median. The upper whisker extends to the maximum data point within 1.5 box heights from the top of the box and the lower whisker extends to the minimum data point within 1.5 box heights from the bottom of the box. Outliers are depicted by an asterisk (*).

The MaxN snapper/tāmure, MaxN biomass and species count data for each site are presented in Appendix 2 and 3.

3. Nga hua | Results

Deployment quality

Of the 29 deployments, six were classified as ‘bad’ and could not be used to calculate MaxN snapper/tāmure or MaxN biomass. Two deployments (949 and 946) were obscured by kelp, two deployments did not settle stably on the seabed (930 and 940), and two deployments were on the reef edge, meaning half of the video frame (the sampling unit) was compromised (953 and 956; Figure 4 & Appendix 4).

One of the sites in the Rāhui Tapu 2023 area was not sampled and three of the deployments in this area were classified as bad, resulting in a smaller number of successful deployments (five) in this area, compared to ten in Rāhui Tapu 2010 (Maunganui Bay) and eight in the Restricted 2023 area (Figure 4).



Bad deployment, Site 946 - image obscured by kelp.



Bad deployment, Site 953 BRUV frame on reef edge



Good deployment, Site 404 – unobstructed image.



Ok deployment, Site 958 – image partly obstructed by kelp.

Figure 4. Examples of ‘good’, ‘ok’ and ‘bad’ deployments.

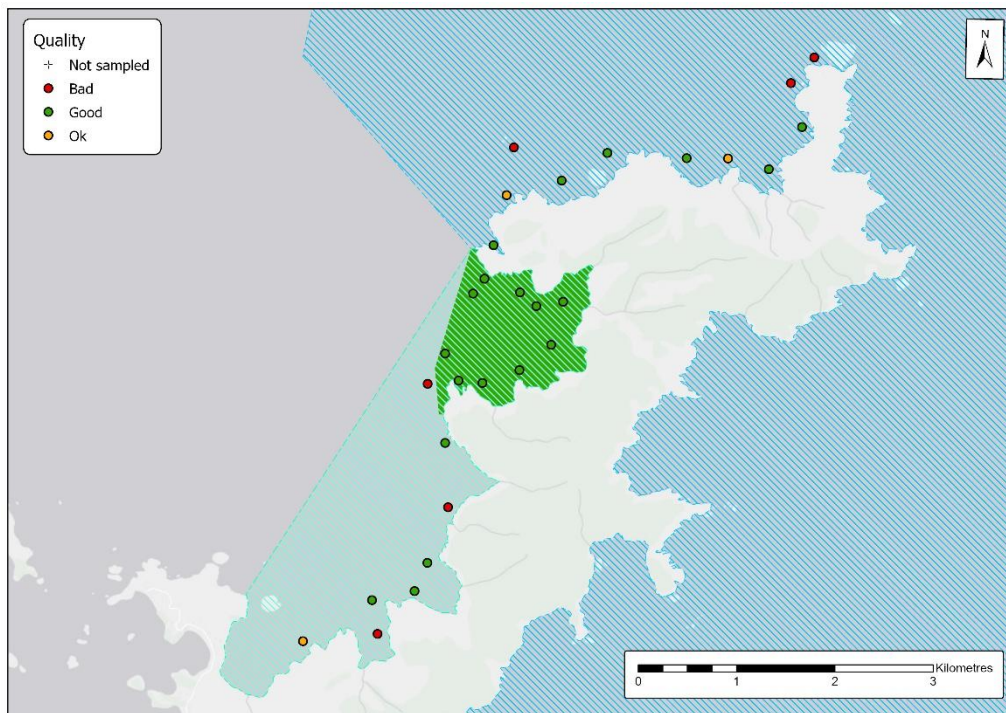
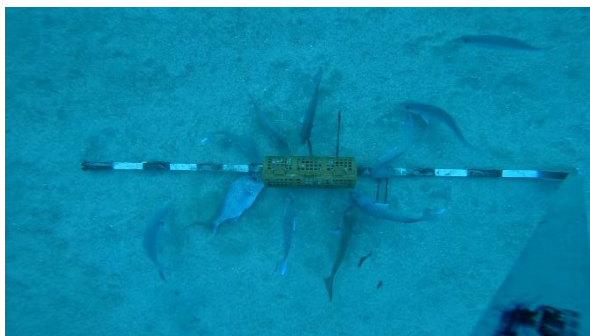


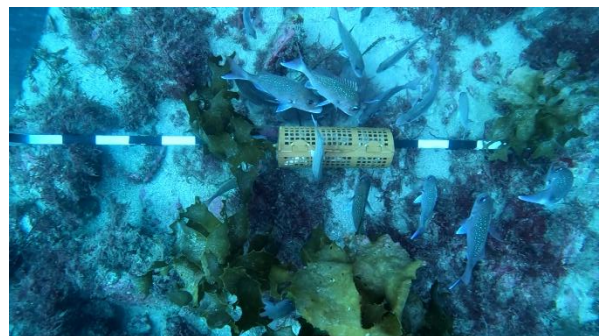
Figure 5. Quality of deployments in Rākaumaungmaunga.

Substrate

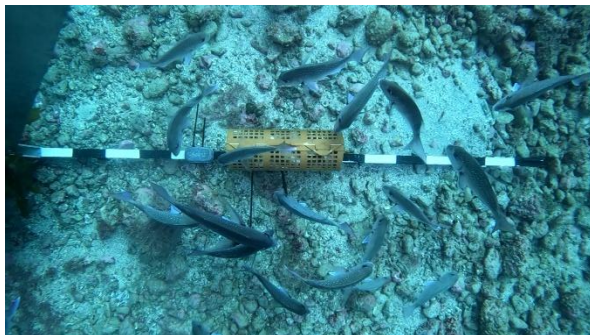
The 23 successful deployments were made on a range of substrates, which were subsequently classified into four categories: sand, rubble (pebbles, cobbles, rock), mixed and reef (Figure 6). Thirteen deployments were made on sandy substrates, four on pebbles, four on mixed substrate, and two on reef. The depth ranged from nine metres to 38 metres with the majority of deployments (74%) between 15 and 25m water depth.



Sand



Mixed substrate



Rubble



Reef

Figure 6. Examples of substate classification.

Fish biodiversity

A total of 25 species were identified from the 23 successful deployments with species richness ranging from two to nine (Appendix 3). Tāmure/snapper were the most frequently observed species, and were recorded in all 23 deployments, followed by trevally/araara (*Pseudocaranx dentex*), which were recorded in 15 deployments, and red pigfish/Paakurakura (*Bodianus unimaculatus*) which were recorded in 14 deployments (Appendix 3). Three species of moray eel and two species of elasmobranchs - an eagle ray and a school shark, were observed.

The lowest median diversity was recorded in the older Rāhui Tapu area (Rāhui Tapu 2010) and the highest diversity in the Restricted 2023 area (Figure 7), but this finding may be an artifact of the different substrates sampled in the different areas. The highest species richness tended to be recorded on reef habitat, with the lowest richness recorded on sand (Figure 8). Seven of the 10 deployments in Rāhui Tapu 2010 were on sand with no reef habitat surveyed in this area. In contrast in the Restricted 2023 area, only three deployments were on sand, and two deployments were on reef habitat.

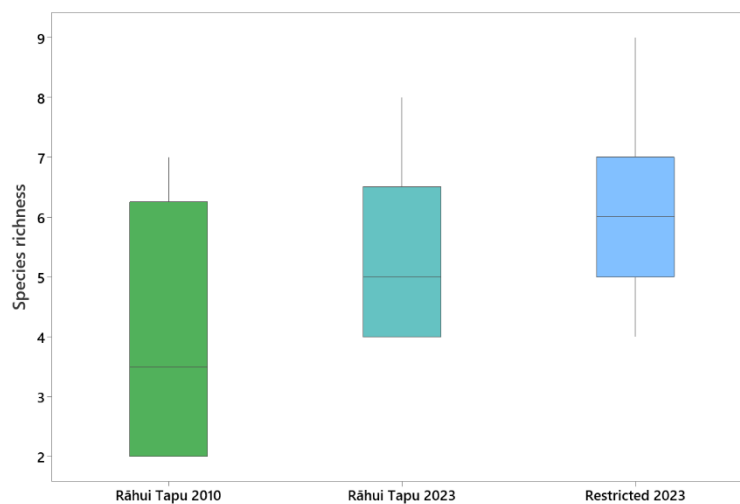


Figure 7. Species richness in different areas of Rākaumangamanga surveyed in 2025.

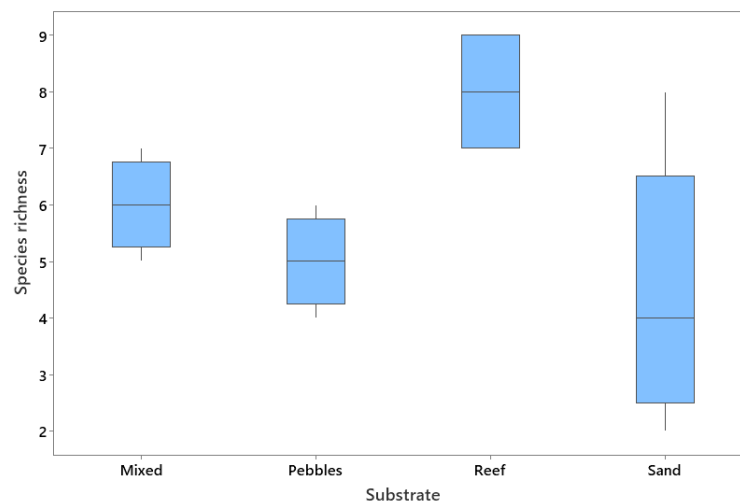


Figure 8. Species richness recorded on different substrate types in Rākaumangamanga in 2025.

Snapper/Tāmure counts and biomass

MaxN tāmure ranged from five to 43 with a mean of 23.5 (Appendix 2). The highest median MaxN tāmure (31) was found in the newest Rāhui Tapu area (Rāhui Tapu 2023), with similar medians in the older Rāhui Tapu 2010 area (19) and the restricted 2023 area (21.5) (Figure 9). However, a higher median MaxN biomass was found in the older Rāhui Tapu 2010 (21.9kg), compared to the newer Rāhui Tapu 2023 area (17kg) and the Restricted 2023 area (6.3kg) (Figure 10). Some of these differences may be explained in part by the different habitats surveyed in the three areas. Higher tāmure biomass tended to be recorded on sandy substrate compared to reef, pebbles and mixed substrate (Figure 11), and seven of the 10 deployments in Rāhui Tapu 2023 were on sandy substrate.

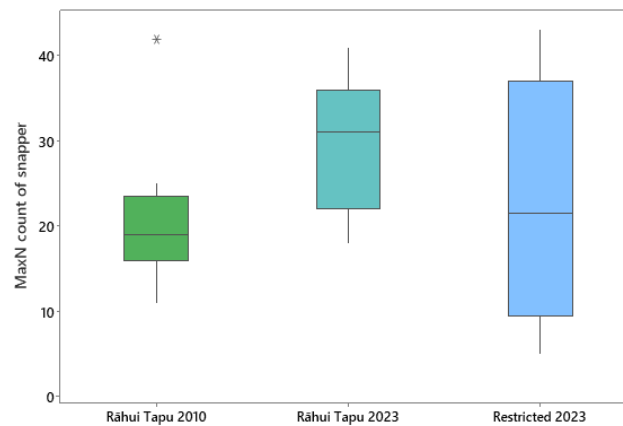


Figure 9. MaxN snapper/tāmure recorded in different areas of Rākaumangamanga in 2025.

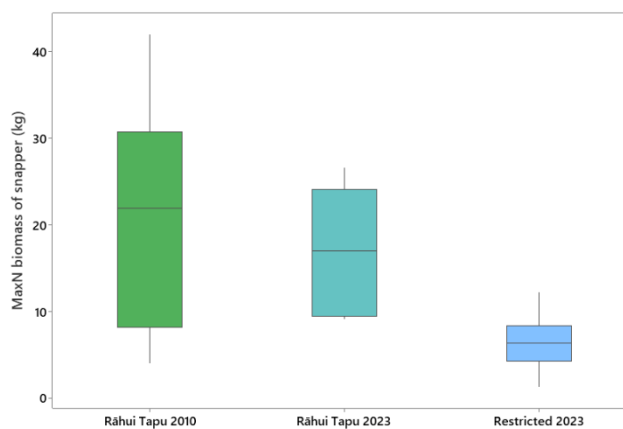


Figure 10. MaxN snapper/tāmure biomass recorded in different areas of Rākaumangamanga in 2025.

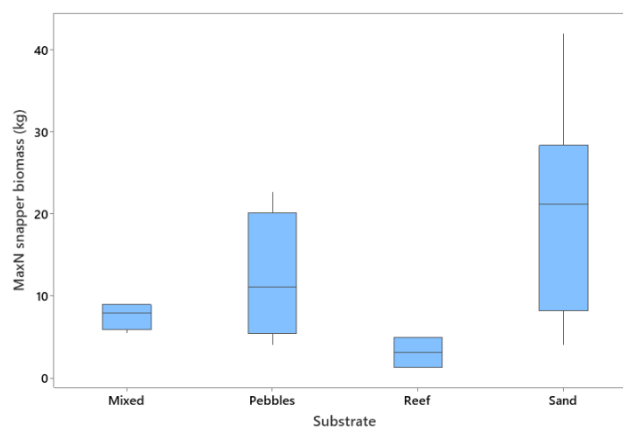


Figure 11. MaxN snapper/tāmure biomass recorded on different substrate types at Rākaumangamanga in 2025

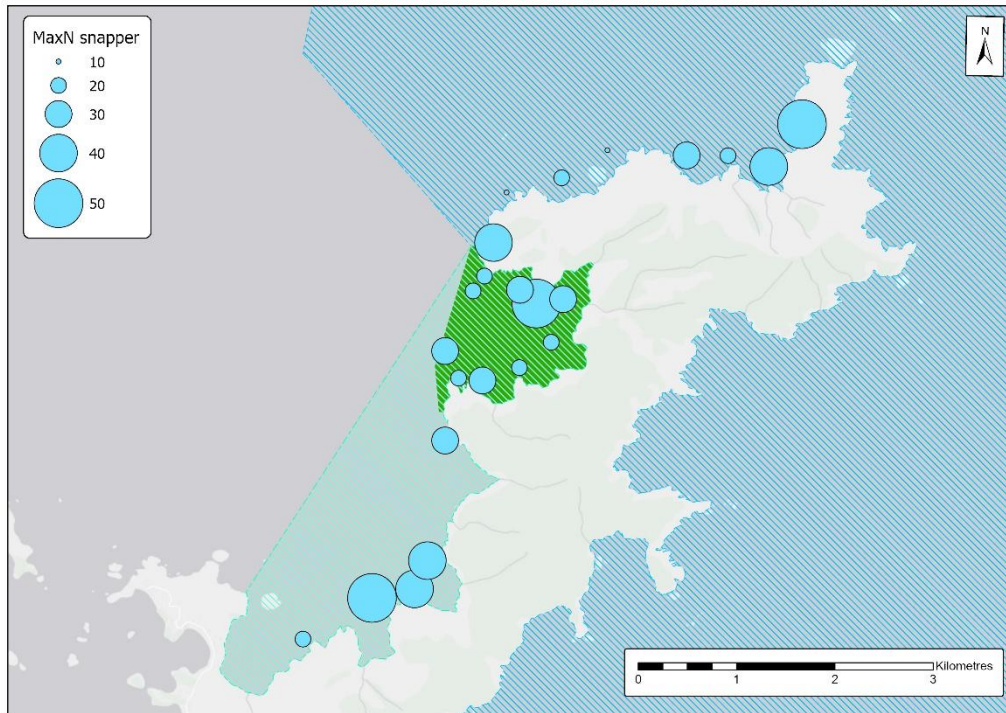


Figure 12. MaxN snapper/tāmure at each sampling site in Rakaumangamanga in 2025.

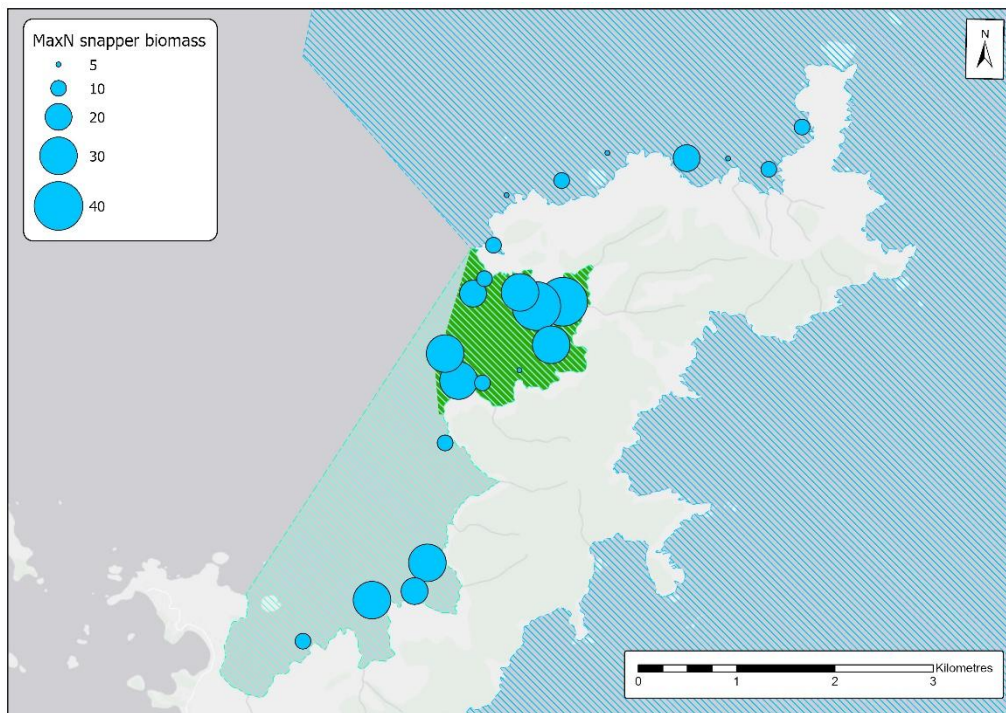


Figure 13. MaxN snapper/tāmure biomass at each sampling site in Rakaumangamanga in 2025.

The length frequency data shows a clear difference in the size structures of fish found in the three areas. In the older Rāhui Tapu area (Rāhui Tapu 2023), there was a much broader size structure, with approximately equal number of individuals above the legal-size limit of 30cm (53%) as those below the legal-size (47%) (Figure 14). Another key feature of the size structure was the presence of larger fish (>500mm), which were absent from the other two areas.

In the newer Rāhui Tapu area (Rāhui Tapu 2023) there is a narrower size structure, with a higher proportion of fish below the legal catch limit (63%) than those above the limit. Some fish above 400mm were observed but no larger fish (>500mm) were recorded. In the Restricted 2023 area, the size structure is highly compressed with the majority of fish (92%) below the legal catch limit and no large fish (>500mm) were observed (Figure 14).

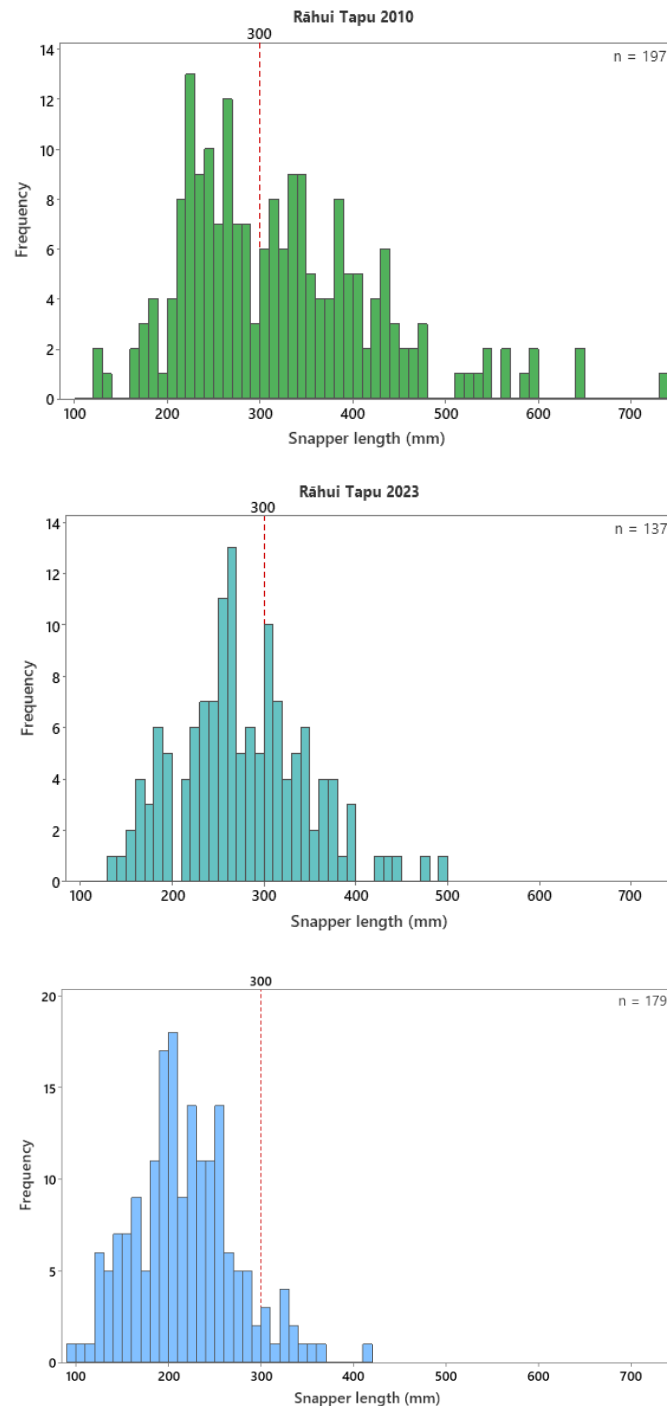


Figure 14. Length frequency data recorded in different areas of Rākaumangamanga in 2025.

Fish behaviour and interactions

The presence of larger tāmure and occasionally aggressive mid-sized tāmure appears to influence the presence of smaller fish and consequently the MaxN count and biomass data. Small tāmure were less frequently observed when large tāmure were present and in some videos aggressive individuals were seen actively chasing and harassing smaller fish (Figure 15).

The appearance of moray eels also appears to influence the snapper/tāmure count and length data. Tāmure, and in particular smaller individuals were seen to leave the video frame when moray eels arrived. Aggressive behaviour by moray eels towards tāmure was frequently observed, with eels actively chasing tāmure away from the bait cage. At one site (958) moray eels swam the bait cage with tāmure seen to be keeping their distance at the periphery of the image (Figure 16). The mean MaxN snapper/tāmure count was 26.4 when no moray eels were recorded in the 30-minute deployment compared to 19.1 tāmure when at least one moray eel was recorded.



Figure 15. A large tāmure aggressively chases smaller fish away from the bait canister.



Figure 16. Moray eels swamping the bait canister.

Comparison with previous surveys

Kerr (2016), recorded 30 species of fish at the 29 sites sampled in 2016 (one of the 30 sites sampled by Kerr (site 408) was excluded from analysis because moray eels had attacked and removed the bait canister). The species recorded was similar to those observed in this survey and the overall species richness is likely to be similar when the smaller number of successful deployments in the current survey is taken into account. Kerr reported that snapper/tāmure were the most frequently observed fish (at 28 sites), followed by leatherjacket (*Meuschenia scaber*) (23), trevally (20) and red pigfish (18), which is similar to what was found in the current survey, with the exception of leatherjacket, which was only found at six sites in 2025.

The MaxN snapper/tāmure reported by Kerr for the 23 sites re-sampled in this survey was typically lower than the current survey. The mean MaxN was 11.1 compared to 23.5 in the current survey and results indicate that there has been an increase in tāmure/snapper abundance in all three areas (Figure 16). The size of the video frame (or sample unit) described in Kerr's study was larger than the current study (2.04m^2 versus $\sim 1.7\text{m}^2$) so the actual increase in tāmure abundance in all three areas may in fact be greater.

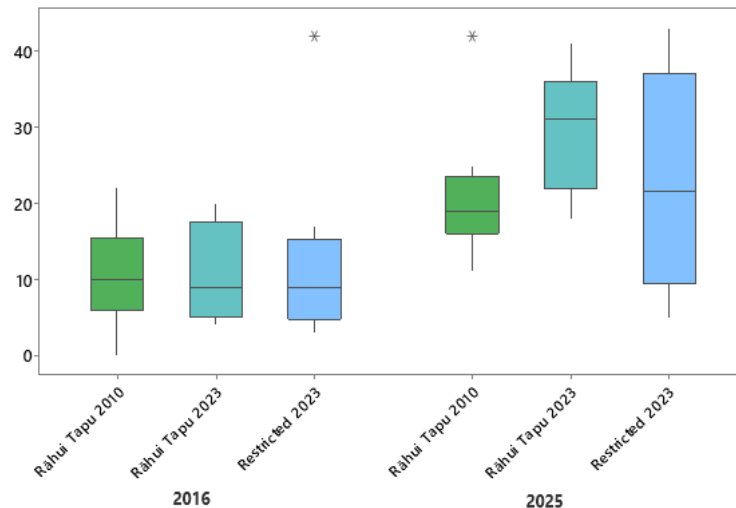


Figure 17 MaxN snapper/tāmure counts in Rākaumangamanga in 2016 (Kerr 2016) & 2025 (current study).

Kerr 2016, did not report biomass on a site-by-site basis so a direct comparison is not possible, but Kerr did report the mean tāmure length for three different ‘zones’, which correspond to the same three areas of the current survey. In 2016, mean tāmure length ranged from 23 to 26 cm in the three ‘zones’, which compares to 21.7 to 32.2cm in the current survey. Kerr also reported the mean MaxN biomass for the three ‘zones’ ranged from 4.3kg to 5.8kg which compares to a range of 6.4kg to 20.4kg in the current survey. Although, it should be noted that Kerr used a different length-weight relationship, when the length data from the current study was re-analysed using the same length-weight relationship (developed by Taylor & Willis 1998) used by Kerr, there was very little difference between the means for the three zones. The mean for the three zones ranged from 6.4 – 19.6 kg using the Taylor and Willis (1998) length-weight relationship. It therefore appears that there has been an increase in biomass in all three zones, and a particularly large increase in the Rāhui Tapu 2023 area.

The most recent survey, conducted by Smith (2025) reported a total of 38 species, but Smith’s survey used a stereo BRUV (which has a broader visual field), and sampled a larger number of sites (42 sites). Smith reported snapper/tāmure as the most widespread species recorded at all 42 sites, followed by trevally, kingfish, red pigfish and eagle ray. This is similar to what was found in the present study with tāmure observed at all 23 sites, and trevally and pigfish both frequently recorded. However, in the current study kingfish were only recorded at five sites and eagle ray at one site. The difference is likely to be due to the different visual fields captured by the two methods. Cundy *et al.* (2017) found that stereo BRUV sampled a different assemblage of fish than downward BRUV, observing significantly more species and individuals.

Smith reported MaxN snapper/tāmure counts of between 12 and 105, which is a much higher range than the current study (five to 43) with an overall mean of 50.3 (23.5 in the current study) and higher biomass in the MaxN frames of between 3.1 and 58.4kg (1.27kg – 41.98kg in the current study). The higher MaxN counts and biomass of tāmure are almost certainly a result of the larger visual field captured by a Stereo BRUV versus the Downward BRUV.

Interestingly, Smith also reported higher MaxN biomass in Maunganui Bay (Rāhui Tapu 2010) than the more recent Rāhui Tapu area (Rāhui Tapu 2023) and the restricted fishing area, which is the same pattern observed in this study. Smith also observed that this was due to differences in the size structure of the fish populations in the different areas, with more large fish in the older Rāhui Tapu area (Rāhui Tapu 2010).

4. Kōrero whakamutunga | Synthesis

Following the notification of the Proposed Regional Plan for Northland in 2017, an appeal to the Environment Court was lodged seeking restrictions on fishing between Maunganui Bay and Ōpourua (Oke) Bay in the Bay of Islands, and around Mimiwhangata Peninsula and Rākaumangamanga (Cape Brett) on the basis that the significant ecological values of these areas had been severely impacted by fishing.

In May 2023, the Environment Court released its final decision on new marine protection rules for Mimiwhangata and Rākaumangamanga (Cape Brett), directing Northland Regional Council to implement new rules, restricting fishing in three areas. The rules created two new Rāhui Tapu (no-take, except kina) areas around Mimiwhangata Peninsula (Mimiwhangata Rāhui Tapu) and between Maunganui Bay and Oke Bay in the Bay of Islands (Rākaumangamanga Rāhui Tapu). In a third area around Rākaumangamanga (Cape Brett) harvesting of fish using seining and trawling methods is prohibited (Ngā Au o Morunga Mai Rākaumangamanga Protection Area). In Maunganui Bay, an earlier Rāhui under s.186 of the Fisheries Act had been in place between 2010 and October 2024, prohibiting commercial and recreational fishing. As a consequence Rākaumangamanga has three areas with different levels of protection from fishing pressure:

- Maunganui Bay - subject to a Rāhui under s.186 of the Fisheries Act preventing recreational and commercial fishing between 2010 and 2024, and ongoing protections under the Rākaumangamanga Rāhui Tapu rules since 2023 (Rāhui Tapu 2010);
- Oke Bay to Motuwheteke Island - subject to Rākaumangamanga Rāhui Tapu rules preventing recreational and commercial fishing since 2023 (Rāhui Tapu 2023);
- a larger area beyond Maunganui Bay and extending around the eastern side of Rākaumangamanga peninsula /Cape Brett, where recreational fishing is still permitted but restrictions on harvesting fish with seining and trawling methods since 2023 (Restricted 2023).

The current survey undertaken by kaitiaki from Ngāti Kuta and Patukeha of Te Rawhiti aimed to resurvey 30 sites previously sampled by Kerr (2016), using a downward facing baited underwater camera to provide baseline data on fish biodiversity, and tāmure abundance and biomass.

Due to time constraints one site was not sampled and six deployments were classified as 'bad' so data from 23 successful deployments was used in the analysis. Despite the reduced sample size, the results indicate a difference in the snapper/tāmure biomass and size structure in the three areas. A key finding was the higher tāmure biomass recorded in Maunganui Bay (Rāhui Tapu 2010), than Rāhui Tapu 2023 and Restricted 2023. The higher biomass appears to be a result of a much broader size structure in Rāhui Tapu 2010, with an equal number of individuals above the catch limit as those below it, and the presence of large fish (>500mm), which were absent from the other two areas.

Interestingly Rāhui Tapu 2023 between Oke Bay and Motuwheteke Island also had a broader size structure than the Restricted 2023 area, with a higher proportion of fish above 30cm, which may be an early impact of the new regional rules (which had been in place for 15 months at the time of the survey). Another possibility is spillover or overflow effect from the adjacent Rāhui Tapu 2010 area, but if that were the case an overflow effect should also have been observed in the Restricted 2023

area, which is also adjacent to the older Rāhui Tapu 2010 area. These findings are similar to those findings reported by Smith (2025) in a Stereo BRUV survey conducted at a similar time. The findings are also consistent with previous surveys of marine reserves, which have shown that the number of large tāmure and overall tāmure biomass can increase rapidly after protections are put in place (Denny *et al.* 2004).

The significance of this increase in large snapper is due to the oversized effect that large tāmure can have on overall reproductive success and recruitment. Older larger female tāmure produce a disproportionately higher number of eggs per spawning event than younger smaller individuals (Crossland 1977, Parsons *et al.* 2014). Marine reserves can therefore have a positive impact on recruitment and fish population well beyond the boundaries of the reserve referred to as overflow effects (Le Port 2014).

It will be fascinating to see how the size structure of tāmure in the restricted 2023 area, responds to the new rules over time. The current survey shows a compressed size structure in this area, with a peak around 200mm and almost all individuals below the legal catch limit (30cm). It will be interesting to see, whether rules restricting commercial fishing using bottom trawling and seine methods will be sufficient for the number of legal-size tāmure to increase over time and whether large tāmure (>500mm) become more common in this area.

Limitation and recommendations

The current survey used a downward BRUV method, which is a cheap non-destructive method to monitor predatory fish in coastal waters. The main advantage is that the gear is lightweight and easy to deploy off small vessels. In this survey it was possible to sample 15 sites in one day, with three crew operating off a 6.7m trailer boat.

One potential limitation of the downward BRUV method is the accuracy of length measurements. There are a number of issues with a single camera capture method when making length measurements. Wide angle cameras such as GoPros create radial distortion, which is when objects at the edge of the image appear curved, making objects appear larger or smaller depending on where they are in the frame. Another issue is parallax distortion, which can lead to length errors if the fish or object being measured is not in the same focal plane as the reference object (scale bar) used to calibrate the image. A final problem is the fish movement and posture. Tāmure use a combination of body and caudal fin movement to swim through the water so their bodies are often curved or twisted.

In order to reduce measurement errors caused by these issues in the current study, length measurements were only made when tāmure were on the same plane as the scale bar on the BRUV unit and considerable effort was also made to try to select the best frames, when individuals were near to the bait cage so they were below the camera to reduce radial and parallax distortion. Care was also taken to select frames when fish were elongated (this often occurred when fish ‘feed’ at the bait canister). In future, it is also recommended that optical corrections are applied to the images.

One limitation of the current survey was the absence of sampling sites in areas with no rules restricting fishing effort. Another limitation was the low replication (n=5) in the newer Rāhui Tapu area (Rāhui Tapu 2023) because of the quality of the deployments and time constraints. It is recommended that in future an approximately equal number of sites (n=10) are sampled in each ‘area’ and that new sites are added along the north-eastern shores of Urupukapuka Island, where fishing restrictions do not apply (i.e. a fished area).

Another consideration is the impact that substrate/habitat has on species richness and tāmure abundance. The data from this survey suggests that habitat type may influence both fish biodiversity and the MaxN snapper/tāmure. Future surveys could be improved by attempting to have a more balanced representation of habitats in the different areas. The presence of moray eels on tāmure abundance and length data should also be investigated. The presence of moray eels was seen to scare tāmure away from the bait canister, with small tāmure more wary of eels than larger fish. The displacement effect of moray eels was particularly apparent, when multiple moray eels were present and swamped the bait canister.

It is recommended that a downward BRUV be repeated in 2026 and 2027 in order to build a robust baseline to assess longer term changes to abundance of tāmure and the size structures of the populations in the different areas. It is also recommended that new sites are established in a fished area, and that attention is paid to the habitats surveyed in the different areas and where possible attempts are made to have a more balanced representation of habitats in the four areas (Rāhui Tapu 2010; Rāhui Tapu 2023, Restricted 2023; and a new area ‘Fished’).

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6. Appendices

Appendix 1. Sampling site co-ordinates.

Site	Area	x	y	Date sampled	Depth	Substrate
947	Rāhui Tapu 2023	1715908	6101220	7/05/2025	15	Mixed
948	Rāhui Tapu 2023	1716253	6101463	Not sampled	-	-
949	Rāhui Tapu 2023	1716666	6101294	7/05/2025	14	Reef
950	Rāhui Tapu 2023	1716611	6101637	14/05/2025	18	Sand
951	Rāhui Tapu 2023	1717043	6101730	7/05/2025	17	Sand
952	Rāhui Tapu 2023	1717173	6102018	14/05/2025	20.9	Sand
953	Rāhui Tapu 2023	1717382	6102584	7/05/2025	17.2	Reef
954	Rāhui Tapu 2023	1717352	6103238	7/05/2025	18	Pebbles
930	Rāhui Tapu 2023	1717176	6103840	7/05/2025	39	-
403	Rāhui Tapu 2010	1717732	6103847	7/05/2025	22.4	Mixed
406	Rāhui Tapu 2010	1718114	6104771	7/05/2025	22.8	Sand
402	Rāhui Tapu 2010	1717353	6104148	7/05/2025	38	Sand
404	Rāhui Tapu 2010	1718108	6103978	7/05/2025	20.8	Sand
503	Rāhui Tapu 2010	1718432	6104237	7/05/2025	24.9	Sand
407	Rāhui Tapu 2010	1718553	6104674	7/05/2025	24.1	Sand
408	Rāhui Tapu 2010	1717639	6104757	7/05/2025	36	Sand
502	Rāhui Tapu 2010	1717488	6103871	7/05/2025	16.7	Pebbles
409	Rāhui Tapu 2010	1717752	6104908	14/05/2025	9	Mixed
405	Rāhui Tapu 2010	1718279	6104631	14/05/2025	21.3	Sand
938	Restricted 2023	1717845	6105251	7/05/2025	18.6	Sand
958	Restricted 2023	1717977	6105760	14/05/2025	23	Reef
943	Restricted 2023	1719811	6106135	14/05/2025	26	Pebbles
957	Restricted 2023	1720231	6106132	14/05/2025	28.7	Reef
940	Restricted 2023	1718053	6106247	14/05/2025	30.5	-
941	Restricted 2023	1718539	6105908	14/05/2025	28.7	Mixed
944	Restricted 2023	1720644	6106024	14/05/2025	21.5	Sand
945	Restricted 2023	1720983	6106452	14/05/2025	22.5	Sand
942	Restricted 2023	1719004	6106190	14/05/2025	34	Pebbles
956	Restricted 2023	1720870	6106901	14/05/2025	24.5	Reef
946	Restricted 2023	1721108	6107160	14/05/2025	17.5	Reef

Appendix 2. MaxN snapper and MaxN snapper biomass for sites sampled in 2025.

Site	Area	Depth	Substrate	Deployment quality	Max N snapper	MaxN snapper Biomass (kg)
947	Rāhui Tapu 2023	15	Mixed	Ok	18	9.08
948	Rāhui Tapu 2023	-	-	Not sampled	-	-
949	Rāhui Tapu 2023	14	Reef	Bad	-	-
950	Rāhui Tapu 2023	18	Sand	Good	41	26.66
951	Rāhui Tapu 2023	17	Sand	Good	31	17.02
952	Rāhui Tapu 2023	20.9	Sand	Good	31	21.42
953	Rāhui Tapu 2023	17.2	Reef	Bad	-	-
954	Rāhui Tapu 2023	18	Pebbles	Good	26	9.81
930	Rāhui Tapu 2023	39	-	Bad	-	-
402	Rāhui Tapu 2010	38	Sand	Good	25	22.58
502	Rāhui Tapu 2010	16.7	Pebbles	Good	17	22.63
403	Rāhui Tapu 2010	22.4	Mixed	Good	21	7.31
404	Rāhui Tapu 2010	20.8	Sand	Good	11	3.93
503	Rāhui Tapu 2010	24.9	Sand	Good	16	21.18
405	Rāhui Tapu 2010	21.3	Sand	Good	42	33.02
406	Rāhui Tapu 2010	22.8	Sand	Good	22	29.97
407	Rāhui Tapu 2010	24.1	Sand	Good	23	41.98
408	Rāhui Tapu 2010	36.0	Sand	Good	17	13.29
409	Rāhui Tapu 2010	9.0	Mixed	Good	16	8.43
938	Restricted 2023	18.6	Sand	Good	31	7.70
958	Restricted 2023	23	Reef	Ok	5	1.27
940	Restricted 2023	30.5	-	Bad	-	-
941	Restricted 2023	28.7	Mixed	Good	19	5.42
942	Restricted 2023	34	Pebbles	Good	8	3.97
943	Restricted 2023	26	Pebbles	Good	24	12.28
957	Restricted 2023	28.7	Reef	OK	14	4.93
944	Restricted 2023	21.5	Sand	Good	39	8.59
945	Restricted 2023	22.5	Sand	Good	43	7.17
956	Restricted 2023	24.5	Reef	Bad	-	-
946	Restricted 2023	17.5	Reef	Bad	-	-

Appendix 3. Species count data for sampling sites at Rākaumangamanga in 2025.

Species counts in 'Rāhui Tapū 2023' area, in 2025.

Fish species	Scientific name	947	950	951	952	954
Snapper	<i>Chrysophrys auratus</i>	18	41	31	31	26
Trevally	<i>Pseudocaranx dentex</i>	2	4	6	3	
Porae	<i>Nemadactylus douglasii</i>					
Kōheru	<i>Decapterus koheru</i>					
Grey moray eel	<i>Gymnothorax nubilus</i>					
Crimson Cleaner wrasse	<i>Suezichthys aylingi</i>					
Kahawai	<i>Arripis trutta</i>		1	1	2	
Demoiselle	<i>Chromis dispilus</i>			1		
Kingfish/Haku	<i>Seriola lalandi lalandi</i>	1			1	
Goatfish	<i>Upeneichthys porosus</i>			1		5
Leatherjacket/Kōkiri	<i>Meuschenia scaber</i>	1				
Redpigfish/Paakurakura	<i>Bodianus unimaculatus</i>		1	1		1
Sweep	<i>Scorpius aequipinnis</i>			1		
John Dory/Kuparu	<i>Zeus faber</i>	1				1
Sandagers Wrasse	<i>Coris sandeyeri</i>					
Orange Wrasse	<i>Pseudolabrus luculentus</i>					
Hiwihiwi	<i>Chironemus marmoratus</i>					
Spotted Moray	<i>Gymnothorax prionodon</i>					1
Yellow Morray	<i>Gymnothorax prasinus</i>					
Red moki	<i>Cheilodactylus spectabilis</i>					
Eagle ray	<i>Myliobatis tenuicaudatus</i>					
Silver Drummer	<i>Kyphosus sydneyanus</i>			1		
Comb wrasse	<i>Coris picta</i>					
Clown Toby	<i>Canthigaster callisterna</i>					
School shark	<i>Galeorhinus galeus</i>					

Species counts in 'Rāhui Tapū 2010' area, in 2025.

Fish species	Scientific name	402	403	404	405	406	407	408	409	502	503
Snapper	<i>Chrysophrys auratus</i>	25	21	11	42	22	23	17	16	17	16
Trevally	<i>Pseudocaranx dentex</i>			5		1	3	1	1	3	15
Porae	<i>Nemadactylus douglasii</i>										
Kōheru	<i>Decapterus koheru</i>										
Grey moray eel	<i>Gymnothorax nubilus</i>								1		
Crimson Cleaner wrasse	<i>Suezichthys aylingi</i>										
Kahawai	<i>Arripis trutta</i>		1							2	
Demoiselle	<i>Chromis dispilus</i>		13								
Kingfish/Haku	<i>Seriola lalandi lalandi</i>	2					1				
Goatfish	<i>Upeneichthys porosus</i>		1						1		
Leatherjacket/Kōkiri	<i>Meuschenia scaber</i>	1									
Redpigfish/Paakurakura	<i>Bodianus unimaculatus</i>	3	2		1			1	1	2	
Sweep	<i>Scorpius aequipinnis</i>	1								1	
John Dory/Kuparu	<i>Zeus faber</i>				1						
Sandagers Wrasse	<i>Coris sandeyeri</i>)				1				2		
Orange Wrasse	<i>Pseudolabrus luculentus</i>		1								
Hiwihiwi	<i>Chironemus marmoratus</i>										
Spotted Moray	<i>Gymnothorax prionodon</i>		2								
Yellow Morray	<i>Gymnothorax prasinus</i>	1								1	
Red moki	<i>Cheilodactylus spectabilis</i>	1									
Eagle ray	<i>Myliobatis tenuicaudatus</i>										
Silver Drummer	<i>Kyphosus sydneyanus</i>										
Comb wrasse	<i>Coris picta</i>										
Clown Toby	<i>Canthigaster callisterna</i>										
School shark	<i>Galeorhinus galeus</i>										

Species counts in 'Restricted 2010' area, in 2025.

Fish species	Scientific name	938	941	942	943	944	945	957	958
Snapper	<i>Chrysophrys auratus</i>	31	19	8	24	39	43	14	5
Trevally	<i>Pseudocaranx dentex</i>		32	1	7	11			
Porae	<i>Nemadactylus douglasii</i>	1	1	2		1		1	
Kōheru	<i>Decapterus koheru</i>					2			
Grey moray eel	<i>Gymnothorax nubilus</i>			3			4	3	13
Crimson Cleaner wrasse	<i>Suezichthys aylingi</i>								
Kahawai	<i>Arripis trutta</i>								
Demoiselle	<i>Chromis dispilus</i>							54	
Kingfish/Haku	<i>Seriola lalandi lalandi</i>				2				
Goatfish	<i>Upeneichthys porosus</i>	1					1	2	1
Leatherjacket/Kōkiri	<i>Meuschenia scaber</i>		1				2	1	
Redpigfish/Paakurakura	<i>Bodianus unimaculatus</i>	1				1	2	1	2
Sweep	<i>Scorpius aequipinnis</i>								
John Dory/Kuparu	<i>Zeus faber</i>								
Sandagers Wrasse	<i>Coris sandeyeri</i>)	1	1						1
Orange Wrasse	<i>Pseudolabrus luculentus</i>							1	1
Hiwihiwi	<i>Chironemus marmoratus</i>						1		
Spotted Moray	<i>Gymnothorax prionodon</i>								
Yellow Morray	<i>Gymnothorax prasinus</i>							1	2
Red moki	<i>Cheilodactylus spectabilis</i>								
Eagle ray	<i>Myliobatis tenuicaudatus</i>	1							
Silver Drummer	<i>Kyphosus sydneyanus</i>								
Comb wrasse	<i>Coris picta</i>						1		
Clown Toby	<i>Canthigaster callisterna</i>		1		2				
School shark	<i>Galeorhinus galeus</i>				1				

Appendix 4. Bad deployments at Rākaumangamanga in 2025.

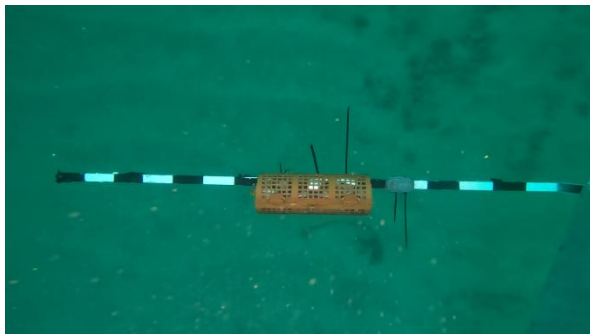
Site	Quality	Notes
953	Bad	Gear is sitting on the reef, edge so half the field of vision is compromised. There is also kelp interfering with the image
949	Bad	Images obscured by kelp
930	Bad	Gear not on seabed
940	Bad	Gear is dragged across reef
958	Ok	Reef - kelp partly obscuring vision
956	Bad	Gear is sitting on the reef, edge so half the field of vision is compromised. There is also kelp interfering with the image.
946	Bad	Image almost completely obscured by kelp.



953 - Gear on reef edge



949 - Images obscured by kelp



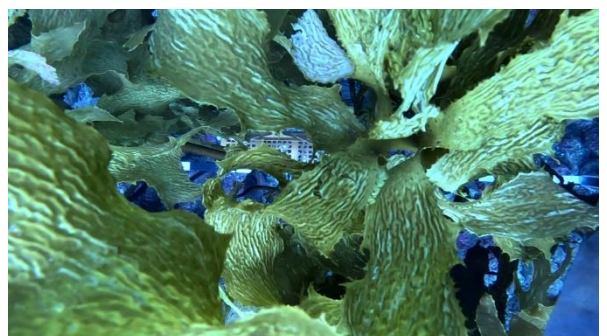
930 – gear not on seabed



940 – gear being dragged across reef



956 - Gear is on the reef & kelp interfering with the image



946 - Image almost completely obscured by kelp.

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