Understanding and Mitigating Seaweed Forest Losses Caused by Environmental Change in New Zealand/Aotearoa

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Objectives:

Losses of seaweed habitat have been reported in New Zealand (NZ, known as Aotearoa in the Māori language), yet there are few formal studies that characterize these losses. This project will document the extent of seaweed-habitat loss to inform the design of future seaweed restoration plans. Commercial datasets that have typically been used to assess impacts of coastal industries (such as power-generation, aquaculture, and port activities) will be analyzed to quantify spatio-temporal patterns of change in seaweed forests in multiple regions of NZ. Then, based on the findings of this analytical work, preliminary restoration-focused experiments will assess possible methods to restore lost or declining seaweeds.

Throughout this project, liaison with Te Kāhui Āio (Cawthron's Māori Business Team) will provide a Māori perspective on the social ramifications of changes in seaweed forests and guide the incorporation of mātauranga Māori (Māori knowledge) in restoration approaches. Information acquired in this project will contribute to Cawthron's restoration efforts as part of the organization's goal to responsibly manage seaweed ecosystems throughout NZ and contribute to seaweed management strategies around the world.

Specific project objectives:

1. Identify areas of current and historical seaweed forest decline in the temperate rocky reefs of New Zealand/Aotearoa as well as causes for the observed declines.
2. Provide recommendations for coastal managers including the New Zealand Government, regional councils, and iwi, hapū and whānau (Māori tribes, sub-tribes and extended family groups – the three tiers of Māori political structure).
3. Develop new context-specific restoration techniques through methods such as culturing seaweed to address habitat loss.

Implications:

Human-induced environmental changes, including more frequent and stronger marine heatwaves, increased nearshore turbidity from agricultural and urban land-use, burgeoning herbivory due to the overfishing of predatory fish, and the proliferation of invasive species have had widespread impacts on the world's seaweed forests and the ecological communities they support.[1,2] In NZ, relatively few studies have quantified losses of seaweed, despite widespread anecdotal information that losses are significant and are impacting nearshore ecosystems, their services, and wider societal benefits.[3,4,5] Specific organisms of high economic value that are negatively impacted by losses in kelp forest habitat include rock lobster, abalone, and reef fish.[6] Thus, this project would be an important step to advance efforts to understand and address seaweed declines in NZ.

Warming ocean temperatures and marine heatwave events pose serious risks to large brown algae by shifting temperature ranges and disrupting kelp physiology, among other impacts.[6,5] The risk that heatwaves pose to kelp-based ecosystems has been documented in regions around the world, including areas in close proximity to NZ such as Tasmania and Western Australia.[7,8] However, the extent of kelp forest decline in NZ and the exact causes behind it have yet to be determined. While studies have started to focus on understanding differences in strains and in their resistance, the development of climate change-resistant strains of seaweed for use in restoration and aquaculture is not yet fully perfected.

The Cawthron Institute is based in Nelson, which is located on New Zealand's South Island along the coast of Tasman Bay. Cawthron supports publicly-funded science, NZ's primary

industries, and works toward protecting the environment. In addition to the direct application of the project's results in NZ, any significant findings could be applied to management of similar resources in other areas of the world.

Equity:

Te Kāhui Āio (Cawthron's Māori Business Team) will guide the incorporation of mātauranga Māori and Kaupapa Māori (the Māori way), leveraging their strong connections with the eight iwi (tribes) in Te Tauihu (Top of the South Island). Doing so will incorporate the perspectives and mātauranga Māori of tangata whenua (local people) across the project. Māori are significant stakeholders and stewards of coastal regions in NZ and are leaders in efforts to restore marine ecosystems. As such, iwi, hapū, and whānau will directly benefit from the knowledge and techniques developed in this project. This component of the project will help inform and promote efforts by the New Zealand Government to engage with Māori in the development of policy solutions that respond to the impacts of climate change.[9]

The Treaty of Waitangi, a contract signed in 1840 between the British and Māori to build a government in NZ, supports Māori land rights and resource management abilities.[10] As such, it will be bound by law to include Māori input in this project. Permitting for any project components will align with the Wai 262 claim. This Claim centers around Māori rights to biological resources such as native flora and fauna.[11]

Available data:

Cawthron has access to historic reef data from their industry partners such as Port Napier and Meridian Energy. Cawthron has also committed to obtaining permission to use the data. The data will include long-term datasets that can be used to assess changes in seaweed abundance in NZ. The data originate from transect surveys of subtidal and intertidal rocky reefs that were originally collected to assess the impacts of various commercial activities in regions such as Fiordland, Marlborough Sounds, and Hawke's Bay (Figure 1). Publicly-accessible map databases, such as that of the Marlborough District Council and Hawke's Bay Regional Council, may be used to complement the reef data. Applying a time-series analysis will allow temporal trends in seaweed abundance to be described. For some datasets, it will be possible to incorporate additional predictor variables (temperature, herbivore abundance, sediment) into the time series analysis to assess their possible influence on seaweed abundance. Where available, mātauranga Māori will provide information on changes in seaweed abundance and how the phenomenon has impacted their culture, economy, and use of natural resources.

The laboratory work associated with the internship portion of the project will generate new data on seaweed aquaculture techniques that can be applied to restoration initiatives.

Possible approach:

To analyze trends in the observed decline of kelp, the project will involve statistical analysis such as analysis of variance (ANOVA) or linear regression. ANOVA would test for the level of significance of decline between kelp populations in different areas. PERMANOVA (permutational multivariate analysis of variance) is a more advanced method of analyzing multivariate datasets that may be more appropriate for assessing the interactions between the different variables involved in the project dataset. Linear regression would attempt to explain factors that are linked to decreased kelp cover, which may involve multiple contributing factors such as water clarity.[5] Additionally, SIMPER (Similarity Percentage) could be used as a method

to help understand which variables drive observed differences between groups of seaweed habitat.[12] These analyses will inform restoration strategies such as environmental remediation or seaweed reseeding.

The summer internship associated with this project will involve experimental work at Cawthron Aquaculture Park (CAP), a research and technology center for the NZ aquaculture sector. Specifically, interns will investigate methods for seaweed-propagule cultivation using experiments that adapt, optimize, and assess existing technologies such as "Green Gravel" and novel techniques currently in development at Cawthron for relevant species of seaweed.[13,14] Because of the significant threat of higher ocean temperatures and the potential for more frequent and intense marine heatwave events, the effects of temperature will be incorporated into the experiments to understand the probability of success in a warmer world. It would also be beneficial to investigate heat-resistant strains of seaweed and, while this is likely beyond the scope of this current study, consideration of this and other future methods will be included as recommendations in the final report.[15]

Additionally, GIS could be used to convey important spatial information of kelp declines to stakeholders, such as areas that seem to be significantly impacted by what is driving the declines. It would also be useful to identify and communicate areas that should be targeted for restoration through GIS mapping.

Deliverables:

1. Final report detailing the findings of the time series analysis, highlighting areas and species of concern, and providing an approach to managing and restoring impacted seaweed forests that includes a preliminary analysis of reseeding techniques.
2. Executive summary to synthesize the contents of the final report in a form that is accessible to the general public.
3. Final presentation in a public setting to detail the rationale for the project, the significance of our findings, and the application of our findings to management strategies and business models in California and around the world.
4. Policy recommendation for the New Zealand Government detailing restoration approaches based on our findings.

Internship:

The Cawthron Institute has committed to providing internships for the members of the group project team, which will vary in number depending on factors such as transportation/housing funding. One to two group project members will apply for funding through the Bren School Summer Internship Fund (SIF) Program. At least one group member will travel to Nelson, NZ to fulfill the internship component. This component will include hands-on laboratory-based research to further develop seaweed-based aquaculture techniques that can be applied to restoration initiatives.

Budget:

- Cawthron will match the $1,000 contribution from the Bren School
- Cawthron will provide 0.05 – 0.01 FTE for student supervision and laboratory costs at Cawthron's National Algal Research Centre
- Those who will take part in the internship(s) will apply for the Bren School Summer Internship Fund Program to alleviate transportation and living costs (up to $6,500 rewarded)
- Envirolink is a New Zealand regional council-driven funding program and potential funding source of up to $10,000 that could be applied to internships and data analysis. This is not committed through Cawthron, but will be a sought after funding source to propel this project.

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Appendix

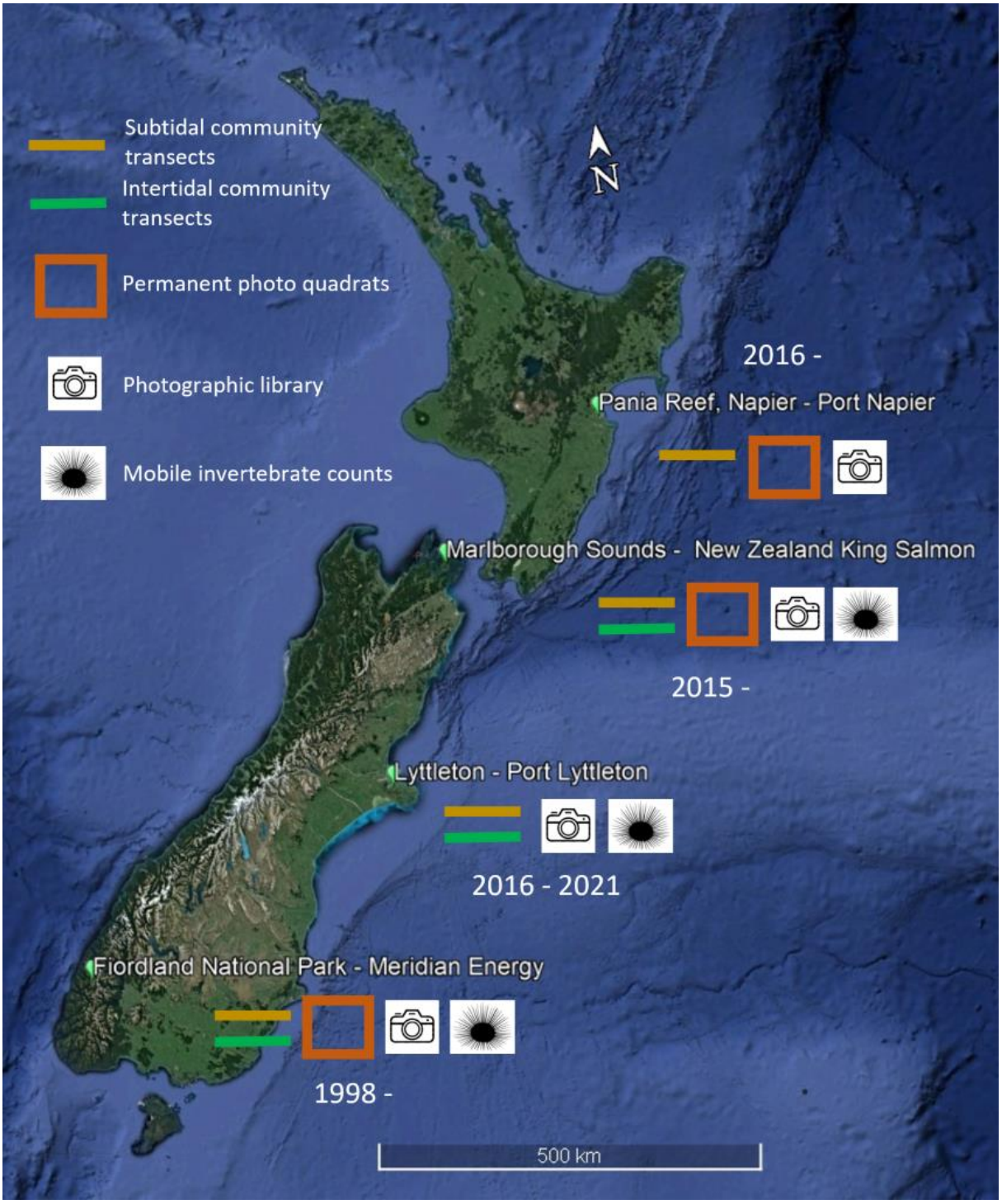


Figure 1: Map of New Zealand which includes locations where Cawthron has conducted ecological monitoring in partnership with industry. These include Napier (Hawke's Bay), Marlborough Sounds, Lyttleton, and Fiordland National Park; the map also illustrates the type of data, time frame of data collection, and data source associated with each location

CAWTHRON INSTITUTE

10 January 2024

Group Project Committee
Bren School of Environmental Science & Management
2400 Bren Hall
UC Santa Barbara, CA 93106 USA

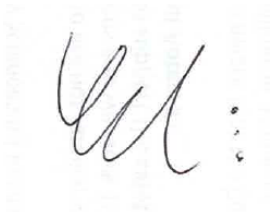
Dear Group Project Committee:

This letter is to confirm **Cawthron Institute**'s support for the group project proposal "Understanding and Mitigating Seaweed Forest Losses Caused by Environmental Change in Aotearoa / New Zealand". The Cawthron Institute is Aotearoa New Zealand's largest independent science research organisation. Since its establishment over 100 years ago, Cawthron has focused on research that contributes to economic growth while preserving our freshwater and coastal ecosystems. We employ ~300 highly skilled scientific and technical staff based in Nelson and have a strong reputation nationally and internationally, with both public and private sector clients. Cawthron has extensive expertise in coastal ecological monitoring and restoration, physical and spatial oceanic modelling, and is committed to supporting iwi (Māori tribe) aspirations with a dedicated team (Te Kāhui Āio) who support Cawthron scientists to build strong relationships with Māori partners.

As you may know there are increasing acute and chronic threats toward important coastal ecosystems around the world, in which Aotearoa New Zealand is not immune. There is leading evidence that warming seas and food web disruption are among the main stressors within Aotearoa New Zealand waters. It is important to quantify declines in coastal habitats and research methods to mitigate losses / build community resilience. This project will investigate changes in temperate rocky reef communities around Aotearoa New Zealand using commercial datasets from Cawthron's industry partners. Importantly, this project will also include "hands-on" laboratory-based research to further develop seaweed-based aquaculture techniques that can be applied to restoration initiatives. Furthermore, collaboration with tangata whenua ("people of the land" or original inhabitants of New Zealand) will strengthen project outputs based on mātauranga Māori (Māori knowledge) and benefit iwi, hapū (Māori sub-tribe), and whānau (Māori family) by knowledge and techniques gained from this project. Cawthron is committed to supporting the application both in terms of resources and personnel to ensure that the best possible outcome is realised from this collaborative international undertaking. Specifically, Cawthron will provide 0.05 – 0.01 FTE for student supervision, laboratory costs at Cawthron's National Algal Research Centre and match the $1,000 contribution from Bren School of Environmental Science & Management.

I believe that the outputs of this project will be critical in identify and mitigating changes in seaweed forests in Aotearoa New Zealand. I also believe that this will be an invaluable collaboration between Cawthron and UC Santa Barbara and, importantly, a productive learning experience for the student group involved.

Yours sincerely



Dr Cath McLeod
Chief Science Officer