I TE KŌTI TAIAO Ō AOTEAROA
IN THE ENVIRONMENT COURT
OF NEW ZEALAND

ENV-2019-AKL-117
ENV-2019-AKL-127

UNDER	the Resource Management Act 1991 (the Act)
IN THE MATTER OF	appeals pursuant to Clause 14 of the First Schedule of the Act against decisions of the Northland Regional Council on the proposed Northland Regional Plan
BETWEEN	**Bay of Islands Maritime Park Incorporated** ENV-2019-AKL-117
	The Royal Forest & Bird Protection Society of New Zealand Incorporated ENV-2019-AKL-127
	Appellants
AND	**Northland Regional Council**
	Respondent

STATEMENT OF EVIDENCE OF VINCE KERR ON BEHALF OF TE URI O HIKIHIKI HAPU

DATED 25th March 2021

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Qualifications and Experience

1. My name is Vincent Carlyle Kerr. I hold a Bachelor of Biological Science degree from the University of Oregon, USA and a National Diploma in Horticulture from the Royal Institute of Horticulture, Lincoln College. I also hold teaching qualifications at High School and Tertiary level. I am a member of the New Zealand Marine Sciences Association. I have been a keen diver and observer of the natural world since childhood. My experience relevant to this evidence is as follows.

2. I am a principal of Kerr & Associates and engaged in environmental consulting with a focus on marine ecology monitoring, habitat mapping and marine protected area design and planning. I have worked as a marine technical officer for Northland Conservancy, Department of Conservation (DOC). I have also worked as a contractor and consultant in marine and freshwater ecology for DOC in Northland. Relevant technical reports and publications that I have authored or contributed to, are identified below.

3. I am a co-founder of the Northland-based Mountains to Sea Conservation Trust, which is among New Zealand's largest marine and freshwater environmental education providers. I currently serve as a science advisor for the Trust and support a number of hapu and community conservation projects as part of the Trust's community engagement program.

4. Over the past twenty years I have led numerous marine habitat mapping projects, coastal inventories, ecological descriptions and have established a number of survey and monitoring programs around Northland. I have been an active diver and marine photographer here in Northland and throughout the central Pacific. My work in the Pacific has been focused on coral reef fish ecology and biodiversity surveys and exploration of remote reef systems in the Pacific.

5. Marine science investigations have been carried out at Mimiwhangata since the early 1970s. There are 34 technical reports and published research papers that specifically involve work at Mimiwhangata. Attachment 1 lists those investigations. My involvement with the science work at Mimiwhangata began in 1999 working as a contractor for the Department of Conservation. I have been involved in various capacities with all investigations and reports from 2002 onwards.

Code of Conduct

6. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014 and agree to comply with it. The contents of this statement are within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed in this statement.

Scope of Evidence

7. I have been asked by Te Uri o Hikihiki to present evidence to the Court, in relation to the matters identified below. In addition, I have been asked by the hapu to give my account of how the partnership between the science investigations and the hapu has worked and benefited both the progress of the science and the understanding of the relevant ecological values.

8. This evidence is structured as follows:

    a. Summary of the history of science research and monitoring investigations
    b. Summary of the ecological implications from the various investigations
    c. The significant contribution from the mātauranga Māori of Te Uri o Hikhiki and leadership of the kaumātua
    d. Habitat mapping at Mimiwhangata and adjoining waters and associated investigations

e. Ecological importance of the deep reefs of Area C and vulnerability of these habitats
f. Decline of algal forests
g. Studies of crayfish abundance and ecology and what we learned about partial protection
h. A summary of fish abundance and the lack of recovery at Mimiwhangata
i. Additional biodiversity notes from Mimiwhangata investigations
j. Conclusion

Executive Summary

9. This evidence summarises research and monitoring investigations at Mimiwhangata carried out between 1973 and 2011. Mimiwhangata ranks amongst the most significant sites in New Zealand from a science perspective. Of particular significance is the long-term nature of the data sets for fish and crayfish and which stretch back into the 1980's. These studies have the added advantage of being paired with the same methods used at the full no-take Tawharanui Marine Park. The results have been published internationally and show that the full no-take reserve was effective in restoring key species exploited by fishing and reversed long-term trophic cascades resulting in algal forest decline. Partial protection where some fishing is allowed to continue did not lead to recovery in species or return of the algal forest. Detailed habitat mapping studies have been carried out in 1973 and 2005 and allowed for analysis of historic aerial imagery dating back to 1950. Results showed that there has been significant loss of the shallow algal forest since the seventies coinciding with increased fishing pressure. The various habitat mapping projects have also provided us with an accurate picture of the deep reef habitats offshore of Mimiwhangata allowing us to begin to appreciate the ecological connectivity between these deep and shallow habitats and their importance generally. Associated studies in other Northland sites support the understanding of the mechanisms at play with the

algal forest loss. They also provide us with an understanding of the process of recovery within full no-take reserves.

10. The proposals put forward by Te Uri o Hikihiki provide an opportunity to reverse the habitat and species declines that are an impact of localised long-term over-fishing. The protection areas and have been designed over a long process of comparing monitoring and research results and protected area design principles with their cultural knowledge and experience. The ecological studies and potential benefits identified in my opinion strongly support this proposal.

Ecological Investigations and Research at Mimiwhangata[1]

11. In the early 1970s Mimiwhangata was owned by NZ Breweries, which commissioned a series of studies (1,2&3) to document the environmental values of the area including the waters of Mimiwhangata. As part of that study the marine ecology team of the late Dr. Bill Ballantine (Auckland University), Dr. Roger Grace (independent scientist) and Wade Doak (marine explorer and author) were brought together. In 1972 and 1973 they completed extensive survey work over the area we now know as the Marine Park. As part of this work, they completed an ecological report and the first subtidal marine habitat map in New Zealand (3). They developed principles and methods for this mapping that form the basis of what we still use today. The Mimiwhangata habitat map was added to by Dr. Grace with a further area covered at adjoining Paparahi Point in 1981 (7). In both habitat maps the kina grazed zone where the shallow *Ecklonia radiata* forest was degraded covered significant areas. This indicates that as far back as the 1970s, overfishing was affecting the ecology of the shallow reefs, although the link between overfishing and the decline of the algal forests was not fully understood at the time.

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[1] Note the numbers in parenthesis following references to research and monitoring reports refer to the numbered list of Mimiwhangata research reports in Attachment 1.

12. In 1976 Dr. Grace set up a monitoring program for the area which focused on species that were thought to be affected by fishing pressure. Permanent transects were established to track abundance of reef fish, crayfish, mussels, tuatua, rock oysters, and scallops. Monitoring reports were completed regularly up until 1986. These reports showed that generally reef fish abundance levels were static over the period with abundance levels generally low and large individuals generally missing from the populations. Mussels, tuatua, rock oysters and scallops were in decline. The Marine Park was fully established in 1984 with the removal of all commercial fishing from the Park. By 1987 Dr. Grace had growing concerns that kina barrens were increasing and there was no apparent recovery of crayfish or fish from what he then described as an overfished state. At this time, the ecological significance of the increasing kina grazed zone was not fully understood. Based on these first periods of monitoring, in 1987 Dr. Grace made the case that the current partial protection approach should be carefully monitored to ascertain if recovery of habitat, reef fish and crayfish was occurring under the Marine Park management rules. Unfortunately, for various reasons monitoring ceased in 1986.

13. The various reports of the first era of investigation paint an accurate picture of the special nature of the Mimiwhangata coastal habitats and the adjoining deep reefs. They describe the wide range of habitats and exposures occurring there, the small offshore islands and the effects of the offshore subtropical currents sweeping around the peninsula and islands extending seaward into deeper waters. They document the presence of a variety of sub-tropical fish species and invertebrates, commenting that the special nature of Mimiwhangata's habitat support a diversity of reef fish species comparable to the some of the best locations in Northland. In the early 1970s, Dr. Grace and Wade Doak explored with scuba dives out to the edge of what we now refer to as the deep reef at Mimiwhangata (4). Their dives went to approximately 47m depth and 1 km offshore, which is approximately the existing boundary of the Marine Park. On these dives they observed a rich and diverse filter feeding community with large areas of pink

Gorgonians *Primoides sp.* and the rarely seen *Occulina virgosa*, often referred to as ivory coral, and Antipatharian black coral. They noted the richness of this sponge and Gorgonian dominated habitat and commented that it could well extend further to the east into deeper waters. They also noted that these deeper reef habitats could play a very important role in the ecology of the Mimiwhangata marine area and that they were biologically rich.

The second era of Mimiwhangata science investigation 1999-2011

14. In the period between 1986 and 1999 Mimiwhangata came into government ownership, with DOC having management responsibility for the land and the Ministry of Fisheries having responsibility for compliance with the regulations applying to the Marine Park. In this period of 13 years there was no program of marine monitoring and the compliance effort was limited to signage and DOC officers reminding visitors of the regulations.

15. In 1999 I was tasked to plan and implement an investigation into the effectiveness of the Marine Park arrangement at Mimiwhangata. This program of work was carried out in the years between 1999 and 2011. The initial objectives of the project were identified as follows:

    a. Engage with the hapu and seek their support and guidance for the investigation and shaping of future options
    b. Review what was learned from the previous monitoring program and what methods should be carried forward
    c. Identify key monitoring and research questions, objectives and updated survey and research methods to support the investigation

16. In the planning stage of the second investigation an expert group was established consisting of myself, Dr. Grace, Dr.Babcock, Dr Ballantine and Dr Shears from the Leigh laboratory of Auckland University (the Expert Group). Some Auckland University scientists

were at that time doing leading work on the effectiveness of full no-take reserves and the recovery of exploited fish species, crayfish and algal forests. The Auckland University scientists were particularly interested in the value of the long-term studies of a partial protection at Mimiwhangata, which was paired with the full no-take area of Tāwharanui Marine Park. At that time there was a paucity of evidence in the international literature and in New Zealand on the effectiveness of the various forms of partial protection in restoring or protecting biodiversity, habitats or fisheries. The collective advice from the Expert Group to DOC regarding Mimwhangata in 2000 was:

a. While the work at Mimiwhangata stretching back to the 1970s offered one of New Zealand's best long-term monitoring data sets, it lacked a clear baseline in which to compare results to. In the 1970s a decline in algal habitats and reef fish abundance was already suspected. Also, there were no adequate reference areas without fishing impacts represented in the monitoring. This conclusion was formed and supported by research work on recovery of algal forest and reef fish ecology being studied at the Leigh Marine Reserve.

b. The extensive historical knowledge of Mimiwhangata held by the local hapu, Te Uri o Hikihiki, would be invaluable to guide us in understanding what could be considered a natural baseline for this area and this would be of great benefit to the study of ecology there.

c. The early-period permanent transects established for reef fish and crayfish should be preserved on the basis of their high value as a long-term data set and usefulness to indicate change over time. Alongside this, set up a monitoring system utilizing baited underwater video (BUV) and randomized underwater diver (scuba) census (UVC) transects. This system would be randomized and include reference areas to the northwest and southeast of the

Marine Park. A similar UVC transect should be set-up for crayfish. This combined monitoring design would allow for current statistical methods of analysis to be applied as well as providing a basis for linking the new investigation to other similar investigations in northeast New Zealand and the long-term data set at both the partial protection area of Mimiwhangata and the no-take then Marine Park at Tāwharanui.

d. The 1973 habitat map at Mimiwhangata needed to be updated adding adjacent areas on all sides of the Marine Park including the deep reefs outwards to depths of 100m.

17. In 2001, a second period of investigation began. The findings can be summarised under three broad themes:
    a. reef fish
    b. crayfish; and
    c. habitat mapping.

18. Over this period of investigation, the scientists (including myself) received various contributions of historic ecological knowledge from the kaumātua of Te Uri o Hikihiki.

19. I have read the evidence of Dr. Shears dated 19 March 2021 that provides the science overview of the ecological significance of the area, being the shallow coastal area of Mimiwhangata and the deep reef areas off Mimiwhangata extending to Cape Brett paragraphs (18-24). The evidence of Dr. Shears captures the key findings of the Expert Group over this second stage of investigation. I agree with the evidence of Dr. Shears as reflecting the ecological findings from the second period of investigation. I also agree with the conclusions that Dr. Shears has drawn in his evidence at [(25-28). Additionally, in paragraphs (29-38) Dr. Shears summarises the current knowledge of the impacts of fishing on these habitats especially in the shallow areas resulting in the loss of keystone predators which regulate kina grazing,

leading to catastrophic decline of our shallow algal forests at Mimiwhangata and more generally on Northland's east coast. I agree with Dr. Shears conclusions in paragraphs (29-38).

Mātauranga and leadership from Te Uri o Hikihiki

20. Early in the second period of the investigations, a strong working relationship was growing between Dr. Grace, myself and the kaumātua of Te Uri o Hikihiki. This relationship was based on the sharing of knowledge. Over time, Dr Grace and myself became increasingly aware of the significance and extent of their knowledge of the area and its value. It helped that the two leading kaumātua, the late Houpeke Piripi and Puke Haika, were life-long divers and fishers and were from families which were likewise in the true sense "people of the sea". Houpeke was a renowned historian in a traditional sense and Puke was hugely experienced as a diver and had a keen interest in traditional knowledge. These kaumātua were wanting to assert their traditional authority in the form of restoring 'life' back to Mimiwhangata.

21. Every year we would have several meetings where Dr. Grace and I would share descriptions of what we were doing and seeing and then Houpeke and Puke would relate their experience and knowledge where relevant to our research. This body of traditional knowledge and observations was often recounted in detailed direct observations going back several generations, which pre-dates industrialised fishing in this area and extends to pre-European times. I will recount some of these observations and descriptions as I go through the ecological information below.

Habitat mapping at Mimiwhangata

22. Three habitat maps have been completed with varying coverage of Mimiwhangata. These studies involve analysis of aerial imagery, various forms of sonar data and ground truthing surveys using ROV or drop cameras and sediment sampling and in some case scuba dives. Figure 1 below shows the spatial relationship

between the two fine-scale mapping studies (1973 and 2005) and additionally the 1981 Paparahi Point map. All of these methods and the mapping processes unveil a lot of information about the characteristics of the areas involved. The maps have shown themselves to be a valuable tool for planning and designing marine protected areas, assessing ecological significance, describing marine communities and identifying spatial areas of habitats to be used as proxies for ecological communities.

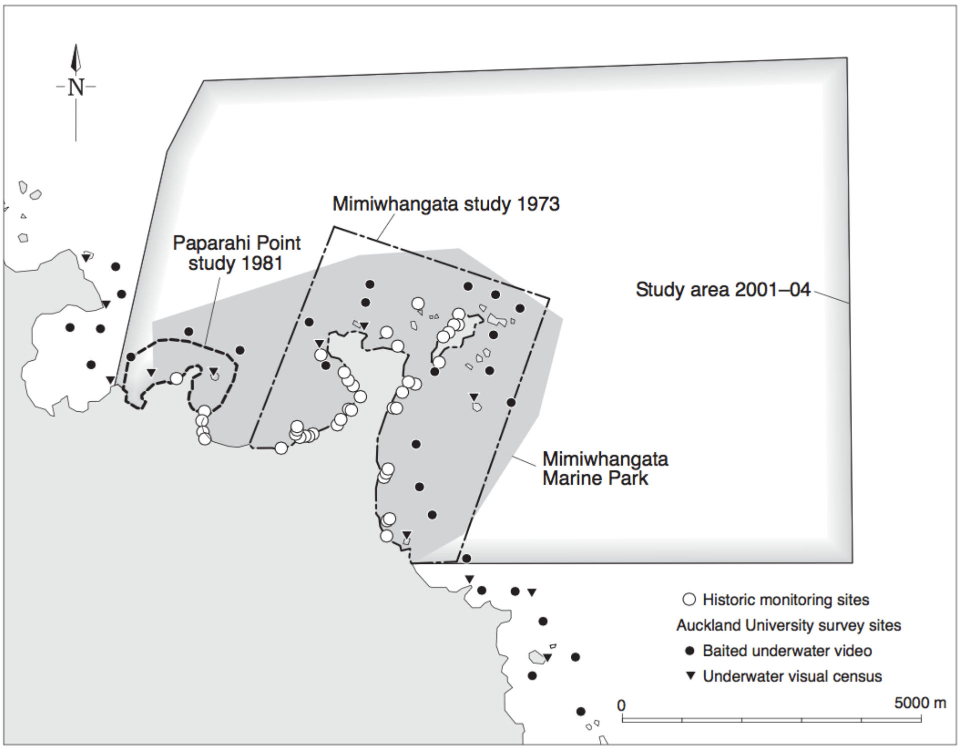

Figure 1 Survey sites at Mimiwhangata established in 1976 by Dr. Grace and the three areas where habitat mapping was completed.

23. The mapping designed around Mimiwhangata in 2005 was completed at a relatively fine scale with most of the map drawn at 1:500 scale. This supported accurate mapping of kina barrens and a more refined habitat classification. The 2005 map further defines and reinforces the descriptions of the special and significant aspects of the area alluded to in the 1973 report (4). The 2005 habitat map is attached as Attachment 3. The ecological

descriptions in the 1973 report were confirmed and extended to a larger spatial area and deep reefs.

24. Mimiwhangata has a very complex coastline creating a great diversity of habitats characterised by varying topography of the sea floor substrates and exposure. The peninsula and the outer islands project eastwards out into oceanic waters and the subtropical currents in warmer months. All these characteristics result in increased shelter, feeding opportunities, and upwellings that result higher plankton productivity and availability to planktivorous fish species. These elements of diversity attract more predators. Importantly, around Mimiwhangata there is a lot of ‘edge’ between reef both deep and shallow and a wide diversity of soft sediment habitats. These edges are known to be very productive. Many species find advantages in foraging for food in both areas and seek shelter and protection from the reef structures.[2] The significance of this complex diversity of habitat at Mimiwhangata cannot be understated and is only really equaled in the Bay of Islands with its diverse array of islands. Mimiwhangata however also combines a strong oceanic influence and proximity to deep habitats, similar to biodiversity hotspots Cape Brett and the Karikari Peninsula. Mimiwhangata also shares another significant feature with both the Karikari Peninsula and Cape Brett in that it has excellent connectivity with a large area of offshore deep reef. Some areas within the system have complex vertical structures and topography. These high relief areas of deep reef support the highest productivity and diversity of filter feeding communities due to greater current and upwelling effects. All this complexity translates to the areas becoming fish and biodiversity hot spots. I will make further comment on the deep reefs of the proposed Area C in paragraphs (30-35) below.

Tarakihi, Hāpuku and traditional habitat knowledge

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[2] Langlois, T.J., Anderson, M.J., Babcock, R.C., 2005. Reef-associated predators influence adjacent soft-sediment communities. Ecology 86, 1508–1519.

25. During the habitat mapping process at Mimiwhangata two significant descriptions of habitats emerged from the kaumātua. The first was a description of an important traditional tarakihi, *Nemadactylus macropterus*, fishing ground.

26. In 2006 while out on a boat offshore north of Mimiwhangata, the kaumātua recalled how they navigated to this ground via triangulation with land features. They regularly fished on this ground and normally easily caught fish at the right time of year. In the years prior to that boat trip, this fishing ground had disappeared. Following this trip, I mapped the triangulation on the habitat map. The ground was located at a prominent edge and corner of one portion of the deep reef, which is the sort of habitat I would expect a 'fishing ground' to be for this species.

Hāpuku at Mimiwhangata

27. Another traditional fishing ground of great significance to the hapu was a hāpuku, *Polyprion oxygeneios*, ground about 1.5km off the coast of Rimariki Island. The kaumātua recounted how they would several times a year at just the right time and weather pattern row out to this ground. At a specific location they would anchor and fish. They again used triangulation of landmarks to navigate to this spot. At this specific location they would regularly catch large hāpuku. When I asked what was large they described a fish that would have been in excess of 50kg. When I mapped this area over the habitat map it was in the middle of the high relief deep reef at 45-50 depth, where we would expect a biodiversity hotspot to be and a perfect habitat for hāpuku.

28. This hāpuku ground also was in the vicinity of the exploratory deep dives that Dr. Grace and Wade Doak completed in the 1970s, which led to their description of the 'remarkably rich deep reef' at Mimiwhangata. We can only ponder how the hapu had such accurate information of these offshore habitats. When I showed them the habitat map and the imagery we had collected they were

interested and amused, but were in no way surprised that they had identified these special areas out of many square miles of ocean.

29. Hāpuku were once an important predator in these 50m reefs. Now even in the shallow reefs they are locally extinct and play no part of their ecological role in these waters of less than 100m. The role of overfishing in this story is significant.

Figure 2 This photo was taken by Dr. Grace when hāpuku could still be seen in diving depths at the Poor Knights Islands.

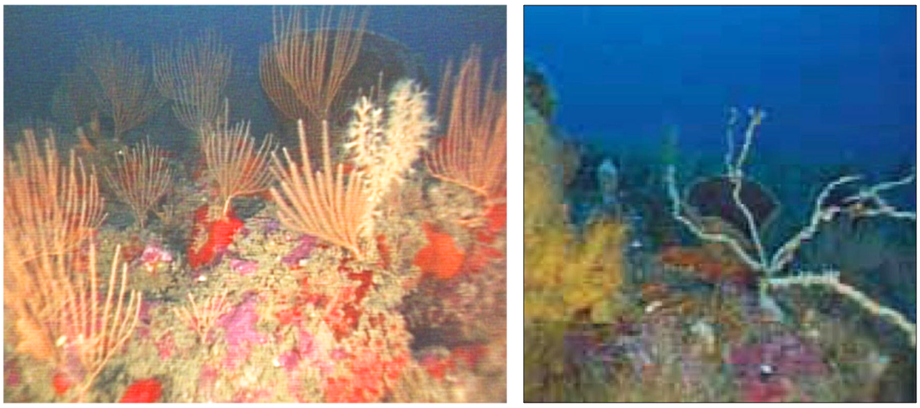

Figure 3 Images of diverse and productive filter feeding invertebrate communities captured on the high relief deep reefs at 50m depth, approximately 1.5 km off Rimiriki Island. (right) an example of a health

community of pink gorgonian fan corals with a large cup sponge in the background and a white Zoanthid species, the understory of this community is a complex mixture of encrusting sponge species; Bryozoans and many other encrusting invertebrate forming a complete cover of the reef and 3-dimensional structure which is home to a large community of reef dwelling invertebrates and fish that feed on this resource. (left) a complex filter feeding community with a large cup sponge in the background and an *Antipatharia* black coral (seen as white) in the foreground. The black coral is protected in all NZ waters by the Wildlife Act.

30. The 2009 Northland map (30) and the data supplied by the Ocean's 2020 survey project for the first time allowed us to see the spatial extent of the offshore deep reefs along Northland's entire east coast. The map in Attachment 4 shows the offshore deep reefs, as well as an indication of the surface topography made by using a type of 3D contour map derived from the Ocean's 2020 multi-beam data.

31. In my opinion, this series of deep reefs is highly significant regionally and also nationally. This conclusion is based on the many survey projects I have participated in in Northland, which have involved sonar and video data collection, as well as a working familiarity with the literature in New Zealand on this subject. I will summarise some key considerations:

    a. The deep reefs in the Area C Protection area extend between the shallow reefs of Mimiwhangata to Cape Brett including depth zones from the edge of the shallow kelp covered reefs at 30m depth to over 100m depths.

    b. There are diverse and ecologically valuable invertebrate filter feeding communities that form the basis of many food chains and support coastal marine species in many ways during different parts of their life cycle.

c. The reefs have complex edges and large areas of soft bottom habitats associated that incorporate a great range of substrates and depths and therefore a corresponding diversity of benthic communities and the ecological functions they support.

d. In my experience of surveying and mapping these reefs, I point to their importance of representing a transition in a north south gradient between deep reefs to the south with more silt and influence of the fine sediment inputs of the Hauraki Gulf to the ‘cleaner reefs’ extending to the North, which have progressively less silt as you go northwards. I believe there is an important transition between Mimiwhangata and Cape Brett, which favors reef invertebrate filter feeding communities and increasing diversity of soft bottom invertebrate communities in association with more sandy and shelly substrates as you travel north up the coast.

e. The connectivity of these deep reefs with the two coastal areas of Mimiwhangata and Cape Brett is I believe significant, as they are both examples of our best coastal sites in terms of fish and habitat diversity and productivity associated with the sub-tropical currents running down the coast and large areas of complex reef.

f. Ecologically these deep reefs would stand out for their biodiversity value and would be ideal representative areas of these habitats to support marine protection and support restoration of adjacent degraded shallow areas. There are currently no examples of this habitat represented in the marine protected area network in Northland.

g. There is a clear threat from any bottom disturbance on these deep rock reefs from the 30m to 150-200m depths. Along Northland’s coast these reefs vary greatly in topography. Flatter reef areas and patch reefs of low relief have probably been most affected by bottom fishing gear, whereas the high relief areas of the reefs may be identified by fishers and not fished due to the expense of losing gear. However, high relief areas can be the most desirable for surface and mid-depth bulk fishing methods as they are often biodiversity hot-spots attracting fish of many species, especially predators. The deep reef filter feeding communities are especially vulnerable to any physical disturbance. Many of the larger species are very slow-growing, very delicate and easily removed from the system.

32. An important New Zealand study of the risk to soft bottom communities from fishing impacts was done in 1998,[3] and remains a clear statement on this subject. In this study in the Hauraki Gulf, 18 study sites were chosen along a gradient of fishing pressure. This summary is from the abstract:

    a. *Samples along a putative gradient of fishing pressure were collected from 18 sites in the Hauraki Gulf, New Zealand. After accounting for the effects of location and sediment characteristics, 15–20% of the variability in the macrofauna community composition sampled in the cores and grab/suction dredge samples was attributed to fishing. With decreasing fishing pressure we observed increases in the density of echinoderms, long-lived surface dwellers, total number of species and individuals, and the Shannon-Weiner diversity index. Our data provide evidence of broad-scale changes in benthic communities that can be directly related to fishing. As these changes were identifiable over broad spatial scales they are likely to have important*

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[3] Thrush, S.F., Hewitt, J.E., Cummings, V.J., Dayton, P.K., Cryer, M., Turner, S.J., Funnell, G.A., Budd, R.G., Milburn, C.J., Wilkinson, M.R., 1998. Disturbance of the marine benthic habitat by commercial fishing: Impacts at the scale of the fishery. Ecological Applications 8, 866-879.

> *ramifications for ecosystem management and the development of sustainable fisheries.*

33. In 2000 a research project led by Dr. Martin Cryer, then with NIWA, surveyed a large area of soft bottom habitat in the Far North off Spirits Bay. [4] In this study an unprecedented array of deep reef filter feeding communities was sampled. The findings revealed numerous new species of international significance and led to this area having a ban on bottom trawling and scallop dredging. This is a rare undisturbed 'shelf' soft bottom area which has such high biodiversity and scientific interest that it was viewed as warranting total protection from any bottom disturbance indefinitely. This rare investigation of a pristine 'shelf' site should shed considerable light on the wisdom of using these fishing methods in a reef/soft bottom complex like that off the coast of Mimiwhangata and Cape Brett or at the very least point to the scientific requirement to have a no-fished reference site against which fishing impacts can be evaluated rigorously.

34. In 2002 in a review paper by Dr. Cryer published in Ecological Applications,[5] large areas of seabed in the depth range of 200-600m were studied. Sixty-six research trawls were spread along an area of 220 km of seabed along a line of fishing pressure gradients. The study found that up to 40% of the invertebrate variation could be attributed statistically to fishing activity. In the discussion section of this paper Dr. Cryer reviewed a large list of ecosystem processes linked potentially to bottom disturbance via bottom trawling. Some 18 years ago when this paper was written Dr. Cryer drew attention to large scale ocean processes threats which may be associated with bottom trawling. In this excerpt Dr.

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[4] Cryer, M, O'Shea, S., Gordon, D., Kelly, M., Drury, J., Morrison, M., Hill, A., Saunders, H., Shankar, U., Wilkinson, M., & Foster, G. (2000). Distribution and structure of benthic invertebrate communities between North Cape and Cape Reinga. Final Research Report for Ministry of Fisheries Research Project ENV9805 Objectives 1 & 2.

[5] Cryer, M., Hartill, B., O'Shea, S., 2002. Modification of marine benthos by trawling: toward a generalization for the deep ocean? *Ecological Applications,* 12(6), 2002, pp. 1824–1839

Cryer was summarising concerns raised by international colleagues:

> a. *… switching off the "biological pump" (sequestration of atmospheric CO2 in deep-sea sediments) would have far more dire consequences than the loss of tens, hundreds, or even thousands of rare species (on which most conservation attention is focused). Thus, understanding and managing impacts on deep-sea benthos may be important for safeguarding ocean processes as well as sustainable fisheries.*

35. This above reference to large scale ecological processes impacted by fishing and bottom disturbance foreshadows a major study recently published in *Nature.*[6] This study reviews current knowledge on the impact of bottom disturbance on the ocean floor's role of sequestering carbon that falls to the seabed from the ocean's biological productivity. This organic carbon builds up on the ocean floor and is essentially trapped in layers of silt on the seafloor. Bulk fishing methods like bottom-trawling stir up this material enabling breakdown of the organic component releasing CO_2 into the water column which is released into the atmosphere. The global figure for the CO_2 released by this fishing impact is estimated at 1 gigaton of carbon/yr. To put this number in perspective, this number is similar to the CO_2 released each year by global commercial air travel. The study proposes that 30% of the areas currently fished with bottom disturbance methods should immediately be designated full no-take reserves. Their modeling shows that beyond the immediacy of climate change mitigation, there could be substantial fisheries benefits derived form this level of protection.

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[6] Sala, E., Mayorga, J., Bradley, D., Cabral, R. B., Atwood, T. B., Auber, A., Cheung, W., Costello, C., Ferretti, F., Friedlander A M, Gaines S D, Garilao C, Goodell W, Halpern B S, Hinson A, Kaschner K, Kesner-Reyes K, Leprieur F, McGowan J, Morgan L E, Mouillot D, Palacios-Abrantes J, Possingham H P, Rechberger K D, Worm B and Lubchenco J., 2021. Protecting the global ocean for biodiversity, food and climate *Nature* 1–6. Published online 17 March, 2021.

36. Decline of algal forests

37. The 2005 habitat mapping study of Mimiwhangata (25) accurately mapped the shallow habitats at scales of 1:500 or better. Spatial extent of potential shallow reef *Ecklonia radiata* habitat was calculated at 975 hectares with kina barrens making up 24.9% of that area. It is important to note that the shallow part of the *Ecklonia radiata* forest where this loss is occurring is the most productive zone of the forest due to the higher light levels driving photosynthesis of the algae. The accurate mapping was made possible by the use of aerial photography completed by Dr. Grace and myself. These images had to be carried out in ideal conditions to allow a view of the underwater features and habitat boundaries. An example of one of the oblique angle photos taken in this study is shown in Figure 4 below.

Figure 4 This image taken by Dr. Grace in 2003 was shot flying over the southeast corner of Rimariki Island looking southwest towards the shore of the Mimiwhangata headland. The lighter grayish looking patches are kina barrens.

Time series analysis of aerial imagery

38. As part of the 2005 study we were able to source good imagery from 1950. This allowed us to test the trophic change assumption that kina barrens at scale are not a natural condition. Figure 5 below shows a comparison of 1950 to 2003 of a shallow reef at Pa Point situated on the southwest end of Mimiwhangata Bay. In the 1950 image the dark solid cover on the reef represents a dense algal forest cover with no signs of kina barrens present. In the 2003 imagery you can see the bare rock appearance of the reef that is predominantly kina barren.

39. As we were doing this work on several occasions we asked the kaumātua Houpeke Piripi and Puke Haika if they recalled extensive kina barrens being present in the early days of their diving (which predates the 1970s). We also asked if there were any examples of descriptions of kina barrens in the historical accounts of their ancestors. The answer to these questions was consistently no, kina barrens were not present prior to the 1960-70s.

40. This account is entirely consistent with our findings of time series analysis in 2005. More recent time series studies have been completed in the Bay of Islands[7], in the Maitai Bay Rahui[8] and at the Leigh Marine Reserve[9]. At these three locations the same trend of decline from a full forest cover to extensive kina barren progresses from the 1970s onwards.

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[7] Booth, J. D., 2015. Flagging kelp: potent symbol of loss of mauri in the Bay of Islands. An essay prepared for Fish Forever, Bay of Islands Maritime Park Inc.

[8] Kerr, V.C., Rutene, W., Bone, O., 2020. Marine habitats of Maitai Bay and the exposed coast of the Karikari Peninsula. A report prepared for Te Whānau Moana/Te Rorohuri, Maitai Bay, Karikari Peninsula, Northland and the Mountains to Sea Conservation Trust.

[9] Leleu, K., Remy-Zephir, B., 2012. *Mapping habitats in a marine reserve showed how a 30- year trophic cascade altered ecosystem structure.* Biological Conservation, 155, 193–201

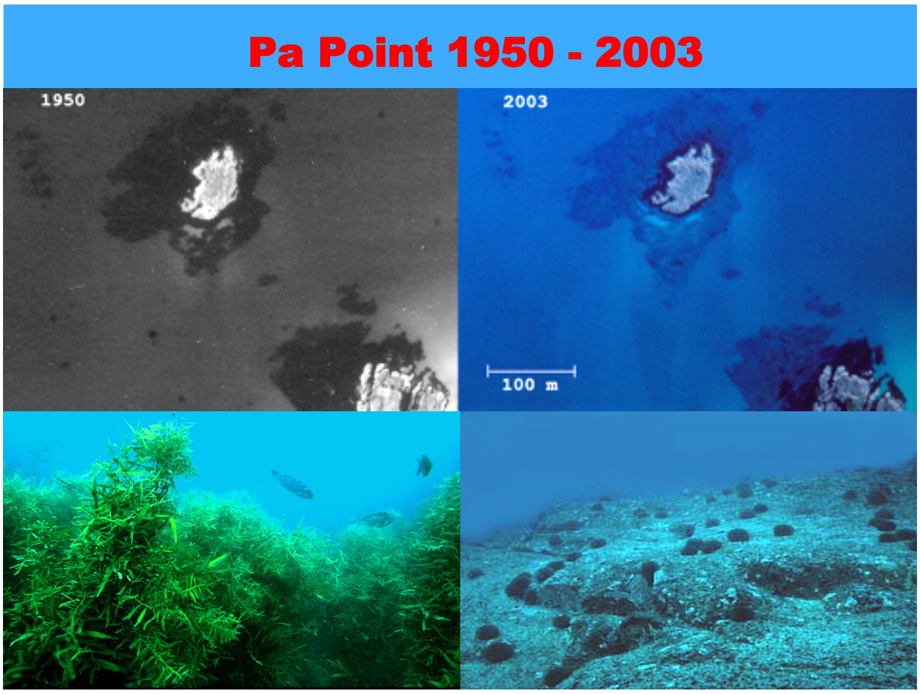

Figure 5 This time series imagery comparison between 1950 and 2003 shows a completely dense cover of kelp in 1950 contrasting with extensive kina barrens in 2003. The lower images show typical images of a healthy kelp forest and a mature kina barren. The kelp in the lower left image is the species *Carpophyllum flexulosum* that replaces or mixes with the common kelp species *Ecklonia radiata* where there is relatively low wave exposure, which is the case in this location at Pa Point. (Images Grace and Kerr)

41. In 2017 Dr. Grace and myself produced a GIS-based meta study of the extent of algal forest decline for Northland's east coast, (34) [10] which used mapping data of kina barrens from six locations stretching from Tāwharanui in the south to Doubtless Bay in the north and including Mimiwhangata. This estimate along with a review of the ecological implications of this decline and relationship with recreational fishing concentrating on shallow reef areas was prepared as a background technical report for the Motiti Rohe Moana Trust. The report also summarised the trends and conclusion from the international literature on the threat of

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[10] Kerr, V.C., Grace, R.V., 2017. Estimated extent of urchin barrens on shallow reefs of Northland's east coast. A report prepared for Motiti Rohe Moana Trust. Kerr & Associates, Whangarei.

overfishing and trophic cascade effect leading to algal forest decline. (See Attachment 5).

42. Based largely on this Northland work I provided ecological evidence for Motiti Rohe Moana Trust appeal in the Environment Court. In this evidence, I outlined in detail the ecological threat and loss associated with localised overfishing and commented on the management proposals by Motiti Rohe Moana Trust. I also proposed specific monitoring methodology and recovery thresholds which could form part of a management regime to track and evaluate the recovery of algal forests expected under medium to long term protection from fishing. [11] I believe this material is directly relevant to this case. (Attachments 5 & 6)

Monitoring restoration in the Rahui Tapu

43. If the Te Uri o Hikihiki proposals are adopted a practical, affordable and effective monitoring program is likely to be required. Fortunately at Mimiwhangata there is a lot of historic data and methodology to inform the next stage of work. There is also a proposed algal forest monitoring methodology to guide the implementation of rules restricting fishing to support ecological restoration, notably the algal forest. In both marine ecological research and fisheries management there is currently a great interest in the move to ecosystem-based management. The development of a method focused on algal forest health is an ecological process monitoring approach and will complement more holistic ecosystem management approaches.

Thresholds proposed to inform management actions (restrictions on fishing)

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[11] Kerr, V.C., 2018. Statement of evidence of V Kerr on behalf of Ngati Makino Heritage Trust (Environment Court), Kerr and Associates Whangarei, New Zealand

44. Based on the monitoring of the shallow portion of the reef classified as sea urchin preferred habitat, the following thresholds could be considered to trigger management arrangements:

45. **Level 1** 5-10% urchin barren extent signals concern that impacts of urchin barrens are becoming significant. If this level persists or expands and is supported by low reef fish diversity counts and low counts of large snapper *Pagrus auratus* and crayfish restrictions of fishing could be considered

46. **Level 2** >10% urchin barren extent which is persistent or expanding and supported by poor monitoring results for reef fish diversity, large snapper and crayfish counts. This level triggers consideration of long term no fishing protection to restore ecological balance and productivity of the reef. Decisions to remove the no-fishing restriction could be considered only after recovery of kelp forest had reached a level better than the Level 1 trigger and where sufficient representative areas in the management area remain as a network of fully protected areas to meet basic marine protection goals.

47. Fishing controls considered should include areas mapped as reef edge habitats and adjacent soft bottom habitats and extend offshore or beyond reef edges to a minimum distance of 2 km where possible. (For more detail and references see Attachment 5, Northland Algal Forest Study.)

48. There are other complimentary monitoring methods which could be adopted from the work done previously at Mimiwhangata. In 2005 Dr. Grace prepared a report for DOC entitled, ‘Towards a Monitoring Strategy for Mimiwhangata’ (24). In this report Dr. Grace explains in some detail the early monitoring methods and explains the changes and additions from the latter years. He gives a number of recommendations about future monitoring and the restoration process.

Crayfish *Jasus edwardsii*

49. Dr. Shears in his evidence effectively covers the implications of chronically low abundances of crayfish, *Jasus edwardii*, on Northland's east coast and generally what we have directly learned from work at Mimiwhangata, Tāwharanui and the Leigh Marine Reserve. I agree with the statements Dr. Shears has made in sections (29-43) regarding the performance and limitations of our fisheries management for crayfish on this stretch of coast.

50. I will now provide further detail of what has been learned from the ecological studies associated with Mimiwhangata and I will relate the science to the long-term ecological evidence held within the mātauranga Māori of Te Uri o Hikihiki.

51. In 2006 a paper was published by Dr. Shears and our monitoring team in the international literature which reviewed the full data set of crayfish monitoring at Mimiwhangata (partial protection with recreational fishing) along with data from Tāwharanui marine park (full no-take protection).[12] The Tāwharanui data included data from adjacent sites which were outside the Marine Park and served as fished reference sites. The results were described as follows:

    a. *On average, legal-sized lobster were eleven times more abundant and biomass 25 times higher in the no-take marine park following park establishment, while in the partially protected marine park (Mimiwhangata) there has been no significant change in lobster numbers. Furthermore, no difference was found in densities of legal-sized lobster between the partially protected marine park and nearby fully-fished sites (<1 animal per 500 m2). Long-term data from fully fished and partially protected sites suggest long-*

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[12] Shears NT, Grace RV, Usmar NR, Kerr V, Babcock RC (2006) Long-term trends in lobster populations in a partially protected vs. no-take marine park. Biological Conservation 132:222–231

> *term declines in lobster populations and reflect regional patterns in catch per unit effort estimates for the fishery. The long-term patterns presented provide an unequivocal example of the recovery of lobster populations in no-take MPAs, but clearly demonstrate that allowing recreational fishing in MPAs has little benefit to restoring populations of exploited species such as J. edwardsii.*

52. A version of these results can be seen in graphic form in Figure 6 below. The results are alarming and point to a collapse of crayfish at Mimiwhangata. Additional surveys at points north and south near but outside of Mimiwhangata showed similar results with very low levels of crayfish and no larger animals present.

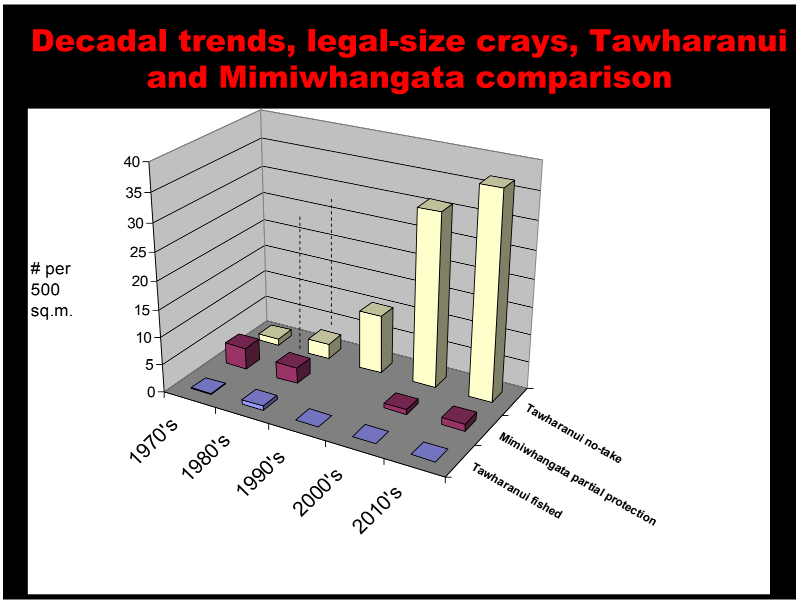

Figure 6 This graph shows the clear trends and contrast between a recovering population of crayfish in the Tāwharanui no take area and the very low levels persisting in the Marine Park at Mimiwhangata which are comparable to fished areas near the Tāwharanui Marine Park.

53. We had several discussions with the kaumātua Houpeke Piripi and Puke Haika about these results. They agreed with the description

that at Mimiwhangata numbers were extremely low with large animals being now very rare. In these descriptions they were quick to add how dramatic this decline has been compared to their early memories of the crayfish at Mimiwhangata and their historic record. Puke recited stories about their traditional method of catching crayfish which was in very shallow water where they would feel for the crayfish with their feet or simply see the antenae and then reach down and grab them. Puke also described the large crayfish that were common and in great detail. He had a particular method of catching very large packhorse crayfish well over 10kg in size. Puke would face the large animal as it challenged him approaching with antenae waving and large claws waving, then in one quick motion would throw a burlap sack over the animal's back and wrap up the animal in a bear hug before swimming to the surface and getting assistance to land the giant packhorse. Puke was a large and very powerful man but he described this encounter as one he approached with great caution. He told us the power in these animals' foreclaws could easily break bones in man's hand. Packhorse crayfish are now rarely seen at Mimiwhangata.

Figure 7 A historic photo showing the large crayfish that were once common on the Northland coast. Their large size enabled then to play a quite different ecological role to our current sparse population of sub-legal and barely-legal sized animals. A large crayfish can easily and quickly open the largest kina and virtually any shellfish species.

54. While the decline in numbers and standing biomass (loss of large animals) is concerning, there is also a growing story of the ecological consequences of allowing such prolonged fishing pressure. The large-scale loss of algal forest and its causes has been well documented. Removing medium to large crayfish form the system certainly contributes to the formation and persistence of kina barrens. There are also many more subtle impacts associated with population decline. There is a substantial body of literature in New Zealand that delves into these ecological consequences. Dr. Alison Diarmid wrote a review paper in 2012 that summarises what we know to date.[13] Dr. Diarmid reviewed historical accounts of crayfish abundance and ecology dating back to Cook's voyage which closely paralleled what we were told by the Mimiwhangata kaumātua.

55. I will briefly list the ecological concerns identified in her paper below:

    a. Fecundity in crayfish increases geometrically with size of female

    b. Female crayfish at mating time prefer 'large males'

    c. Large male crayfish can service many times more crayfish than smaller animals

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[13] MacDiarmid, A. B., Freeman, D., Kelly, S., 2013. Rock lobster biology and ecology: contributions to understanding through the Leigh Marine Laboratory 1962–2012, New Zealand Journal of Marine and Freshwater Research, 47:3, 313-333

d. Low abundance populations lacking in large animals may fail to effectively reproduce or do so at greatly reduced levels to a population with a more normal ages structure

e. Crayfish have complex social behaviours which varies with time of year around growth, moulting and mating periods. There is evidence that low abundance levels and impacted age structures can detrimentally affect these behaviours. There is evidence that recruitment on to reefs is reduced when there are no or few older crayfish present.

f. Crayfish periodically leave their home territory on the reef to feed on surrounding soft bottom habitats up to 4km from the home reef but typically 1-2kms. Management of fishing and design of protection and restoration areas needs to take these behaviours into account.

g. Research on diets has found that crayfish have a widely varying diet and may be important in grazing and control algal turf habitats that are often a response to long term persistence of kina barrens.

h. Loss of genetic diversity is a possiblity at such high fishing levels

i. Loss of habitat utilisation due to algal forest decline – most notably in the previously high productivity shallow portion of the *Ecklonia radiata* forests.

j. Four ecosystem New Zealand modeling studies for shallow coastal reefs were reviewed by Dr Diarmid which showed that crayfish have gone from being one of most important predators in the system to the least important in terms of biomass and impact – crayfish's role in the Hauraki Gulf was described as 'functionally extinct' in ecosystem terms.

Figure 8 A crayfish eating a pipi sitting in a shallow estuarine seagrass bed, illustrating the wide ranging ecological connections of this key species, taken in Parenenga Harbour (Kerr & Grace)

Reef Fish

56. Reef fish have been the subject of monitoring efforts at Mimiwhangata during both periods 1976 – 1986 (Grace) and 2001-2011 (Grace and Kerr) and (Auckland University). In the first period, the transect studies designed by Dr. Grace were paired with Tāwharanui Marine Park which had ‘no take’ status. In the later period the early period permanent transects were surveyed and Auckland University scientists set up a randomised sampling regime which offered the ability to compare Mimiwhangata to a range of other fully protected areas and reference fished areas. All of the studies that occurred at Mimiwhangata are referenced in Appendix 1. Of these reports there have been several internationally published papers reporting on the results. To summarise this large body of work I would like to quote from one of these published papers from the Auckland University work: (15)[14]

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[14] Denny CM, Babcock RC (2003) Do partial marine reserves protect reef fish assemblages? Biological Conservation 116:119–129

a. *Fish assemblages in the Mimiwhangata Marine Park, an area closed to commercial fishing but open to most forms of recreational fishing, were compared with adjacent fished areas. Two survey methodologies were used; baited underwater video and underwater visual census. Snapper (Pagrus auratus), the most heavily targeted fish species in the region, showed no difference in abundance or size between the Marine Park and adjacent control areas. When compared to the fully no-take Poor Knights Island Marine Reserve and two other reference areas open to all kinds of fishing (Cape Brett and the Mokohinau Islands), the abundance and size of snapper at the Marine Park were most similar to fished reference areas. In fact, the Marine Park had the lowest mean numbers and sizes of snapper of all areas, no-take or open to fishing. Baited underwater video found that pigfish (Bodianus unimaculatus), leatherjackets (Parika scaber) and trevally (Pseudocaranx dentex) were significantly more common in the Marine Park, than in the adjacent control areas. However, none of these species are heavily targeted by fishers. Underwater visual census found similar results with five species significantly more abundant in the Marine Park and five species more abundant outside the Marine Park. The lack of any recovery by snapper within the Marine Park, despite the exclusion of commercial fishers and restrictions on recreational fishing, indicates that partial closures are ineffective as conservation tools. The data suggest fishing pressure within the Marine Park is at least as high as at other 'fished' sites.*

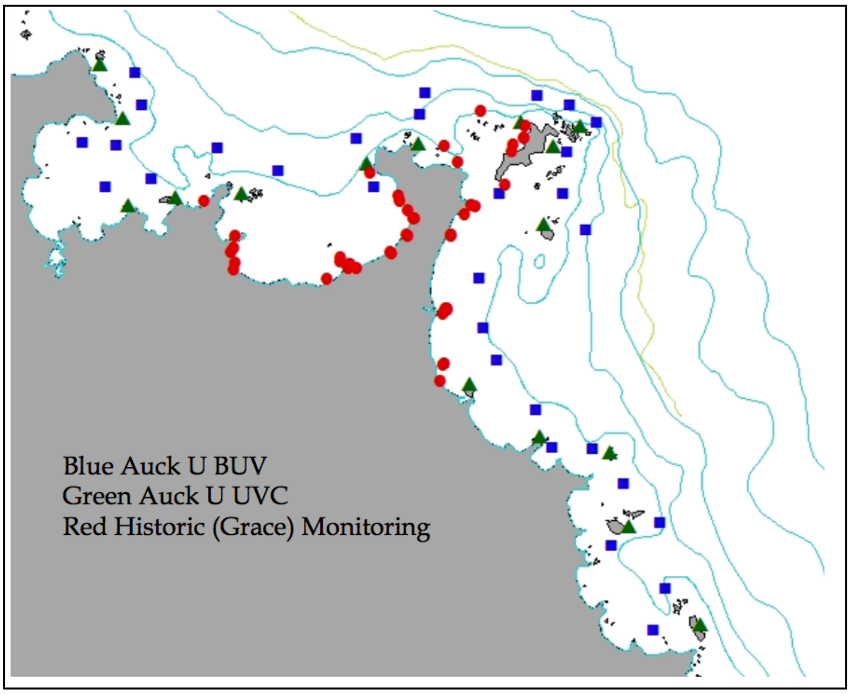

Figure 9 Sampling locations for reef fish at Mimiwhangata Park showing the permanent transects from the early period (Grace) and BUV and UVC sites established in the Auckland University survey.

57. Following the 2003 publications of results, monitoring continued for another period ending with the last survey in 2011. Results of BUV were reported by Buisson in (2009) (29). In this analysis, Mimiwhangata results were compared to the Poor Knights Islands, Cape Brett, Karikari Peninsula and North Cape. Overall results were quite similar to those reported by Denny (2003). Mimiwhangata results showed low counts and virtually no large fish and were comparable to the fished locations. However, in comparison to the snapper data at Poor Nights Marine Reserve which by 2009 had been in full no-take status as a marine reserve for ten years, there was a dramatic difference. Figure 10 below represents average biomass of the snapper per BUV drop. The Poor Knights level of biomass reflects a rapid recovery of snapper after 10 years of full protection (543% increase) resulting from the increased presence of large individuals. This is similar to the long-term recovery seen at Leigh Marine Reserve and is indicative of what a more natural age structure of a snapper population would

look like on our shallow reefs.

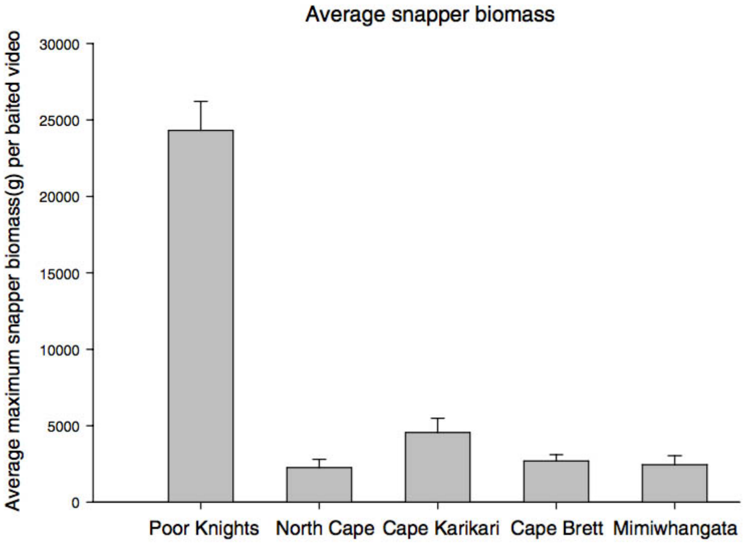

Figure 10 Average maximum snapper biomass per baited video in 2009 and standard error bars (from Buisson 2009)

58. The results of these surveys are clear evidence that there is a long-term impact of fishing popular species like snapper which is frequently spatially focused on areas like reefs and islands. The specific spatial nature of the impact of fishing close to shore and on and near reefs does not appear to enter into consideration within our fisheries management system. There is clear evidence that our history and current pattern of fishing removes a large portion of the medium and large size individuals from the population.. The Mimiwhangata experience has shown that this approach has led to major tropic changes to algal forest largely due to the removal of these large snapper from the system along with crayfish and hāpuku. While we can dramatically see and measure the decline of algal forest the question arises what other impacts are occurring that haven’t been clearly identified, such things as loss of genetic diversity, loss of learned behaviors, reduced breeding success and the many other ecosystem level connections that a keystone species like snapper or crayfish are associated with.

59. Contrasting with the picture of negative impacts and biodiversity decline at Mimiwhangata is the positive picture of restoration, which has taken place in our full no-take areas at Poor Knights and Leigh where we can clearly see recovery at the trophic level (algal forests) and specifically for the exploited species of the reef system like snapper. These areas today act as a vital baseline allowing ecological impact studies to take place by providing a baseline similar to an unfished system against which to understand fishing impacts or other disturbances to the system. Studies of recovery are positive; evidence is building of their larger scale contribution as nursery areas to help support recovery and productivity of the greater area. Possibly, their greatest contribution is that they are a form of insurance against losing species and ecological function, which is central to a concept of a precautionary approach to managing the ocean.[15] [16]

Reef fish diversity at Mimiwhangata

60. Because of the biogeographic position and its influence of tropical and sub-tropical species, Northland's east coast has the highest fish diversity in New Zealand by some margin. Brook in 2002 reported on surveys of fish diversity conducted around Northland's coast. [17] In these surveys, the Mimiwhangata results were at the top of coastal sites generally but were lower than Northland's top fish diversity sites led by the Poor Knights Islands followed by Cape Brett, the Karikari Peninsula and Cape Reinga. Mimiwhangata had 63 species of fish, with the subtropical component making up 19% of species. The top-ranking sites had a range of 98-80 species and a proportion of subtropical species

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[15] Le Port A, Montgomery JC, Smith ANH, Croucher AE, McLeod IM, Lavery SD. 2017 Temperate marine protected area provides recruitment subsidies to local fisheries. Proc. R. Soc. B 284: 20171300.

[16] Ballantine, B., 2014. Fifty years on: Lessons from marine reserves in New Zealand and principles for a worldwide network. Biological Conservation 176: 297-307.

[17] Brook, F.J., 2002. Biogeography of near-shore reef fishes in northern New Zealand. Journal of the Royal Society of New Zealand 32(2): 243-274.

making up a range of 30-37 % of the fish fauna. It is important to note that this figure is not an absolute measure of diversity because it is based on limited amount of looking and sampling, the actual total diversity could be considerably higher, in the range of 20-30% higher.

61. The proportion of sub-tropical species occurring on Northland's east coast reefs with exposure to oceanic currents is by far the highest of any region and demonstrates the importance of our biogeographical position in relation to the East Auckland current that sweeps past the Northland coast each summer. That current brings biodiversity in the form of fish larvae and occasionally adult species from tropical coral reef systems of New Caledonia and Vanuatu. These areas are visited by currents connecting them with Australia's Great Barrier Reef and further afield to Micronesia and eventually Indonesia (believed to be origin of tropical reef fish evolution). Similar west to east currents also distribute tropical species across the central Pacific all the way eastwards to French Polynesia. Our fish fauna is constantly evolving and part of the overall diversity of the central Pacific.

62. As we experience rapid climate change, this connection to the tropical biodiversity of the north may prove to be an important factor for our fish fauna to adjust to these changes and warming. Northland will likely lead in these changes as the most northerly part of our coastal system and its position in direct contact with the East Auckland current.

63. At Mimiwhangata Dr. Grace and myself compiled a composite list of all the species we had encountered in all surveys. This list is included in this evidence as Attachment 2. There are 71 fish species appearing on our list. The importance of this view of overall fish diversity is to show that these systems are very complex and productive ecologically. Each of these species utilises the reef environment in complex patterns that span the full range of feeding styles and lifestyle strategies. Mimiwhangata in terms of diversity of species is special and significant on a

Northland scale. Indeed, in terms of fish diversity, all these top sites in Northland would top any national list in terms of reef fish diversity. The current concern at Mimiwhangata is that this complex system may be going through a process of overall decline with ecological aspects being lost before we can know of their presence scientifically. We may be crossing an ecological line where irreversible losses are occurring or resilience in the face of rapid climate chance is being reduced. [18]

Seagrass, *Zostera novazelandica*, and the important benthic community at Mimiwhangata Bay

64. Figure 11 below shows an aerial image from 2019 of the east end of Mimiwhangata Bay. The dark mottled patch is a subtidal seagrass bed. The bed shown in the photo is approximately 18 hectares in size. This is quite an unusual occurrence to have a bed of this size located in what I would describe as a moderate exposure site. Large northeast swells generated from cyclones do sporadically affect even this end of the bay which is the more sheltered end often used as an anchorage for visiting yachts but not in a northeast swell condition. Dr. Grace and myself first observed this seagrass bed around the 2005 period as a series of small patches. It has since that time been steadily expanding.

65. Seagrass beds are a recognised biogenic habitat of special significance to many fish species in the early parts of their life cycle. They also support a rich and diverse invertebrate fauna. Dr. Morrison summarises this importance in Section (15) of his evidence in the context of the Bay of Islands. I am not aware of other seagrass beds of this size anywhere between the Bay of Islands and Whangarei Harbour associated with the open coast. I would say that this bed has special significance because of its proximity to the diverse shallow reefs of Mimiwhangata.

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[18] Ling, S.D., Johnson, C.R., Frusher, S., Ridgway, K., 2009. Overfishing reduces resilience of kelp beds to climate-driven catastrophic phase shift. Proc. Natl. Acad. Sci. USA 106, 22 341–22 345.

66. Mimiwhangata Bay also has a rich and diverse benthic environment. Dr. Grace and I did a number of exploratory scuba dives there. There is a wide range of substrates ranging from clean sand to shelly and gravelly sands. The most dominant benthic species is the small bivalve clam *Tawera spissa* that forms very dense beds. Once following a cyclone swell I observed piles of dying Tawera stacked up in mounds waist high on the beach. There would have been many tonnes of shellfish washed up on that day. There are also historical accounts of scallops being present in Mimiwhangata Bay but they have not been seen in recent years.

67. From my experience at Mimiwhangata I would say that the benthic area of Mimiwhangata Bay is a very important nursery area for snapper and a number of other important fish species. On dives there in the summer months significant numbers of newly recruited juvenile snapper can be seen. The development of the seagrass bed will be enhancing this function of the bay.

Figure 11 Subtidal seagrass bed at the east end of Mimiwhangata Bay (2019)

Spotted black grouper, *Epinephelus daemelii*

68. The New Zealand Coastal Policy Statement and our Northland Regional Policy Statement place great emphasis on the protection of endangered and threatened species. However, in the marine environment development of a threats classification is poorly developed with few species being recognised. This is compounded by the disperse nature and mobility of many species in the marine environment. We are still discovering new fish species and new sub-tropical species can arrive in Northland at any time becoming a range extension for those species, important in the context of protecting species' resilience to climate change.

69. Mimiwhangata has been shown to be one of those sites where subtropical species establish. Dr. Grace had a soft spot for the very elusive spotted black grouper and was always on the lookout for them at Mimiwhangata. There are several specific spots where these fish were found. They were typically ledges or small caves of a certain size. Dr. Grace and I would check on these specific holes most years. More often than not there would be a young spotted black grouper there. What is extraordinary about this is that over time these were not the same fish; we could tell this was the case because they were always the same size. The adult black grouper and breeding population is centered around the Kermadec Islands. Apparently as young fish they go on a long journey with some individuals ending up on Northland's east coast. The fish we observed over the years at Mimiwhangata were always the same size up to about 3-5kg. How these fish find these specific holes and why they make this great journey remains a mystery. There is no measure of how many of these young groupers visit northern New Zealand but probably they are rare. Certainly they are rarely seen. Many of the grouper species worldwide appear on threatened and endangered species lists as they are sought after

food fish globally. Under the Wildlife Act 1953, in all New Zealand waters the spotted black grouper is protected.

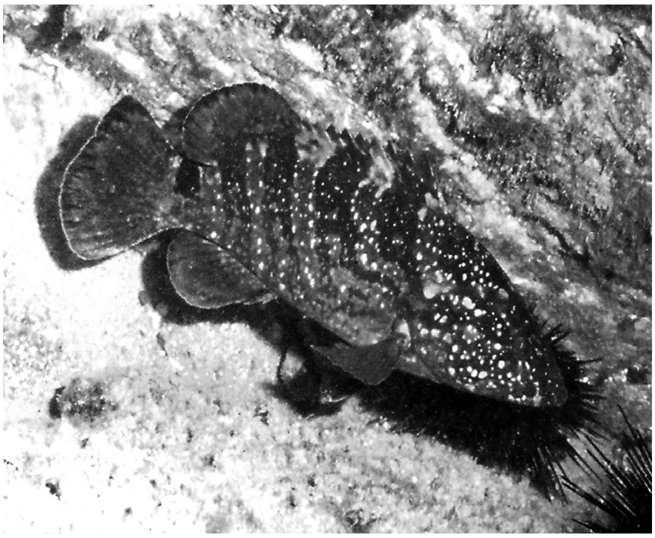

Figure 12 A Spotted black grouper (*Epinephelus daemelii*) appearing on the cover of a Mimiwhangata monitoring report in 1984 photo Dr. Grace (8)

70. Conclusion

71. Mimiwhangata joins the Poor Knights Islands and the Leigh Marine Reserve as being one of the most studied coastal sites in New Zealand. The scientific importance of this parallels the high biodiversity values and a long and rich association of the tangata moana, Te Uri o Hikhiki, who hold in their knowledge system our longest view of the ecology of this area. We now have a clear picture of major losses of species abundance, natural age structures and potentially loss of genetic diversity. Kelp forests have been in multi-decadal decline. This is a concern because this habitat has wide ranging ecological connectivity and importance as a primary coastal energy source. Kelp forests supply energy sources to adjoining habitats via the rapid turn-over of organic matter production and regular storm induced dispersal of drift kelp to literally fuel beach systems adjacent to reefs, soft bottom areas and the water column plankton and larval communities. The kelp

forests themselves support a rich diversity of fish and invertebrate species that reside in the forest or visit the forests during part of their life cycle. By 1986 Dr. Grace in his monitoring reports signaled these concerns, but even now decades later fishing pressure remains.

72. As the decades of decline have been measured and explored our ecological studies have added detail to the losses and understanding of the local ecology. The greatest value of the Mimiwhangata studies is that Dr. Grace had the foresight to pair the monitoring framework and methods with the full no-take Tāwharanui Marine Park. These studies have shown that fishing impacts can be reversed and algal forest can restore once the balance of predators and grazers is restored. This paired study has shown that partial protection in the form of allowing some forms of fishing impairs recovery, whereas full no-take protection supports a process of substantial recovery. The full no-take protection area studies have allowed for the opportunity for Mimiwhangata to be compared to the more natural state or near natural baseline resulting in the full no-take reserves. Ecological studies must have this natural ‘control area’ to be truly valid in a scientific sense. It is clear that Mimiwhangata’s future under its present fished status is uncertain. It is not fully known how serious or how long term the ecological impacts will be at Mimiwhangata, but we do know they are not minor. In contrast, the full no-take areas have demonstrated many benefits to the area restored but also in contributing disproportionately to supporting adjacent fished area via spawning and spill-over benefits. Arguably the greatest benefit of the full no-take reserves is that they provide protection against localised or even regional biodiversity loss and ecological function.

73. The proposals of Te Uri o Hikihiki in my opinion are consistent with and supported by the body of science work completed at Mimiwhangata.

Dated 25 March 2021

Attachment 1 Mimiwhangata research and monitoring reports

1. Commissioner for the Environment. 1982. .Mimiwhangata Marine Park: Environmental Impact Audit. Wellington: Commission for the Environment, December.
2. Dart, J., Drey, B. & Grace, R. V. (1982). Mimiwhangata Marine Park Environmental Impact Report. 143p.
3. Darby, J. and Darby, M. 1973. Mimiwhangata 1973: Ecological Report. Auckland: Turbott & Halstead.
4. Ballantine, W.J., Grace, R.V., Doak, W.T., 1973. Mimiwhangata Marine Report, Auckland, Turbott and Halstead/New Zealand Breweries Limited. 98 p.
5. Grace, R.V.; Grace, A.B. 1978: Mimiwhangata marine monitoring programme: report on progress 1976-1978 Vol. 1. Report for Lion Breweries. Mimiwhangata Trust.
6. Grace, R.V. 1981. Mimiwhangata marine monitoring programme: report on progress to 1981. Mimiwhangata Farm Park Charitable Trust and Bay of Islands Maritime and Historic Park.
7. Grace, R.V. 1981. Paparahi Marine Survey. Report to Mimiwhangata Farm Park Charitable Trust. Hauraki Gulf Maritime Park Board.
8. Grace, R.V. 1984: Mimiwhangata marine monitoring programme. Report on progress to 1984. Bay of Islands Maritime and Historic Park.
9. Grace, R.V. 1985: Mimiwhangata marine monitoring programme. Report on progress to 1985. Bay of Islands Maritime and Historic Park.
10. Grace, R.V. 1986: Mimiwhangata marine monitoring programme. Report on progress to 1986. Bay of Islands Maritime and Historic Park.
11. Grace, R.V., Kerr V.C. 2002. Mimiwhangata deep reef survey draft report 2002. Unpublished report to Department of Conservation, Northland Conservancy, Whangarei.
12. Grace, R.V.; Kerr, V.C. 2002: The Mimiwhangata Marine Investigation Progress Report August 2002. A report to Northland Conservancy, Department of Conservation (unpublished).
13. Grace, R.V. Kerr, V.C., 2002. Mimiwhangata Marine Park Draft Report 2002 Historic Marine Monitoring Update. A Report to Northland Conservancy, Department of Conservation, Whangarei September 2002
14. Denny, C. M., Babcock, R.C. 2002. Fish survey of the Mimiwhangata Marine Park, Northland, Report to Department of Conservation, Northland Conservancy, Leigh Marine Laboratory, University of Auckland
15. **Denny CM, Babcock RC (2003) Do partial marine reserves protect reef fish assemblages? Biological Conservation 116:119–129**
16. Denny, C.M., Babcock, R. C. 2002. Fish survey of the Mimiwhangata Marine Park, Northland. A report to the Department of Conservation, Northland Conservancy. Leigh Marine Laboratory University of Auckland.
17. Usmar NR, Denny CM, Shears NT, Babcock RC (2003) Mimiwhangata Marine Park monitoring report 2002-2003, Leigh Marine Laboratory, University of Auckland.
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Mimiwhangata Species Lists 1973 - 2004, R.V. Grace & V.C. Kerr

Colour Code for entries
Mimiwhangata Marine Report 1973
Mimiwhangata Ecological Report 1973
Marine Report 1976-7
Marine Report 1978
Environmental Impact Report 1982
Marine Report 1984
Fish survey 2002

BIRDS

Bush
APTERYGIDAE
Apteryx australis (brown kiwi)
COLUMBIDAE
Hemiphaga novaeseelandiae (kereru, native pigeon)
CUCULIDAE
Chrysococcyx lucidus lucidus (shining cuckoo)
MELIPHAGIDAE
Prosthemadera novaeseelandiae (tui)
Anthornis melanura (bellbird)
MUSCICAPIDAE
Gerygone igata (grey warbler)
Rhipidura fuliginosa (fantail)
PLATYCERCIDAE
Platycercus eximius (eastern rosella)
STRIGIDAE
Ninox novaeseelandiae novaeseelandiae (morepork)

Open field & swamp
ACCIPITRIDAE
Circus approximans (Australasian harrier)
ALAUDIDAE
Alauda arvensis arvensis (skylark)
ALCEDINIDAE
Halcyon sancta vegans (kingfisher)
ARDEIDAE
Botaurus stellaris poiciloptilus (Australasian bittern)
CRACTICIDAE
Gymnorhina tibicen (Australian magpie)
HIRUNDINIDAE
Hirundo tahitica neoxena (welcome swallow)
MOTACILLIDAE
Anthus novaeseelandiae (New Zealand pipit)
MUSCICAPIDAE
Turdus philomelos clarkei (song thrush)
PHASIANIDAE
Meleagris gallopavo (wild turkey)
Phasianus colchicus (pheasant)
PLOCEIDAE
Passer domesticus domesticus (house sparrow)
RALLIDAE
Porphyrio porphyrio melanotus (pukeko)
STURNIDAE
Acridotheres tristis(myna)
Sturnus vulgaris vulgaris (starling)
ZOSTEROPIDAE
Zosterops lateralis lateralis (waxeye)

Coastal
ARDEIDAE
Ardea novaehollandiae novaehollandiae (white-faced heron)
Egretta sacra sacra (blue heron)
CHARADRIIDAE
Charadrius obscurus (New Zealand dotterel)
HAEMATOPODIDAE
Haematopus unicolor (variable oystercatcher)
LARIDAE
Larus novaehollandiae scopulinus (red-billed gull)
Larus dominicanus (black-backed gull)
PHALACROCORACIDAE
Phalacrocorax varius (pied shag)
Phalacrocorax carbo (black shag)
RECURVIROSTRIDAE
Himantopus himantopus leucocephalus (pied stilt)
SPHENISCIDAE
Eudyptula minor (little blue penguin)
STERNIDAE
Sterna striata (white fronted tern)
Hydroprogne caspia (caspian tern)

Oceanic
PROCELLARIIDAE
Puffinus gavial (fluttering shearwater)
Pachyptila turtur (fairy prion)
Puffinus griseus (sooty shearwater)
Puffinus carneipes (flesh-footed shearwater)
SULIDAE
Sula bassana serrator (Australasian gannet)

FRESHWATER STREAMS

Freshwater bullies
Freshwater prawns
Galaxiidae (whitebait, various species)
Koura (freshwater crayfish)
Larval stages of caddis flies, stone-flies, mayflies, etc.

FISHES
Names to be updated according to Francis (2001)
Expected were sharks, sunfish, eels, flyingfish, sprats, clingfish.
2003 Records
Foxfish (to be added from video 2002)

Conger eel
Red cod
Long-snouted pipefish
Crested weedfish

Girella cyanea (bluefish, rare)

Thresher shark
Hammerhead shark
Combfish
Piper

Labracoglossa nitida (blue knifefish)

Canthigaster callisternus (sharp-nosed pufferfish)

Prionurus maculata (surgeonfish; juvenile, tropical) *

Aplodactylidae
Aplodactylus meandratus (marblefish) * *
Aplodactylus etheridgi (notch-headed marblefish) * *

Arripididae
Arripis trutta (kahawai) * *

Berycidae
Hoplostethus elongatus (slender roughy)

Blennidae
Blennius laticlavius (crested blenny)

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

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

Chironemidae
Chironemus marmoratus (kelpfish/hiwihiwi) * *

Dasyatidae
Dasyatis brevicaudata (short-tailed stingray)
Dasyatis thetidis (long-tailed stingray; **2002**)

Diodontidae
Allomycterus jaculiferus (porcupine fish) *

Gempylidae
Thyrsites atun (barracouta)

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

Labridae
Notolabrus celidotus (spotty) * * *
Notolabrus fucicola (banded wrasse) *
Pseudolabrus miles (scarlet wrasse) *
Notolabrus inscriptus (green wrasse) *
Pseudolabrus luculentus (orange wrasse) * *
Coris sandageri (sandagers wrasse) *
Verreo oxycephalus (red pigfish) *
Bodianus unimaculatus (pigfish) – maybe same as above

Latridae
Latridopsis ciliaris (blue moki)

Monacanthidae
Parika scaber (leatherjacket) * *

Mugiloididae
Parapercis colias (blue cod)

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

Muraenidae
Gymnothorax prasinus (yellow moray eel) *

Myliobatidae
Myliobatus tenuicaudatus (eagle ray) * * *

Odacidae
Coridodax pullus (butterfish) *

Pempheridae
Pempheris adspersus (big eye) *

Pomacentridae
Parma alboscapularis (black angelfish) *
Chromis dispilis (demoiselle) *
Chromis hypsilepis (single-spot demoiselle)
Chromis sp. (yellow demoiselle)

Scorpaenidae

Scorpaena cardinalis (Northern scorpionfish) *
Helicolenas papillosus (sea perch)

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

Serranidae
Ellerkeldia huntii (redbanded perch) *
Caesioperca lepidoptera (butterfly perch)
Caprodon longimanus (pink maomao)
Epinephelus daemelii (spotted black grouper) *
*

Sparidae
Pagrus auratus (snapper) * * *

Sphyrnidae
Sphyrna zygaena (hammerhead shark)

Trichonotidae
Limnichthys randalli (sand fish)

Tripterygiidae
Tripterygion sp. C. (oblique swimming blenny)
*
Tripterygion sp. B. (yellow/black blenny)
Tripterygion varium (mottled blenny)
Gilloblennius tripennis (spectacled blenny)
Species undetermined (saber-tooth blenny,
single specimen)
Trachelochismus sp.

Zeidae
Zeus japonicus (john dory) * *

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MAORI MIDDEN SHELLS

Amphidesma subtriangulatum (tua-tua) (still on sandy shores)
Cellana ornata (still on rocky shores)
Cellana radians (still on rocky shores)
Chione stutchburyi (common cockle, nearest habitat probably Whangaruru)
Cominella maculosa (still on rocky shores)
Cominella virgata (still on rocky shores)
Cookia sulcata (herbivorous turban, still on rocky shores)
Crassostrea glomerata (rock oyster) (still on rocky shores)
Dosinia anus (offshore on sandy bottom)
Haliotis australis (still on rocky shores)
Haustrium haustorium(still on rocky shores)
Lunella smaragda (cats-eye) (still on rocky shores)
Melagraphia aethiops (still on rocky shores)
Tawera spissa (offshore on sandy bottom)
Thais orbita (still on rocky shores)

DRIFT SHELLS

Some names need updating.

P = Pa Point shell beach
M = Mimiwhangata beach
0 - Okupe Beach

GASTROPODS
Alcithoe arabica P M
Amalda australis P
Anisodiloma lugubris P
Buccinulum lineum P
Cantharidus purpureus P
Cellana ornata P
Cellana radians P 0
Cellana stellifera P
Charonia rubicunda 0
Cirostrema zelebori P
Cominella adspersa P M
Cominella maculosa P
Cominella virgata P
Cookia sulcata 0
Haliotis australis P M
Haliotis iris P M 0
Haliotis virginea P M 0
Haminoea zelandiae M
Haustrum haustorium P
Lepsiella scobina P
Lunella smaragda (cat's eye) P M *
Maoricrypta costata P M 0
Maoriculpus roseus P M
Maurea punctulata P M
Maurea tigris M
Mayena australasia P M
Melagraphia aethiops P
Monoplex australasiae 0
Nerita melanotragus P
Patelloida corticata P
Penion adustus M
Quibulla quoyana P M
Scutus breviculus M
Serpulorbis zelandicus P
Sigapatella novaezelandiae P M 0
Spirula spirula
Stephopoma roseum P
Struthularia papulosa P M 0
Thais orbita P 0
Trochus viridis P
Tugali elegans P
Zeacumantus subcarinatus M
Zethalia zelandica (wheel shell)

BIVALVES
Amphidesma subtriangulatum (tuatua) P M 0 *
Amphidesma ventricosum (toheroa) 0 *
Angulus gaimardi M
Anomia walteri M
Atrina zelandica M
Bassina yatei P M
Chione stutchburyi (cockle/tuangi) M 0 *
Chlamys zelandiae (fan shell) P 0 *
Crassostrea glomerata P M 0
Divaricella huttoniana P
Dosinia anus P M 0 *
Dosinia subrosea M *
Gari lineolata M
Glycymeris laticostata 0 *
Longimactra elongata (mactra shell)?
Macomona liliana M
Mactra discors M
Modiolus areolatus (fringed mussel) P M *
Myadora striata M 0
Panopea zelandica M
Paphirus largillierti M
Pecten novaezelandiae (large Queen scallop) P M 0 *
Perna canaliculus (green mussel) M 0 *
Ryanella impacta P M
Spisula aequilateralis (triangle shell)
Tawera spissa (morning-star shell) P M 0 *
Venericardia purpurata P 0
Xenostrobus pulex (small mussel)
Zearcopagia disculus M

INVERTEBRATES

Arthropoda

Insecta
Philanisus plebeius (marine caddis fly)

Crustacea
Calantica villosa (stalked barnacle)
Chamaesipho brunnea (high level surf barnacle)
Chamaesipho columna (small barnacle, sheltered detrital zone)
Elminius modesta (small barnacle)
Epopella plicata (large ribbed barnacle)

Isopoda
Cirolana
Decapoda (hermit crabs)
Jasus edwardsi (spiny red crayfish; surge channels, deep canyons and gullies) * *
Jasus verrauxi (green crayfish; surge channels, deep canyons and gullies; now rare)
Leptograpsus variegatus (large shore crab)
Squilla (mantis shrimps) *
Ovalipes (swimming crab)
Ozius truncatus (black finger crab)
Paleamon affinis (shrimp)
Plagusia capensis (large red rock crab, shallow surge channels)?
Pyromaia tuberculata (Californian spider crab; import via Japan)
Scyphax
Tanaidacea
Unidentified Callianassid (pink, burrowing ghost shrimp; Australian import)

Brachiopoda

Articulata (lampshells, including small red brachiopod specimen)
Terebratella inconspicua (red lamp shell)

Coelenterata

Actinothoe albocincta (white anemone, shallow surge channels)
Antipatharian coral (black coral)
Corynactis haddoni (jewel anemones; deep winding canyons)
Culicea rubeola (encrusting coral)
Monomyces rubrum (cup coral)
Oculina virgosa (ivory coral, deep, east of Rimariki Island) *
Primnoides sp. (gorgonian fan, deep, east of Rimariki Island) *
Solandaria sp. (3m, sheltered 'detrital' zone, shallow surge channels)
Unidentified zoanthis

Polychaeta

Aglaophamus macroura *
Armandia maculata
Axiothella australis *
Euchone sp. (small fan worm)
Eunice
Glycera americana *
Hemipodus
Lumbrinereis sphaerocephala *
Magelona papillicornis *
Orbinia papillosa *
Pectinaria australis
Perinereis sp.
Sigalion
Unidentified Nereids
Unidentified Sabellids

Echinodermata

Apoda
Astropecten polyacanthus (comb-star)
Astrostole scabra (giant seven-armed starfish, shallow surge channels)
Amphiura (brittle stars; Porae Point)
Centrostephanus rodgersii (3-4m, large purple-spined urchin, sheltered 'detrital' zone, shallow surge channels) *
Coscinasterias calamaria (eleven-armed star)
Evechinus chloroticus (sea urchin, 0-10m, sheltered 'detrital' zone, medium depth) * *
Fellaster (sand dollar)
Goniocidaris corona (small club-spined urchin)
Heliocidaris tuberculata (brown sea urchin)
Holopneustes inflatus (pink tennis-ball urchin)
Holothuria (sea-cucumber, soft-bottom)
Knightaster bakeri (brilliant yellow starfish, very deep) *
Ophidiaster kermadecensis (yellow and brown starfish)
Ophidiaster mcknighti (cream and brown starfish, very deep) – maybe the same as above
Patiriella regularis (cushion star)
Stegnaster inflatus (starfish, sheltered 'detrital' zone 0-10m)
Stichopus mollis (sea cucumber, echinoderm, sheltered 'detrital zone 0-10m)

Mollusca

Amphineura
Amaurochiton glaucus
Craspedochiton rubiginosus
Craspedochiton rubiginosus (small chiton, soft-bottom)
Eudoxochiton nobilis (large chiton, sublittoral fringe exposed rocky shores)

Guildingia obtecta (large chiton, sublittoral fringe of exposed rocky shores)
Ischnochiton maorianus
Notoplax violacea
Sypharochiton pelliserpentis (snakeskin chiton)

Gastropoda
Amalda australis
Amalda novaezelandiae
Antisolarium egenum
Astraea heliotropum (turbinid)
Bullina lineata (red-lined bubble shell)
Cellana ornata (limpet, littoral zone)
Cellana radians (limpet, littoral zone)
Cellana stellifera (limpet, subtidal)
Charonia rubicunda (large trumpet)
Cominella adspersa (carnivorous whelks , sand offshore) *
Cominella maculosa (rocky shores)
Cominella quoyana (carnivorous whelk, sand offshore)
Cominella virgata (rocky shores)
Cookia sulcata (herbivorous turban, rocky shores)
Haliotis australis (rocky shores)
Haustrium haustorium(rocky shores)
Hydatina physis (lined bubble shell)
Lepsiella scobina (snail; oyster borer, rocky shores)
Lunella smaragda (cat's eye shell, littoral zone/sub-littoral fringe)
Marginella pygmaea
Maurea punctulata (deep canyons and gullies)
Maurea tigris (deep canyons and gullies)
Melagraphia aethiops (snail, rocky shores)
Melagraphia oliveri (snail, littoral fringe)
Micrelenchus rufozonus (sublittoral fringe)
Nassarius spiratus (whelk)
Neoguraleus interruptus
Nerita melanotragus (Black Nerita snail, littoral zone) *
Notoacmea parviconoidea (limpet)
Notoacmea pileopsis (limpet, littoral fringe)
Notoacmea scopulina (limpet, littoral fringe)
Notoacmea sp.
Patelloida corticata (limpet, littoral zone)
Pervicacia tristis
Pterotyphis eos paupereques (rare carnivorous gastropod)
Pupa kirki (sediments offshore)
Sea slugs (deep canyons and gullies)
Sigapatella novaezelandiae (circular slipper shell, subtidal rocks)
Siphonaria zelandica (limpet, very exposed rocky shores)
Small rissoids (sublittoral fringe)
Stiracolpus pagoda (screw shells , sand offshore)
Thais orbita (rocky shores)
Xenophalium labiatum (helmet shell)
Zegalerus tenuis (small slipper shell)

Bivalvia
Amphidesma subtriangulatum (tua-tua) * *
Arthritica bifurca
Chione stutchburyi (common cockle)
Corbula zelandica (little basket cockle)
Crassostrea glomerata (rock oyster) * * *
Crassotrea gigas (pacific oyster)
Cuna sp.
Dosinia anus (offshore on sandy bottom)
Dosinia subrosea (channel b/w Rimariki Is. and the mainland) *
Fellaniella zelandica
Gari lineolata
Gari stangeri
Glycymeris laticostata (large dog cockle) *
Glycymeris modesta (small dog cockle)
Gomphina maorum *
Longimactra elongata (juv) *
Modiolus areolatus (fringed mussel) * *
Myadora boltoni
Myadora striata
Mytilus edulis aoteanus (blue mussel)
Nucula nitidula
Perna canaliculus (green mussel) *
Scalpomactra
Soletellina nitida (juv)
Tawera spissa (morning star shell, sandy bottom) *
Xenostrobus pulex (small mussel) *
Ascidians
Asterocarpa caerulea (ascidian)
Entalophora sp. (finely-branching coral-like bryozoan)
Sigillinaria arenosa (colonial ascidian)
Steganoporella neozelania (bryozoan, deep sheltered, deep canyons and gullies)

Forams
Ammonia becarrii
Angulogerina
Bolivina compacta (Sidebottom)
Bolivina pseudoplicata (Heron-Allen and Eurland)
Brizalina sp.
Buliminella
Cassidulina spp.
Cibicides sp.
Discorbis dimidiatus (Parker and Jones)
Elphidium argenteum (Parr)
Elphidium charlottensis (Vella)
Elphidium novozealandicum (Cushman)
Elphidium simplex (Cushman)
Fissurine spp.
Notorotalia
Oolina

Patellinella inconspicua (Brady)
Pseudopolymorphina sp.
Quinqueloculina seminula (porcellaneous form)
Rosalina sp.

Porifera

Ancorina alata (massive grey sponge, deep)
Aplysilla rosea (pink sponge – deep winding canyons)
Callyspongia ramosa (tall fan-shaped sponge, deep)
Cliona celata (yellow encrusting sponge)
Desmacidon (tall orange branching sponge, very deep, east of Rimariki Island)
Iophon (tall yellow branching sponge, very deep, east of Rimariki Island)
Polymastia fusca (brown massive sponge)
Polymastia granulosa (massive yellow sponge, medium sheltered, deep)
Raspailia sp. (orange branching sponge, deep, east of Rimariki Island)
Siphonochalina latituba (mauve branching tube sponge, shallow surge channels)
Stelleta crater (massive sponge)
Stelleta hauraki (massive crimson bowl-shaped sponge)
Tethya aurantium (orange golf ball sponge)
Tethya ingalli (pink golf ball sponge)

From Auck Uni Mimiwhangata 2002 Report
(Need to check with overall list)

Table 4. **Scientific name, species, and family of fish species observed in underwater visual census at Mimiwhangata, April 2002.**

Scientific name	Species	Family
Allomycterus jaculiferus	Porcupinefish	Diodontidae
Aplodactylus arctidens	Marblefish	Aplodactylidae
Arripis trutta	Kahawai	Arripadae
Bodianus unimaculatus	Pigfish	Labridae
Cheilodactylus spectabilis	Red moki	Cheilodactylidae
Chironemus marmoratus	Hiwihiwi	Chironemidae
Chromis dispilus	Demoiselle	Pomacentridae
Coris sandageri	Sandagers wrasse	Labridae
Decapterus koheru	Koheru	Carangidae
Epinephelus daemelii	Spotted black grouper	Serranidae
Girella tricuspidata	Parore	Girellidae
Gymnothorax prasinus	Yellow moray	Muraenidae
Kyphosus sydneyanus	Silver drummer	Kyphosidae
Myliobatus tenuicaudatus	Eagle ray	Myliobatidae
Nemadactylus douglasii	Porae	Cheilodactylidae
Notolabrus celidotus	Spotty	Labridae
Notolabrus fucicola	Banded wrasse	Labridae
Obliquichthys maryannae	Oblique swimming t	Tripterygiidae
Odax pullus	Butterfish	Odacidae
Pagrus auratus	Snapper	Sparidae
Parika scaber	Leatherjacket	Monacanthidae
Parma alboscapularis	Black angelfish	Pomacentridae
Pempheris adspersus	Bigeye	Pempheridae
Pseudolabrus luculentus	Orange wrasse	Labridae
Pseudolabrus miles	Scarlet wrasse	Labridae
Scorpaena cardinalis	Northern scorpionfish	Scorpaenidae

Scorpis lineolatus	Scorpidae	Sweep
Scorpis violaceus	Scorpidae	Blue Maomao
Seriola lalandi	Carangidae	Kingfish
Trachurus novaezelandiae	Carangidae	Jack mackerel
Upeneichthys lineatus	Mullidae	Goatfish

ALGAE

'Coralline paint' (thin encrusting seaweed, sheltered 'detrital' zone, shallow exposed zone, medium depth)
Asparagopsis (red alga)
Carpophyllum angustifolium (tough brown algae; shallow exposed zone, shallow surge channels)
Carpophyllum flexuosum (sheltered 'detrital' zone)
Carpophyllum maschalocarpum (sheltered 'detrital' zone, shallow surge channels)
Carpophyllum plumosum
Champia (red seaweed, shallow water, broken rocky bottom)
Ecklonia radiata (kelp) (sheltered 'detrital' zone, medium depth, deep canyons and gullies)
Gigartina alveata (exposed intertidal rocks near sand)
Gigartina circumcincta (red alga)
Hormosira banksii (Neptune's necklace; intertidal semisheltered rocks)
Landsburgia quercifolia (oak-leaf weed; exposed, shallow subtidal rock)
Lessonia variegata (shallow exposed zone, deep canyons and gullies)
Lithothamnia (coralline seaweed)
Lophurella
Melanthalia abscissa (red)
Nemastoma
Pachymenia hymantophora
Pterocladia lucida ('agar' weed; sheltered 'detrital' zone, shallow surge channels)
Sargassumsinclairii (out from Pa Point, low relief rock bottom)
Vidalia colensoi (serrated-leaved red algae, shallow surge channels)
Xiphophora chondrophylla (sheltered 'detrital' zone ; exposed low tidal rocks)

Attachment 3

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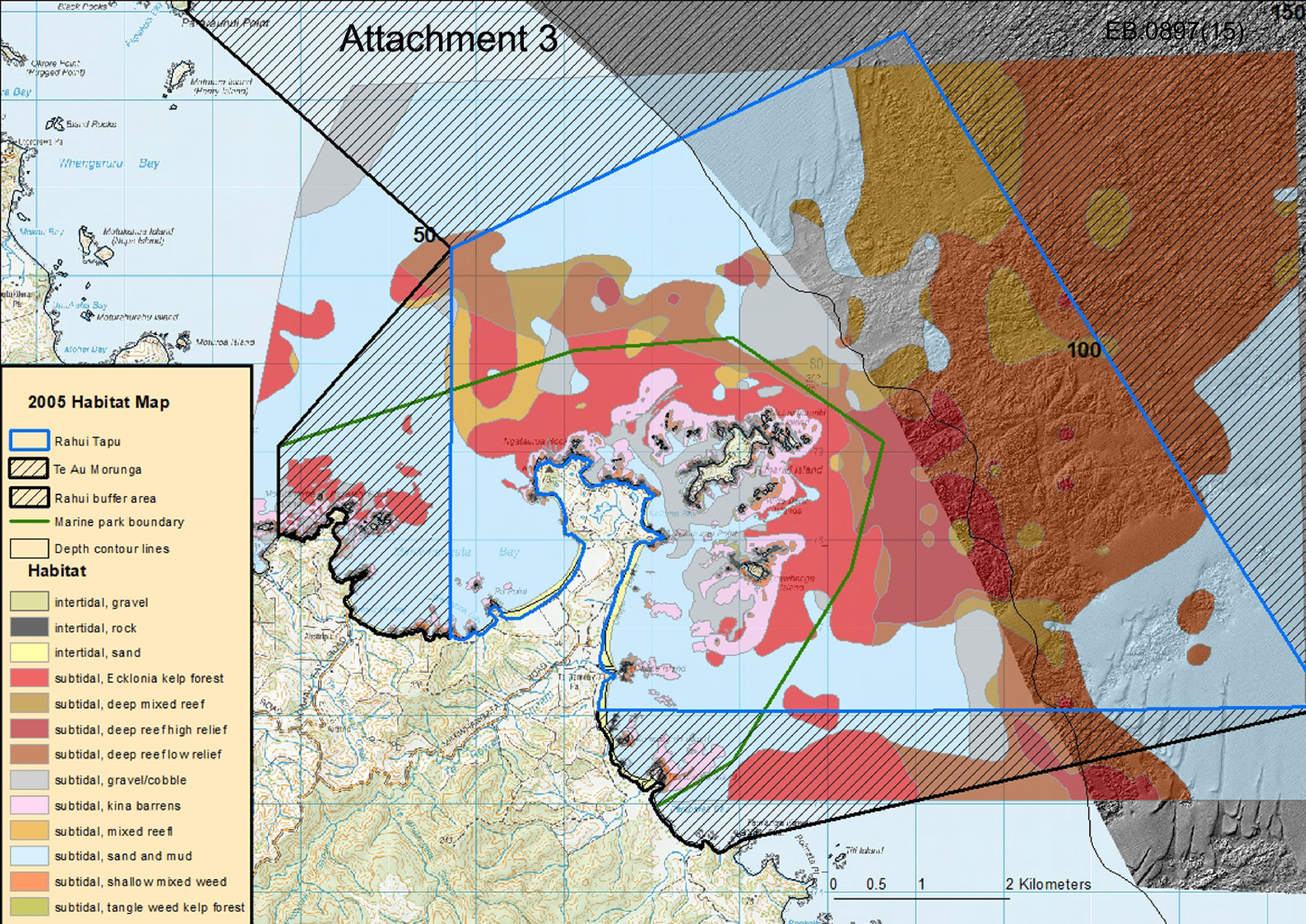

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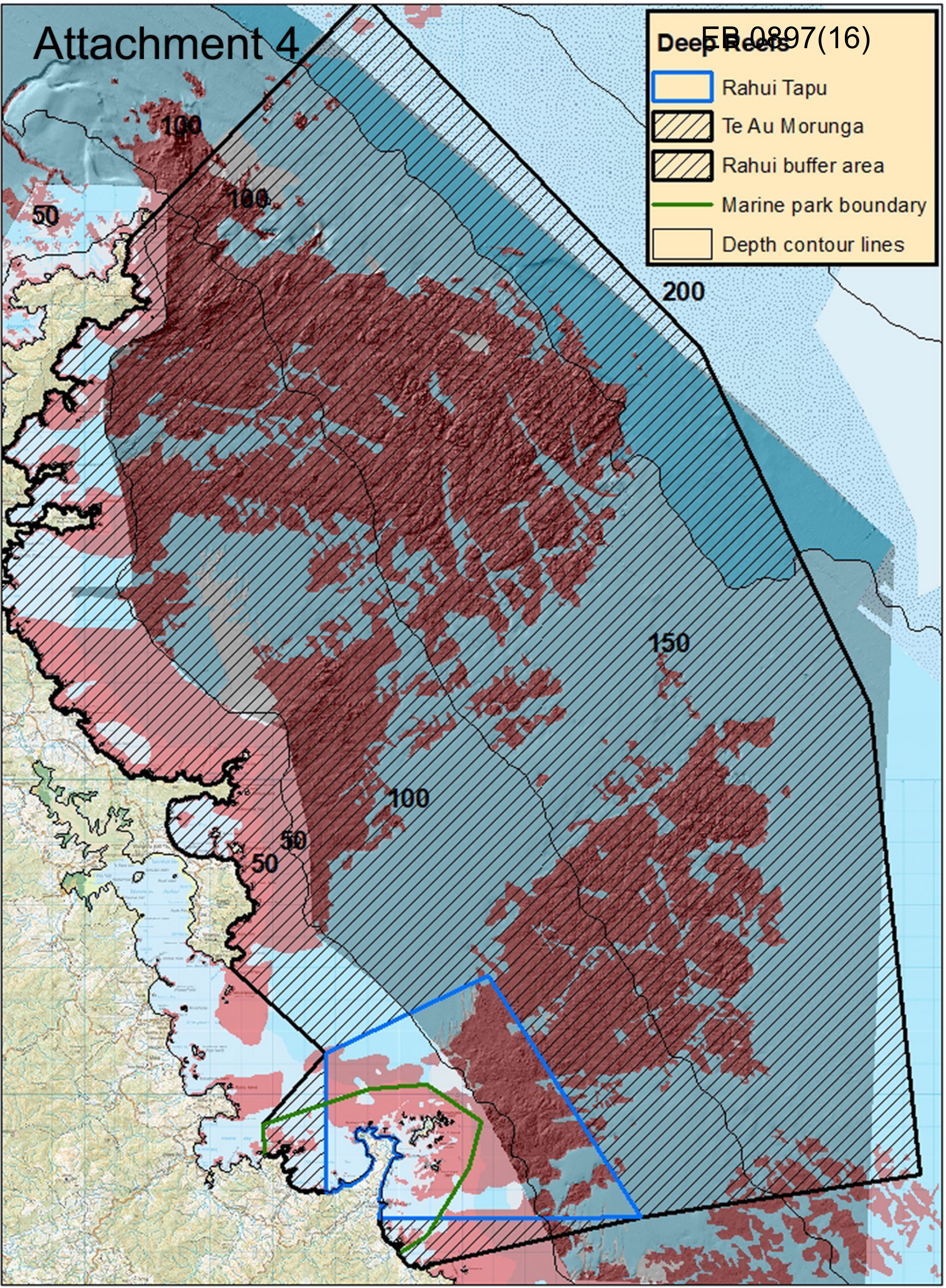

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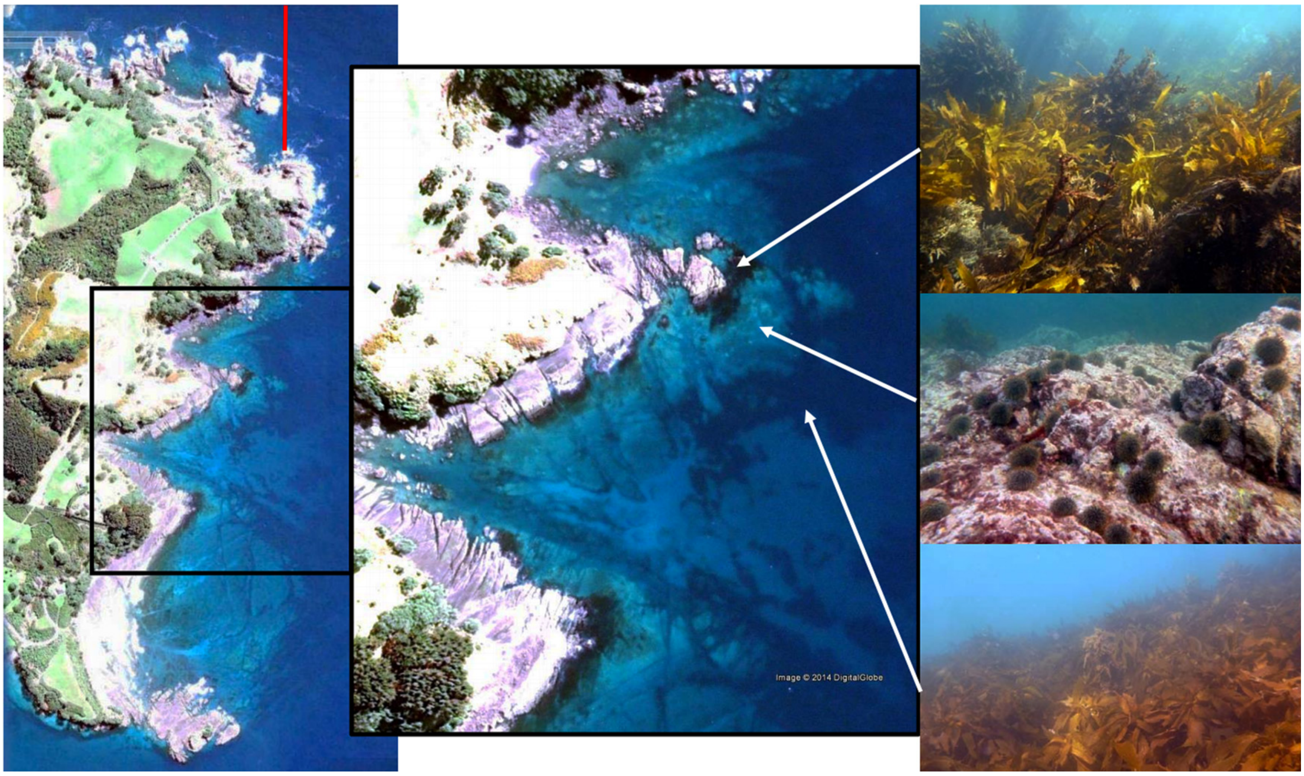
Estimated extent of urchin barrens on the east coast of Northland, New Zealand

Vince Kerr and Roger Grace,
October 2017



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Cover Photo: An example of the urchin barren condition taken just south of the Cape Rodney to Okakari Point (Leigh) Marine Reserve at Cape Rodney, showing the greyish bare rock appearance of the urchin barren contrasted with the dark appearance in the aerial view of the algal forests. These photos also demonstrate the typical zonation of macroalgal forests and urchin barrens found in fished areas in northern New Zealand. Photo credit: Nick Shears

Keywords: urchin barrens, marine habitat mapping, habitat classification, algal forest health, algal forest restoration, wave exposure, marine reserves, partially protected areas, Northland

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Executive summary

Overfishing of sea urchin predators on shallow reefs can lead to the loss of kelp forests and transition to ‘urchin barrens’. In this study we estimate the extent of urchin barren habitat along New Zealand’s Northland coast. The study area was the entire exposed east coast running from Ahipara in the Far North to Tawharanui at the entrance of the Hauraki Gulf. Two large scale habitat maps covering the entire study area were used to compute the total area of rocky reef. Six fine scale maps spread along the coast from Doubtless Bay to Tawharanui where urchin barrens were mapped were used to compute extent of urchin barrens. In the study area there was an estimated total of 32,515 hectares of rocky reef (≤30 m depth). The projected estimate of urchin barren extent (based on the six mapped areas) for the entire study area came to a total of 5,528 hectares, representing 17% of the available rocky reef system. It is important to note that most of the urchin barrens in the region occur at depths <10 m meaning that urchin barrens occupy a considerably higher proportion of shallow reefs. Mapping data also allowed us to compare inside the two marine reserves with fished areas outside the marine reserves and the partially protected Marine Park at Mimiwhangata. Inside the two marine reserves, where sea urchin predators are abundant, urchin barrens covered 1 % of the available reef. In contrast in the partially protected Marine Park, where recreational fishing is still allowed, the extent of urchin barrens was 21.23%. These results are consistent with previous research that have demonstrated that the recovery of crayfish and reef fish (mainly snapper) can lead to a recovery of kelp forests in no-take marine reserves. Region-wide mapping demonstrates that urchin barrens are a prominent feature of the entire Northland coast and indicates that shallow kelp forests are vulnerable to intensive fishing at large-spatial scales. The results suggest greater understanding and recognition of the key biodiversity status and productivity of kelp forests is needed to better understand the ecosystem-level consequences of fishing on rocky reefs. Future management of coastal ecosystems must use a range of available tools to address these ecological challenges. We discuss various factors affecting the estimation of urchin barren extent and provide a set of initial thresholds for kelp forest monitoring which could be used to inform management decisions.

Client brief

Kerr & Associates has been requested by the Motiti Rohe Moana Trust to provide a summary of 'lessons learned' from research on algal forests in northeast New Zealand and in particular Northland's east coast shallow reefs. Below is a list of the specifics of what the Motiti Rohe Moana Trust has asked to investigate:

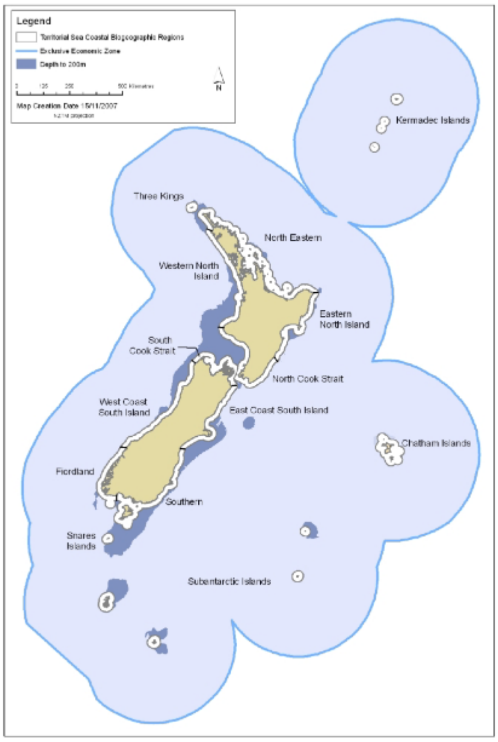
1. Describe what is known about the threat and extent of the urchin barren decline condition in shallow algal forests in Northland
2. Examine the relevance or similarity of shallow reef ecology and urchin barren studies to shallow rocky reefs in Bay of Plenty
3. What are the ecological implications of the decline in algal reef health as seen in Northland studies?
4. What have we learned in Northland and elsewhere from various locally applied management actions involving localised controls on fishing?
5. Would the extent and persistence of urchin barrens be a suitable SOE indicator, and could this be measured and monitored in an ongoing system that was efficient?

Background

The Northland region is unique in several aspects relating to marine habitat mapping. First, Northland has an extensive coastline and a very large area of shallow rocky reefs. Many of the Northland reef systems have an ecological sequence with large areas of offshore 'deep reefs' (rocky reef structures occurring at depths greater than 30m). Secondly, Northland has had more marine habitat mapping projects completed than any other region. In this study we have brought all this information together in a GIS based project to question the state of health of shallow rocky reefs, particularly the extent of the habitat type known as 'urchin barrens', large numbers of sea urchins have removed kelp forests. This study area also has a rich body of ecological information about shallow rocky reefs based on decades of studies in the two long term no-take marine reserves located at Cape Rodney to Okakari Point (Leigh) and Tawharanui where habitat mapping, observations, experiments and monitoring date back to the 1960's. Tawharanui was set up as a Marine Park in the 1980's, but was effectively a marine reserve with a full 'no-take' rule in place. It has recently obtained full marine reserve status. A third site of interest in the study area is the partially protected Mimiwhangata Marine Park.

A Bioregional view of similarities between Northland's east coast and Bay of Plenty

In our view the results and implications of the extensive work done on shallow reefs in Northland is largely applicable to the Bay of Plenty region. This view is supported by extensive work supporting the creation of a regional classification system for coastal New Zealand. This classification system appears in its most updated form in the Government's Marine Protected Areas Policy and Implementation Plan (DOC & MPI, 2008) (please refer to Map 1 below). Northland's east coast shares the same regional classification, 'Northeast Bioregion', with Hauraki Gulf, Coromandel, and Bay of Plenty. Underpinning this bioregional level classification is a large body of data that shows that these three regions share similar currents, water temperatures and flora and fauna groups. Detailed studies testing the validity of the bioregional classification and specifically similarities between the shallow reefs across the bioregion have been carried out and also support the concept and application of the current classification (Shears et al. 2008; Shears & Babcock, 2007), Shears & Babcock, 2004).



Map 1 Currently adopted bioregional boundaries for coastal New Zealand.

Ecological significance of shallow rocky reefs and the urchin barren dynamic

Shallow rocky reef systems in ecological terms are generally accepted to be one of the most significant habitats of the exposed coast marine environment, however there is no current regime of monitoring that looks specifically at the health of algal forests which are the foundation of productivity and structure for this habitat. Most of the information we do have on the health of rocky reefs comes from habitat mapping projects which have been arranged to support marine protected area planning. The shallow rocky reef ecosystem is very rich in biodiversity of flora and fauna. Unravelling the details of such a complex habitat is a big job. A big picture review of the ecology of Northland's reefs and coastal environments was completed by NIWA (Morrison, 2005). This review highlights the fact that many commercially important fish species spend part of their life cycle on the shallow rocky reefs. Also highlighted in the NIWA report is the high diversity levels of invertebrates and algal species in this habitat. In Northland and Bay of Plenty our coasts are regularly swept with warm subtropical currents which bring with them an extra dimension of larvae from subtropical origins. As a result the northeast bioregion has by far the New Zealand's highest fish diversity associated with its shallow reefs. This was documented in a comprehensive Northland rocky reef fish diversity study (Brook, 2002). Some of the most diverse sites in Northland like the Poor Knights Islands can have in excess of one hundred species resident on the reefs. At the fine scale under the kelp canopy there are also fascinating studies of the diversity occurring associated with kelp plants and their holdfast structures (the base holding the plant to the reef surface) (Smith et al. 1996) (Anderson et al. 2005). In these micro habitats small invertebrates are largely hidden from sight however they are a significant part of the overall diversity and food sources for reef dwelling fish and large invertebrates like crayfish. Up to one hundred species of invertebrates have been counted living in a single kelp holdfast.

The sea urchin, *Evechinus chloroticus,* known as kina in New Zealand, is widespread in the Northeast Bioregion. In addition to being a traditional food species, it plays a key role as a primary grazer of kelp. Early studies in north east New Zealand documented kina's role as a habitat creator through grazing of kelp (Choat, 1982), (Grace 1983), however at that time it was thought that barren areas on the reef caused by urchin grazing was a 'natural' characteristic of our reefs.

In subsequent decades, the dynamics between kelp forests, sea urchins and exploitation of sea urchin predators (mainly snapper and crayfish) has been investigated in New Zealand (Shears et al. 2004; Shears and Babcock, 2002). The Mimiwhangata habitat mapping report (Kerr & Grace 2005) illustrated dramatic decline of the kelp forests over wide areas, starting sometime in the 1960s or 1970s. During the Mimiwhangata habitat mapping exercise, local kaumatua were interviewed and stated with confidence that the current condition of extensive urchin barren areas was not known prior to about 1960-1970 or mentioned in their tribal knowledge handed down from elders.

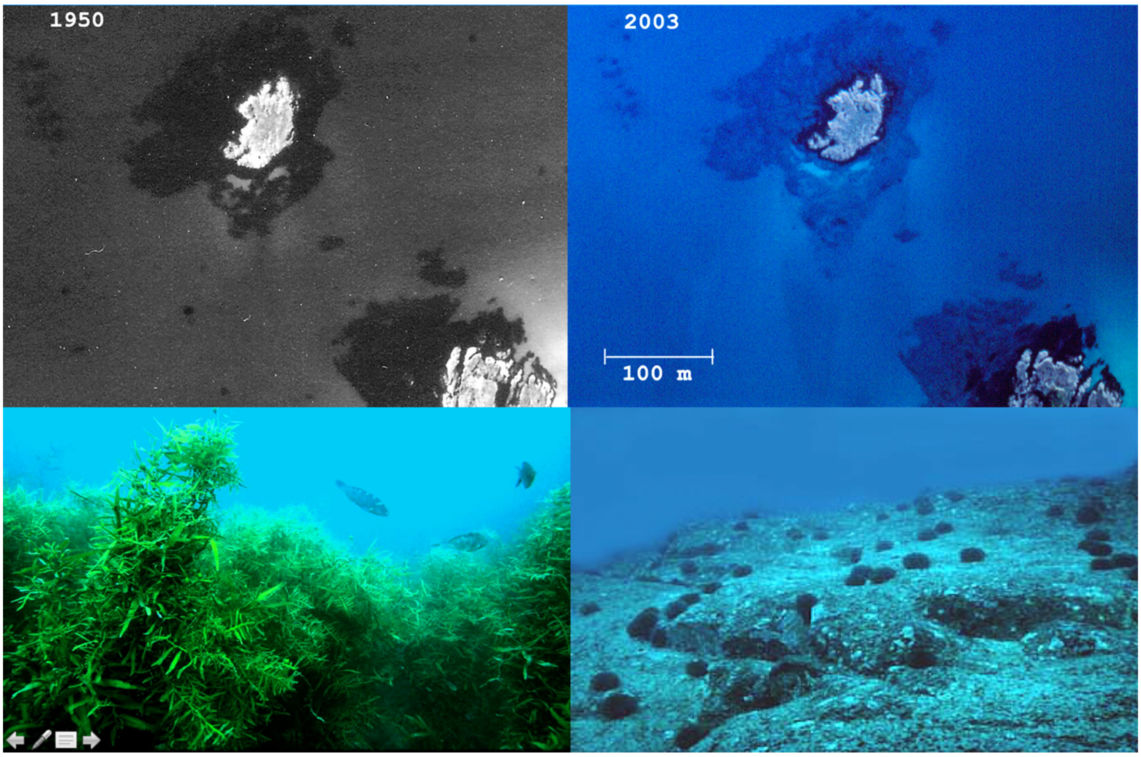


Figure 1 An illustration of the progression of urchin barrens at Pa Point, Mimiwhangata showing dense algal forest seen as dark in the aerial photo (1950) top left and the advanced state urchin barrens seen in the 2003 photo. Bottom photos taken on scuba depict the algal forest once typical at this location and a typical urchin barren.

In northern New Zealand it was found that large snapper and crayfish are the main predators of urchins (Shears & Babcock, 2002). In their absence, 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. Much of this research was based around the Leigh marine reserve where after thirty years of full protection the urchin barren areas which were extensive in the 1970's reverted to kelp forests, in parallel with the predator species re-establishing in the marine reserve. Overseas, a similar dynamic has been reported in virtually every other country with extensive temperate shallow rocky reef and kelp forest habitats (Ling, 2015). 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 (Andrew, 1998) (Andrew, 2000) (Ling et al. 2009) (Ling, 2008). In the temperate areas of Australia there is now significant concern over biodiversity loss due to the increase of urchin barren areas and concern that this phase shift (as it is referred to) appears to be difficult to reverse in circumstances where current fishing pressures are maintained. Such diversity loss gives rise to further concerns around reefs' reduced ability to fulfil their natural role of fixing carbon and thus reduce greenhouse gas and potentially serious reduction in the reef systems' resilience to rapidly changing environmental conditions brought on by global warming.

Recognition of the importance of shallow rocky reefs and the threat of diversity and productivity loss due to overfishing and urchin barren establishment in New Zealand has unfortunately not yet lead to a point where it features in any monitoring programs regionally. Northland as a region however has begun a process to recognise the importance of the shallow reef habitats. Northland Regional Council as part of its revision of the Regional Coastal Plan for Northland has mapped all reef areas and an adjacent transition or edge habitats where the reefs join a soft sediment habitat (Kerr, 2016 a,b,c,d). In the current Proposed Regional Coastal Plan these areas are classified as 'significant ecological areas', providing a way for the Council to consider their biodiversity values when evaluating an application for use of the marine environment. Rules can also be made for the protection of these values.

In Figure 2 below you can see a glaring example from the Bay of Islands of the extent of urchin barrens in an area badly affected. There would naturally be continuous heavy kelp forest covering this entire reef (seen as dark brown). What we see is a thin edge of specialised shallow water seaweeds, species of *Carpophyllum* less palatable to urchins, and a remnant of the *Ecklonia radiata* (large brown kelp), seen here below about 10m depth only covering a small area of the bottom of the reef near where it drops off on to an edge with a sandy bottom habitat. This barren condition represents a major loss of productivity, habitat and diversity. The overall situation of kelp forest decline in the Bay of Islands is a major concern especially in low exposure areas. Research efforts of the marine conservation group Fish Forever have now documented this threat in three research reports (Kerr & Grace, 2015), (Booth, 2015) and (Booth, 2017).

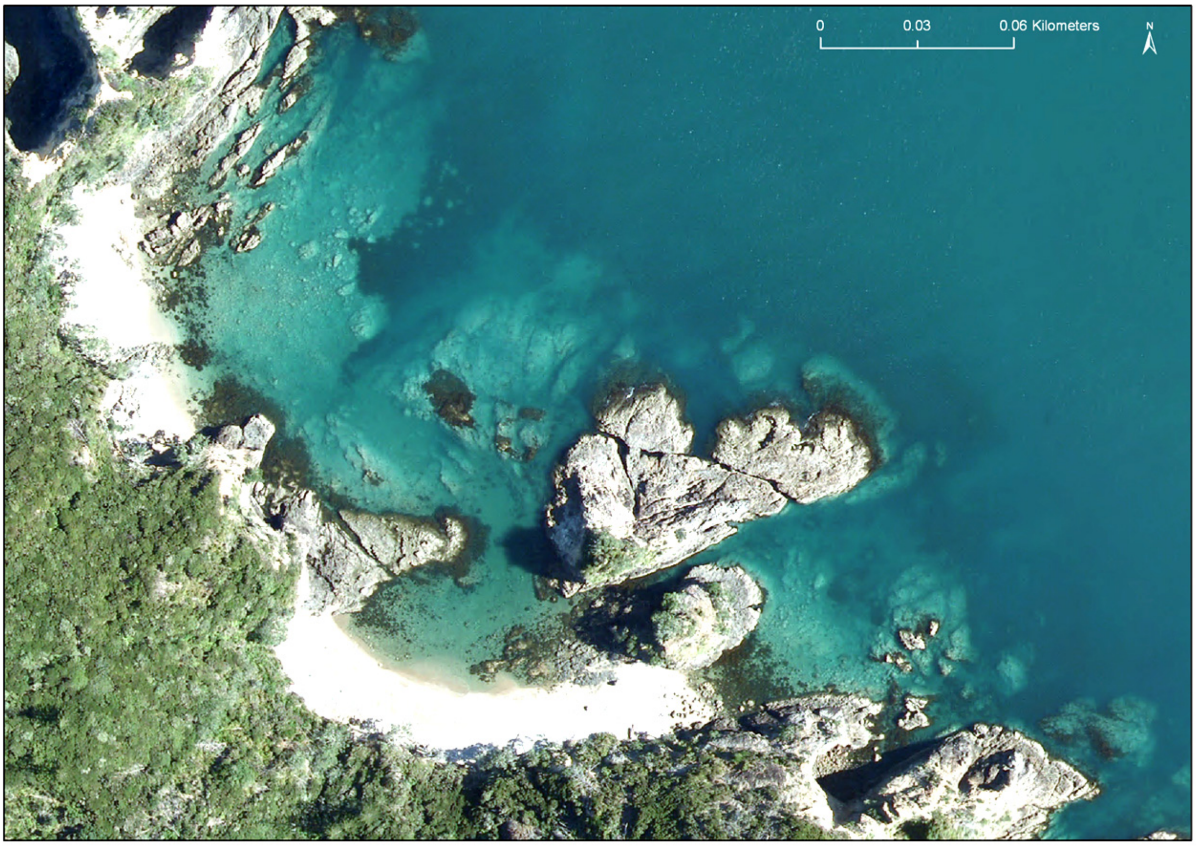


Figure 21 An Oceans 20/20 aerial photo of the east shore of Motukiekie Island, eastern Bay of Islands displayed at the 1:1,500 mapping scale. Pale greyish areas are urchin barrens.

Methods

Habitat surveys

To estimate the extent of urchin barrens on Northland reefs (≤30 m depth), habitat maps were brought together in a GIS project which covered the area from Tawharanui to Ahipara. The maps have all been prepared with similar methodologies but not drawn to the exactly same scale. Ground truthing of the mapping effort, as well as precision, varied in approach across the maps. The maps used are described in groups below corresponding to how the data were used for calculations of the shallow kelp forest in this study. There were four groups of habitat maps: areas where urchin barrens were mapped, areas in or out of marine reserves, and areas where urchin barren were not mapped with shallow rocky reefs mapped as an undifferentiated reef habitat. These four groups are described below:

Group 1 Areas where urchin barren were not mapped (large scale base maps)

- Northland Habitat Map Ahipara to Mangawhai ver. 1 (Kerr, 2010)
- Hauraki Gulf Marine Habitat Map (DOC, 2014)

Group 2 Areas where urchin barrens were mapped inside marine reserves

- Leigh Marine Reserve Habitat Map (Leleu and Remy-Zephir, 2012)
- Tawharanui Marine Reserve Habitat Map (Grace, unpublished work completed for DOC 2006)

Group 3 Areas where urchin barrens were mapped outside and adjacent to a marine reserve boundary

- Leigh Marine Reserve Habitat Map (Leleu and Remy-Zephir, 2012)
- Tawharanui Marine Reserve Habitat Map (Grace, unpublished work completed for DOC 2006)

Group 4 Areas where urchin barrens were mapped in open fishing areas

- Doubtless Bay Marine Habitat Map (Grace & Kerr, 2005)
- Marine Habitats of the proposed Waewaetorea Island Marine Reserve (Kerr & Grace 2015)
- Marine Habitats of Cape Brett and Maunganui Bay (Kerr, 2016)
- Mimiwhangata Marine Habitat Map (Grace & Kerr, 2005)

A set of seven maps taken from this study can be viewed in Appendix 1.

Mapping methodologies

All of the maps used, except two, have publications or technical reports including details of methodology, scale, information sources, habitat descriptions, ground truthing approach and reliability estimates.. The two exceptions are the Tawharanui map and DOC's Hauraki Gulf habitat map. The Tawharanui map was drawn by Dr Roger Grace and used very good quality aerial photos for the entire coastline mapped and side scan surveys to delineate the reef/soft bottom edges. Dr Grace has also done many research dives throughout this area and has permanent transects established on each of the major reef areas which he mapped at fine scale (less than 5m error) for all his transects. It is reasonable to assume that the Tawharanui habitat is at least as accurate as the other maps used in this study. The DOC Hauraki Gulf map was produced by a number of DOC staff and contractors and drew information layers from many sources and approaches to mapping. For this reason, and the lack of a technical report to support this layer, it is beyond the scope of this report to comment on precision, however in the context of this study only a relatively small stretch of the coastal fringing shallow reef is used in the calculations, so even if there are sizeable errors in establishing the reef edge in this map it will not overly affect the results of this study.

If the reader wishes to further explore the classifications used, mapping methodology and precision or reliability considerations we advise study of the reports for the Northland map, (Kerr, 2010), the Mimiwhangata map (Kerr & Grace, 2005) and the Bay of Islands Waewaetorea Island map (Kerr & Grace 2015). In each case the various mapping approaches are detailed and are roughly common across all the maps used in this study. The Mimiwhangata map details an approach to mapping urchin barrens and also introduces a study of a time series of aerial photos tracking progression of the urchin barren over several decades. The Waewaetorea Island map also used similar methodology to that used at Mimiwhangata for the mapping of urchin barrens and is our best example of a 'low exposure coast'.

GIS process

A GIS project was created containing all the data acquired for the study which was all of the shallow rocky reef polygons from all the maps of the study extending from Tawharanui in the south to Ahipara in the north. The GIS environment allows for a range of display and spatial analysis approaches to be used. A common attribute field was created listing all of the main classifications used to describe shallow reef habitats across all the maps. The two larger scale base maps (Northland and Hauraki Gulf) were cut for the areas where the smaller scale maps were located resulting in one continuous layer of shallow rocky reef for the entire shallow rocky reef defined as extending to the 30m depth contour. The Northland map included shallow rocky reef areas of offshore islands like Poor Knights and the Hen and Chicks Islands. A line was drawn across the entrance to all Northland estuaries and these estuarine shallow reefs were excluded in this study. This is not to say that the urchin grazing and barrens do not exist on shallow reefs within the entrances, however in our extensive estuaries there are a number of environmental factors operating on the urchins, the urchin predator species and the algal forests themselves that are substantially different from our exposed coastal environments. For this reason for this first study we excluded this complication by removing the estuarine shallow reefs.

A second attribute field was created that identified all polygons in terms of the four groups. This was done to allow calculations of the area of urchin barrens across these four groups.

The four basic analysis groups

1. urchin barren were not mapped (larger scale base maps with shallow rocky reefs mapped)
2. urchin barrens were mapped inside marine reserves
3. urchin barrens were mapped outside and adjacent to a marine reserve boundary
4. urchin barrens were mapped in open fishing areas and Mimiwhangata (partial protection)

Determination of exposure

Exposure to wind, wave energy and currents is known to influence the development of biological communities. Observations to date by the authors in the various mapping efforts in Northland have indicated that there is considerable variation in extent of urchin barrens which parallel to an unknown degree exposure and the impacts of wave energy on the reef system. For this reason we decided to carry out a simple exercise of producing a 3-way exposure layer. For consistency with the Marine Protected Areas Guidelines (DOC, 2008), we adapted the approach in that document which is outlined below.

The Marine Protected Areas Guidelines identify exposure as important in defining marine habitats for the purpose of its classification system. The guidelines define three exposure categories: low, medium, and high.

- High – areas of high wind/wave energy along open coasts facing prevailing winds and oceanic swell (fetch > 500 km e.g. ocean swell environments or currents > 3 knots).
- Medium – areas of medium wind/wave energy along open coasts facing away from prevailing winds and without a long fetch (fetch 50-500 km e.g. open bays and straits).
- Low – areas where local wind/wave energy is low (fetch <50 km e.g. sheltered areas; small bays and estuaries; current <3 knots).

This definition was applied by drawing a series of lines along the coast in our GIS project outward from the coastline within the survey area to approximately indicate the degree of exposure and fetch at each significant turn or 'point' along the coastline. In each of these locations fetch and fetch angle was interrogated according to the above guidelines and then a polygon for the coastal waters for that corresponding stretch of coast was drawn. Each polygon has an exposure classification of low, medium or high. This layer was then merged with the entire shallow reef layer which effectively split the shallow reefs into three exposure classifications and allowed the urchin barren calculations to be interpreted by exposure.

Results

In Appendix 1 seven maps are presented which show the study area, the exposure classification map and the extracted shallow reef habitats for the study area. The boundaries of the areas which were mapped for urchin barrens are also illustrated.

Urchin barren extent

Tables 1-5 below detail the various calculations made to:

- assess the spatial extent of kina barrens in all areas where they were mapped;
- asses a percentage value of urchin barrens where mapped which reflects how much of the shallow rocky reef is in the urchin barren condition;
- asses a value for spatial extent of all habitats by exposure class;
- extrapolate the mapped percentage value of urchin barren extent to the entire shallow reef study area; and
- compare directly urchin barren extent between urchin barren mapped areas across the entire study area.

Table 1 shows the respective areas of shallow reef involved in this study for the coastline stretching from Tawharanui in the south to Ahipara in the north. The area of shallow reefs that were mapped for urchin barrens is 4,362 hectares representing 13.41% of the total study area shallow reef area of 32,515 hectares.

Mapped Areas Totals		
Mapping description	**Hectares**	**Percentage of total study area**
Northland total area of shallow reefs with urchin barrens mapped	4,362	13.41%
Northland total area of shallow reefs without urchin barrens mapped	28,153	86.59%
Total shallow reef area study area	32,515	100%

Table 1 Total calculated areas of urchin barren mapped shallow reefs and shallow reefs where urchin barrens were not mapped.

Table 2 provides a summary of the areas of shallow reefs classified in the three exposure classes low, medium and high. Note that there is a relatively small area that was assessed as low exposure. A large part of this low exposure area was located in the sheltered side of islands of the Bay of Islands.

Northland exposure classes	Hectares
High	27,809.21
Medium	4,551.04
Low	154.41
Total Northland shallow reefs area	32,514.67

Table 2 Shallow reef area totals calculated for each of three exposure classes.

Table 3 gives the calculated values of each shallow reef habitat by exposure class. The third column presents a percentage of spatial extent of each habitat on shallow reef by exposure class for all the areas where urchin barrens were mapped. The fourth column lists the value in hectares of each of these habitats by exposure class extrapolated to the entire study area. The fifth column then calculates a percentage value of spatial extent for each habitat and exposure class from the extrapolated areas calculated in column four. The column five percentage values reflect the predicted make-up for the entire shallow reef system of the study area.

Note that the low exposure urchin barren result represents a very small area within the entire study area but it has a very high spatial extent of urchin barrens (33%). For a more detailed discussion of this data see the Waewaetorea Island habitat report (Kerr & Grace, 2015).

Exposure	**Habitat type**	**% of reef area based on habitat maps (non-reserve)**	**Estimated area for Northland (hectares)**	**Estimated % of total reef area in Northland**
High	*Ecklonia* forest	73.60%	20,466.47	62.95%
Medium	*Ecklonia* forest	91.23%	4,152.06	12.77%
Low	*Ecklonia* forest	27.06%	41.78	0.13%
High	Shallow mixed weed	6.92%	1,925.39	5.92%
Medium	Shallow mixed weed	4.40%	200.10	0.62%
Low	Shallow mixed weed	38.58%	59.57	0.18%
High	Urchin barren	**19.02%**	**5,288.95**	**16.27%**
Medium	Urchin barren	**4.11%**	**186.97**	**0.58%**
Low	Urchin barren	**33.83%**	**52.24**	**0.16%**
High	*Carpophyllum flexuosum* forest	0.40%	111.78	0.34%
Medium	*Carpophyllum flexuosum* forest	0.26%	11.92	0.04%
Low	*Carpophyllum flexuosum* forest	0.53%	0.82	0.00%
High	Algal turfs	0.06%	16.62	0.05%
Medium	Algal turfs	0.00%	0.00	0.00%
Low	Algal turfs	0.00%	0.00	0.00%

Table 3 Calculated values of habitats by exposure classes and extrapolated areas and percentage extent for the entire study area based on the values measured in areas where urchin barrens were mapped.

For the shallow rocky reef systems of the study area, 17% of the area is estimated to be in the urchin barren condition. This corresponds to a total of 5,528 hectares. To put this in some sort of perspective, the total shallow reef habitat area of the study area is 32,515 hectares this is approximately 30% larger than all of Doubtless Bay which is 15 km across. This is more than thirty times larger than the entire area of the Leigh Marine Reserve. The estimated urchin barren extent for the study area at 5,528 hectares is five times larger than the Leigh marine reserve and roughly a quarter of the size of Doubtless Bay.

Marine reserves vs fished areas

Table 5 offers a comparative view of the spatial extent of areas where urchin barrens were mapped, listing values for in and outside of the marine reserves mapped for urchin barren habitats in the study. Essentially the result shows a picture where outside the marine reserve the extent of urchin barren is large and is a significant part of the make-up of the shallow reef ranging from 33.83% (low exposure), 19.02% (high exposure), 4.11% (medium exposure) outside the marine reserves, to around 1% or less urchin barren extent in the marine reserves (Leigh .87% & Tawharanui 1.69%). This result of virtually complete recovery of kelp forests in the two marine reserves Leigh and Tawharanui is well documented and represents a long observation period (30 plus years) over which this restoration took place (Leleu & Remy-Zephir, 2012). Examination of aerial photos clearly shows the transition near the boundaries at these reserves from extensive urchin barrens outside the marine reserves to virtually no visible urchin barrens in the reserves. In these boundary areas this dramatic difference or transition can be seen over a distance of only a few hundred meters (see Figure 2 below).

Exposure	**Habitat Type**	**Percentage of shallow reefs by exposure class and habitats for non-reserve areas where urchin barrens were mapped**	**Percentage of shallow reefs by exposure class and habitats for marine reserves where urchin barrens were mapped**
High	*Ecklonia* forest	73.60%	64.99%
Medium	*Ecklonia* forest	91.23%	12.23%
Low	*Ecklonia* forest	27.06%	0.00%
High	Shallow mixed weed	6.92%	19.51%
Medium	Shallow mixed weed	4.40%	30.46%
Low	Shallow mixed weed	38.58%	0.00%
High	Urchin barren	19.02%	1.15%
Medium	Urchin barren	4.11%	0.00%
Low	Urchin barren	33.83%	0.00%
High	*Carpophyllum flexuosum* forest	0.40%	6.23%
Medium	*Carpophyllum flexuosum* forest	0.26%	22.25%
Low	*Carpophyllum flexuosum* forest	0.53%	0.00%
High	Algal turfs	0.06%	8.12%
Medium	Algal turfs	0.00%	35.06%
Low	Algal turfs	0.00%	0.00%

Table 5 Comparison of percentage of spatial habitat areas by exposure class for areas mapped for urchin barrens inside versus outside marine reserves.

The differences between values in Table 5 above for the *Carpophyllum flexuosum* and algal turfs are mainly reflective of localised habitat differences and different mapping conventions and interpretations used to describe the shallow mixed weed habitat zone for the Leigh and Tawharanui habitat maps.

Partial protection

This study also provided an opportunity to look at urchin barren extent in a key partially protected area that has a good history of monitoring and research. Mimiwhangata Marine Park located on the Whangarei coast has been a partially protected area since the 1980's. In establishing the park, fisheries regulations were created that banned commercial fishing and restricted recreational fishing to non weighted line fishing. Long term monitoring studies for reef fish and crayfish have enabled researchers to track the effectiveness of this partial protection management approach over several decades. Results are conclusive and dramatic for both reef fish (Denny & Babcock, 2004) and crayfish (Shears et al., 2006). The conclusion drawn from this body of monitoring data is that there has been no recovery of key predators over the history of the partially protected marine park. The calculated urchin barren extent at Mimiwhangata from our study is 21.23% of the shallow reef area in urchin barrens. This result seems to be consistent with trends found in the long term reef fish and crayfish studies. This poor result is also higher than the 17% figure estimated for the entire coast where no special restrictions on fishing apply and contrast markedly with the results from established fully protected marine reserves where algal forests recover fully over the same time period Mimiwhangata has been under a partial protection management regime.

Discussion

The canary in the mine

For over five decades researchers both here (northern New Zealand) and overseas have witnessed a decline in temperate shallow reef algal forests. It has become apparent that this decadal trend parallels intensive fishing on a broad commercial scale. This decline trend is likely exacerbated by a spatially disproportionate recreational fishing effort focused on 'accessible' shallow reefs. Fisheries research carried out by NIWA (Harthill et al., 2013) indicates that the recreational catch of snapper in northern New Zealand is significant compared to the commercial catch, but is spatially concentrated on shallow coastal reef areas. At a more localised level, John Booth (2017) prepared a report for the Bay of Islands Fish Forever group which uses the MPI recreational fishing data to compare and comment on localised recreational fishing and its now serious impacts on shallow rocky reefs at the local scale.

Results of this study clearly show that sea urchin barrens are prevalent along the Northland coast of New Zealand. Research in New Zealand and overseas has demonstrated that shifts in tropic state from kelp forests to urchin barrens are occurring in association with overfishing predators of sea urchins (Shears and Babcock 2002, Babcock et al 2010, Ling et al. 2009). Establishment and persistence of urchin barrens also appear to be context dependent and as a result variable (Shears et al., 2008), suggesting that environmental factors can also limit urchin grazing and formation of urchin barrens. The ecological impact of fishing has not been a consideration in fisheries management decisions or 'models' to date. Despite the significance of the rocky reef habitat to many fish species and the coastal environment, the loss of shallow algal forests and greater ecological consequences have not been monitored in any comprehensive manner. We suggest that this story of significant impact of persistent heavy fishing is a canary in the mine scenario. The extensive areas of decline on our reefs should now trigger a response of asking a multitude of questions. How serious is our situation? What other ecological imbalances are playing out that we haven't looked for or are not seeing? What is the best way to address this threat on a regional scale? There is a long and important list of questions to address.

There are clear pointers to how we can address these challenges. Directly contrasting with this story of decline is the story of recovery of kelp forests documented at the marine reserves at Goat Island and Tawharanui (Babcock et al 1999, Shears and Babcock 2002, Leleu et al., 2012) where full protection has allowed predators of urchins to restore natural control of their grazing. The fieldwork for the Leleu study work was completed in 2006. In this study the historic habitat map done at the Leigh Marine Reserve in 1981 (Ayling) was compared to a new survey and map. The result showed that the large areas of urchin barren (44 ha) in 1981 had virtually completely restored to healthy *Ecklonia* forest, with only 4.5 ha of urchin barren documented in 2012. The Leleu survey also found that the boundary areas immediately outside the reserve continued to have large urchin barren zones. A similar result of kelp restoration resulting from long-term full protection from fishing has been observed by the authors at Tawharanui.

Strengths and weaknesses of the GIS approach and mapping sources

A large scale mapping exercise like this by definition is completely reliant on the methods, precision and accuracy of all the component parts making up the study. Also it must be appreciated that in the mapping methodologies scale really matters. In this case mapping scale of the various layers does vary, which we will comment on. A primary objective of all these mapping efforts is to create a map with full spatial coverage of the area of interest. Fulfilling this objective allows for the map to be useful for any form of spatial analysis and planning. As a result of this, mapping projects are compelled to produce the best possible map at the best precision with the resources they can bring together. What this means is that data layers vary in precision and quality. The end result is then the best precision that can be achieved with the time, technology and resources at hand. In this set of Northland maps most of the maps have detailed reports supporting them and descriptions of methodology and reliability. All the mapping projects were completed by a small team of Northland researchers and in one case graduate students working with this Northland team.

We will now comment globally on the reliability of overall estimate of urchin barren extent. First, there is the overall figure of shallow reef area. The best way to evaluate this figure is to look at the large scale Northland habitat map (Kerr, 2010). Since shallow reefs were drawn from a series of data sources there is no one value for error. Shore boundaries and shallow water boundaries were drawn with very accurate (<5m error) aerial photography resulting in a mapping error of well under 10m in virtually all areas. The seaward boundaries were largely bathymetry based as most Northland reefs extend seaward beyond 30m depth and transition to 'deep reef' habitats. The actual error of the bathymetry data set used is not known but in areas where it was ground truthed or matched with more accurate multibeam data, accuracy was good and typically did not exceed 20m or so in regard GPS positioning. There are also areas where the seaward boundary is determined by varying sonar methods, these errors could range from less than 5m for the best multi-beam data sets to areas with sparse single beam sonar coverage where mapping error could range between 5m to as high as 100m in a worst case scenario. To summarise the base shallow reef data set from the Northland map in our opinion would be within a 10-15% margin of error overall for the total area calculated. For the finer scale habitat maps where urchin barren habitats were mapped, the mapping scale was much finer often in shallow areas down to 1:500 and working with state of the art aerial photos with accuracy of <2m. Typically the seaward boundaries were drawn at finer scales with higher resolution data too. As a result we would argue that the shallow reef component for these maps would be within 10 % accuracy for the areas calculated. This brings us to the mapping of urchin barrens themselves. Essentially in all the studies this mapping was primarily done with high resolution aerial photography with high spatial accuracy. The only significant sources of error are interpretation by the mapper or variable water clarity conditions. In all these maps the mappers had years of experience with the interpretation and all studies had ground truthing efforts documented in reports. The quality of photos is however a significant variable and factor which we strongly suspect results in an underestimate of urchin barrens in many locations. The areas where the method has the most difficulty is in steeply sloping coastlines. A recent diver transect based study of one of these 'difficult to map' areas at Cape Brett indicated that these areas do indeed have urchin barrens. Urchin barren patches were sometimes missed by our commonly used methods (Kerr, 2016). Putting all these error sources together in a rough estimate, we would suggest that the overall shallow reef habitat mapping error would be in the range of ±10-15% of the total reef area mapped. The mapping of urchin barren extent would be well under ± 10% of the area mapped as it was done at finer scales and using much finer scale data. All areas mapped for urchin barren extent in this study had good quality aerial photography.

Urchin barren dynamic and non-fishing factors

There are three further aspects of our 17% urchin barren estimate that we would like to comment on:

Variations in reef habitat zonation with depth

For this study we used the definition of seaward extent of the shallow rocky reef habitat as 30m depth. This figure represents what we have measured on Northland reefs as a good average value of the approximate depth where due to lack of light kelp forests thin out and make way entirely for the deep reef habitats dominated by filter feeding invertebrates. However as was first defined in a regional algal forest zonation report (Grace 1983), this value varies with location and water clarity. In the southern part of our study area the lower boundary of the algal forest zone would be more like 20m depth. However the reef area in the south is very small in comparison to the north of the study area. As a result our figure for the overall shallow reef area is overstated to a small degree. Within this variation of depth description for the zone of algal growth urchins have a shallower preferred habitat zone which could be described as 1 to 15m depth in the North and offshore islands to 1 to 10m depth at the entrance to the Hauraki Gulf (Grace 1983, Shears et al., 2004). If we recalculated the percentage figure for urchin barren extent based on the urchin barren preffered depth zone only the figure would be much higher, possibly as high as 25-40%. Urchin barren extent of this magnitude has been mapped in Bay of Islands, Mimiwhangata and recorded on transect studies for a number of locations around Northland occurring outside marine reserves (Shears et al., 2004). This calculation using only the shallow portion of the reef could be completed in a further study or applied locally in monitoring.

Zonation and habitat preference of urchin species and algal forest productivity

Density and productivity of large brown kelps decreases markedly in the lower third of the depth range (20-30m depth). This lower third of the habitat is normally not a preferred habitat of urchins, resulting in most urchin barrens occurring in the depth range of 1-15m.

The prevalence of urchin barrens in shallow water also has disproportionate effects on kelp forest productivity. Shallow water kelp forests (<10 m depth) are much more productive than those found in deeper water where sea urchins are rare (Rodgers et al 2016). Potentially a preferred sea urchin habitat zone could be identified and matched with data on algal forest productivity as a function of depth. This zone definition would vary to a degree along the coast.

Natural (non-fishing related) dynamics of urchin barrens

While reduced predation of urchins is suggested as a primary cause of long-term urchin barren formation, there is a known list of other factors that also affect the dynamic relationship between the algal forest and urchins as its primary browser. These factors include:

1. wave exposure
2. reef slope and topology which may affect the impact of wave energy on urchins; the abundance of crevices and other refugia for urchins;
3. effects of sedimentation;
4. storm damage and recovery of kelp forest ;
5. urchin and kelp disease outbreaks.

All these factors have been observed to operate on urchins and can influence the dynamic between urchin population density, urchin grazing and the persistence of urchin barrens (Grace 1983, Shears and Babcock 2004, Shears et al 2008). In the case of factors 1 & 2 & 3 the result is a positive one for kelp forests in that there will be a tendency for the kelp forest to persist even in the face of removal of the local reef predators. In the case of factors 4 & 5 our observations to date are that these impacts are short term in nature and are not a major factor in urchin barren formation or persistence. Kelp forest have high reproductive potential and growth rates, full recovery from episodes with these natural impacts typically occur within 1-2 year time spans, leading to the conclusion that the large and persistent urchin barrens we have seen develop in the last five decades are not caused by these factors. This is also consistence with the long term observation of our marine reserves.

A further observation from long term observations and transect studies at places like Mimiwhangata and Tawharanui is that in the early phase of urchin barren formation there can be a number of years where the size of the barren fluctuates with apparently a balance between the urchin barren grazing and the kelp's recovery hanging in the balance. Typically over time this balance at some point shifts and the large urchin barrens are established. These larger urchin barren areas appear to be something like a stable state as they are rarely reversed in our experience. Our observation is consistent with studies carried out in Tasmania on the persistence of urchin barrens (Ling et al., 2015).

Extent and persistence of urchin barrens as a state of the environment indicator

There are compelling reasons why urchin barren extent and persistence should be considered as a key ecological indicator summarised in the list below:

1. Shallow kelp forests and their adjacent soft bottom edge habitats are arguably one of the most valuable coastal habitats. In Northland they are clearly threatened by prolonged localised fishing.

2. A monitoring system focused on urchin barrens is essentially measuring primary production (kelp forest), the primary grazer population density and grazing impact, and indirectly the keystone predator presence or absence on the reef. These are the main drivers of all ecosystems and as such affect all other species associated with the reefs.
3. Our experience here and overseas is that the serious impacts of fishing resulting in urchin barrens can be reversed completely by long term cessation of fishing.
4. Experience here and overseas has demonstrated that urchin barrens can be effectively mapped and their extent quantified over time. A range of low cost methods have been employed to date to support mapping. There are new exciting technologies now on stream to further improve our ability to monitor kelp forest health. Combination of high resolution satellite imagery, conventional aerial photography, drone imagery, underwater photography, low cost sonar systems supported by software algorithms designed for mapping underwater vegetation and accurate 3D mapping systems are now all tools that can support efficient kelp forest mapping and monitoring efforts.

Thresholds in urchin barren development that could be used to inform management arrangements

We anticipate a great deal of future interest in the move to ecosystem based monitoring and management approaches. Focus on key habitats especially those with high social economic and cultural values that can be monitored effectively will no doubt be subject to a great deal of research development and new adaptive management systems of the future. However the known threat of urchin barren development occurring today dictates that it is our responsibility to adapt management approaches based on current knowledge. In taking this action we can begin to reverse the current decline as well as inform future management. To this end we are offering here some initial guidelines for thresholds which could be measured in a low cost monitoring system. Results of this system could guide planning and decisions around local control of fishing to allow for recovery of the ecology of rocky reefs and associated biodiversity.

Working assumptions

For a given management area, a basic marine habitat map is completed outlining the extent of rocky reefs

A system of representative monitoring sites are established where the reef's biological zonation is mapped.

At each site a shallow reef depth zone is established representing preferred urchin habitat zone, (shown in white in figure 3 below). Typically this would range from 10-15m or the depth of the reef edge if it is less than this figure. Wave exposure would guide this determination.

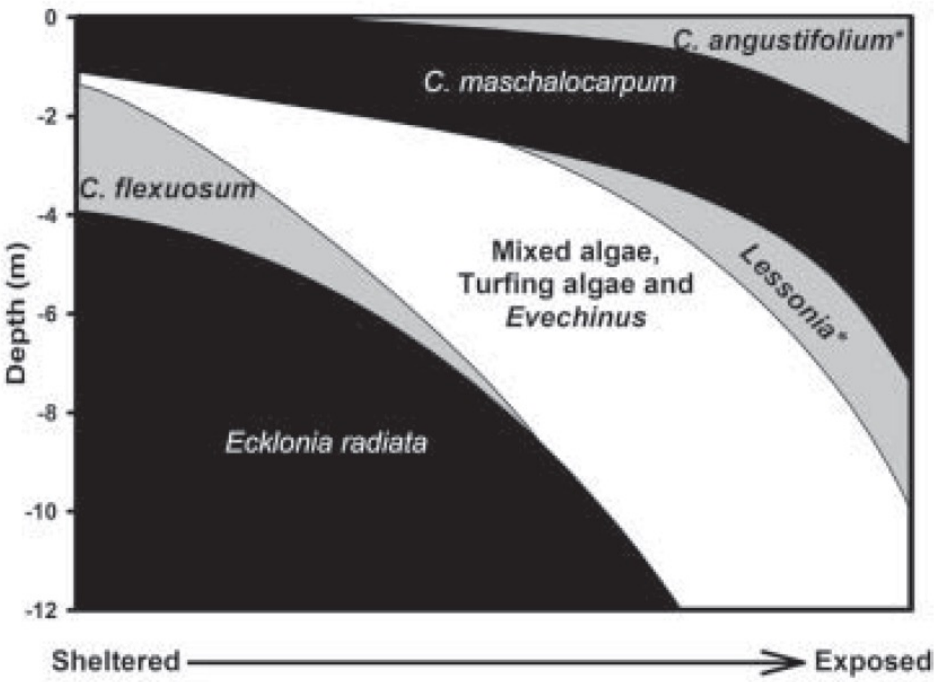


Figure 3 A proposed model for rocky reef zonation as a function of depth and wave exposure, (taken from Shears et al. 2004).

Thresholds used to inform management actions (restrictions on fishing)

Based on the monitoring of the shallow portion of the reef classified as sea urchin preferred habitat, the following thresholds could be considered to trigger management arrangements:

Level 1 5-10% urchin barren extent signals concern that impacts of urchin barrens are becoming significant. If this level persists or expands and is supported by low reef fish diversity counts and low counts of large snapper and crayfish restrictions of fishing could be considered

Level 2 >10% urchin barren extent which is persistent or expanding and supported by poor monitoring results for reef fish diversity, large snapper and crayfish counts. This level triggers consideration of long term no fishing protection to restore ecological balance and productivity of the reef. Decisions to remove the no-fishing restriction could be considered only after recovery of kelp forest had reached a level better than the Level 1 trigger and where sufficient representative areas in the management area remain as a network of fully protected areas to meet basic marine protection goals.

Fishing controls considered should include areas mapped as reef edge habitats of adjacent soft bottom habitats and extend offshore to a minimum distance of 2 km where possible. This design guideline is informed by studies of crayfish (Kelly, 2001 & MacDiarmid & Kelly, 2003) and snapper home range (Parsons et al. 2003) and use of reef edge soft bottom habitats (Langlois, 2005 & 2006).

Recommendations

1) We have identified a specific biodiversity threat to shallow rocky reefs, which is not being taken into account by the current fisheries management framework. This leads us to a conclusion that there is a valid reason to adopt other means to support biodiversity conservation and restoration by pursuing localised management controls on areas where fishing is having serious adverse effects. This would support fisheries management overall.

2) Support further investigations into the special nature of habitats and biodiversity in the shallow coastal zone where localised heavy fishing pressure can have specific ecological impacts. Fish, algal communities, benthic invertebrate communities, and deep reef encrusting invertebrate communities are all good candidates for future investigations.

3) Establish a set of representative rocky reef study areas where long-term changes can be documented and understood.

4) Develop a research programme that reviews the spatial implications of various forms of fishing and specific impacts on shallow rocky reefs. The specific impacts of fishing intensity at the local or reef scale must be quantified for its ecological impact role to be understood.

5) Support ongoing study of the restoration of kelp forests in New Zealand marine reserves and other fully protected areas. Studies of marine reserves have demonstrated that marine reserves can reverse the urchin barren condition back to a restored kelp forest and offer an essential ‘control area’ to evaluate the impacts of fishing at a local scale.

6) Create a research project that examines the climate change implications of loss of kelp forests. In Tasmania loss of kelp forest is believed to significantly reduce carbon absorption and reduce resilience to unstable or fast changing environmental conditions associated with climate change (Ling, 2009).

7) Develop a model for documenting the ecological goods and services value of shallow rocky reefs and the ecological, economic and cultural losses associated with the loss of kelp forests verses the positive value of their restoration (Van den Belt & Cole 2014).

8) Develop local and regional goals or design objectives for the extent and arrangement of a network of fully protected areas that would insure against further decline of shallow reefs and support restoration of kelp forests at a regional scale.

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It has been a pleasure and privilege to work with the team at the Motiti Rohe Moana Trust on this project. We look forward to the day when their hard work and vision will reap rewards for the marine environment and their community. We can do better in engaging our communities in local marine conservation and management work and we will profit from the coming together of matauranga maori and scientific approaches to caring for the sea.

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Appendix 1 Map Book

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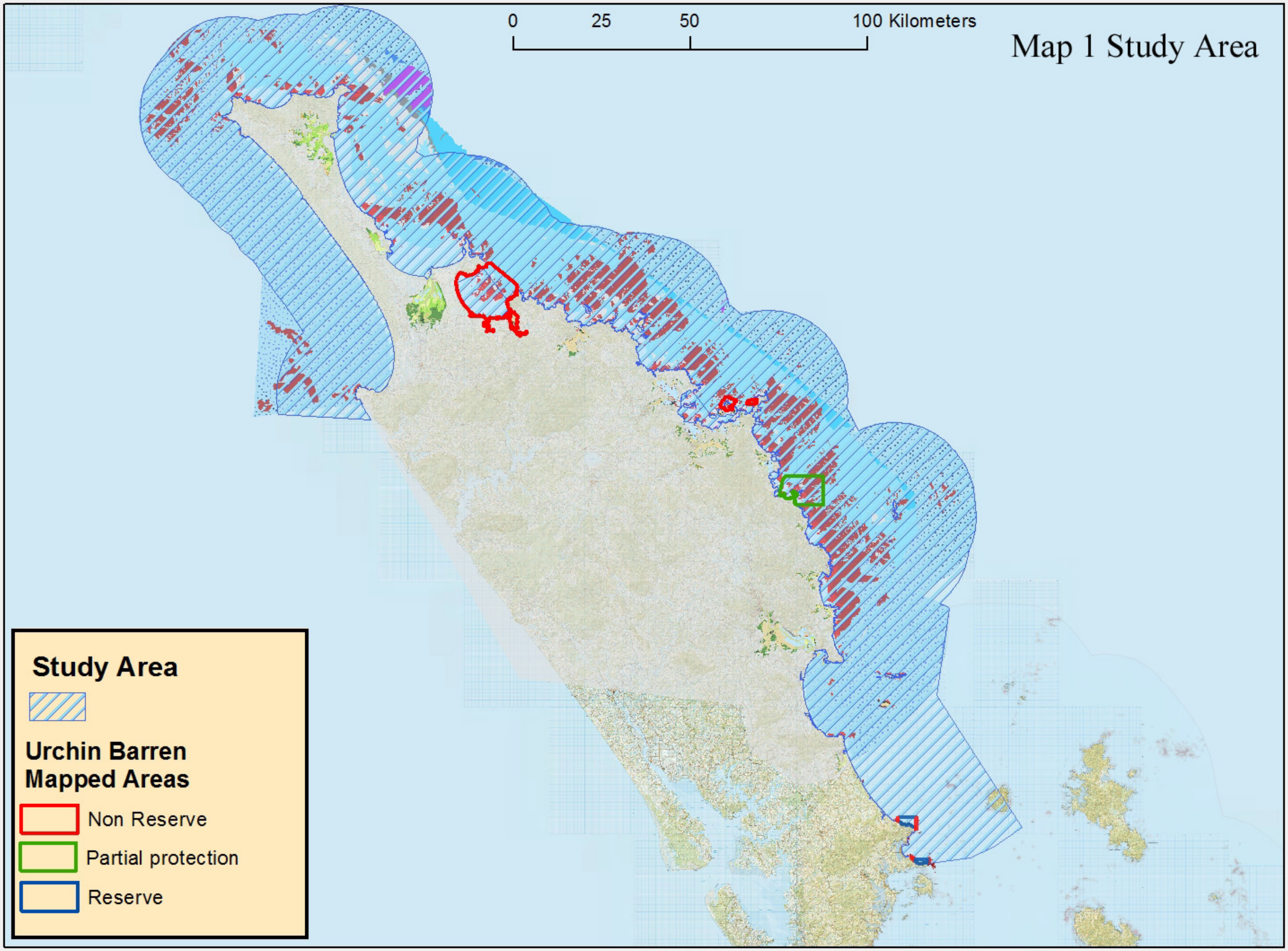
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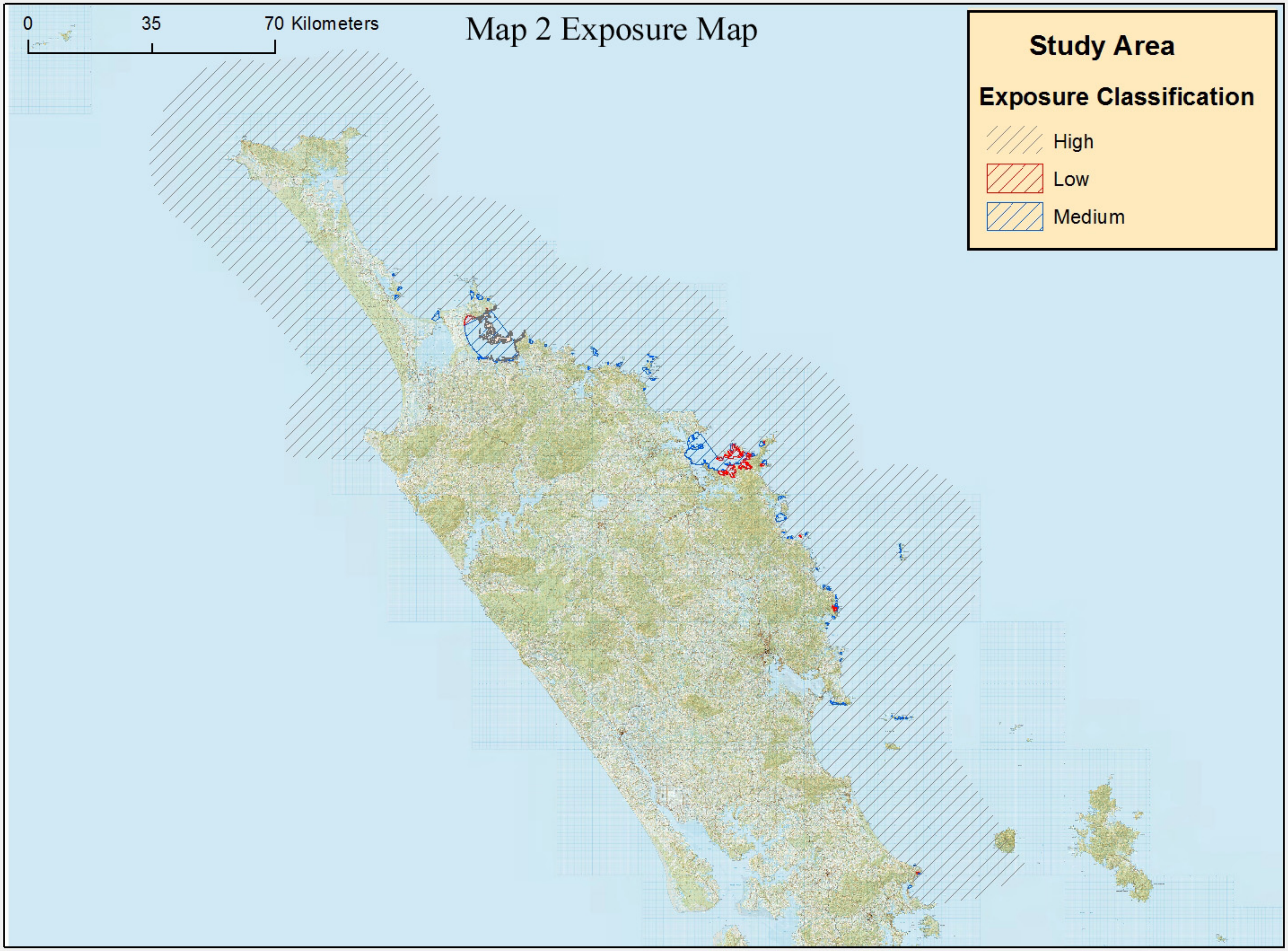
Study Area
Urchin Barren Mapped Areas
Non Reserve
Partial protection
Reserve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Study Area
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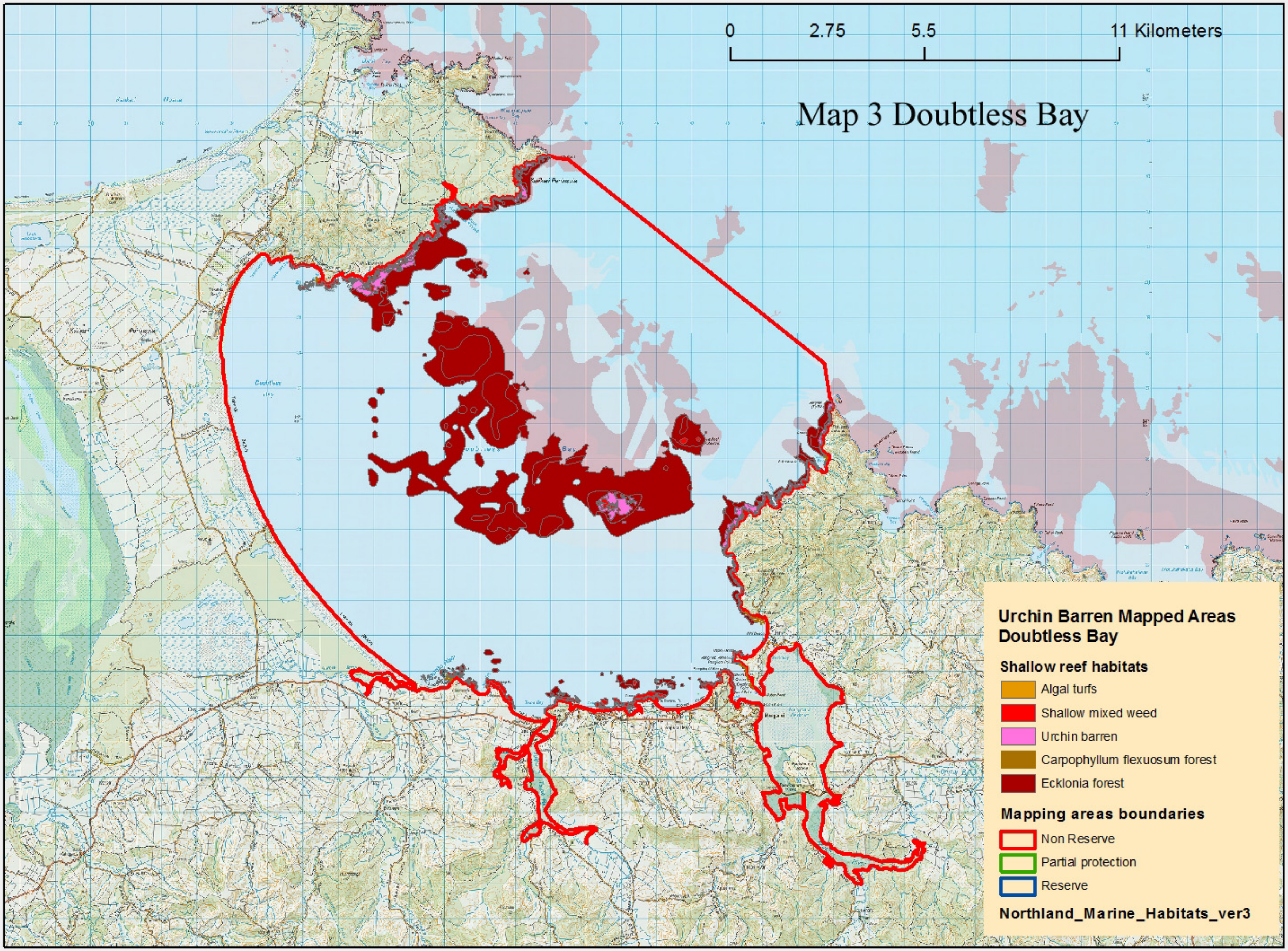
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Map 3 Doubtless Bay
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Doubtless Bay
Shallow reef habitats
Algal turfs
Shallow mixed weed
Urchin barren
Carpophyllum flexuosum forest
Ecklonia forest
Mapping areas boundaries
Non Reserve
Partial protection
Reserve
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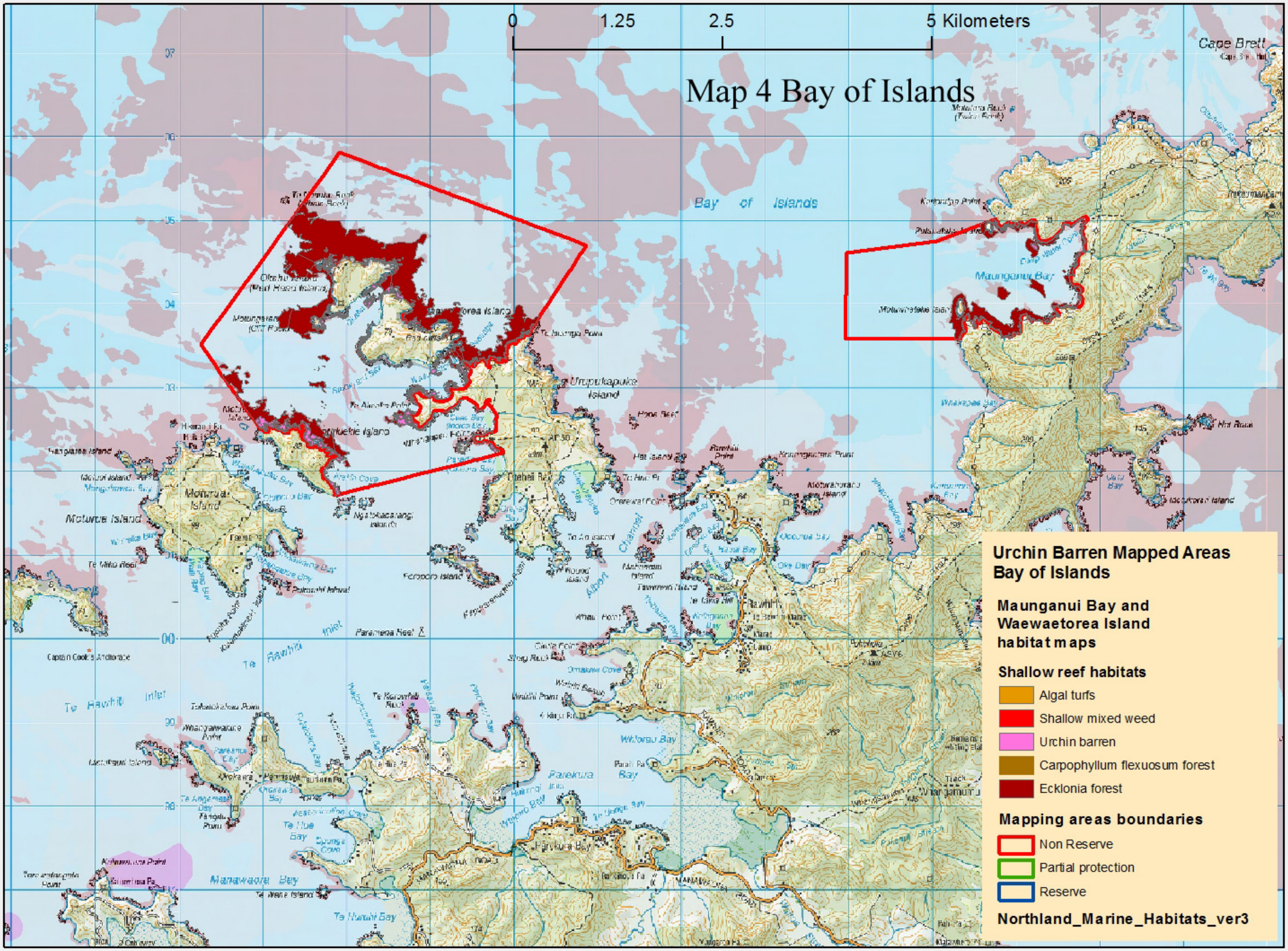
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5 Kilometers
Map 4 Bay of Islands
Cape Brett
Bay of Islands
Maunganui Bay
Urupukapuka Island
Moturua Island
Moturoa Island
Te Rawhiti Inlet
Captain Cook's Anchorage
Paramena Reef
Albert Channel
Parekura Bay
Manawaora Bay
Te Hue Bay
Rawhiti
Urchin Barren Mapped Areas
Bay of Islands
Maunganui Bay and
Waewaetorea Island
habitat maps
Shallow reef habitats
🟧 Algal turfs
🟥 Shallow mixed weed
🟪 Urchin barren
🟫 Carpophyllum flexuosum forest
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Mapping areas boundaries
▭ Non Reserve
▭ Partial protection
▭ Reserve
Northland_Marine_Habitats_ver3

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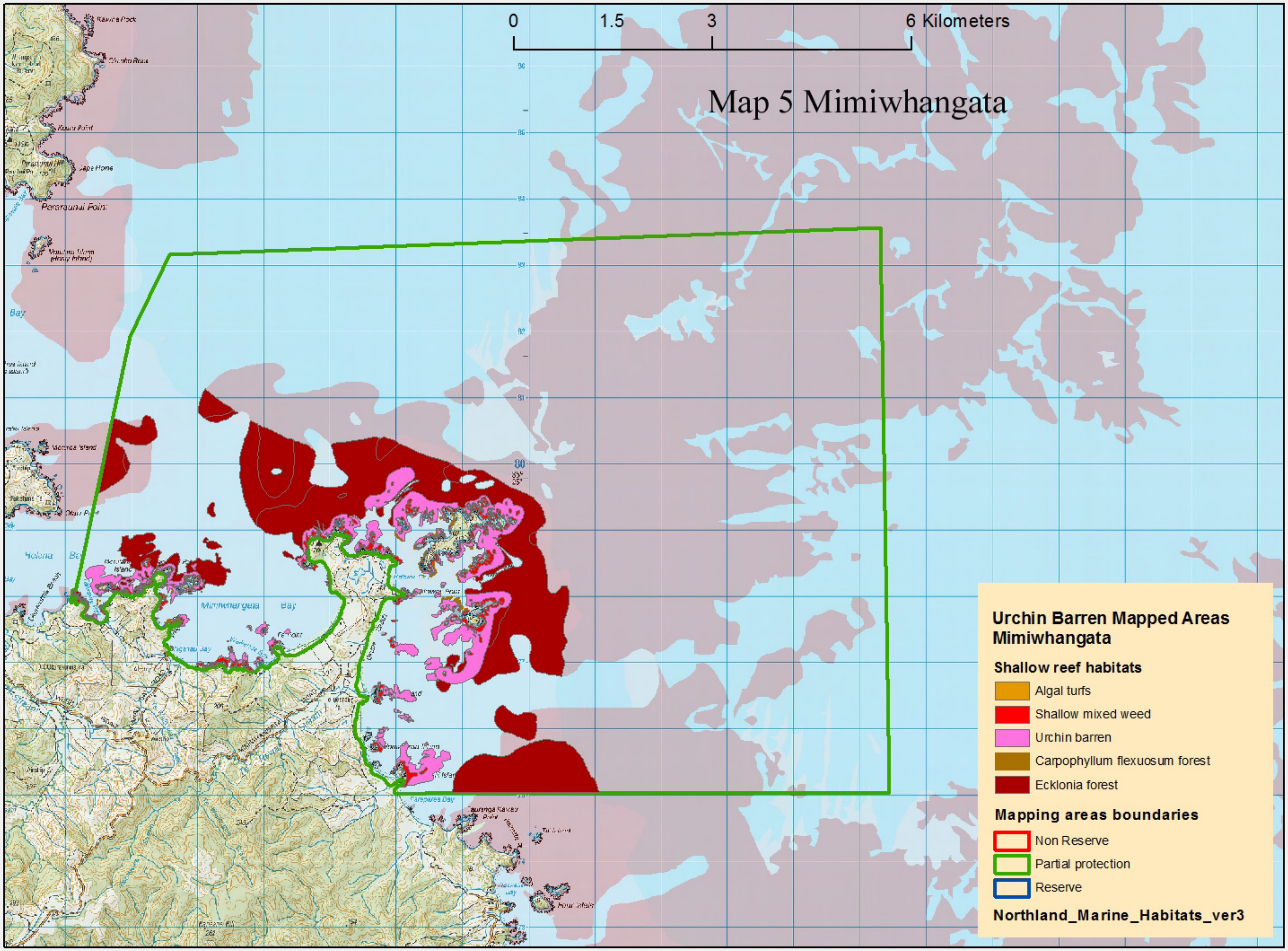
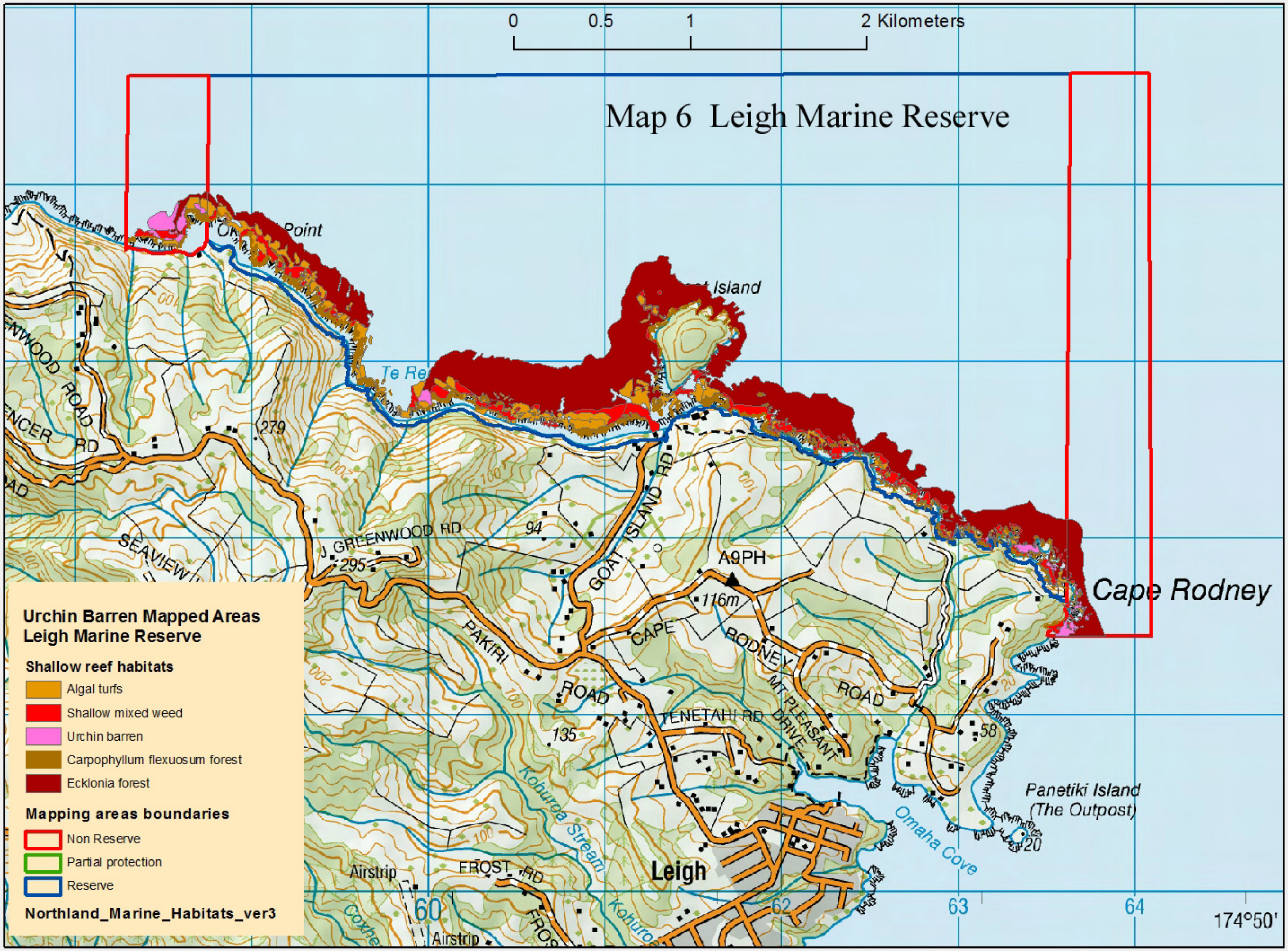
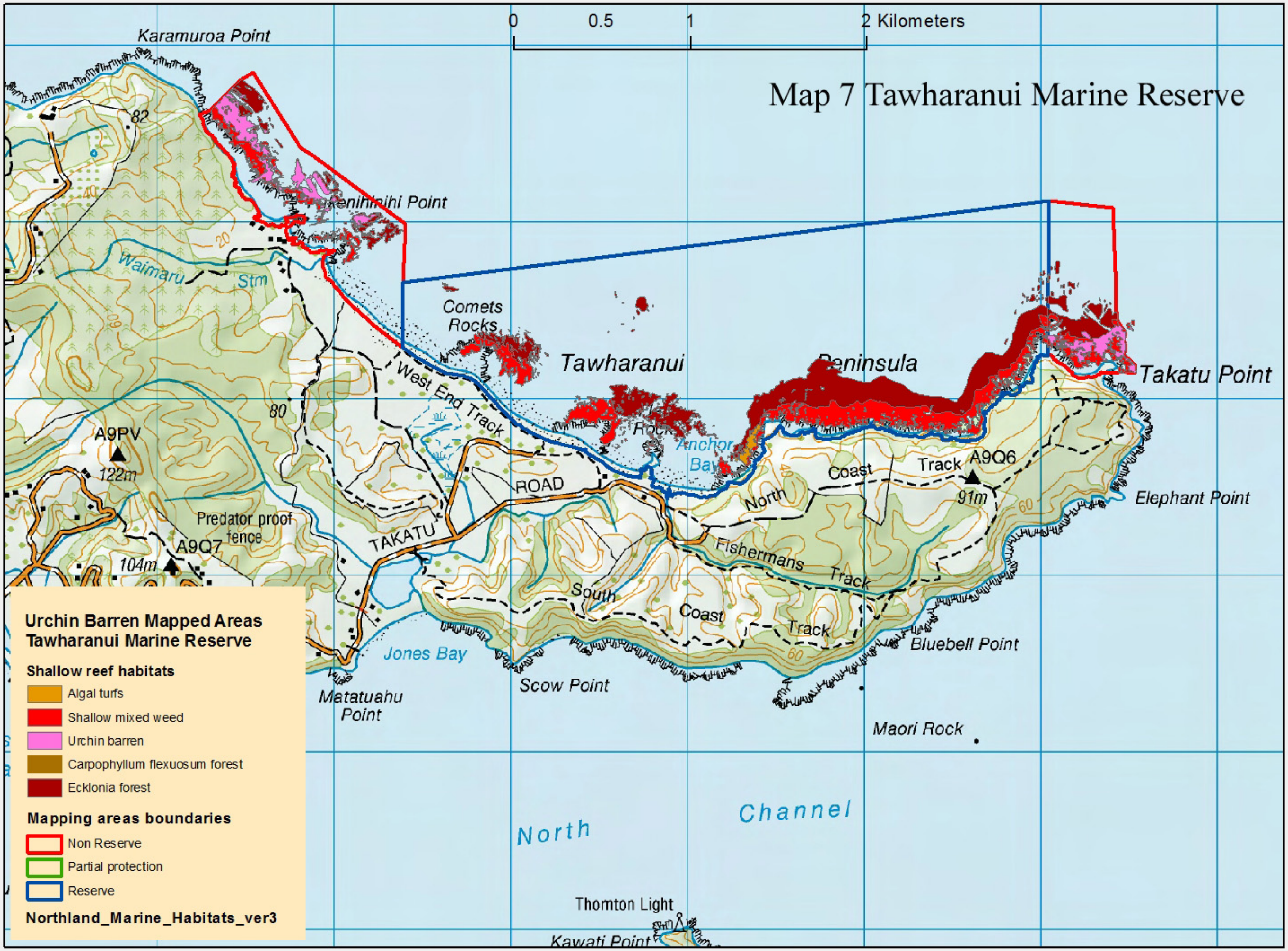


Map 5 Mimiwhangata



Map 6 Leigh Marine Reserve



Map 7 Tawharanui Marine Reserve

Urchin Barren Mapped Areas
Tawharanui Marine Reserve

Shallow reef habitats

- 🟧 Algal turfs
- 🟥 Shallow mixed weed
- 🟪 Urchin barren
- 🟫 Carpophyllum flexuosum forest
- 🟥 Ecklonia forest

Mapping areas boundaries

- ☐ Non Reserve
- ☐ Partial protection
- ☐ Reserve

Northland_Marine_Habitats_ver3

BEFORE THE ENVIRONMENT COURT
Auckland Registry

ENV 2015 AKL 0000134

IN THE MATTER of the Resource Management Act 1991

AND of an appeal under Clause 14 of the First Schedule of the Act

BETWEEN **TRUSTEES OF MOTITI ROHE MOANA TRUST**

Appellant

AND **BAY OF PLENTY REGIONAL COUNCIL**

Respondent

STATEMENT OF EVIDENCE OF VINCENT CARLYLE KERR ON BEHALF OF NGĀTI MĀKINO HERITAGE TRUST

24th October 2017

Introduction

1. My name is Vincent Carlyle Kerr. I hold a Bachelor of Biological Science degree from the University of Oregon, USA and a National Diploma in Horticulture from the Royal Institute of Horticulture, Lincoln College. I am a member of the New Zealand Marine Sciences Association. I am the principal of Kerr and Associates and am engaged in environmental consulting with a focus on marine ecology work and marine protected area planning. I was a former marine technical officer for Northland Conservancy, Department of Conservation (DOC). I have also worked as a contractor and consultant in marine and freshwater ecology for DOC in Northland. I am the current chairman of the Northland based Mountains to Sea Conservation Trust which is amongst New Zealand's largest marine and freshwater environmental education providers. **Annexure A** is my CV.

Experience

2. I have been involved professionally with marine work in Northland. This work has included development of information systems, marine habitat mapping, coastal inventories, ecological descriptions and survey and monitoring. Since 2012 I have worked as a consultant in marine ecology and conservation and established a consultancy, Kerr & Associates.

3. I have been responsible for developing the marine protected area program for Northland with DOC and participated in marine protection working groups at national and regional level.

4. I have been a certified commercial diver and have logged approximately 1,000 scuba dives in Northland waters.

5. I am experienced in GIS operation and marine mapping methodologies.

6. I have also done extensive survey work in the Central Pacific with a focus on coral reef ecology and conservation initiatives.

7. I have carried out mapping work on the entire Northland east and west coasts, developing habitat mapping methodologies with side scan sonar, video surveys and aerial photo analysis.

Environment Court Expert Witness Code of Conduct

8. I have read and agree to comply with the Environment Court Expert Witness Code of Conduct. I have complied with the code in preparation of this evidence.

9. My role in presenting this evidence is to produce research prepared by me in relation to shallow reef ecology and the values associated with ecological processes. I have not undertaken a site visit to the Motiti Rohe Moana Natural Environment Management Area. However I do not consider that is necessary in order to produce my research on the values given my experience with representative ecological environment of the North East Coast of New Zealand. I consider this research is relevant to Otaiti (Astrolabe) reef.

10. I have had opportunity to review draft planning provisions prepared by Graeme Lawrence and associated maps prepared by Diane Lucas (landscape architect) as relevant background material.

Research

11. This work formed the base information for the GIS based marine habitat map of Northland's east coast. Field work for this project included analysis of aerial photos, and literature reviews relevant to the North East Coast of New Zealand and the Bay of Plenty. I have done a large number of scuba and snorkel dives along the North East Coast of New Zealand over a 30 year period.

12. I have been requested by the Motiti Rohe Moana Trust to provide a summary of 'lessons learned' from research on algal forests in northeast New Zealand and in particular my experience with North east coast shallow reefs. "Shallow reefs" refers to a depth range where algal forests dominate the biological community. In the Northland studies a standised range of 0-30m depth was adopted. Below 30m depth the reefs biological communities are dominated by filter feeding invertebrate communities. This major zonation occurs as a result of insufficient light penetrate the deeper zone to support macro algae species. Within this 'shallow reef' habitat there are further zones algal communities. Urchins typically

prefer the upper two-thirds of the ‘Shallow reef’.[1] As a result of this habitat preference of urchins the end result of urchin barrens occurs only in the shallower part of overall shallow reef. In Northland this zone of preferred habitat of sea urchins is typically 1-15m in depth, but local variations and environmental condition exist.

13. Below is a list of the specifics of what the Motiti Rohe Moana Trust has asked to investigate:
    1. Describe what is known about the threat and extent of the urchin barren decline condition in shallow algal forests in Northland.
    2. Examine the relevance or similarity of shallow reef ecology and urchin barren studies to shallow rocky reefs in Bay of Plenty

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[1] Morrison, Jones, Consalvey, Burkenbusch (2012) provides relevant commentary on the definition of **biogenic habitat**:
“Fisheries research and management has traditionally been focussed on the fish populations, while the habitats and environments which underpin their production have been largely ignored. This situation is changing, with an increasing awareness that habitats are important and can be degraded through human activities, both marine and land-based. While the wider field of marine ecology has been researching such fish-habitat themes for a number of decades, the species worked on are often small, site-attached, and relatively short-lived; while fisheries species tend to be larger bodied, and operate over much larger spatial and temporal scales. Given this, quantitatively linking fisheries species to habitats is a challenge, and an active field of research. One type of habitat that appears to be especially important for many demersal species are those referred to as ‘biogenic’ habitats.

These biogenic habitats are formed by plants and animals, and occur from the inter-tidal out to the deep sea. Well known biogenic habitats include salt marshes, mangrove forests, seagrass meadows, kelp forests, bryozoan fields, and shellfish beds. For the purposes of this review, biogenic habitats are defined as a) those living species that form emergent three-dimensional structure, that separate areas in which they occur from surrounding lower vertical dimension seafloor habitats and b) non-living structure generated by living organisms, such as infaunal tubes and burrows. A sub-set of these habitats are biogenic “reefs”, which are visually imposing, and are defined as "solid, massive structures which are created by accumulations of organisms, usually rising from the seabed, or at least clearly forming a substantial, discrete community or habitat which is very different from the surrounding seabed. The structure of the reef may be composed almost entirely of the reef building organism and its tubes or shells, or it may to some degree be composed of sediments, stones and shells bound together by the organisms.

The functions provided by these habitats are diverse, and can include the elevation of biodiversity, bentho-pelagic coupling, sediment baffling, protection from erosion, nutrient recycling, the provision of shelter and food for a wide range of other organisms, and even the creation of geological features over longer time scales. They also directly underpin fisheries production for a range of species, through: 1) the provision of shelter from predation, 2) the provision of associated prey species, and in some cases, 3) the provision of surfaces for reproductive purposes e.g. the laying of elasmobranch egg cases; as well as, 4) indirectly in the case of primary producers through trophic pathways.” (Executive Summary, p1)

3. What are the ecological implications of the decline in algal reef health as seen in Northland studies?
4. What have we learned in Northland and elsewhere from various locally applied management actions involving localised controls on fishing?
5. Would the extent and persistence of urchin barrens be a suitable state of the environment indicator, and could this be measured and monitored in an ongoing system that was efficient?

Outline of Issues

14. Overfishing of sea urchin predators on shallow reefs can result in loss of kelp forests and consequential ‘urchin barrens’. This process of ecological disruption is discussed below.

15. Effectiveness of the proposed rules framework for the Motiti Natural Environment Area (in the form of waahi tapu and waahi taonga areas where fishing techniques and methods are prohibited or restricted).

16. Performance measures and activity thresholds for application in the waahi taonga area.

Importance of Temperate Reef Ecological Assemblages

17. Recent research (discussed below) confirms that the recovery of crayfish and other reef fish (mainly snapper) can lead to a recovery of kelp forests in no-take marine reserves.

18. The application of Region-wide mapping of urchin barrens as a prominent feature of the coast indicates that shallow kelp forests are vulnerable to intensive fishing at large-spatial scales. The results of the attached report suggest greater understanding and recognition of the key biodiversity status and productivity of kelp forests is needed to better understand the ecosystem-level consequences of activities on rocky reefs.

19. Future management of coastal ecosystems must use a range of available tools to address these ecological challenges. We discuss various factors affecting the estimation of urchin barren extent and provide a set of initial thresholds for kelp

forest monitoring which could be used to inform management decisions impacting fishing techniques and methods within the Motiti Natural Environment Management Area.

Background

20. The north east coast region is unique in several aspects relating to marine habitats. Firstly, Northland has an extensive coastline and a very large area of shallow rocky reefs. Many of the Northland reef systems have an ecological sequence with large areas of offshore ‘deep reefs’ (rocky reef structures occurring at depths greater than 30m), not dissimilar to that of the Motiti Natural Environment area (MNEA). Secondly, Northland has had more marine habitat mapping projects completed than any other region.

21. In my experience and expressed in the attached report (**Annexure B**) we have brought all this information together in a GIS based project to question the state of health of shallow rocky reefs in particular in the Northland region. This regional scale analysis is relevant to MNEA, particularly the extent of the habitat type known as ‘urchin barrens’, where large numbers of sea urchins have lead to the loss of kelp forests. I consider the estimated extent of urchin barren areas are having dramatic effects on the coastal ecological assemblies, productivity, biodiversity of the marine environment, especially reef resident and reef specialist species.

22. Our study and data included analysis of different types of activity management including two marine reserve and a partial protection area. Tawharanui was set up as a Marine Park in in the 1980’s, but was effectively a marine reserve with a full ‘no-take’ due to rules in place, and subsequently obtained full marine reserve status. The Cape Rodney to Okakari Marine Reserve was established in the 1970’s. A third relevant site is an area that has had partial protection in place since the 1980’s. Mimiwhangata Marine Park has all commercial fishing and some method restrictions on recreational fishers.

23. I understand that MRMT proposes a cultural and biodiversity based marine spatial plan with associated rules that is intended to have ecological benefits through preventing or restricting fishing techniques and methods within identified areas (waahi tapu and waahi taonga areas).

North East Coast Bioregional View Of Similarities

24. I consider that ecological conditions associated with shallow reefs in Northland are likely to have substantial similarities with the Bay of Plenty region; accordingly my research is relevant to the ecological conditions likely to apply to the Motiti Natural Environment Management Area. This view is supported by extensive work supporting the creation of a regional classification system for coastal New Zealand. This classification system appears in its most updated form in the Government's Marine Protected Areas Policy and Implementation Plan (DOC & MPI, 2008) (Map 1 below). Northland's east coast shares the same regional classification, 'Northeast Bioregion', with Hauraki Gulf, Coromandel, and Bay of Plenty.

25. This bioregional level classification is a large body of data that shows that these three regions share similar currents, water temperatures and flora and fauna groups. Detailed studies testing the validity of the bioregional classification and specifically similarities between the shallow reefs across the bioregion have been carried out and also support the concept and application of the current classification (Shears et al. 2008; Shears & Babcock, 2007, Shears & Babcock, 2004).

26. In Northland and Bay of Plenty our coasts are regularly swept with warm subtropical currents which bring with them an extra dimension of larvae from subtropical origins. As a result the northeast bioregion has by far the highest fish diversity associated with its shallow reefs. These habitats have been documented in a comprehensive Northland rocky reef fish diversity study (Brook, 2002).

27. I do note that sub-regional ecological responses may occur at a local level in relation to specific influences of micro-habitat orientation to current, swell, light, biological availability and other physical and environmental parameters.

Ecological Significance Of Shallow Rocky Reefs And The Urchin Barren Dynamic

28. The shallow rocky reef ecosystem is very important for biodiversity value of flora and fauna. Shallow rocky reef systems in ecological terms are generally accepted

to be one of the most significant habitats of the exposed coast marine environment.

29. There is no current regime of monitoring that looks specifically at the health of algal forests which are the foundation of productivity and structure for this habitat. [2] The evidence I have prepared on the health of rocky reefs comes from habitat mapping projects which have been arranged to support marine protected area planning and spatial frameworks.

30. A big picture review of the ecology of the North East Coast, in particular my experience with Northland's reefs and coastal environments, is consistent with the attached NIWA Report (Morrison, 2005) and the wider review of Biogenic Habitats, 2014 by the same author. This review highlights the fact that many commercially important fish species spend part of their life cycle on shallow rocky reefs. Also highlighted in the NIWA report is the high diversity levels of invertebrates and algal species have a critical habitat relationship which is intrinsic in nature.

31. The sea urchin, *Evechinus chloroticus*, known as kina in New Zealand, is widespread in the Northeast Bioregion. In addition to being a traditional food species, it plays a key role as a primary grazer of kelp. Early studies in north east New Zealand documented kina's role as a habitat creator through grazing of kelp (Choat, 1982), (Grace 1983), however at that time it was thought that barren areas on the reef caused by urchin grazing was a 'natural' characteristic of our reefs.

32. In subsequent decades, the dynamics between kelp forests, sea urchins and exploitation of sea urchin predators (mainly snapper and crayfish) has been investigated in New Zealand (Shears et al. 2004; Shears and Babcock, 2002). The Mimiwhangata habitat mapping report (Kerr & Grace 2005) illustrated dramatic decline of the kelp forests over wide areas, starting sometime in the 1960s or 1970s.

33. As part of our methodology for the Mimiwhangata habitat mapping exercise, local kaumatua were interviewed and stated with confidence that the current condition

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[2] I understand that Dr Kepa Morgan will provide evidence on the mauri-model developed by him that may assist with measurement of reef health and biodiversity.

of extensive urchin barren areas was not known prior to about 1960-1970 and was not mentioned in their tribal knowledge handed down from elders.

34. In northern New Zealand it was found that large snapper and crayfish are the main predators of urchins (Shears & Babcock, 2002). In their absence, population density of urchins can raise 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.

35. There is a large body of research based around the Leigh marine reserve where after thirty years of full protection the urchin barren areas which were extensive in the 1970's reverted to kelp forests, in parallel with the predator species re-establishing in the marine reserve.

36. Diversity loss gives rise to further concerns around reefs' reduced ability to fulfil their natural role of fixing carbon and thus reduce greenhouse gas and potentially serious reduction in the reef systems' resilience to rapidly changing environmental conditions brought on by global warming.

37. Recognition of the importance of shallow rocky reefs and the threat of diversity and productivity loss due to overfishing and urchin barren establishment in New Zealand has unfortunately not yet lead to a point where it features in any monitoring programs regionally.

38. To highlight the potential effects of the rules on urchin kelp relationships in Figure xx below you can see a glaring example from the Bay of Islands of the extent of urchin barrens in an area badly affected. There would have been naturally continuous heavy kelp forest cover across the entire reef (seen as dark brown). What we see is a thin edge of specialised shallow water seaweeds, species of *Carpophyllum* less palatable to urchins, and a remnant of the *Ecklonia radiata* (large brown kelp), seen here below about 10m depth only covering a small area of the bottom of the reef near where it drops off on to an edge with a sandy bottom habitat. This barren condition represents a major loss of productivity, habitat and diversity. In contrast the fully restored reefs under full protection have a consistent coverage of macro algae species and high productivity and

biodiversity values. I have provided a more detailed explanation in my appended report.

Partial Protection From Activities

39. Our research has provided an opportunity to measure algal forest health recovery responses in a partially protected area, measuring urchin barren extent.

40. There is a good history of monitoring and research at Mimiwhangata Marine Park. It was established as a marine park, with fisheries regulations which restricted commercial activities and provided special recreational fishing provisions in the form of a regulation allowing fishing only with non weighted lines.

41. Based on long term monitoring studies for reef fish and crayfish, researchers have tracked the effectiveness of this partial protection management approach over several decades. Results are conclusive and dramatic for both reef fish (Denny & Babcock, 2004) and crayfish (Shears et al., 2006). It can be concluded that there has been no recovery of key predators over the history of the partially protected marine park. Urchin barren areas are extensive and have not recovered.

Discussion

42. In my opinion it has become apparent that this decadal trend parallels intensive fishing practices. This decline trend is likely exacerbated by a spatially disproportionate recreational fishing effort focused on ‘accessible’ shallow reefs. Fisheries research carried out by NIWA (Harthill et al., 2013) indicates that the recreational catch of snapper in northern New Zealand is significant compared to the commercial catch, but is spatially concentrated on shallow coastal reef areas.

43. At a more regional and localised level, John Booth (2017) prepared a report for the Bay of Islands Fish Forever group which uses the MPI recreational fishing data to compare and comment on localised recreational fishing and its’ now serious impacts on shallow rocky reefs at the local scale. Dr Booth relevantly notes that:

> “The loss of shallow-reef kelp in the Bay of Islands has been intensive and extensive (up to 90% or more in places), and is likely to have led to a multitude of cascading consequences, most of them not yet even recognised let alone understood. The kelp community plays pivotal ecological roles (e.g., Tegner & Dayton 2000; Schiel, 2003; Leleu et al. 2012; Hesse et al. 2016): kelps are highly productive, fixing carbon, and fuelling the ecosystem; and they provide habitat for all manner of animals and plants. Shallow kelp forests provide areas for fish spawning and larval settlement, and shelter for juveniles, by reducing exposure to water movement and predation. Red rock lobster postlarvae often settle out of the plankton among shallow-reef kelp, and juvenile snapper are strongly associated with it.
>
> Whereas the reason for the emergence of sea-urchin/kina barrens in northeastern New Zealand was for a time contested, there now appears to be consensus that these barrens are a direct result of the overharvesting of keystone predators (predators whose impact on the ecosystem is disproportionately large relative to their abundance) such as snapper and red rock lobsters - the ones capable of preying on kina (Andrew & MacDiarmid 1991, Shears & Babcock 2002, Ayling & Babcock 2003, Schiel 2013, Ballantine 2014) and other sea urchins. In Schiel’s (2013) cascading, ‘trophic-effect model’ for northeast Northland, reductions in the proportions of large individuals of these predatory species have led to burgeoning sea urchin (kina in particular) populations and to the widespread loss of shallow-reef kelp. Resulting sea-urchin barrens such as these are a world-wide phenomenon and one surprisingly difficult to reverse (Ling et al. 2014).” ([5.3] Discussion & Conclusion, p58)

44. Establishment and persistence of urchin barrens also appear to be context dependent and as a result variable (Shears et al., 2008), suggesting that environmental factors can also limit urchin grazing and formation of urchin barrens.

45. The ecological impact of fishing has not been (in my experience) a consideration in fisheries management decisions or ‘models’ to date. Despite the significance of the rocky reef habitat to many fish species and the coastal environment, the loss of shallow algal forests and greater ecological consequences have not been monitored in any comprehensive manner. It is therefore relevant to any management regime introduced to control fishing techniques and methods as part of the MNEA.

46. I consider that there is a clear need for an ability to apply restrictions on fishing techniques and methods such as those sought by the Motiti Rohe Moana Trust. These are likely, over time, to support and restore natural control of kelp forest

grazing by restoring a functional ecological balance and trophic interactions between predator, prey, grazer.

Potential Thresholds for Algal Forest Health

47. In both marine ecological research and fisheries management there is currently a great interest in the move to ecosystem based management. The development of a method focused on algal forest health is an ideal ecological monitoring approach and will complement more holistic ecosystem management approaches.

48. I have not been involved in developing the rules framework for the Motiti Natural Environment Area. Hence I can only comment at the level of principle and not on specific wording proposed. I consider that the proposal to ban fishing techniques and methods completely within identified areas (known as waahi tapu) is likely to result in benefits to indigenous biodiversity and the habitat of valued fish and flora species such as snapper, hapuku and crayfish. However, as Dr Roger Grace notes in his draft evidence, the benefits will be related to the size and quality of habitat of “no-take” areas. In principle, I also consider that restricting fishing techniques and methods within identified areas (known as waahi taonga) until transect studies confirm sustainable populations of key species of flora or fauna (for example, *Eklonia* (rimurimu or brown kelp) are restored is likely to result in benefits to indigenous biodiversity and the habitat of valued fish and flora species. Benefits will be related to the level of management control imposed and other variables such as size and quality of habitat.

49. I therefore support, in principle, the proposal that areas within the Motiti Natural Environment Area cannot be fished until brown kelp is restored to a healthy state within those areas. The trigger we offer below level 2 is arguably a threshold where negative impacts on the reef system are substantial and from what we know headed towards further decline and a shift to a more stable unproductive state. The level 2 extent of persistent urchin barren could be considered for this management approach to indicate the threshold level of a healthy reef. Levels between Level 1 and 2 could trigger a warning that an unhealthy state may develop. Levels below Level 1 could be considered to be at a natural and very

healthy condition parallel to what we see in a restored algal forests in our long term marine reserves.

50. I would like to offer here some initial guidelines for thresholds which could be measured in a low cost monitoring system with the provision of the following working assumptions:
    50.1. For a given management area, a basic marine habitat map is completed outlining the extent of rocky reefs;
    50.2. A system of representative monitoring sites are established where the reef's biological zonation is mapped;
    50.3. At each site a shallow reef depth zone is established representing preferred urchin habitat zone (shown in white in figure 3 below). Typically this would range from the 1 m to 10-15m depth levels or the depth of the reef edge if it is less than this figure. Wave exposure and water clarity affect this depth zonation.

Thresholds Marine Use Activity

51. Based on the monitoring of the shallow portion of the reef classified as sea urchin preferred habitat, the following thresholds could be considered to trigger management arrangements:

    51.1. Level 1: 5-10% urchin barren extent signals concern that impacts of urchin barrens are becoming significant. If this level persists or expands and is supported by low reef fish diversity counts and low counts of large snapper and crayfish restrictions of fishing could be considered.

    51.2. Level 2 : >10% urchin barren extent which is persistent or expanding and supported by poor monitoring results for reef fish diversity, large snapper and crayfish counts. This level triggers consideration of long term no fishing protection to restore ecological balance and productivity of the reef. Decisions to remove the no-fishing restriction could be considered only after recovery of kelp forest had reached a level better than the Level 1 trigger and where sufficient representative areas in the management area remain as a network of fully protected areas to meet basic marine protection goals.

51.3. Fishing controls considered should include areas mapped as reef edge habitats of adjacent soft bottom habitats and extend offshore to a minimum distance of 2 km where possible. This design guideline is informed by studies of crayfish (Kelly, 2001 & MacDiarmid & Kelly, 2003) and snapper home range (Parsons et al. 2003) and use of reef edge soft bottom habitats (Langlois, 2005 & 2006).

51.4. As noted earlier, there are variables in the urchin barren effect in terms of ‘other environmental factors’ which affect urchin behaviour or population density. They are things like disease, storms, wave exposure, sedimentation and topography. In short at times and at certain places these factors effectively limit urchin populations and grazing so that even in the absence of urchin predators there are few or no urchin barrens, but there is a depleted fish community and potentially other ecological imbalances etc. The urchin barren is not a perfect indicator for all stretches of coast. Ideally what we can learn from this indicator is applied with other forms of monitoring and knowledge to design protection at large scales.

Recommendations

52. I have made specific recommendation in my report to the Motiti Rohe Moana Trust and reiterate them below.

52.1. We have identified a specific biodiversity threat to shallow rocky reefs, which is not being taken into account by the current fisheries management framework. This leads us to a conclusion that there is a valid reason to adopt other means to support biodiversity conservation and restoration by pursuing localised management controls on areas where fishing activities result in significant reduction in biodiversity (or other) identified values of shallow reefs.

52.2. Support further investigations into the special nature of habitats and biodiversity in the shallow coastal zone where localised heavy fishing pressure can have specific ecological impacts. Fish, algal communities, benthic invertebrate communities, and deep reef encrusting invertebrate communities are all good candidates for future investigations.

52.3. Establish a set of representative rocky reef study areas where long-term changes can be documented and understood.

52.4. Develop a research programme that reviews the spatial implications of various forms of activities and fishing and specific impacts on shallow rocky reefs. The specific impacts of fishing intensity at the local or reef scale must be quantified for its ecological impact role to be understood.

52.5. Support ongoing study of the restoration of kelp forests in New Zealand marine reserves and other fully protected areas. Studies of marine reserves have demonstrated that marine reserves (or equivalent areas where a “no-take” regime is in place) can reverse the urchin barren condition back to a restored kelp forest and offer an essential ‘control area’.

52.6. Create a research project that examines the climate change implications of loss of kelp forests.

52.7. Develop a model for documenting the ecological goods and services value of shallow rocky reefs and the ecological, economic and cultural losses associated with the loss of kelp forests versus the positive value of their restoration (Van den Belt & Cole 2014).

52.8. Develop local and regional goals or design objectives for the extent and arrangement of a network of fully protected areas that would insure against further decline of shallow reefs and support restoration of kelp forests at a regional scale.

DATED at Whangarei this 24th day of October 2017.

Vincent Kerr

Vince Kerr