IN THE HIGH COURT OF NEW ZEALAND
WELLINGTON REGISTRY

I TE KŌTI MATUA O AOTEAROA
TE WHANGANUI-Ā-TARA ROHE

CIV-2023-485-541

UNDER THE	Judicial Review Procedure Act 2016
IN THE MATTER OF	An application for judicial review of a decision of the Minister of Oceans and Fisheries under s 13 of the Fisheries Act 1996
BETWEEN	**THE ENVIRONMENTAL LAW INITIATIVE**
	First Applicant
AND	**DALLAS WILLIAMS** on behalf of **Ngāti Hau & Ngāti Kaharau Hapū ki Hokianga**
	Second Applicant
AND	**MINISTER FOR OCEANS AND FISHERIES**
	First Respondent
AND	**NEW ZEALAND ROCK LOBSTER INDUSTRY COUNCIL INC**
	Second Respondent

AFFIDAVIT OF VINCENT CARLYLE KERR
AFFIRMED 19 APRIL 2024

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AND **SEAFOOD NEW ZEALAND LTD**

Third Respondent

AFFIDAVIT OF VINCENT CARLYLE KERR

I, **Vincent Carlyle Kerr**, science advisor of Whangarei, solemnly and sincerely affirm:

Introduction and background

1. I am a principal of Kerr & Associates and am 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 the Northland Conservancy, Department of Conservation (**DOC**). I have also worked as a contractor and consultant in marine and freshwater ecology for DOC in Northland.

2. I am a co-founder and former Chairperson of the Northland-based Mountains to Sea Conservation Trust, one of 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 hapū and community conservation projects as part of its community engagement program.

3. I hold a Bachelor of Biological Science 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 the secondary and tertiary levels. 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.

4. Over the past twenty years and more, I have led numerous marine habitat mapping projects, coastal inventories, and ecological descriptions and have established several survey and monitoring programs around Northland. I have been an active diver and marine photographer 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 Central Pacific.

5. My experience diving on Northland's east coast portion of the CRA1 Quota Management Area (**the CRA1 QMA**) extends over four decades. I am familiar with the estuaries and all of this long coastline. My work as a marine scientist on this coast began over three decades ago. I have worked on crayfish, also known as spiny rock lobster, *Jasus edwardsii* monitoring along with kelp forest mapping at a range of sites in Northland, including Motukaroro Marine Reserve, Mimiwhangata, the outer islands of Bay of Islands, Cape Brett, Maunganui Bay and in the Far North Maitai Bay and Doubtless Bay.

6. Of these projects, Mimiwhangata stands out as the most well-studied site. Several papers have been published in the scientific literature about Mimiwhangata, along with 34 technical reports. This makes up one of the longest sequences of studies and data in New Zealand marine ecology for a single site. Significantly, these studies include the first subtidal marine habitat map[1] and compare results from a partial protection regime, adjacent open fishing areas and now full protection under recent Northland Regional

[1] Darby, J. and Darby, M. 1973. *Mimiwhangata 1973: Ecological Report*. Auckland: Turbott & Halstead.

Council (**NRC**) Coastal Plan rules, inserted by the *Northland Regional Council case*.[2] My involvement with the science work at Mimiwhangata began in 1999 when I was working as a contractor for DOC. I have been involved in various capacities with all Mimiwhangata investigations and reports from 2002 onwards.

7. In addition to the scientific research and monitoring work summarised above, I have acted as a marine ecological advisor and expert witness in recent Environment Court cases:

   (a) In the *Motiti* case,[3] I provided expert evidence that presented the results of a large-scale Northland-based GIS study of the extent of kelp forest loss due to the removal of sea urchin predators from overfishing. That case concerned the Bay of Plenty, but the Court accepted that Northland findings were applicable because for marine ecology purposes, the waters are in the same bioregion as eastern Northland waters (as is the case with Hauraki Gulf waters); and

   (b) In the *Northland Regional Council* case, my evidence covered the results of my decades of past research and monitoring centred on Mimiwhangata and the impacts of algal forest decline[4].

8. I was the lead contractor to NRC in the early stages of its Coastal Plan development, and in this capacity responsible for establishing the Ecological Significant Areas mapping methodology, resource descriptions, and evaluation protocols that have since been used in the Northland Regional Plan. As mentioned above at [7](b), I later served as an expert witness in the Environment Court concerning appeals to ecological provisions in the Regional Coastal Plan.

9. I gave expert evidence in ELI's successful judicial review on the Minister's preceding CRA1 total allowable catch (**TAC**) decisions for the 2021/22 and 2022/23 fishing years. I append that evidence to this evidence as **VCK-1**. Much of my evidence in that case, and that of Associate Professor Shears and Professor Jeffs, was accepted by the Court and I do not intend to repeat it at length in this affidavit. That evidence described the decline in abundance of crayfish and algal forest cover and the increase in kina barrens within the CRA 1 QMA.

10. Since the High Court judgment on the preceding TAC decisions, I have written a new scientific paper on kelp forest loss in Northland. The paper is co-authored with Associate Professor Shears and Dr Grace,[5] and has been

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[2] See rules inserted in the Northland Regional Coastal Plan by order of the Environment Court on 4 November 2022, reported at *Bay of Islands Marine Park Incorporated v Northland Regional Council* [2022] NZEnvC 228.

[3] *Motiti Rohe Moana Trust v Bay of Plenty Regional Council* [2018] NZEnvC 67.

[4] In this affidavit, I refer to algal and *Ecklonia radiata* forests. Algal forest is a general term that varies in species composition depending on the geographical context. In Northland, *Ecklonia radiata* is the predominant species of kelp found in algal forests. While other kelp species are present in different depth zones and wave energy situations, *Ecklonia radiata* is the dominant species, especially in the most productive zone of the algal forest. Therefore, algal forests in Northland are often referred to as *Ecklonia radiata.*

[5] Sadly, Dr Grace recently passed away.

accepted for publication by the New Zealand Journal of Marine and Freshwater Research. The paper combines all of the marine habitat mapping studies done to date and the GIS data associated with these studies to estimate kelp forest loss at a Regional Scale. This estimate includes the area from Cape Reinga in the north to the southern boundary of CRA1 and a small part of the CRA2 QMA.

The scope of my evidence

11. I have read the pleadings and evidence filed in this proceeding to date. I have been asked to provide my opinion on what is needed to ensure the sustainability of the crayfish population and to allow crayfish, as the *Review of sustainability measures for crayfish (CRA 1) for 2023/24 – Fisheries New Zealand Decision Paper* (**Decision Paper**) puts it, "to play their part in controlling kina populations and delivering other ecosystem functions". Specifically, I have been asked to give my view on:

    (a) What information relevant to these issues was reasonably available to the Minister at the time of the resulting decision (April 2023 TAC Decision), including my views on any information that has become available since the preceding TAC decisions.

    (b) The extent to which the advice in the Decision Paper correctly reflects the available information and the gaps and uncertainty in that information.

    (c) The extent to which the advice in the Decision Paper may omit what I consider to be essential scientific information, published or otherwise.

    (d) What management steps are needed to avoid, remedy or mitigate the adverse effects of rock lobster fishing on the aquatic environment.

    (e) Whether the advice in the Decision Paper contains any options that will have that effect, and if so, whether the Minister's Decision will have that effect.

12. I have read the expert evidence of Associate Professor Nick Shears and Professor Andrew Jeffs. To the extent that their evidence is within my area of expertise, I confirm that I agree with their opinions.

13. I have read the Code of Conduct for expert witnesses in Schedule 4 of the High Court Rules 2016, and I agree to comply with it. Where my affidavit contains matters of expert opinion evidence, I confirm the statements made are within my area of expertise.

Summary of my evidence

14. Here I give a very high-level summary of my evidence.

15. In my view there are several flaws in Fisheries New Zealand (**FNZ**) approach to managing CRA1. These affect the ongoing sustainability and utilisation of both the stock and wider aquatic ecosystem in the CRA1 QMA. These flaws include:

(a) significant limitations with the inputs into the stock assessment model relied on by FNZ. These limitations introduce significant uncertainties into model outputs, but are almost wholly un-acknowledged in the Decision Paper;

(b) inadequate or total lack of consideration of relevant information regarding crayfish ecological factors, and the relevance of this information to understanding the effects of fishing CRA1, and developing management options;

(c) insufficient regard to Mātauranga Māori knowledge, which can help locate the current state of crayfish abundance the fishery in a long historical context; and

(d) lack of discussion of the only proven solution to the problems identified on the East Coast of CRA1.

16. My evidence will discuss each of these topics in turn. First I set out the geographic factors which bear on my evidence and the extent of the kelp forest loss.

Geographic considerations and scope of my evidence regarding CRA1

17. In my evidence, I will refer to our main spiny lobster species, *Jasus edwardsii*, as crayfish, a commonly used name in New Zealand. My experience with crayfish ecological research and marine habitat mapping applies directly to the east coast portion of the CRA1 QMA, namely reporting areas 903 and 904, and part of area 902 as shown in the map at Figure 8 of the Decision Paper. Overall, most of my research also applies to the whole of the CRA2 QMA, which has similar reef communities, fishing histories, and lies in the same bioregion.

18. The other areas of the CRA1 QMA, areas 901, 939 and part of 902, are different. These areas have a strong west coast dimension to their shallow reef communities, including differences in currents, fishing conditions and fishing histories, and are in different bioregions. The west coast of the CRA1 QMA likely has different recruitment dynamics than the east coast, which could be an important consideration when assessing the ecosystem effects of fishing. For these reasons, I am not in a position to relate my evidence directly to the above areas i.e. the west coast and Three Kings. That is not to say that evidence for the east coast does not provide important information for the entire CRA1 QMA, but consideration of the different local factors is required.

19. For these reasons it is positive to see that in making the April 2023 TAC decision, the Minister directed officials to provide advice on a QMA split or sub-area catch limits,[6] however I understand that this work programme has essentially been shelved since then, as indicated in a September 2023 policy paper entitled *Proposed approach to address kina barrens*.[7]

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6 See Decision Paper at page 55.

7 B23-0581, at [39].

Extent of kelp forest loss/ kina barrens

20. It is heartening to see that FNZ now largely accepts the link between the low biomass of crayfish in CRA1 and the loss of kelp forests. This link, and the importance of kelp forests, was accepted by the High Court as consensus evidence.[8] However I do not think the urgency and extent of the problem was adequately conveyed to the Minister in the Decision Paper. In an upcoming kelp forest paper soon to be published along with Associate Professor Shears,[9] we updated the information supporting a Regional estimate of kelp forest loss in Northland. The results are similar to that presented in the *Motiti* case evidence however we updated the earlier information with a more detailed calculation method and additional work done after the *Motiti* case. Our paper states a regional estimate that 30% of shallow reefs (depth range 10-16m) in fished areas are in kina barrens. In total it is estimated that 30.5 km^2 of kina barrens occur between Cape Reinga and Tāwharanui.

21. While this paper was not available at the time of the Minster's 2023/24 TAC decision, much of the underlying research was. From 2000's onwards there have been many papers published which clearly signalled the extent of kina barrens and pointed to a large-scale problem present. Many of these papers derived from the research in Northland and the Hauraki Gulf undertaken by myself, Associate Professor Shears and other researchers at Leigh Marine Laboratory. Between 2005 and 2021, we produced two peer-reviewed journal articles and four technical reports about our habitat mapping research program.[10] These six reports form the essential basis of the data and results of our current 2024 paper. The technical reports were registered and deposited in the National Library System and existed online on my consultancy website and other online sites. Numerous media coverage events were associated with this research, including national media attention on two marine reserve proposal consultations that featured the research. The data archive of our current kelp forest publication lists the technical

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8 See *Environmental Law Initiative v Minister for Oceans and Fisheries* [2022] NZHC 2969, at [69].

9 Shears, N.T.; Kerr, V.C., (forthcoming) *Estimating the extent of urchin barrens and kelp forest loss in northeastern Aotearoa, New Zealand* New Zealand Journal of Marine and Freshwater Research

10 The two published papers are: Kerr, V.C., Grace, R.V., 2005. *Intertidal and subtidal habitats of Mimiwhangata Marine Park and adjacent shelf*. Department of Conservation Research and Development Series 201, 55 p; and Leleu, K., Remy-Zephir, B., Grace, R., & Costello, M. J. (2012). *Mapping habitats in a marine reserve showed how a 30-year trophic cascade altered ecosystem structure*. Biological Conservation, 155, 193-201. The four technical reports are: Kerr, V.C., Grace, R.V., 2015. *Marine habitats of the proposed Waewaetorea Marine Reserve*. A report prepared for Fish Forever, Bay of Islands Maritime Park Inc; Kerr, V.C., 2016. *Marine habitats of the proposed Maunganui Bay Marine Reserve*. A report prepared for Fish Forever, Bay of Islands Maritime Park Inc; Grace, R.V., Kerr, V.C., 2005. *Intertidal and subtidal habitats of Doubtless Bay, Northland, N.Z.* Contract report for the Department of Conservation, Northland Conservancy, Whangarei; 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.

reports, published papers, and their links to the National Library.[11] All of these papers and reports point to only one conclusion: the very serious ecological loss on Northland's east coast has been known for decades.

Limitations of the CRA 1 stock model

22. In my view, there are issues with the basic inputs of the stock assessment model used by FNZ when setting the CRA1 TAC. These issues are not raised in the Decision Paper and in my view represent gaps in the advice to the Minister. A key issue is that the model is not indexed against actual surveys of crayfish abundance. Nor is there discussion in the Decision Paper of the results of diver studies of crayfish abundance,[12] This means the Minister is not receiving accurate data on crayfish biomass.

23. I will not address the statistical working of the model itself because that is a specialised field which lies outside my areas of expertise. That said, I wish to emphasise that if the inputs in a model fall short of representing what is occurring in the species or marine communities we are studying, then it follows that the conclusions drawn from the modelling or target results are likely to be flawed.

24. In this section, I set out what indexing is, why it is important to do it and the results of actual surveys of crayfish populations on the east coast of CRA1.

Failure to index the stock assessments against a proper census

25. It does not appear from reading the Decision Paper that the current FNZ assessment model process is measured against a more robust actual census of the stock. The stock assessments appear to be derived from Catch Per Unit Effort (**CPUE**) data. The CPUE method of monitoring or assessing a population is referred to as a relative abundance measure. By relative abundance I mean that it is a sample of count information taken according to a consistent protocol that is practical and achievable. The working assumption behind a relative abundance measure is that the sample taken represents a consistent of proportion of the actual abundance of a population. Usually it is used because it is faster and easier than an absolute monitoring method. In the case of the crayfish CPUE based data what is recorded is the number, sex, and size of crayfish caught each pot. It is important to question whether these numbers are proportional to the actual abundance of the crayfish and whether there is important population information that is missed by this method.

26. The normal practice with relative abundance measures is that they are 'indexed' against a more robust actual census. Indexing in this context means that the relative abundance measure is paired directly with an absolute measure such as a statistically valid diver count study to determine how accurately the relative measure represents the actual census counts. In some cases the indexing study can produce a conversion factor to aid in interpretation of the relative measure.

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11 Kerr, Vince (2024). *GIS data of urchin barren mapping in Northeastern New Zealand* [Dataset]. Dryad. https://doi.org/10.5061/dryad.8gtht76w3

12 See also Nick Shears evidence at [17] and [18].

27. In early 2000, DOC commissioned JD Booth to produce a technical report on crayfish research methods with the aim of using it for the development of a monitoring and ecological study of crayfish in Te Tapuawae o Rongokako Marine Reserve.[13] In the report, Booth outlines the purpose of indexing and outlines a method to achieve it. He states understanding the relationship between CPUE data and actual abundance "would make an important contribution to the crayfish stock assessment capability in New Zealand".[14] He described a suggested method: "Two key pieces of information are required to quantify the relationship between CPUE and absolute abundance: the fishing radius of a pot and the actual abundance of lobsters on the seafloor. Actual lobster abundance can be determined through dive surveys." As far as I can determine, this part of the recommendation did not become part of the program at the Marine Reserve and has also not been formally used in the recent FNZ stock assessments.

28. Even if FNZ failed to follow Booth's scientific directive to index stock modelling with diving work, others have. Methodologies for quantifying crayfish abundance, juvenile abundance and sex and age structure have been developed and standardised using a diver transect system, and these. approaches have now been widely adopted and used across research programs within the CRA1 region.[15]

29. The failure to index the crayfish CPUE data means that there are serious limitations to the usefulness of the results from the stock assessment model – in other word serious uncertainties in the model output. This uncertainty is acknowledged at paragraph 78 of the Decision Paper, but its importance is wholly understated. In short, the result is that the model output (e.g., an estimate of abundance) may not be related to the true ecology or abundance of the species.

The importance of indexing against actual abundance

30. It is important to index CPUE derived data against an actual stock census because CPUE data can be impacted by fisher behaviour, either advertently or inadvertently. There is a long list of potential inconsistencies in the data collection over time affecting CPUE data. These inconsistencies reflect variations in fisher behaviour and practice and include changes made to the recording systems themselves, which change over time. Here are my observations of some of the potential issues with the potting data used by FNZ:

(a) variable compliance by fishers with recording rules and guidelines;

(b) changes in fishers operating in the fishery;

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13 Booth JD, 2003, *Research sampling design for rock lobsters in Te Tapuwae o Rongokako* Marine Reserve. DOC Science Internal Series 128.

14 At page 19.

15 The importance of diver transect systems was discussed in MacDiarmid AB, 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. I discuss this paper in more detail below.

(c) changes in fishing techniques and strategies;

(d) changes in the frequency of potting and/or potting density in a given reef system;

(e) use of saturation potting (catching as many crayfish as possible in a locality until the pots come up empty) vs best practice of careful rotation of fished areas to avoid overfishing at local reef scales;

(f) competition with recreational fishers in some months and locations;

(g) changes in soak times; and

(h) changes in the number and density of potting events per season relative to a reef area.

31. All these variations in fishing effort and the degree to which they impact each individual reef each year can lead to local depletion below desirable levels and the risk of long-term regional-scale adverse impacts on the crayfish population and associated species. In a fishery managed at sustained low levels, the risk of complete depletion becomes critical, and the probability that fishing at the allocated quota is causing harm increases. The biggest danger here is that the harm is only visible once it is very serious.

32. Table 6 of the Decision Paper itself indicates that CPUE levels for areas 903 and 904 have been low for a long time and, at paragraph 98, that commercial fishing effort has moved to the west coast. It is therefore not credible to consider that FNZ were unaware of the impacts of overfishing on the east coast of CRA1 and urgency required to address it to ensure the sustainability of the stock.

33. The interpretation of CPUE numbers for CRA1 are further confounded because the east, west and north recording areas are all averaged together, masking the seriousness of the situation on the east coast. (Particularly in light of the differences between west coast, Three Kings and east coast CRA1 areas I set out above at [18]). In my view it is not justified to lump all CRA1 fishing effort into one averaged CPUE figure because there are substantial differences in environmental influences, recruitment and fishing history. In the case of the east coast portion of CRA1 the serious decline in crayfish abundance is simply not accurately reported in this CRA 1 average CPUE figure which is an input variable in the stock model.

Results of actual abundance surveys

34. Critically low crayfish biomass on the east coast of CRA1 has been documented for many years. There are peer-reviewed studies published in international journals dating back to 2003 and 2006 which stem from the extensive monitoring of crayfish and snapper done at Mimiwhangata over decades.[16] The papers provided strong evidence of extremely low

[16] Denny CM, Babcock RC (2003) *Do partial marine reserves protect reef fish assemblages? Biological Conservation* 116:119–129; Shears, N.T., Grace, R.V., Usmar, N.R., Kerr, V.C., Babcock, R.C., 2006. *Longterm trends in lobster populations*

abundance levels of crayfish and snapper at Mimiwhangata, a partially protected reserve. The crayfish publication and the kina barren story drew national attention in 2006. I appeared on a primetime TV3 news story and there was a RNZ science long format program done on this research with me.

35. As part of a 2013 review of ecological research done on New Zealand crayfish, Dr MacDiarmid reviewed four New Zealand ecosystem modelling studies for shallow coastal reefs.[17] All four models highlighted the key ecological role played by crayfish as the most important predator in coastal environments. However, results from three of the studies showed that due to biomass decline, crayfish have gone from being the ecosystem's most important predator to the least important in terms of biomass and impact. Dr MacDiarmid states that in these areas of low biomass, the crayfish could be considered as 'functionally extinct' in ecosystem terms, meaning that they no longer fulfil their ecological role. I discuss Dr MacDiarmid review in greater detail in a later section.

36. In my view, based on the research and studies referred to above, and by reference to my observations diving for nearly forty years within the CRA1 area, Dr MacDiarmid's finding that crayfish are ecologically extinct certainly applies to the ecosystems within the CRA1 area. For the long term sustainability of crayfish and associated species there needs to be a significant increase in crayfish populations. Associate Professor Shears in his evidence addresses the need and urgency rebuild crayfish stocks in CRA1 east coast and I agree with his evidence fully.[18]

Summary

37. The failure to undertake any actual abundance measures on the east coast and instead rely on CPUE measures of relative abundance across the whole of CRA1, masks the extent of the population decline in this region, and therefore the urgency required to take measures to ensure the ongoing sustainability of the stock. The available studies of actual abundance indicate that we are in either a long-term ecological decline or near collapse of the crayfish population. The small changes to quota proposed, at best, will maintain a slow decline of the crayfish population.

38. Later in my evidence at [63]–[66], I discuss the solutions which are needed to reverse this decline and ensure the long-term sustainability of the species.

Missing relevant scientific information and its relevance

39. In this section of my affidavit, I will discuss the key ecological characteristics of crayfish identified in the scientific literature, the relevance of this literature

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in a partially protected vs. no-take Marine Park. Biological Conservation. 132 (2006) 221-231.

17 MacDiarmid AB, 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, DOI: 10.1080/00288330.2013.810651

18 See also evidence of Associate Professor Shears at [31]–[33].

to management of the CRA1 stock, and the extent to which the Decision Paper deals with this well-established knowledge.

40. An understanding of the unique ecological characteristics of crayfish reveals serious risks to the sustainability of the stock and the wider ecosystem if fishing pressure remains as it is. These risks are an important factor to consider in the management of the CRA1 ecosystem.

41. The idea that further research needs to be undertaken in order to effectively apply our existing ecological knowledge to the fisheries management of crayfish is largely false. In an international review paper on the global plight of kelp forests, Professor Steneck stated, "We know much more about how environmental forcing functions operate in kelp forests than we do for most other ecosystems. Kelp forests are ideally located and scaled for human study; most components of the system are readily observable".[19] In the last four decades, Steneck's statement aptly describes the context in which New Zealand's progression in crayfish ecology research and its relationships with kelp forests have advanced.

Crayfish research and ecological knowledge in New Zealand

42. In 2013, one of New Zealand's leading scientists, Dr Alison MacDiarmid, along with her colleagues, published a review of ecological research done on New Zealand crayfish at the Leigh Marine Laboratory of Auckland University. She also noted contributions from other research. The abstract of this paper paints a picture of how developed this body of information was at that time and its potential relevance to managing fisheries and the impacts of fishing.

43. The Abstract to the MacDiarmid review paper states:

> We review the contributions from research conducted through the Leigh Marine Laboratory (LML) since its establishment in 1962 to the understanding of the biology and ecology of the rock lobster, *Jasus edwardsii*. The number of publications (103 since 1978), their breadth of subject matter, and their citation frequency indicate this research effort's influence. The development of an underwater population sampling tool at the LML has been key to the research on lobster distribution, abundance, size structure and sex ratios. These, in turn, allowed significant insights into the impact of fishing on lobster populations, population recovery in marine reserves, the mating system of lobsters, and the cascading effects of lobster removal on reef communities. Other key research has focused on the planktonic larval and post-larval stages. **It is likely that *J. edwardsii* has received a greater level of ecological research effort through the LML than any other species.** The location of the LML on a stretch of rocky coastline with year-round easy access to the field, and the availability of a rebuilding population of *J. edwardsii* in an adjacent marine reserve, allowed coupled laboratory and field research to rapidly develop without the confounding effects of fishing. The LML is well placed to address outstanding questions about lobster biology and ecology,

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[19] Steneck RS, Graham MH, Bourque BJ, Corbett D, Erlandson JM, Estes JA. 2002. *Kelp forest ecosystems: biodiversity, stability, resilience and future.* Environ. Conserv. 29, 436–459. doi: 10.1017/S0376892902000322

> and to further contribute to the conservation and management of this important resource.

(emphasis added).

44. The important ecological factors of crayfish identified by Dr MacDiarmid in her review that are relevant to appropriate ecosystem management include:

    (a) Fecundity (e.g., egg production) in female crayfish increases significantly (i.e., geometrically) with size.

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

    (c) Large male crayfish can service many times more crayfish than smaller animals e.g. a large 3 kilogram crayfish male can mate and successfully fertilise the eggs from a combined female biomass of 17 kilograms in single six week mating season, comparatively a small just mature male can only mate with a combined female biomass of 1 kilogram in that time.

    (d) Populations with low abundance and lacking in large animals may fail to effectively reproduce or do so at greatly reduced levels compared to a population with a more normal age and size structure.

    (e) Crayfish have complex social behaviours which varies with time of year around growth, moulting and mating periods. There is evidence that populations with low abundance levels and impacted age structures can detrimentally affect these behaviours.

    (f) There is evidence that recruitment of new crayfish onto reefs is reduced when there are no or few older crayfish present.

    (g) Crayfish periodically leave their home territory on the reef to feed on surrounding soft bottom habitats - typically 1-2 km from the home reef but up to 4km. Fishing management and the design of protection and restoration areas need to take these behaviours into account (e.g., crayfish living within marine reserves can still be caught when they move outside it).

    (h) Research on diets has found that crayfish have a widely varying diet and may be important in grazing and controlling algal turf habitats, which are often a response to the long-term persistence of kina barrens.

    (i) Loss of genetic diversity within crayfish populations is a possibility at such high fishing levels.

    (j) Loss of habitat utilisation by crayfish due to loss or decline of algal forests – most notably in the highly productive, shallow portion of the *Ecklonia radiata* forests.

45. When population levels fall critically low, it is likely that all of the ecological characteristics of crayfish identified by Dr MacDiarmid will be impacted. The threshold where low population levels of crayfish will have an impact on their

ecological characteristics is arguably well above the current levels of crayfish on the Northland east coast. Crayfish breeding biology has evolved in the New Zealand context over millions of years. Typically, organisms cannot sustain their populations over time where there is this level of impact on their breeding biology. This population collapse scenario affects a long list of ecological interactions as seen through trophic cascades we have documented in the kelp forests. Dr MacDiarmid's research has specifically illuminated the role of large females and large males in all these processes, and makes clear that age structure matters. As identified in the previous section according to the available studies of crayfish populations on the east coast of CRA 1, there are extremely low numbers of large individuals present and, on some reefs, possibly none.[20] Low numbers of large individuals will affect the reproductive success of crayfish in these areas, this in turn may result in settlement failure (i.e., the failure of new larvae/juveniles to colonise a location). Given the very low numbers of crayfish on the east coast it is likely recruitment failure is already occurring.

46. The Decision Paper contains a reference to MacDiarmid et al's important paper in its reference section: Section 18, at page 59. This is unsurprising as the paper is widely-known. However, the paper is not referred to in the body of the Decision Paper at all. In terms of substance, the Decision Paper omits to discuss many of the issues raised by MacDiarmid et al at all. What it does contain by way of discussion on these issues (which we find for example at Section 3.1 and Table 10) do not convey the importance or relevance of this information in any proportion corresponding to the reality. For example, whereas this information points in my view to a need for:

(a) area closures, the advice simply dismisses this option, without basis, as at paragraph 394; or

(b) a much higher management target, advice on that is either effectively silent, as at paragraphs 60-63, or discouraging, as at paragraphs 233-234.

Crayfish recruitment and settlement

47. Two of the most important aspects of crayfish ecology for the sustainability of the population are recruitment and settlement. Recruitment is the process by which new individuals are added to the population, in the case of crayfish this process is complex and takes many years for the young crayfish to reach breeding age. Settlement is the process by which crayfish pueruli (larvae) settle onto reefs after spending 12-24 months offshore as larvae in the plankton community. Settlement of young crayfish on the reef begins a new and challenging period in their life as they adapt to life on the shallow reefs. During these first few years they are very vulnerable to predation.

48. Recruitment inputs to the stock model appear to be based on settlement data collected in CRA3 which does not share the same larval transport life history characteristics as CRA1. Chiswell and Booth modelled larvae settlement of

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[20] Shears, N.T., Grace, R.V., Usmar, N.R., Kerr, V.C., Babcock, R.C., 2006. *Longterm trends in lobster populations in a partially protected vs. no-take Marine Park.* Biological Conservation. 132 (2006) 221-231.

crayfish around New Zealand. [21] They concluded that most settlement on the east coast of CRA1 originates from the west coast. The west coast of Northland historically has a steady south to north current along the coast fuelled by prevailing southwest winds. As a result, the model shows the larvae that settle in CRA1 come from reefs of the west coast of the North Island and specifically the west coast portion of CRA1. These larvae travel around North Cape in prevailing currents to spend time offshore of Northland's east coast and finally arrive on Northland's east coast reefs, with a small portion ending up in CRA2. The model also shows that the bulk of larvae settling in CRA2 arrives from CRA1 sources. Therefore if we allow larval production to fail in CRA1 due to dramatically reduced spawning capability, according to our current larval transport model, we risk settlement and recruitment failure in CRA2.

49. Again, the Decision Paper does not refer to this potential effect of CRA1 fishing, or to the paper establishing this potential effect (refer paragraphs 165 and 166, which refer to sections 8.6 and 8.4 respectively). Framed in terms of interdependence of the CRA1 and CRA2 stocks, for example, the Decision Paper is virtually silent in my view: see paragraph 195 and 196. And framed in terms of effects on the aquatic environment, the picture is similar: we find no comment whatsoever on potential effects on the Hauraki Gulf ecosystem in section 8.4).

A climate change risk to recruitment in CRA 1 and CRA 2

50. To reduce the impacts of rapid climate change we must manage natural resources like kelp forests to be as strong and healthy as possible so that they are as resilient as they can be when rapid changes to currents and sea temperatures occur. In the case of Northland we are currently doing the opposite by damaging kelp forests. It is early days in terms of quantifying how these currents are changing with climate change and thus any impacts on crayfish larval transport and settlement. However my observation having lived and worked in Northland for four decades is that there are changes occurring characterised by less strong southwest winds more easterly winds. I have talked to many locals who are also observing changes to the currents on the west coast as well. While we can observe these rather sudden large shifts in local climate, we still need to quantify or model changes in these currents to inform our model of larval transport.

51. Climate change could have unknown and potentially serious consequences for recruitment in the CRA1 and CRA2 fisheries. The impact of climate change may already be affecting these populations. This risk should bear upon our assessment of the population. Recruitment is crucial to a recovering population and can become a critical factor to the decline of a overfished population of crayfish. This risk scenario suggests we need a much more conservative approach to quota allocation, better information inputs and a strengthening of precautionary measures. In my opinion it is a serious red flag that these risks are not explained or discussed in the Decision Paper.

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[21] Chiswell SM, Booth JD, 2008. *Sources and sinks of larval settlement in Jasus edwardsii around New Zealand: Where do larvae come from and where do they go?* Marine Ecology Progress Series

52. It takes four years from the settlement of pueruli (larvae) on a reef for crayfish to grow to legal size. This is a precarious four years for crayfish. I have read Professor Jeffs evidence on this issue and agree with it. A healthy shallow kelp forest with an adult crayfish population including large individuals present appears to be an essential requirement for successful recruitment of crayfish. We are treading on dangerous ground by ignoring these aspects of known ecology which do not appear in Decision Paper. We can predict that a large portion of critical habitat for recruiting crayfish will no longer be able to function once the transition to kina barrens is established. We are limiting future commercial production and a long list of ecological functions of our shallow coastal system. The extent of the problem which kina barrens in the shallow reef pose for successful transition from settlement to young adulthood for crayfish is not adequately outlined in the Decision Paper.

53. Again these important considerations go un-discussed in the Decision Paper's discussion on climate change: see paragraphs 174 – 177.

Summary

54. In his evidence Associate Professor Shears states in conclusion that there is a need for a complete change in '*mindset*' with a focus on rebuilding the stock levels to significantly higher level where a fishing allocation could be assessed in a context of ecological requirements for sustaining this species. Associate Professor Shears provides evidence from published research that continued fishing and small incremental changes in catch will continue a decline scenario for crayfish on Northland's east coast. I am in complete agreement with Associate Professor Shears' evidence and have personally witnessed the decline in progress over several decades.

55. These fundamental and well-studied aspects of crayfish biology clearly bear on the ongoing sustainability of the species itself, which in turn relates directly to the sustainability of rocky reef environments across northeastern New Zealand as a whole. It does not appear from reading the Decision Paper that any regard to was had to this science. In particular, the risks to crayfish recruitment and settlement by such low levels of the stock biomass generally are not adequately discussed in the Decision Paper. Such low levels of crayfish, and the absence of large individuals means that they are unable to fulfil their ecological role in shallow coastal environments. This is also disastrous for the long term sustainability of the stock. The Decision taken to reduce TAC by approximately 11 per cent is not likely to address any of these problems or allow crayfish populations to recover on the east coast of CRA1.

Mātauranga Maori

56. In order to understand any marine community and its ecology, we must have an understanding of three basic things:

    (a) what were the characteristics of the unfished state;

    (b) what are the characteristics of the current state; and

    (c) what goals should we commit to manage or restore the current state to a long term sustainable state, and specifically the path to achieving that.

57. All three knowledge areas are essential; however, the long view of the natural state provides a context in which ecological studies can progress. Progressing ecological science requires knowledge of a baseline condition.

58. In New Zealand, we have one great advantage in marine studies, which lies within the knowledge system of coastal Māori. Over three decades, with each of the projects I have undertaken in Northland, I have sought out local kaumātua and kuia to help me learn about their story of the abundance of our key species like crayfish and changes in habitats, specifically kelp forests. I have published some of these accounts[22] and in previous court evidence.[23] The published accounts from me are the tip of the iceberg really because in fact all the coastal hapū of Northland I have engaged with have an extensive account of this history.

59. In partnering with Māori in these studies, we need to appreciate the potential in these accounts – I have found at times they are incredibly detailed, for instance there are reefs at Mimiwhangata that I know in great detail. Prior to 2005, there were kaumātua there who could describe in visual terms to me exactly what they experienced and what they saw as boys or young men diving this same reef. In addition, they could also relate historical accounts from their parents, uncles and grandfathers. These accounts often included detailed stories passed on from further generations back in time. In this way, I could construct a visual story about crayfish and the shallow kelp forest that was detailed in terms of the abundance and size of the animals and their behaviours. This has helped me to interpret what I have observed and the data I have been involved with in the last thirty years.

60. Based on the Mātauranga Māori knowledge that has been shared with me, I believe the historical natural crayfish population in the CRA1 QMA was, in fact, much larger than any estimate we have derived from fisheries data, and also larger than what we have measured in any 'recovering marine reserve'. We have the choice and opportunity to revisit an estimate of unfished abundance and use this knowledge to interpret what we have more recently learned about crayfish and related species ecology.

61. From my experience with local kaumātua and kuia, it is clear that there is a wealth of information available about the east coast of Northland marine ecosystem from Mātauranga Māori. It does not appear that Fisheries New Zealand have fully utilised this information in reaching their decisions about CRA1.

Solutions - the necessity and benefits of an effective full no-take network of reserves.

62. Spatial closures are necessary to mitigate or remedy the adverse effects of fishing for crayfish on the stock itself, its habitats and related species. There is nothing novel about this predicament; fisheries have collapsed repeatedly worldwide, including in New Zealand. Making small changes to our existing quota and talking about incremental progress towards a future unclear

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22 Kerr, V.C., Grace, R.V., 2005. *Intertidal and subtidal habitats of Mimiwhangata Marine Park and adjacent shelf. Department of Conservation Research and Development Series* 201, 55 p.

23 In the Northland Regional Council, referred to above at n 2.

sustainable goal, has little value and, as we can currently see, has created a significant east coast kelp forest decline at a regional scale with serious implications for the sustainability of our shallow coast. While I paint a dire picture of our current state, we are fortunate that marine systems have good restoration potential.

63. Marine protection and restoration have been practised and studied worldwide for many decades. There is abundant information on how to do this, a lot of which has come from studies of our marine reserves in New Zealand.[24] Internationally, there has been steady growth of marine protection and increasing integration of protected areas design and implementation with fisheries goals. The results are positive and modelling of how best to do this is an advanced science both internationally and here and in New Zealand. We have no reason to avoid transitioning to a focus on restoration to a more productive and sustainable future.

64. The Shears et al. paper,[25] mentioned above, was a paired study which compared Mimiwhangata, a partially protected area (recently upgraded to full no-take protection in 2023) and Tāwharanui Marine Park, an established full no-take marine park. At the time of the 2006 study, Tāwharanui had a recovering kelp forest and an impressive abundance of crayfish, including large individuals. In comparison, as mentioned above, Mimiwhangata had extremely low levels of abundance. This study highlights that no-take reserves are vital for the recovery of the CRA1, and to ensure crayfish are eventually able to fulfil their ecological function and control kina populations.

65. As mentioned at [7(b)] above, I presented evidence in an Environment Court Case challenging the Northern Regional Plan to address issues of the decline of marine life at Mimiwhangata and Cape Brett. In my supplementary evidence in that case, I set out in some detail why there is urgency to adopt a restoration strategy centred on a network of fully protected reserves. That evidence is entirely relevant to managing the issues brought before the Court here. A copy of my supplementary evidence is appended to this evidence as **VCK-2**.

Conclusion

66. It is fitting this case is being argued in the context of Northland's east coast. While CRA1 does not rank amongst the most commercially valuable crayfish fisheries in New Zealand, its extensive subtropical reef systems are the largest and most species diverse in the country. These coastlines and crayfish are part of our culture. They are a taonga in every sense. The east coast and Hauraki Gulf and Bay of Plenty is all part of one great bioregion and is home to a large proportion of New Zealand's human population. It is also notably where many traditional Māori communities still live on the coast. We are faced with the question are the interests of Māori and the people of New Zealand being protected in this case in terms of provisions protecting species and habitats in the Fisheries Act?

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

[25] Shears, N.T., Grace, R.V., Usmar, N.R., Kerr, V.C., Babcock, R.C., 2006. *Longterm trends in lobster populations in a partially protected vs. no-take Marine Park*. Biological Conservation. 132 (2006) 221-231.

67. There is good news here, unlike many environmental challenges of our time our kelp forests and crayfish population can be fixed. We have a very large body of ecological knowledge about these kelp forests and crayfish ecology, and we have decades of experience of what recovery looks like in fully protected reserves. The principles and design guidelines are well defined and ready to use to embark on a different future than decline and loss, including a better future for fishers. As I reach the end of three decades of work as a marine ecologist, I have witnessed the decline of our kelp forests. I take heart that these deliberations on what to do are finally taking place. As a last word, I want to urge everyone involved to act now – there is urgency; every day, every week, we are losing parts of our coastal ecology. It is in decline.

68. Is it this serious? How valuable are kelp forests and the crayfish once in extraordinary abundance in our kelp forests? My answer is ask any local person who lives on this coast and enters the sea. And then, if you are not convinced of the seriousness of our loss, consider this comment from one of the first European scientists to land on these shores:

"The number of living creatures of all Orders, whose existence intimately depends on the kelp, is wonderful… I can only compare these great aquatic forests of the Southern Hemisphere with the terrestrial ones in the intertropical regions. Yet if in any country a forest was destroyed, I do not believe nearly so many species of animals would perish as would here, from the destruction of the kelp."

Charles Darwin, The Voyage of the Beagle

SWORN / AFFIRMED by

Vincent Carlyle Kerr

at this

day of April 2024 before me

_____ _____

Vincent Carlyle Kerr

"VCK-1"

This is the exhibit marked "**VCK-1**" referred to in
the affidavit of **VINCE CARLYLE KERR** sworn/affirmed
at _____ this 19th day of April

_____
a person enrolled as barrister and solicitor of the High Court of New Zealand

IN THE HIGH COURT OF NEW ZEALAND
WELLINGTON REGISTRY

I TE KŌTI MATUA O AOTEAROA
TE WHANGANUI-Ā-TARA ROHE

CIV-2021-485-676

UNDER THE	Judicial Review Procedure Act 2016
IN THE MATTER OF	An application for judicial review of decisions of the Minister for Oceans and Fisheries under s 13 of the Fisheries Act 1996
BETWEEN	**THE ENVIRONMENTAL LAW INITIATIVE**
	First Applicant
AND	**CARMEN HETARAKA** on behalf of **TE URI O HIKIHIKI HAPŪ**
	Second Applicant
AND	**MINISTER FOR OCEANS AND FISHERIES**
	First Respondent
AND	**NEW ZEALAND ROCK LOBSTER INDUSTRY COUNCIL LTD**
	Second Respondent
AND	**NEW ZEALAND SPORTS FISHING COUNCIL INC**
	Intervener

AFFIDAVIT OF VINCENT CARLYLE KERR
AFFIRMED MAY 2022

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AFFIDAVIT OF VINCENT CARLYLE KERR

I, **Vincent Carlye Kerr**, science advisor, of Whangarei, solemnly and sincerely affirm:

Introduction and background

1. 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.

2. 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 hapū and community conservation projects as part of the Trust's community engagement program.

3. 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 secondary 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.

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 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 within the rohe moana of Te Uri o Hikihiki, at Mimiwhangata, since the early 1970s. Mimiwhangata is located within the CRA1 quota management area. There are 34 technical reports and published research papers that specifically involve work at Mimiwhangata. Schedule 1 to this affidavit lists those investigations. My involvement with the science work at Mimiwhangata began in 1999 when I was working as a contractor for DOC. I have been involved in various capacities with all Mimiwhangata investigations and reports from 2002 onwards.

6. In addition to the science research and monitoring work summarised above, I have acted as a marine ecological advisor and expert witness in two recent Environment Court cases.[1] In the Motiti case I provided expert evidence which presented results of a large-scale Northland based GIS study of the extent of kelp forest loss due to removal of sea urchin predators from overfishing. This study is discussed below at paragraph 33. In the Northland Regional Council

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[1] *Motiti Rohe Moana Trust v Bay of Plenty Regional Council* [2018] NZEnvC 67 and *Royal Forest & Bird Protection Society of New Zealand Incorporated v Northland Regional Council*, which is currently awaiting decision by the Environment Court.

case, my evidence covered the results of the decades of past research and monitoring centred on Mimiwhangata and the impacts of algal forest decline[2] and associated degraded populations of crayfish and ecological implications. Those findings are summarised in this affidavit.

7. I have read the pleadings and evidence filed in this proceeding to date. I have been asked to provide evidence describing the decline in abundance of red rock lobster and algal forest cover and increase in kina barrens within the CRA 1 quota management area, in particular:

   (a) the research and monitoring at Mimiwhangata between 1973 and 2011;

   (b) mātauranga and leadership from Te Uri o Hikihiki;

   (c) habitat mapping showing algal forest decline and the extent of kina barren on Northland's east coast; and

   (d) crayfish abundances over time based on both ecological and Mātauranga Māori evidence.

8. On the basis of my evidence in those areas, I also comment on the options before the Minister for Oceans and Fisheries (**Minister**) for his 2021/22 and 2022/23 CRA1 total allowable catch decisions (**CRA1 TAC Decisions**).

9. I have also read the expert evidence of Dr Nick Shears and Dr Andrew Jeffs. To the extent that their evidence is within my area of expertise, I confirm I agree with their opinions.

10. I have read the Code of Conduct for expert witnesses in Schedule 4 of the High Court Rules and I agree to comply with it. Where my affidavit contains matters of expert opinion evidence, I confirm the statements made are within my area of expertise.

Research and monitoring at Mimiwhangata between 1973-2011

11. 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 stocks, which stretch back into the 1980s. Detailed habitat mapping studies have been carried out in 1973, 1981 and 2005. These have allowed for analysis of historic aerial imagery dating back to 1950.

12. Those 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 remotely operated or drop

[2] In this affidavit I refer to both algal forest and *Ecklonia radiata* forest. Algal forest is a general term that varies in species composition depending on the geographical context. In Northland, *Ecklonia radiata* is the predominant species of kelp found in algal forests. While other kelp species are present in different depth zones and wave energy situations, *Ecklonia radiata* is the dominant species, especially in the most productive zone of algal forest. For that reason, algal forest within Northland is often named after the *Ecklonia radiata* as the dominant species.

cameras, sediment sampling, and in some cases 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 (**Pa 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.

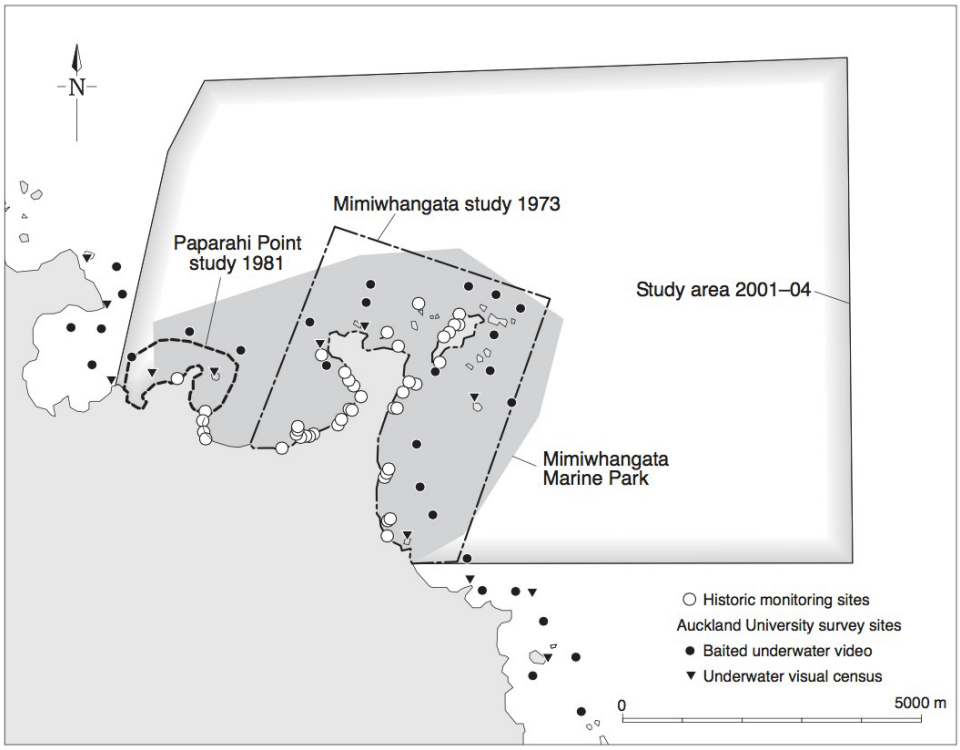

Figure 1 *Survey sites at Mimiwhangata established in 1976 by Dr Grace and the three areas where habitat mapping was completed in 1973, 1981 and 2005.*

13. The crayfish research projects at Mimiwhangata also included areas adjacent to the North and South of the current Marine Park. These areas represent sampling of the coast between Whananaki and Helena Bay. Mimiwhangata's long time-series of diving-based permanent fixed transects were paired with a study of the former Tāwharanui Marine Park, which was a no-take reserve until recently, when it became a marine reserve. In addition to my involvement in those projects, I have been diving on the Northland coast since the early 1980s and have been observing crayfish abundance and ecology of crayfish along with habitat mapping projects up and down the coast. In my experience, the results in and around Mimiwhangata are indicative of what I have observed all along Northland's east coast. I also interact regularly with other divers and coastal hapū groups that I work with. Their observations also reflect this description of red rock lobster being at very low levels of abundance with large individuals typically no longer seen.

14. The results of the habitat mapping studies showed that there has been significant loss of the shallow algal forest since the 1970s, coinciding with increased fishing pressure in this area and significant decreases of stock levels

(crayfish and snapper) reported in fisheries planning documents. Associated studies in other Northland sites support the understanding of the mechanisms at play with the algal forest loss. The pattern is similar and shows widespread loss and indications that the change in state from healthy *Ecklonia radiata* kelp forest to kina barren is quite stable once large kina barrens emerge. The studies also provide us with an understanding of the process of recovery within full no-take reserves, as we have clear examples of kelp forest being restored and maintained in full kelp forest cover at Leigh and Tāwharanui. These findings are discussed in more detail below.

The first era of research at Mimiwhangata: 1970s-1980s

15. In the early 1970s, Mimiwhangata was owned by New Zealand Breweries Ltd, which commissioned a series of studies (referred to at 1, 2 and 3 of Schedule 1) 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 (University of Auckland), the late Dr Roger Grace (independent scientist) and the late Wade Doak (marine explorer and author) were brought together. In 1972 and 1973, the team completed extensive survey work over the area we now know as the Marine Park at Mimiwhangata. As part of this work, they completed an ecological report and the first subtidal marine habitat map in New Zealand (referred to at 3 of Schedule 1). 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 (referred to at 7 of Schedule). 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.

16. In 1976, Dr Grace set up a monitoring program for the area that 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 gradual removal of all commercial fishing from the Park over the period 1984-1993. Recreational fishing was permitted, but crayfish could only be hand collected or potted in a single pot per person, party or boat. Unfortunately, for various reasons monitoring ceased in 1986.

17. By 1987, Dr Grace had growing concerns that kina barrens were increasing within the Marine Park and that 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, from 1980 to 1987 Dr Grace made the case in his reports for New Zealand Breweries 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. During this period, the then-Ministry of Fisheries had oversight of the Marine Park.

18. By the 1970s and 1980s, it was apparent that commercial fishing had increased dramatically in the coastal zone of northeast New Zealand, with advances in fishing technologies, growing markets domestically, the beginning of export markets, and rapidly growing foreign ownership and participation in inshore fishing in New Zealand. While the 1973 Mimiwhangata report made a valuable contribution to the descriptions of the habitats of Mimiwhangata and description of the diversity of the reef community, it did not attempt to describe or measure the impacts of fishing on the shallow reef ecology. However, there were many observations made in that report that could be compared to historical anecdotal accounts of the size of fish and crayfish with past decades.

19. Local knowledge, anecdotal accounts of recreational fishers, local commercial fishers and local Māori were describing significant declines in local fish and crayfish stocks. By this time, it was generally known that school fish like kahawai were declining, hapuku were disappearing from the shallow reefs, tarikihi were reduced, snapper were dramatically reduced in size, and crayfish numbers were described as only a small fraction of what was once present. Large individual crayfish were, by this time, rarely seen. This summary of where we were at in the 1970s is supported by fisheries' historical data and population modelling at large scales. The problem for the scientists in reporting on these observations is that at that time there were only anecdotal descriptions of natural abundances and a cultural history held by the hapū. In other words, fishing was allowed to take place in all locations for decades without an accurate baseline of information on what is a natural state and balance for these areas. This lack of a "natural baseline of information" exacerbates the difficulty of understanding ecological impacts of continued heavy fishing.

The second era of research at Mimiwhangata: 1999-2011

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

21. 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:

    (a) Engage with the hapū 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.

22. In the planning stage of the second investigation, an expert group was established consisting of myself, Dr Grace, Dr Russell Babcock, Dr Ballantine and Dr Shears from the Leigh laboratory of the University of Auckland (**the**

Expert Group). Some University of Auckland 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. Those 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 Mimiwhangata 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, natural (unfished) baseline in which to compare results to. As set out above at paragraphs 18-19, in the 1970s a decline in algal habitats and reef fish abundance was already suspected. Also, there were no adequate unfished reference areas 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 hapū, 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 randomised 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 100 metres.

23. In 2001, a second period of investigation began. Between 2001 and 2004, investigations at Mimiwhangata were undertaken in order to update the 1973 and 1981 habitat maps, including by expanding the mapping area as described at paragraph 22(d). above. The results from the updated habitat mapping are set out in a 2005 paper by Dr Grace and myself for DOC. A copy of that paper is annexed and marked "VCK-1", and the results are discussed in more detail below under the heading "Extent of algal forest decline and kina barrens in Northland". Over this period of investigation, the scientists (including myself) received various contributions of historic ecological knowledge from the

kaumātua of Te Uri o Hikihiki, some of which are recorded in the 2005 paper, and which I discuss in the next section.

Mātauranga and leadership from Te Uri o Hikihiki

24. 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 the late 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.

25. 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. Consistently with Māori oral tradition, this knowledge was generally shared verbally. 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. In this respect, this knowledge represents a natural baseline of information regarding abundances. I will recount some of these observations and descriptions as I go through the ecological information below.

26. I have read the evidence of Carmen Hetaraka filed on behalf of Te Uri o Hikihiki in this proceeding. Carmen was the person chosen by the kaumātua, Houpeke and Puke, for the traditional knowledge to be passed on to. Carmen was chosen, schooled and prepared for this role for years by these kaumatua, as is their custom. Today, he holds the mātauranga Māori I refer to above. In addition to the experiences and observations handed down to him, he also has extensive first-hand experience. He is one of Te Uri o Hikihiki's predominant divers and has more experience diving on the coastline within the hapū's rohe moana than anyone else. As such, in my view, the observations made in his affidavit represent some of the best available information within that rohe moana.

Extent of algal forest decline and kina barrens in Northland

27. The 2005 habitat mapping study of Mimiwhangata accurately mapped the shallow habitats at scales of 1:500 or larger. 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. By "productive" I mean the collective total biological activity that flows from the primary plant growth of the kelp forest and the many dependent marine organisms that utilise this large quantity of plant material. There are many other benefits to this production than just food, as set out in the affidavit of Dr Jeffs at paragraphs 15–21. 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 2 below.

Figure 2 *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, greyer patches of the ocean are kina barrens.*

28. These changes are concerning as 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 biodiversity of fish and invertebrate species that reside in the forest or visit the forests during part of their life cycle.

29. 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. By that I mean we were able to test the hypothesis that removal of crayfish through fishing had created a trophic cascade, resulting in the formation of kina barrens, rather than kina barren being caused by some other, natural cause. Figure 3 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.

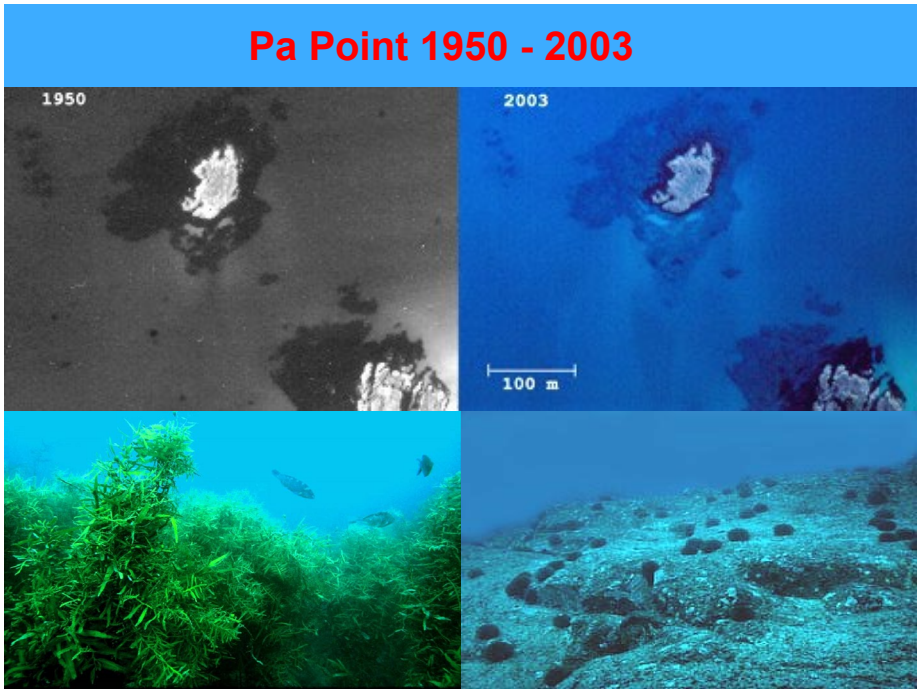

Figure 3 *This time series imagery comparison between 1950 and 2003 shows a completely dense cover of kelp in 1950 contrasting with extensive kina barrens in 2003. The lower images show typical images of a healthy kelp forest and a mature kina barren. The kelp in the lower left image is the species Carpophyllum 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)*

30. As we were doing this work, on several occasions we asked the kaumātua Houpeke and Puke 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 1960s-1970s. The kaumātua felt that fishing had impacted the life of the area to such an extent that the mauri was threatened and impacted, and that action had to be taken to allow natural or active restoration to take place.

31. In other words, the traditional knowledge held by the Te Uri o Hikihiki kaumātua about the trophic change assumption 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,[3] in the Maitai Bay Rahui,[4] and at the Leigh Marine Reserve.[5] At these three locations the same trend of decline from

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3 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.

4 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.

5 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.

a full forest cover to extensive kina barren progresses from the 1970s onwards. The findings of the Maitai Bay Rahui study are discussed further below at paragraph 36.

32. In the period between 2005 and 2020, I have completed four habitat studies that follow a similar methodology to the Mimiwhangata 2005 study. The habitat studies, taken collectively, look in detail at a range of sites covering the entire length of the east coast of Northland. These are not minor or trivial samples; they cover hundreds of hectares of reef carefully mapped at fine scales. While we might remain interested in the variations involved in this process of decline of kelp forests (for the reasons described in Dr Shears' affidavit, including wave exposure), there can be no disputing it is large scale and ecologically significant.

33. In 2017, Dr Grace and I produced a GIS-based meta study to estimate the extent of kina barren habitat for the entire exposed Northland east coast from Ahipara in the Far North to Tāwharanui at the entrance of the Hauraki Gulf. Two large scale habitat maps covering the entire study area and six fine scale maps of kina barrens within the study area were used to compute the extent of kina barrens. That study was originally produced by us for the Motiti Rohe Moana Trust and was referred to in both the *Motiti* and *Northland Regional Council* proceedings, and is available to the public on my website. A copy of the study is annexed and marked "VCK-2".

34. The study's findings included:

    (a) The projected estimate of kina barren extent represented 17% of the available rocky reef system within the study area.

    (b) Inside the no-take marine reserves within the study area, kina barrens covered 1% of the available reef, compared with 21.23% in the partially protected Marine Park at Mimiwhangata, where recreational fishing is permitted.

    (c) Within the shallower, preferred kina habitat zone (1-10 or 1-15 metres depth, as opposed to 1-30 metres for the entire study) the incidence of kina barrens is much higher: 25-40%.

    (d) The prevalence of kina barrens within the preferred kina habitat zone has disproportionate effects on kelp forest productivity. Shallow water kelp forests are much more productive than those found in deeper water, where the prevalence of kina was not as common.

    (e) The large and persistent urchin barrens observed, which had developed in the last five decades, were most likely to be caused by removal of predators rather than other factors, which I discuss below.

35. The study observed that, while reduced predation of kina is suggested as the primary cause of long-term urchin barren formation, other factors had been identified as affecting the dynamic between urchin population density, urchin grazing, and the persistence of urchin barrens. Of those identified factors, however:

(a) Wave exposure, complex topology, and sedimentation may have a positive effect on algal forest stability in that there could be a tendency for the algal forest to persist even in the face of removal of predators of kina.

(b) Storm damage, and urchin and kelp disease outbreaks have short-term impacts, and are not a major factor in kina barren formation or persistence given the high reproductive potential and growth rates of algal forests.

36. As noted above, between 2017 and 2020, I conducted a marine habitat survey of the waters in and around Maitai Bay on the Karikari Peninsula in the Far North. That study calculated the extent of kina barrens as covering 39.9% of estimated historic area of high productivity kelp forests. A copy of that study is annexed and marked "VCK-3".

37. The results of that study validate the results of our 2017 study in terms of the 25-40% incidence of kina calculated for the "preferred kina habitat zone". This is because the study at Maitai Bay introduced a more refined method of expressing the ecological significance of kelp forest loss. Prior to this study, we had generally mapped the total spatial area of the kina barrens and total spatial area of the entire potential and existing *Ecklonia radiata* kelp forest, which allowed us to calculate a percentage of the loss of forest. The problem with this first approach is two-fold:

(a) First, kina prefer an upper zone of the kelp forest, which varies locally as result of wave energy and water clarity. Typically, in Northland waters this zone where kina are active is between 2 and 12 or 15 metres depth. Below this depth, kina are not typically active.

(b) Second, in waters deeper than 12-15m, the *Ecklonia radiata* forest thins out and is less productive in an increasing trend until around 30 metre depths where it is very sparse and then gives way to encrusting invertebrate communities (because light penetrating from the surface is no longer strong enough to support plant growth).

38. The new calculation method developed for the 2020 study addressed these issues by effectively dividing the kelp forest by depth into a high productive (shallow) zone where kina barrens may arise and a (deep) zone where the kelp forest is less productive (and therefore less ecologically significant) and where kina barrens do not typically form. The point of refining this simple calculation is that it enables us to evaluate, in a more defined way, the ecological implications of this loss we are observing.

39. Finally, I note that in his statement of defence, the Minister says that kina barrens are "usually mixed with algal habitat".[6] The widespread kina barrens I have referred to in my evidence and in the various habitat studies are not described in this way. While there may be small kina grazed areas with remaining macro algae and various encrusting algae, this condition is minor in significance compared to the areas mapped as kina barrens.

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6 At [19].

40. In the various evidence offerred on kelp forests and kina barren establishment, I have described the findings using a simple habitat classification that is either kelp forest or kina barren. This is a defined classification in our marine habitat mapping. While it is of course a simplification to facilitate mapping on large scales, it needs to be noted that this classification has a tremendous amount of ground-truthing work behind it to validate how it is used, and typically this process is defined in any report. In any case, the kina barrens referred to in my evidence do not have significant percentage areas of large brown kelp species and generally algal species are dramatically reduced to seasonal filamentous and a variety of encrusting coralline red algal species. To the human eye, at any scale, these areas look bare. The functional aspect of the kelp forest has been reduced to near zero as an algal forest habitat.

Crayfish (red rock lobster and packhorse lobster) abundances over time based on ecological and Mātauranga Māori evidence

41. 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.

42. In 2006, a paper was published by Dr Shears and our monitoring team that compared the full data set of red rock lobster monitoring at Mimiwhangata Marine Park (where there was partial protection with commercial fishing phased out gradually over the period 1984-1993) against the data from Tāwharanui Marine Park (full no-take protection from 1983 onwards). 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:

> 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-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*.

A copy of this paper is annexed and marked “VCK-4”.

43. A version of these results can be seen in graphic form in Figure 4 below. The results are alarming and point to a collapse of crayfish at Mimiwhangata. Additional surveys at points north and south of Mimiwhangata Marine Park

showed similar results with very low levels of crayfish and no larger animals present.

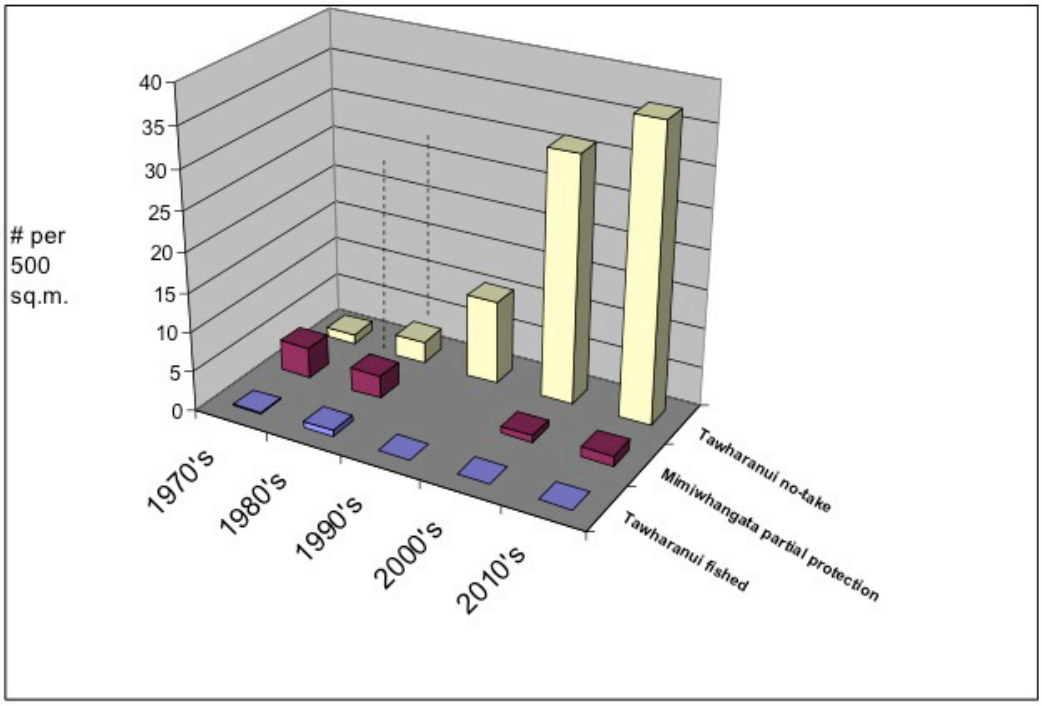

Figure 4 *This graph shows the decadal trends in numbers of legal-size crayfish and the contrast between a recovering population of crayfish in the Tāwharanui no-take area and the very low levels persisting in the Marine Park at Mimiwhangata, which are comparable to fished areas near the Tāwharanui Marine Park.*

44. We had several discussions with the kaumātua, Houpeke and Puke, about these results. They agreed with the description that at Mimiwhangata numbers of both species of crayfish 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. This statement applies to both species of crayfish, the red rock lobster *Jasus edwardsii* and packhorse lobster *Sagmariasus verreauxi*.

45. 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 antennae and then reach down and grab them. Puke also described in great detail the large crayfish that were common. He had a particular method of catching very large packhorse crayfish well over 10 kilograms in weight. Puke would face the large animal as it challenged him approaching with antennae and large claws waving, then in one quick motion would throw a burlap sack over the animal's back and wrap it up in a bear hug before swimming to the surface and getting assistance to land it. Puke was a large and very powerful man, but he described this encounter as one he approached with great caution. He told us that the power in these animals'

foreclaws could easily break bones in a man's hand. Packhorse crayfish are now rarely seen at Mimiwhangata.

Figure 5 *A packhorse lobster caught off Matauri Bay, Bay of Islands in 1961. These large lobsters were once common on the Northland coast. Large crayfish can easily and quickly open the largest kina and virtually any shellfish species.*

46. 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 from 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 MacDiarmid wrote a review paper in 2012 that summarises what we know to date. Dr MacDiarmid reviewed historical accounts of rock lobster abundance and ecology dating back to Cook's voyage which closely paralleled what we were told by the Mimiwhangata kaumātua. A copy of Dr MacDiarmid's paper is annexed and marked "VCK-5".

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

(a) Fecundity in rock lobster increases geometrically with size of female.

(b) Female rock lobster at mating time prefer large males.

(c) Large male rock lobster can service many times more rock lobster than smaller animals.

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

(g) Research on diets has found that rock lobster 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 models constructed of shallow coastal reef systems around New Zealand were reviewed by Dr MacDiarmid, which showed that rock lobster have gone from being one of most important predators in the system to the least important in terms of biomass and impact. The rock lobster's role, at present levels of fishing, was described as "ecologically extinct" in ecosystem terms.

48. In my view, based on the research and studies referred to above, and by reference to my observations diving for nearly forty years within the CRA1 area, Dr MacDiarmid's finding that rock lobster are ecologically extinct certainly applies equally to ecosystems within the CRA1 area.

The Minister's TAC decisions

49. I have been asked to comment on the options proposed to the Minister for his 2021/22 and 2022/23 CRA1 TAC Decisions, namely:

(a) In respect of his 2021/22 Decision:

(i) maintaining the TAC of 203 tonnes on the basis that the 2020 rapid assessment update projected that, as a result of the 2020 TAC decision, vulnerable biomass and spawning biomass would increase within the next four years; or

(ii) decreasing the TAC to 180.5 tonnes in order to improve the likelihood that the vulnerable biomass would increase.

(b) In respect of his 2022/23 Decision:

(i) Option 1.1: maintaining the TAC of 203 tonnes on the basis that the TAC was recently decreased and the decrease had assisted in maintaining CRA1 above the BMSY reference level, which is expected to allow rock lobster to continue to fulfil its role in in the ecosystem;

(ii) Option 1.2: decreasing the TAC by 5% (193 tonnes) recognising CRA1 is near the BMSY level and aiming to increase the certainty that the stock will remain at or above this level, which is expected to allow rock lobster to fulfil its role in the ecosystem to an unknown but potentially greater level than option 1.1;

(iii) Option 1.3: decreasing the TAC by 9% (185 tonnes) recognising CRA1 is near the BMSY level and aiming to increase the certainty that the stock will remain at or above this level, which is expected to allow rock lobster to fulfil its role in the ecosystem to an unknown but potentially greater level than options 1.1 or 1.2; or

(iv) Option 1.4: decreasing the TAC by 12% (179 tonnes) recognising CRA1 is near the BMSY level and aiming to increase the certainty that the stock will remain at or above this level, which is expected to allow rock lobster to fulfil its role in the ecosystem to an unknown but potentially greater level than the other options.

50. I have a number of concerns with the proposed options, which I explain below.

Baseline for assessments

51. I have concerns over the numbers the stock assessment model presents. In work that Dr Grace and myself undertook sampling rock lobster numbers, we would describe the population as crashing in many areas, indicating a much lower figure for % of virgin biomass existing than the figures presented to the Minister.

52. Long-term research and monitoring, such as that undertaken at Mimiwhangata, reflects the stocks more accurately, however this information is not used to validate the stock assessments, or calculate the proposed TAC. In any case, as described above, even long-term data such as that from Mimiwhangata does not allow for a natural baseline of information to be established as fishing had already begun to impact abundance of stocks prior to monitoring commencing.

Recovery

53. The advice to the Minister in respect of both his 2021/22 and 2022/23 Decisions refer to biomass increasing as a result of the TAC options proposed. As reflected in the 2006 Shears et al study, once rock lobster stocks have been fished to low levels, there is no evidence that even drastic changes to fishing quotas (for example, allowing recreational fishing only, as was the case at Mimiwhangata Marine Park) will result in long-term recovery.

54. Once stocks are at present low levels, only the application of no-take areas or fishing moratoriums can support recovery effectively. In my view, and based on the findings of the Shears study, the levels of crayfish currently within CRA1 would require no-take, and the adjustments to the TAC proposed for both the 2021/22 and 2022/23 Decisions would not allow for recovery, contrary to what the advice to the Minister suggests.

Ecological effects

55. The ecological effects of allowing crayfish to be taken at unsustainable levels is significant, both in terms of the effects on the aquatic environment (given the established link between removal of crayfish and proliferation of kina barren) and to the species itself, as described by Dr MacDiarmid. These ecological effects are extensively documented and well understood. To the extent that the advice to the Minister stated that the science is controversial, hypothetical or equivocal, or that the matter is complex and the relationship between rock lobster abundance and urchin barrens is unknown, that advice is wrong.

56. These effects, and how to avoid, remedy, and/or mitigate them, do not appear to have been considered at all when developing the TAC proposals that were put before the Minister in respect of his 2021/22 Decision. The advice to the Minister in respect of his 2022/23 Decision is that all of the proposed options would allow rock lobster to continue to fulfil its ecological role within CRA1. As noted above, in my view rock lobster are ecologically extinct within CRA1, and as such cannot fulfil their ecological role at current levels. For the reasons set out above under the heading “Recovery”, in my view the advice that any of the TAC options would allow rock lobster to continue to fulfil, or fulfil its ecological role to a greater extent, is wrong.

AFFIRMED by Vincent Carlyle Kerr at Whangarei this day of May 2022 before me:)

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Vincent Carlyle Kerr

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Schedule 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.
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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.
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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.
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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).
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15. Denny CM, Babcock RC (2003) Do partial marine reserves protect reef fish assemblages? Biological Conservation 116:119–129
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18. Grace, R. V., Kerr, V.C. 2003. Mimiwhangata marine monitoring programme, summer sampling 2003, update on historical monitoring. Report to Department of Conservation, Whangarei.
19. Grace, R.V.; Kerr, V.C. 2003: Mimiwhangata Marine Park draft report 2003 historic marine survey update. A report to Northland Conservancy, Department of Conservation.
20. Kerr, V.C., and Dr R. V. Grace, 2004. Mimiwhangata Marine Reserve Proposal: Community Discussion Document. Published by Northland Conservancy, Department of Conservation. Northland Conservancy, PO Box 842, Whangarei, NZ.
21. Grace, R.V.; Kerr, V.C. 2004: Mimiwhangata Marine Park monitoring report 2004 historic marine survey update. A report to Northland Conservancy, Department of Conservation (unpublished).

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33. Kerr, V.C., 2016. Significant marine ecological areas of Northland: a GIS based mapping, supporting technical reports and a collection of 45 assessment worksheets covering harbours and estuaries, open coastal areas, estuarine wading and aquatic birds, coastal and island wading and aquatic birds and general marine values of highly mobile and dispersed species (marine mammals and seabirds). Prepared for the Northland Regional Council. Kerr & Associates, Whangarei, New Zealand. *(Note: view on NRC GIS web pages)*
34. 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.

"VCK-2"

This is the exhibit marked "**VCK-2**" referred to in
the affidavit of **VINCE CARLYLE KERR** sworn/affirmed
at _____ this 19th day of April

_____
a person enrolled as barrister and solicitor of the High Court of New Zealand

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**

SUPPLEMENTARY STATEMENT OF EVIDENCE OF VINCE CARLYLE KERR

ON BEHALF OF TE URI O HIKIHIKI HAPU AND NGĀTI MANUHIRI

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Introduction

1. My name is Vincent Carlyle Kerr. I provided evidence in chief on behalf of the Te Uri o Hikihiki Hapū dated 25 March 2021.

2. My primary evidence addressed the marine ecological work that has been completed in the Mimiwhangata area relevant to the appeal raised by Te Uri o Hikihiki Hapū. I also presented evidence on the ecological and conservation values of the relief sought by the Hapū.

3. This supplementary evidence will address:

    a. how the proposed Rāhui Tapu area at Mimiwhangata was designed and summarises principles and international best practice alongside a context of design of protected areas in New Zealand; and
    b. report on recent field survey work and analysis of aerial photography aimed at checking on the current status of kina barrens in the proposed Rāhui Tapu area at Mimiwhangata

4. In my primary evidence I set out my qualifications and experience, and confirmed compliance with the Code of Conduct for Expert Witnesses. I confirm that I have also complied with the Code of Conduct in preparing this supplementary evidence.

Development of Design Principles for full no take reserves

5. The design of full no-take reserves and systems or networks of reserves is not a new field of applied marine ecology. New Zealand pioneered in this area with the design of the first marine reserve at Leigh in the 1970's. Since that time, marine ecologists in New Zealand have steadily built a large body of information on design criteria and ecological understanding of the impacts and benefits of no take reserves. The benefits are many

and include: and range across multiple aspects of biodiversity protection, restoration of exploited specie, education and recreation.

6. In this evidence I will summarise the design principles and criteria that have been adopted internationally and the relationship of these principles and criteria with the formation of systems or networks of marine reserves. I will then speak specifically to the design process that has led to the current version of the Rāhui Tapu being proposed by Te Uri o Hikihiki.In New Zealand the development of practical guidelines for the design of marine reserves was pioneered by the late Dr. Bill Ballantine, who for many years was the manager of Leigh Laboratory in his role as a professor of marine biology with the University of Auckland. Dr. Ballantine's work is highly regarded internationally and is quoted throughout the international literature. Dr. Ballantine set out to create a set of principles to guide design, which was first published in 1997[1]. Much of the work leading to the principles arose out of observations and the many studies undertaken at the Leigh Marine Reserve in its first two decades since its establishment. It is a testament to his work that these principles are still used today and have formed the basis of the design process for numerous Marine Protected Networks around the world including the extensive guidelines and network targets adopted by the United Nations in their global Ocean conservation program. [2] [3] The principles also appear in modified form in the New Zealand MPA Policy and Implementation Guide. [4]

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[1] Ballantine, W. J. 1997 *Design principles for systems of 'no-take' marine reserves.* Presented at a workshop on 'The Design and Monitoring of Marine Reserves' at Fisheries Centre, University of British Columbia, Vancouver, February 1997.
[2] IUCN World Commission on Protected Areas (IUCN-WCPA) (2008). Establishing Marine Protected Area Networks—Making It Happen. Washington, D.C.: IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy. 118 p
[3] Secretariat of the Convention on Biological Diversity, 2004. Technical Advice On The Establishment and Management of a National System of Marine and Coastal Protected Areas, SCBD, 40 pages (CBD Technical Series no. 13).
[4] Ministry of Fisheries and Department of Conservation. (2008) Marine Protected Areas: Classification, Protection Standard and Implementation Guidelines. Ministry of Fisheries and Department of Conservation, Wellington, New Zealand. 54 p.

7. In his 1997 paper, Dr. Ballantine stated the principles for a core full no take reserve. In one section he stated his experience of what people could easily understand about the meaning of the principles:

"Over the past 30 years I have spoken on marine reserves to a large number of public meetings, schools, and other groups, including elected politicians. This experience covers several countries, many different regions. and a wide range of initial hostility/support. I have found that the great majority of people (even when they have only thought about the matter briefly) do believe the following points:

Representation:

(a) Different pieces of the sea (regions and habitats) have different animals and plants.
(b) We do not know all the species, still less what they all do.
(c) Keeping examples of all (and their habitats), until we do know, is common sense.
(d) Setting theoretical priorities for doing this is silly. It is like trying to rate the priority of parts of your own body - i.e. pointless unless you are forced to do so, and then pointless because it will happen anyway.

Replication

(a) Most knowledge depends on having more than one instance.
(b) For important things, we need separate examples, in case of accidents or mistakes.
(c) If 'undisturbed' examples of some habitats are popular for education, recreation or any other common use, then we need more of them.

Network

(a) Covering all the options is better than picking one, especially if we know very little.

(b) The dispersal and migrations of different species will be different

(c) Currents are likely to vary a lot between years.

(d) A system should maximise the benefits by multiplying the possibilities. It should not calculate the theoretically 'best' arrangement and just have that one.

Amount

(a) The area where fishing is allowed is less important than the state of the fish stocks.

(b) Banning fishing in 20% of the area of a stock is likely to be helpful in the long run.

(c) Fishing and mining are not the only uses of the sea or the most important ones - merely those that are easiest to argue about.

(d) *The really important functions of the sea - like control of the world climate - are only dimly recognised and far from understood. (e) A 'no-take' marine reserve system must be able to sustain itself, and should aim at sustaining all the functions of the sea."*

8. Dr. Ballantine summarised the principles at the end of the paper in the context of how they should be considered alongside socio-economic considerations:

"There are already enough examples of 'no-take' marine reserves to show they are practical in socio-political terms and provide a wide range of benefits.

2. The benefits include:

(a) direct benefits - to scientific research, education at all levels, many forms of recreation, provision of information to management, monitoring natural marine variation and the conservation of marine diversity (genetic, species and habitat).

(b) indirect benefits - by providing marine ecosystem support and general insurance against unpredictable or unpreventable events, especially for harvested species.

3. These benefits would be optimised if 'no-take' systems had the following principles:

(a) ***representation*** *(of all biogeographic regions and all ecological habitats in these)*

(b) replication (several separate examples of each representation)

(c) network design (maximising the pathways for recruitment and other support)

(d) a total amount sufficient for the system to be self-sustainable.

4. The ***total amount*** *(by area) required to provide for the direct benefits would need to be at least 10%, the total amount to optimise the indirect benefits would be ~ 20-30%.*

5. Moving to systems of marine reserves, and applying the above principles in the order stated, avoids most of the scientific problems that arise in 'one-by-one' or problem- solving approaches. Detailed predictions of effects are no longer expected and difficult cases at each level (biogeographic, ecological, replication, network) can be treated as simple decisions at the next level.

6. Accepting the principle of representation removes any scientific need to place regions or habitats in an order of priority. The principles of representation, replication and network design mean there is no scientific need to precisely locate the sites, nor for detailed survey data

to achieve this.

7. Provided that the principles are adhered to, it is scientifically permissible for socio- political reasons to be used to develop the detailed priorities and precise locations of actual 'no-take' reserves in the system.

8. Moving to multi-purpose systems of marine reserves (and accepting the principles) avoids most of the political problems that are serious at present when each reserve is considered separately. The general public will give active support to sensible systems, whereas local proposals attract little attention except from those adversely affected.

More tools more information but the principles remain

9. In the last two decades information supporting marine protected area design has grown and there have been a number of large networks established [5] [6] [7]. There is refinement in our understanding of each of the principles and we have learned collectively a lot about the process of establishing reserves and networks. We now have a clearer picture of the '*Amount*' principle. Scientific consensus is clear that networks should contain a core system of fully no-take reserves that deliver the maximum benefits to fisheries and biodiversity protection and restoration when the 20-30% of all habitats are incorporated in the protection network. This body of work was summarised in a review paper calling for this to be the accepted amount goal for network design criteria. This goal figure has since been accepted by the IUCN biodiversity program.

[5] Fernandes, L. et al (2005). Establishing representative no-take areas in the Great Barrier Reef: large-scale implementation of theory on marine protected areas. Conservation Biology, 19 (6). pp. 1733-1744. http://eprints.jcu.edu.au/6122/

[6] Bernstein, B., Ludicello, S., Stringer, C., 2004. Lessons Learned from Recent Marine Protected Area Designations in the United States A Report to: The National Marine Protected Areas Center NOAA. The National Fisheries Conservation Center, Ojai, California.

[7] Munguia-Vega, A., Green, A.L., Suarez-Castillo, A.N. *et al.* Ecological guidelines for designing networks of marine reserves in the unique biophysical environment of the Gulf of California. *Rev Fish Biol Fisheries* **28,** 749–776 (2018)

10. Many ecological research programs have looked at the size question in design of reserves. In determining the most appropriate size there has been great progress in looking at a range of ecological factors (the list of ecological factors is in fact is very long) including: species home ranges, protection of genetic diversity, larval transport and recruitment, ecological roles of keystone species, behaviour studies, predatory-prey interactions, and full scale trophic level and ecosystem modeling projects. While all these areas of investigation inform design they don't necessarily produce perfect or 'best' answers to design questions. As Dr Ballantine predicted, there is no one answer and no perfect design, what is important is that we have enough of everything in full protection for system properties and connectivity to operate. Researchers can demonstrate specific results pertaining to target species and test reserves size and configuration for that species, however, while this is helpful it is also clear that the marine ecology and individual species go about their lifestyle at vastly different scales. It is also apparent that in the sea all scales matter and there is connectivity between them. For example, a marlin has a home range of hundreds or thousands of kilometers while its food species and their food webs may have much smaller home ranges. A kelp plant or some invertebrates may have a home range of only hundreds of meters. They can both benefit from protection from disturbance, however there is no one size that is best for a reserve design.

11. There are numerous examples of how networks have been designed and what is working and what is not and there are excellent guideline publications that synthesize this knowledge into practical approaches. I would like to quote this summary of key concepts relating to size and

shape of reserves from the IUCN publication, *Establishing Marine Protected Area Networks—Making It Happen.* [8]

"Key aspects to maximize individual MPA contribution to the network:

Size

• To ensure self-seeding of a reserve it should be as large as the mean larval dispersal distance of the target species (Shanks et al. 2003, Botsford 2001). Aim for MPAs that are 10 to 20 km in diameter across their minimum width.

• To meet both fishery and conservation goals, intermediate sizes of MPAs and a variation of sizes within a network is considered ideal.

• If the design is focused on target species, optimal sizing may differ depending on the particular species characteristics.

• One approach to network design is to establish the size of MPA based on adult neighborhood sizes of highly fished species, and space the MPA based on larval neighborhood scales.

Spacing

• To facilitate dispersal and promote connectivity between MPAs, MPAs should be placed appropriately to capture the middle range of dispersal distances. Spacing guidelines vary by habitat and region, with estimates ranging from 10 to 20 km of one another (Shanks et al. 2003) to 50 to 100km (CDFG 2007) to capture effective connectivity.

• MPAs should be spaced to capture the biogeographic range of variation in habitat and species.

• Variable spacing is better than fixed spacing when there are several small MPAs rather than a few large MPAs."

[8] IUCN World Commission on Protected Areas (IUCN-WCPA) (2008). Establishing Marine Protected Area Networks—Making It Happen. Washington, D.C.: IUCN-WCPA, National Oceanic and Atmospheric Administration and The Nature Conservancy. 118 p.

Shape

• The shape of the MPA should capture the gradient from onshore-offshore or habitat-habitat shifts of species of interest.

• A shape that allows for clear marking of boundaries for both resource users and enforcement personnel awareness may increase effectiveness. MPAs should be contiguous, compact and easily delineated.

• When designing shape for biodiversity conservation it is important to minimize edge habitat and maximize interior protected area. In contrast, for fisheries management, it is important to consider the type and spatial extent of the habitat bordering the MPA, since this will influence emigration (e.g. continuous habitat inside and outside of the reserve will enhance spillover effects (Carr et al. 2003)).”

Design history and process for the Mimiwhangata Rāhui Tapu area

12. The design of the current Rahui Tapu area had its beginning during the second Mimiwhangata investigation period beginning in 2000. The investigation itself, which is detailed in my primary evidence, was developed to support consideration of a marine protection proposal if it was determined that the current Marine Park arrangement was not effective.

13. Between 2000 and 2003, as the monitoring work and habitat mapping progressed the conclusion was reached by the science team that the Marine Park arrangement was not working and there were serious biodiversity decline issues.

14. The Te Uri o Hikihiki kaumatua in 2003-2004 made a decision to support an application for a Marine Reserve at Mimiwhangata for the purpose of

restoring the marine life there. The Kaumatua declared a Rāhui over the waters of Mimiwhangata at that time. With the cooperation of the Department of Conservation (**DOC**), the Hapū articulated their desire to establish a co-management regime for the Marine Reserve and they requested a generational review to be established similar to what exists for the Te Tapuwae Ronokako Marine Reserve on the Gisborne Coast. On this basis, design work then progressed under the guidance of the Kaumatua.

15. I lead the design work for DOC. At that time we set ourselves the goal of designing a reserve that:

    (a) met local criteria;
    (b) achieved restoration of the key predator species; snapper and crayfish; and
    (c) allowed for the shallow kelp forests to restore.

16. We also aimed to design a reserve that would meet all of the requirements to contribute to network goals at the Northland scale as understood at that time from best international practice.

17. By 2004 we had good quality habitat mapping and a good picture of the status of the key species, snapper *Pagrus auratus* and the main crayfish *Jasus edwardsii* and their role in controlling sea urchins in balance with the kelp forests. For both species we had new knowledge about home ranges of these two species and information on spillover, behavioral changes in the reserves happening with these and other species [9] [10] [11] [12]

[9] Babcock R.C., Attwood C.G., Egli D.P., Parsons D. & T.J. Willis (2002). Optimising Marine reserve design in New Zealand - Part II: Individual-Based models. Leigh Marine Laboratory, report to the Department of Conservation.
[10] Ballantine, W.J. 2014, ***Fifty years on: Lessons from marine reserves in New Zealand and principles for a worldwide network.***
Biological Conservation Volume 176, pages 297-307.

[13] [14] [15] [16]. At the Leigh Marine Reserve we were also learning about the 'edge affect' where fishing near the boundaries was affecting these two species (snapper and crayfish) within in the reserve, a certain distance from the boundaries. As a result of this information, along with the habitat mapping and ecological information, we formed a specific local criteria for the reserve design, which I will summarise as follows:

(a) bigger is better;
(b) shoreline distance at least as long as the Leigh Marine Reserve (6km) or longer if possible;
(c) offshore boundaries would if possible go out to at least 2km offshore;
(d) include the widest diversity of habitats possible ranging from the deep reefs (>30m depth) to the intertidal habitats;
(e) the widest possible range of exposures would be included,
(f) boundaries should wherever possible avoid cutting through major habitat areas;
(g) reef edges and adjoining soft sediment edge habitats should be included wherever possible;
(h) Connectivity between the shallow reefs (<30m depth) and the deep reefs (>30m depth) would be maximized wherever possible; and

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[11] Willis T.J., Millar R.B. & R.C. Babcock (2003). Protection of exploited fishes in temperate regions: high density and biomass of snapper Pagrus auratus (Sparidae) in northern New Zealand marine reserves. Journal of Applied Ecology, 40: 214-227
[12] Gell, F.R. and Roberts, C.M. 2003: Benefits Beyond Boundaries: the fishery effects of marine reserves. TRENDS in Ecology and Evolution. Volume 18, Number 9, 9 September 2003.
[13] Parsons, D.M., Babcock, R.C., Hankin, R.K.S., et al., 2003. Snapper *Pagrus auratus* (Sparidae) home range dynamics: acoustic tagging studies in a marine reserve. Mar. Ecol. Prog. Series 262, 253–265.
[14] Langlois, T.J., Anderson, M.J., Babcock, R.C., Kato, S., 2006. Marine reserves demonstrate trophic interactions across habitats. Oecologia 147, 134–140.
[15] Freeman DJ, MacDiarmid, A.B., Taylor, R.B. (2009) Habitat patches that cross marine boundaries: consequences for the lobster *Jasus edwardsii*. Marine Ecology Progress Series
[16] 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

(i) boundaries and seaward corners would be established with the most practical approach to ease navigation at sea and support compliance.

18. In 2004-2005 an initial design was completed and a proposal was presented to the public in the form of a consultation document [17]. There was also a detailed boundary investigation and report released at this time exploring local criteria (6) above [18].

19. From the consultation process in 2004 considerable input was received from submitters, which is summarised in the boundary report.[18]

20. By 2006 this new information was applied to the initial design and the boundaries were consequentially changed to what is shown as the Rāhui Tapu proposal currently. Essentially these changes made allowance for some recreational fishing to continue at the West and East ends of the proposed reserve. In 2006, a formal Marine Reserve Application had been prepared and was close to notification when DOC made the decision to withdraw from Marine Reserve applications. This decision coincided with release of the first version of the MPA Policy document. DOC stated at the time of the release of the MPA policy that all 'current' marine reserves projects would be 'incorporated' into the new MPA forum processes introduced in the Policy. From this turning point in 2006 marine conservation projects in Northland have been community and hapu lead with funding mainly coming from community based organisations and the philanthropic sources.

[17] Kerr, V.C., Grace, R.V., 2004. Marine Reserve Proposal Mimiwhangata Community Discussion Document. Department of Conservation.
[18] Fleming, A., Hawkins K., 2005. Boundary Options Assessment Report associated with the Mimiwhangata Marine Reserve Proposal. Northland Conservancy, Department of Conservation.

21. In the years following the events of 2006, Te Uri o Hikihiki remained dedicated to the kaupapa. There were several attempts to negotiate with Government Departments to support the proposal (which was renamed as the Rāhui Tapu proposal) . The only substantive changes to the proposal from 2006 onwards were in the management sections where the goal statements around co-management and implementation of those goals were strengthened with more practical detail added. Over the years from 2006 leading to the current Appeal case the Hapū has been supported by the Mountains to Sea Conservation Trust and Forest & Bird Protection Society. I have also supported the Hapū in providing ongoing ecological advice. The work from 2006 has mainly focused on management options and consultations with Government. There has been no other substantive changes made to the Rāhui Tapu proposal design during these years from 2006 to the present proposal.

Summary of design features of the Rahui Tapu proposal

Size matters

22. The Rāhui Tapu proposal is 4,890 hectares in total size, with the West and East buffer areas being 672 and 551 hectares in size respectfully. In comparison the Leigh Marine Reserve which is 518 ha in size, the Rāhui Tapu proposal is over nine times the size of the Leigh Marine Reserve. Of the 43 marine reserves on the mainland coastal area of New Zealand only two are bigger than the Rāhui Tapu proposal. Kahurangi on the West Coast of the South Island is 8,419 ha and Hikurangi at Kaikoura is 10,416 hectares. Kahurangi and Hikurangi are both more recently established reserves and thus their size reflects a general shift to larger reserves where this is practical. The Hikurangi reserve has a very small coastline with a larger area offshore covering the Kaikoura canyons.

23. With today's knowledge it is clear that the Leigh Marine Reserve should have extended further out to sea to include the outer deep reef areas and sufficient edge habitats and adjoining soft sediment areas where crayfish from the reserve regularly forage for food. While this is just one aspect of big is better, in the case of the Leigh Marine Reserve it has proved to be an important consideration. [14] [16]

24. The Mimiwhangata Rāhui Tapu has a coastline of 9.2 km with the West buffer area and the East buffer area having a coastline of 5.0 km and 3.2 km respectfully. This compares with the Leigh Marine Reserve coastline, which is approximately 6 km long. (Note these measurements of coastline length are approximate, as they will vary depending on the scale at which they were drawn).

25. In the early stages of creating a marine protected area network, each reserve contributes to representation of habitats by default as in Northland's case where there are no open coast protected areas other than the offshore Poor Knights Islands. It is typically hard for people to appreciate the sizes of the habitats and the coastal systems we are dealing with. To create some perspective around the area sizes involved with the Rāhui Tapu proposal I have calculated the area values represented in Table 1 below. While at first glance the areas of the habitats in the Rāhui Tapu may appear large, they are actually quite small in relation to Northland's East Coast, which is a logical scale to assess system or network connectivity and design.

26. Based on the 2009 Northland habitat map[19], deep reef systems for all of Northlands East Coast total 156,000 ha. The deep reef area within the Rāhui Tapu is about 1,800 ha which is approximately 1.2 % of the larger

[19] Kerr, V.C. 2010. Marine Habitat Map of Northland: Mangawhai to Ahipara Vers. 1. Technical Report, Department of Conservation, Northland Conservancy, Whangarei, New Zealand.

Northland deep reef area, whereas our protection goal would be 10% - 30% of the total habitat area in full protection to maximize benefits. From this perspective the Rāhui Tapu areas are small. Another context is that we are at the beginning of developing a protected area network in our coastal waters, and each step forward demonstrates and grows the overall system benefits of the network. [1]

Table 1 Calculated area values of habitats in the proposed Rāhui Tapu. (Note: source of area calculations for the Rahui Tapu are derived from Kerr & Associates GIS project and are unpublished.)

Habitat	Size
shallow *Ecklonia* forest reef <30m depth	300 ha
kina barren	180 ha
deep reef high relief >30m depth	300 ha
deep reef low relief and patch reef >30m depth	1,500 ha
Mimiwhangata's Rāhui Tapu deep reef as a % of East Coast Northland's deep reef area	1.2%

Habitat quality and diversity

27. The Rāhui Tapu proposal as described in my primary evidence and commented on in the primary evidence of Dr Shears has a high diversity of habitats and exposures. It is near the top of the list of Northland sites in fish diversity and includes virtually every exposure type and corresponding marine community and habitat found on Northland's East Coast. The proposal area also includes connectivity between this diverse array of shoreline and shallow habitats and shallow reef kelp forest

habitats and deep reefs. There is no other coastal marine reserve in New Zealand that has this extensive array of values.

28. Mimiwhangata is also strategically positioned in a triangle with the Poor Knights Marine Reserve and Cape Brett making connectivity gains and emergent benefits of network connections between these high quality habitats an important possibility for the future. Connectivity between reserves in the network is one of the most important design criteria with benefits growing exponentially as connectivity between reserve increases. [1] [10] [20] [12] [21]

29. For all these reasons the Rāhui Tapu area is expected to become a valuable contribution and design example for our emerging network of fully protected areas.

ANALYSIS OF KIN BARREN FIELD WORK

30. I have been asked by Te Uri o Hikihiki to do a check of the current status of the kina barrens. The last detailed mapping of the habitats and the kina barrens at Mimiwhangata was completed in 2004. [22] There has been no detailed study of kina barrens at Mimiwhangata since 2004, however I routinely check any new aerial photographs that come available and I have visited the area diving a number of times over the years.

[20] Roberts CM et al (2017) Marine reserves can mitigate and promote adaptation to climate change. Proc Natl Acad Sci USA 114:6167–6175. https://doi.org/10.1073/pnas.1701262114

[21] Sala E, Costello C, Dougherty D, Heal G, Kelleher K, et al. (2013) A General Business Model for Marine Reserves. PLoS ONE 8(4): e58799.

[22] Kerr, V.C., Grace, R.V., 2005. Intertidal and subtidal habitats of Mimiwhangata Marine Park and adjacent shelf. Department of Conservation Research and Development Series 201, 55 p.

31. I have not noticed any change in the status of the barrens over that time from these cursory observations. To complete a rapid survey of the kina barrens recent online aerial imagery was searched and a day of field based survey was completed at two reefs using a drop photo frame camera system.

Methodology field survey

32. A collection of aerial imagery having good quality visibility of the subtidal reefs from years 2016, 2018 and 2019 was georeferenced into layers in ArcGIS to compare to the 2005 habitat map and historic aerial imagery (source Grace & Kerr) from 2003 and 2006. Two reefs were selected to examine with a combination of methods utilizing comparison of overlaid imagery and habitat map layers in the GIS project and field ground truthing utilizing a 1 m^2 quadrat drop camera system. Transects lines of approximately 100m length were selected that crossed the profile of the reefs in the depth range of 4-8 m. Three transects were completed. The GoPro camera was set on continuous shooting at 5 second intervals taking 7 mega pixel images. The boat was moved slowly along the transect line while the frame was dropped to the bottom at approximately every 5-10 m intervals. In post processing an image was selected for analysis from each drop position when the frame was on the bottom and there was reef habitat. A score was recorded for the number of kina seen in the 1m^2 frame. The percentage of macro algal cover was estimated and notes were kept on the species of macro algae present.

Figure 1 The GoPro drop camera quadrat apparatus used for the field survey

Aerial photography method and analysis

33. Imagery from Google earth taken in 2016 and 2018 was obtained which had sufficient quality to support subtidal habitat interpretation and comparison with the aerial layers from 2003 & 2006 and the 2005 habitat map [1] for Mimiwhangata. The image layers were georeferenced in ArcGIS and assembled as layers allowing reef features and kina barren condition to be compared at relatively fine scales (down to 1:500 scale). A large area (1 km x 2 km) between the Mimiwhangata headland and Rimariki Island was selected for the comparison. This area has the largest area of kina barrens in the Mimiwhangata Park and is complex in terms of coastline and exposure to wave energy providing a good area to test the persistence of the kina barrens since the 2004 period. Examples of the imagery are shown in Figures 2 & 3 below with the photo frame quadrat transects indicated by red lines.

Figure 2 The aerial image is from the Grace and Kerr collection taken June 2006. The three transects used for the photo frame quadrats are indicated in red (map scale 1:5,000)

34. Figure 2 above gives us a view of the kina barren condition as of 2006. This image allows for reliable interpretation of the three main shallow subtidal habitats featuring in the 2005 habitat map; shallow mixed weed, kina barrens and *Ecklonia radiata* kelp forest. The shallow mixed weed can be seen typically as a dark band situated just below the low tide mark and extending downwards to 1-4m depth varying with exposure. This group of kelp species is resistant to wave action and is also typically more resistant to kina grazing than *Ecklonia radiata*. In persistent kina barrens the kina can gradually reduce this zone of the kelp forest community. This band of kelp is seen as a dark band along the shoreline or around rocks. Below the shallow mixed weed zone in most areas there is a zone extending down the reef, which appears lighter in the

image and at higher magnification, can be recognised as bare rock. This is the kina barren zone. Typically near the bottom of the reef or at about 12-15 m depth the kina barren reaches a solid stand of *Ecklonia radiata* kelp which extends downwards to a soft bottom edge or a depth of 30m where lack of light limits the range where the *Ecklonia* kelp can grow. In the Figure 2 image these bands of *Ecklonia* kelp can be seen as darker areas at the deeper edges of the reefs.

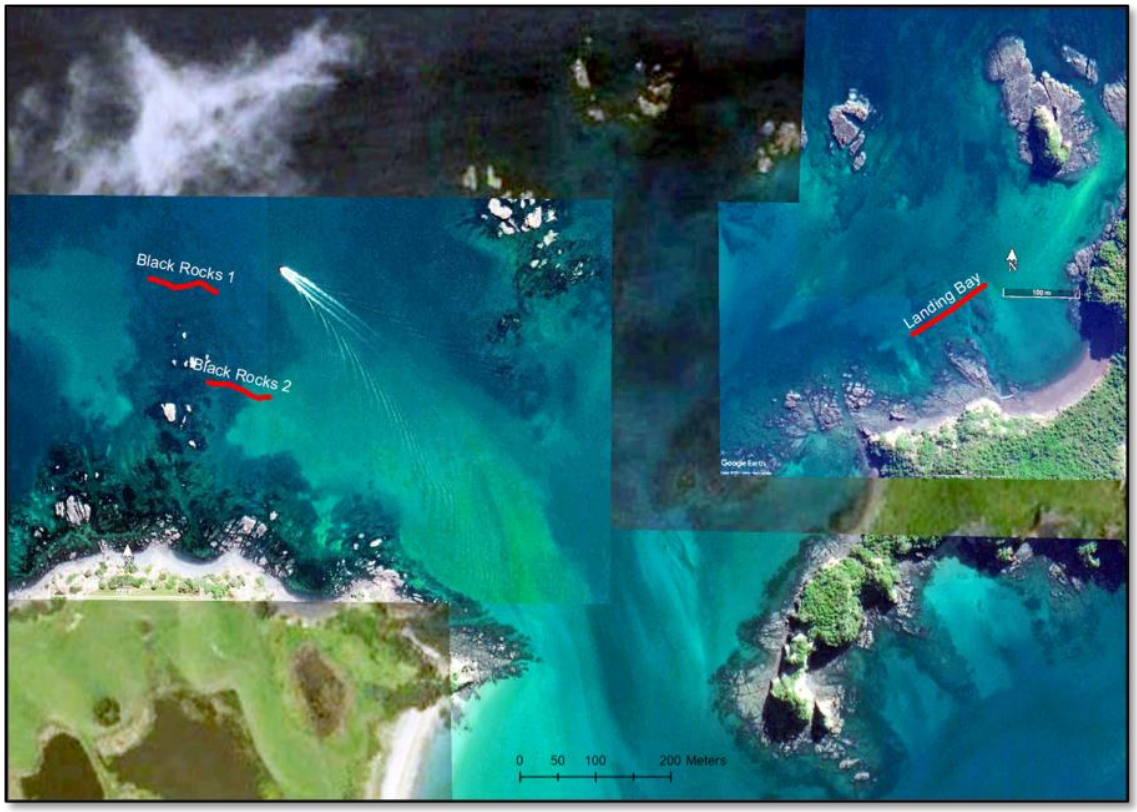

Figure 3 Aerial layers sourced from Google Earth imagery. The layer covering Black Rock Reef is from 2016 and the coverage of Landing Bay reef and the layer in bottom right corner was taken in 2019 (map scale 1:5,000)

35. Figure 3 shows the study area with an overlay of the recent images taken in 2016 and 2019. The quality and resolution of these images is

not quite at the high standard of the 2006 image, however in my opinion the quality was good enough to allow comparison of the spatial extent of the kina barren areas.

Result of aerial imagery analysis

36. The capabilities of the GIS environment allows for the various images to be turned off and on and also ‘swiped’ over the top of each other facilitating careful examination of the habitat boundaries. The interpretation in this way can be compared with the 2005 habitat map shown below in Figure 4. The reefs in the test area depicted in Figures 2-4 were examined looking for changes in the habitat boundaries. I was not able to find any of the reefs in this area that showed significant change in status of the kina barren extent between 2006 and 2016-2019.

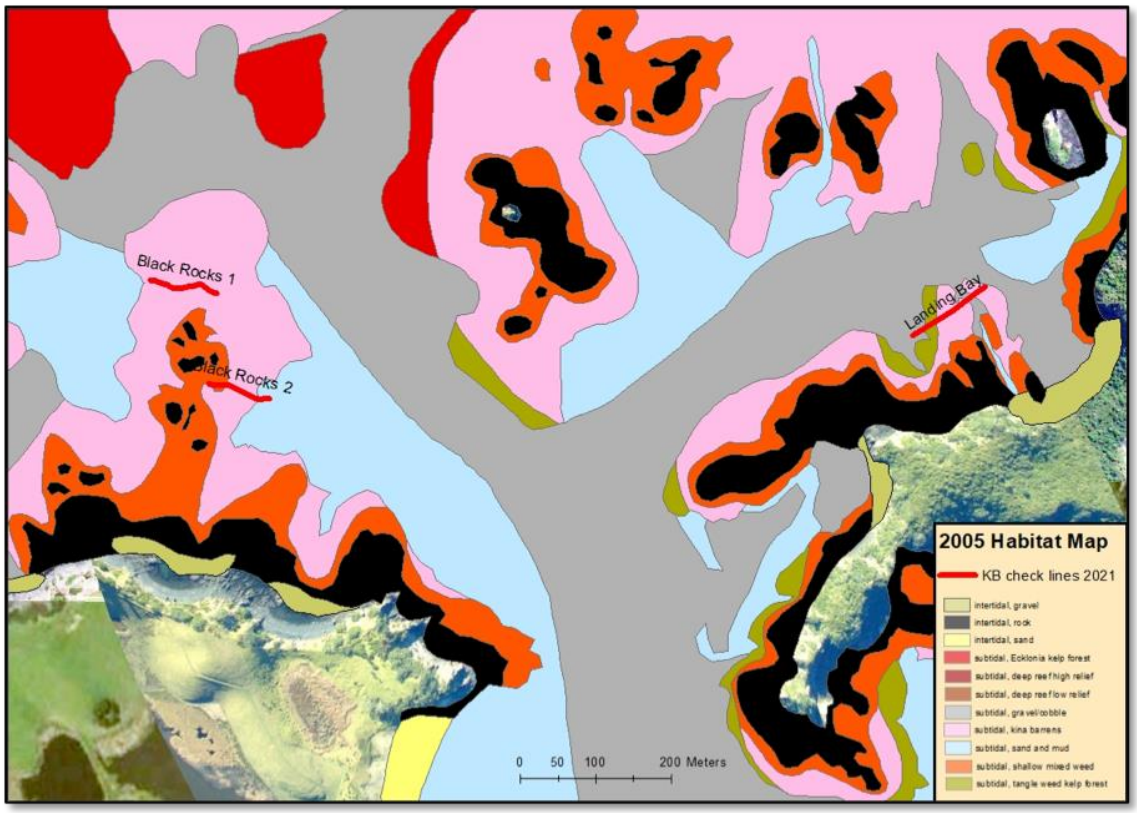

Figure 4 Photo frame transects shown as red lines located on the 2005 habitat map[1], kina barren areas are colored pink

Results of drop cam 1m^2 photo quadrats

37. Table 1 below shows the results of the photo frame drop cam survey on the three transect completed.

Table 1

reef transect name	average kina count number per square meter	average kelp % cover	highest kina count per square meter	number of photo quadrats scored
Black Rocks 1	5.5	15.4	16	12
Black Rocks 2	3.0	3.5	20	10
Landing Bay	6.2	1.2	10	13

38. Kina density per square meter is a standard measure used to track formation of kina barrens, persistence of kina barrens and in restoration trials based on kina culling. Kina densities greater than 4/m^2 are considered high enough to lead to formation of new kina barrens. Kina densities near zero are currently considered a threshold for kelp recovery (pers. com Dr. Nick Shears).

39. The average kelp coverage results ranging from 1.2 – 20 % are within the range of what is seen on kina barrens. In this case of these two reefs most of kelp plants growing were young *Carpophyllum flexulosum* that is found typically in areas of low exposure and can form tall dense forests up to 2m high. This kelp species is known to be less palatable to kina but in these locations is unlikely to form a permanent forest as the wave energy level is expected to be too high for them to persist.

Interpretation of the photo frame results

40. In my opinion the imagery and data derived from the photo frame transects supports a conclusion that these areas are persisting as long-term kina barrens and have not substantially changed since the mapping period of 2004-2005. This conclusion is consistent with other studies of long-term persistence of kina barrens here in Northland and overseas [23] [24]. Please refer to my primary evidence sections 38-48 for more detailed discussion of the persistence and ecological implications of kina barrens in Northland.

Observations on the water of kina barren extent

41. During the course of the field survey recently conducted at Mimiwhangata I was able to drive over most of the reefs shown in Figures 2 & 3. Visibility into the water was about 6m on the day of the survey. This allowed me to directly observe the kina barren status in these shallower areas. Everything I observed directly from the boat was

[23] 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.
[24] Ling, S.D. et al., 2015. Global regime shift dynamics of catastrophic sea urchin overgrazing. Phil. Trans. R. Soc. B 370: 20130269.

consistent with the conclusion that the kina barrens in the study area are persistent and consistent with the mapping done in 2004.

Examples of the photo frame quadrats from each of the three transects completed are shown below in Figures 5-7.

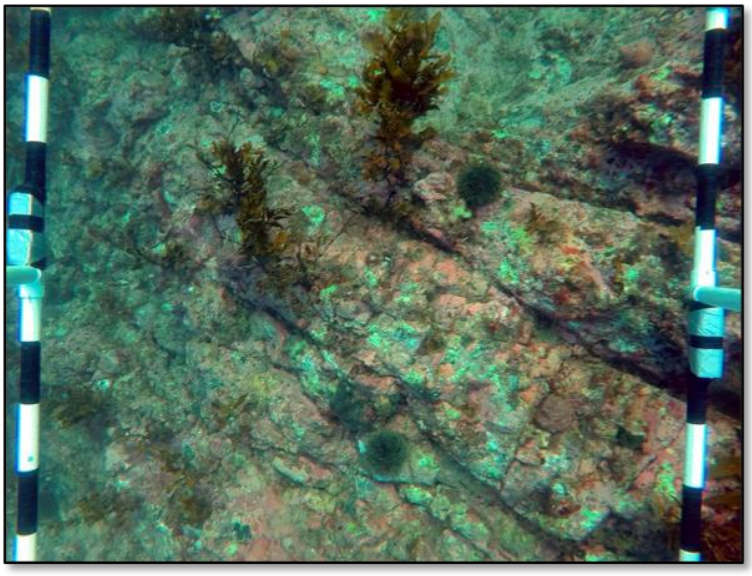

Figure 5 Black Rock Reef transect 1, three young plants species, *Carpophyllum flexulosum* can be seen and several kina

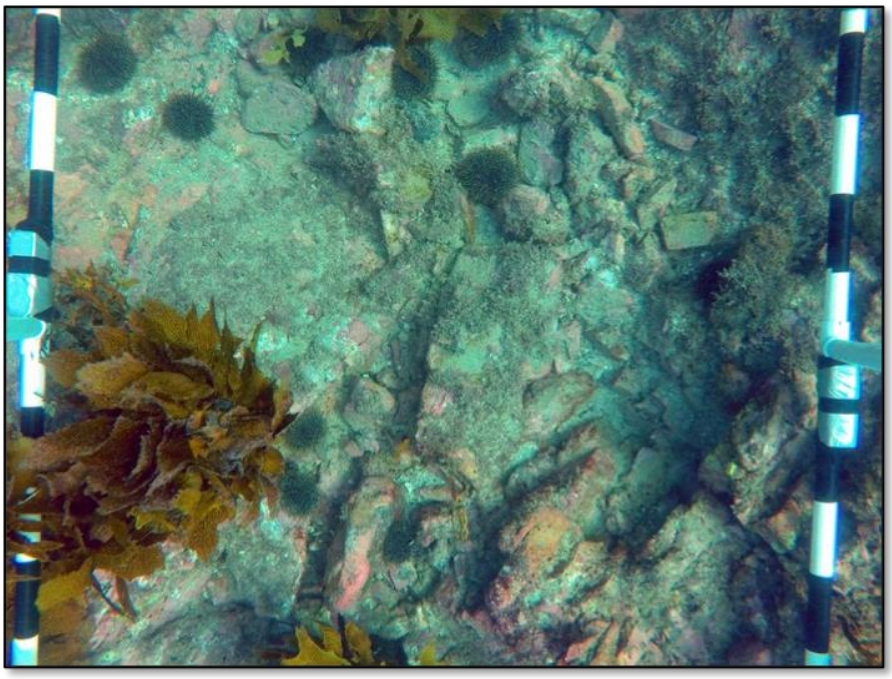

Figure 6 Black Rock Reef transect 2, kelp plant is a young *Ecklonia radiata*

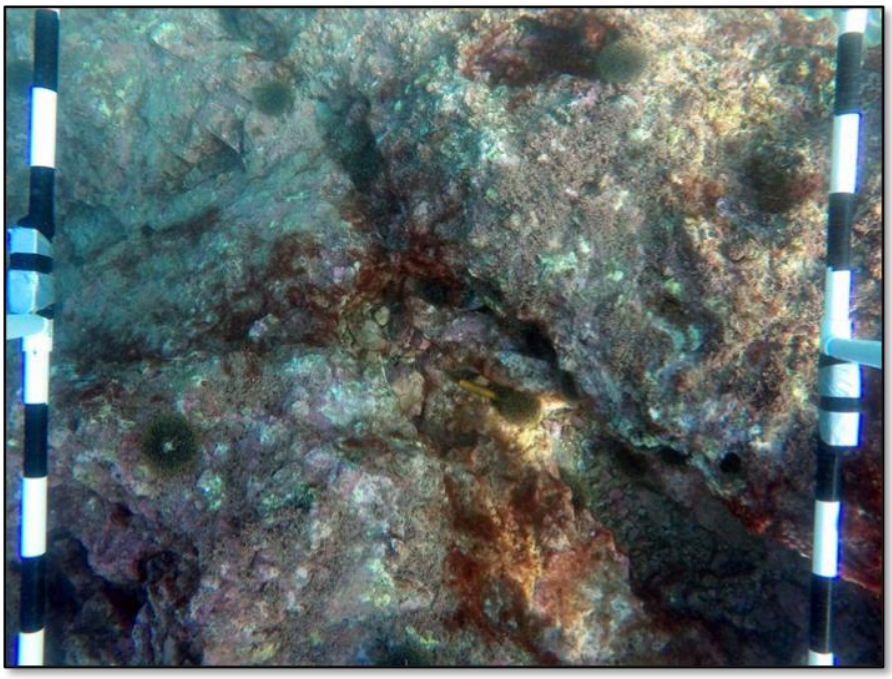

Figure 7 Landing Bay transect no kelp present and kina scattered over the area

Dated 14 May 2021