Research Proposal

A. PROJECT TITLE	Kohunga Kutai
"SHORT" TITLE	Kohunga Kutai
B. THEME / PROGRAMME	Blue Economy Innovation Fund

C. PROJECT KEY RESEARCHERS

Role	Name	Institution / company	Email
Project Leader	Andrew Jeffs	University of Auckland	a.jeffs@auckland.ac.nz
Project Co-Leader	Nicola MacDonald	Ngāti Manuhiri Settlement Trust	nicolamacdonald17@gmail.com
Post-Doc Researcher	Brad Skelton	University of Auckland	
Researcher	Katarina Tawiri	Manaaki Whenua	

D. PROJECT PARTNERS

Name	Organisation / company / agency / Iwi / Māori	Role in project
Ngāti Manuhiri & Ngāti Rehua	Ngāti Manuhiri & Ngāti Rehua	Co-leadership of project, provision of mātauranga Māori, kaiwhatu expert, use of pā harakeke.
Katarina Tawiri	Manaaki Whenua - Landcare Research – Te Kohinga Harakeke o Aotearoa— National NZ Flax Collection	Facilitating access to unique Aotearoa native plant resource collection, technical knowledge on native plant fibre resources, http://www.landcareresearch.co.nz/resources/collections/harakeke
Ross Dockery	Aotea Marine Farms Ltd	Māori-owned mussel spat collector who will assist with running field experiments on their dedicated spat collection site.
Peter James	Rough Waters Ltd	Māori-owned inshore mussel farm operation in the Hauraki Gulf who will assist with testing effectiveness of transferring spat caught on novel spat catching material onto mussel farms in coastal waters.
Peter Vitasovich	Whakatōhea Mussels (Ōpōtiki) Ltd	Māori-owned offshore mussel farm operation in the Bay of Plenty who will assist with testing effectiveness of novel spat catching material in offshore waters.

E. ABSTRACT/SUMMARY

Māori are major stakeholders in the NZ aquaculture industry, especially for the production of Greenshell™ mussels (kuku or kutai). This Māori stakeholding is growing rapidly, with large areas of new offshore farming space being granted to Māori as their economic success in aquaculture expands. Of major concern to Māori is the sustainability of their Greenshell™ aquaculture activity within their rohe moana, especially spat (seed mussel) collection, which relies heavily on the use of plastic ropes. There are growing concerns about the release of plastic into the marine environment, including from the large quantities of plastic involved in aquaculture activities. This project directly addresses this issue through the application of mātauranga Māori associated with the traditional use of native plant fibres, which have strong traditions in their wide variety of uses including, lashing waka components, fishing, and for holding live mussels. In this research we will experimentally evaluate the use of a wide range of native plant fibres for the harvesting of mussel spat and transfer to on-growing. We will be guided by mātauranga Māori for identifying these fibres, including their sources, processing and uses. A talented team will tackle this research, combining deep knowledge of both native plant fibres and mussel biology, while being partnered with a select group of Māori aquaculture businesses. The ultimate aim of this research project is to deliver a viable pathway for Māori stakeholders to achieve sustainable aquaculture, whilst also creating new economic opportunities for Māori from the production of traditionally used native plants.

F. PROBLEM DEFINITION/OPPORTUNITY

Every year the New Zealand Greenshell mussel industry deploys thousands of kilometres of fibrous plastic ropes into the sea to catch the seed mussels that are used to stock their farms. There is widespread public concern about the fate of lost plastic ropes, and the plastic fibres shed from the ropes into the sea. Indeed in a recent resource consent hearing to establish a new mussel spat gathering farm, the hearing commissioners banned the use of one type of plastic spat gathering rope because of the pieces that were shed from the sample they were shown. Further bans on the use of plastic in mussel aquaculture are likely into the future. Internationally there is also growing public and scientific concern over the ecological effects of the more than 15 trillion individual pieces of microplastic now estimated to be in the world's oceans.

Developing biodegradable alternatives to plastics offer a solution to this problem. In this instance, mātauranga Māori may have a ready solution. Mussel larvae are known to be attracted to settle and attach strongly to native plant fibres including muka fibre from harakeke (flax), kuta (swamp reed) and tī kōuka (cabbage tree) when placed in the sea. Plant fibres with a wide range of qualities are highly prized by Māori, from fine whatu muka used for finger weaving through to the coarse tī kōuka taura, which are used for anchor ropes and lashings. Individual plants with unique fibre properties are prized and often replanted into protected areas for safe keeping, such as flax gardens (pā harakeke). This unique botanical resource and its associated mātauranga Māori is a valuable resource with outstanding potential to provide a uniquely indigenous solution as an alternative to plastic for catching mussel spat for aquaculture. Consequently, this research aims to apply the mātauranga Māori for plant fibres from native plants to investigate the potential for developing a novel biodegradable mussel seed capture system to improve the sustainability of the New Zealand's Greenshell™ industry. Doing so will also create a potential new economic activity for the growing and processing of native plants for their unique fibres to supply this novel application.

G. OUTPUT/SOLUTION

The solution to the problem of using fibrous plastic ropes to catch wild mussel seed, involves applying mātauranga Māori in relation to the strong natural attraction of mussel seed to natural fibre from native plants, such as muka (flax fibre) and fibre from kuta (swamp reed) and tī kōuka (cabbage tree).

Our proposed research will quantify the relationship between a wide range of these natural fibres and their effectiveness for the capture and retention of mussel seed in situ at commercial mussel spat collecting sites both onshore and offshore. We will also assess the strength and durability of the natural fibres as a direct replacement for the plastic products currently used in the mussel aquaculture industry by using scientific measures, including strain and shear gauges, especially in relation to their exposure to seawater. With the identification of the best spat catching and most durable sources of fibre we will then proceed to assess the best methods for incorporating their use into commercial spat collection and subsequent transfer of the spat encrusted fibre to mussel farms for on-growing.

We will combine this new knowledge to advance a novel solution for providing a sustainable pathway for improved seeding of Aotearoa's Greenshell mussel farms, by replacing their widespread use of polluting plastic products with a natural indigenous product built on mātauranga Māori working in true partnership between researchers, iwi and the Māori aquaculture industry.

H. PROPOSED RESEARCH/APPROACH

The overall aim of the research is to develop an effective product for the capture and transfer of commercial quantities of wild mussel spat onto mussel farms for on-growing using biodegradable fibres sourced from native plants. Essentially, the aim is to develop a biodegradable replacement for the existing use of plastic spat catching ropes in the Greenshell™ aquaculture industry (Fig. 1), using fibres from native plants. The overall approach is based on mātauranga Māori of the relationship between kuku (mussels) and plant fibres, especially muka from harakeke (Fig. 2), and traditional knowledge of difference sources of fibres and how to extract and prepare them. Biologically this relationship is not surprising given that the larvae of many mussel species, including green-lipped mussels, selectively settle on filamentous organisms, especially seagrasses and fine seaweeds (Bologna & Heck 2000; Alfaro & Jeffs 2002; Alfaro et al. 2004; Gribben et al. 2011; Jeffs et al. 2018).

Figure 1. Example of a commercial spat catching rope widely used in the Greenshell™ aquaculture industry which consists of cut strands of polypropylene to simulate filamentous seaweed and hydroids onto which spat normally prefers to settle in the wild. Note the plastic particles lying around the rope that have been shed from the rope with handling.

Figure 2. Mātauranga Māori is familiar with the attraction of kuku (green-lipped mussels) to plant fibres. Coarse flax fibre or muka is well known in this regard. In this photo taura (rope) has been woven from muka by Ngāti Whātua o Ōrākei weavers who have harvested their harakeke to use for holding kuku for experimental restoration deployments in their rohe at Ōkahu Bay with support from Auckland University marine scientists (gulfjournal.org.nz/article/world-first-hanging-mussel-taura-in-okahu-bay/).

This research is structured to sequentially deliver on a set of eight milestones over the two year period. The steps to achieve each of these milestones are detailed below.

1) Detailed Research Plan by 31 December 2020

In the first two months a detailed research plan will be prepared based on combining a review of the scientific literature (facilitated by Andrew Jeffs and Brad Skelton) with mātauranga Māori from Ngāti Manuhiri and Ngati Rehua and other iwi willing to participate (facilitated by Nicola MacDonald), and additional technical knowledge on the available plant resources and the required processing to recover appropriate fibres (facilitated by Katarina Tawiri). The available plant resources include those of Ngāti Manuhiri and Ngati Rehua's plantations of specifically selected flax strains (pā harakeke) and access to Te Kohinga Harakeke o Aotearoa—National NZ Flax Collection curated by Katarina Tawiri at Manaaki Whenua - Landcare Research. Iwi partners will share their tikanga and he pukenga for the harvest and processing of harakeke into muka that is suitable for mussel larval settlement and retention, and with additional input from Katarina Tawiri's technical experience from many years of working with these plants and fibres. Additional sources of information will also be consulted, such as a University of Auckland research team from Chemical Sciences currently investigating the industrial application of harakeke fibre for packaging under an MBIE funded programme. The aim will be to pre-screen the available plant fibre resources for their known properties to arrive at a selection of 12 sources of fibre for further testing in the project. The details of the framework for this further testing will then be discussed, reviewed and confirmed among research partners

2) Comparisons of Plant Fibres by 30 April 2021

Plant material for the 12 selected fibres will be sourced and prepared using mātauranga Māori from Ngāti Manuhiri and Ngati Rehua kaiwhatu (a muka /fibre craftsperson) and technical advice from Katarina Tawiri. Useable fibre yield will be quantified and fibres will be characterised (fibre diameter, length, breaking strength and shear strength) using specialist instrumentation available through the Material Engineering Department of the School of Engineering at the University of Auckland. Comparisons will also be made with measures from existing plastic rope spat collecting products.

3) Durability of Plant Fibres by 31 October 2021

Replicated samples of the 12 characterised fibres will be placed in the sea in a manner consistent with coastal spat catching conditions and recovered after 2 and 3 months, periods commensurate with the typical deployment of spat catching equipment. After each period the fibres will be re-characterised (fibre diameter, length, breaking strength and shear strength) using specialist instrumentation available through the Material Engineering Department of the School of Engineering at the University of Auckland.

The three most durable fibres will be identified for further development for spat catching.

4) Spat catchability of Plant Fibres by 31 March 2022

The three most durable plant fibres identified through the previous steps of the research will be experimentally tested for their ability to attract settling mussel larvae and to retain the spat once settled. This will be done in both inshore (Aotea Harbour - Aotea Marine Farms Ltd) and offshore (Bay of Plenty - Whakatōhea Mussels (Ōpōtiki) Ltd) commercial spat collecting locations. Equivalent quantities of each of the fibres will be looped and held within an inert plastic holder. Spat settlement and retention behaviour on material can be highly variable spatially (Alfaro & Jeffs 2003; South et al. 2017; Skelton & Jeffs 2020), so at least eight replicates of each type of fibre will be tested at two locations within both inshore and offshore spat collection sites. Replicates of existing plastic rope spat collecting products will also be deployed alongside the biodegradable types of fibre for comparison. Six to eight weeks after deployment the spat collectors will be recovered and all spat counted and measured using methods previously developed by the research team (South et al. 2017, 2019a, 2019b; Skelton & Jeffs 2020; Supono et al. 2020). The comparative results will be analysed with ANOVA and PERMANOVA (count data) to identify the top performing natural fibre for spat catching.

5) Arrangement of Plant Fibres for Spat by 30 June 2022

The top performing plant fibre for spat catching identified through the preceding research will need to be configured in a manner that is consistent with common commercial practice of larger scale deployments of spat catching material into spat catching sites. Up to three practical configurations for deploying the top performing spat catching fibre will be devised in conjunction with commercial spat catching partners, and then fabricated and replicates experimentally deployed at two locations within both inshore and offshore spat collection sites. Replicates of existing plastic rope spat collecting products will also be deployed alongside the biodegradable types of fibre for comparison. Six to eight weeks after deployment the spat collectors will be recovered and all spat counted and measured using methods previously developed by the research team (South et al. 2017, 2019a, 2019b; Skelton & Jeffs 2020; Supono et al. 2020). The comparative results will be analysed with ANOVA and PERMANOVA (count data) to identify the top performing configuration for natural fibre for spat catching.

6) Post –Catch Spat Performance by 31 August 2022

Mussel spat caught on lines at spat catching locations is normally transferred to mussel farming sites for on-growing to a larger size. The transport and handling of the spat during this period frequently results in high losses of spat, known in the Greenshell™ industry as poor spat retention. The ability of the top performing configuration of natural fibre for spat catching will be experimentally assessed by deploying sufficient natural fibre configuration at a spat catching site to become encrusted with mussel spat. This will be harvested and sampled to determine spat abundance and size, and immediately transferred to at least two mussel farm sites for experimental on-growing. After four to six weeks the configuration will be sampled to determine the change in spat abundance and size since transfer. Replicates of commercially available plastic rope spat collecting products will also be deployed and assessed alongside the biodegradable types of fibre for comparison. The comparative results will be analysed with ANOVA and PERMANOVA (count data) to determine the effectiveness of natural fibre for transfer of captured spat to mussel farms for on-growing.

7) Product Evaluation by 30 September 2022

Background information on the cultivation and processing of the target plant species providing the top performing natural fibre for spat catching will be sourced, and where possible information on industrial processing methods and costs will be obtained. This information will be combined with the results of the study to this point to provide an overall evaluation of the cost-benefit of sourcing, processing and using high performing plant fibre for spat catching for commercial scale mussel aquaculture.

8) Horizons Hui by 31 October 2022

A meeting of the project partners, and others if appropriate, will be held to discuss and agree future steps for advancing the application of the research results.

References

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I. CONTRIBUTION TO BLUE ECONOMY IN AOTEAROA NEW ZEALAND

The proposed research has the potential to greatly improve the sustainability of New Zealand's largest aquaculture industry by reducing its ongoing release of plastic into the coastal waters of Aotearoa, through developing a unique natural alternative fashioned through mātauranga Māori. As mussel seed appear to have a strong natural affinity for attaching to some plant fibres, this research also has the potential to greatly improve aquaculture performance because it is likely to overcome the difficulties with poor seed retention on plastic ropes that currently plagues the Greenshell™ industry. Māori are major stakeholders in the Greenshell™ industry so that improvements in production sustainability and efficiency arising from such new innovations will return widespread and direct benefits.

A biodegradable spat catching and holding material built from native plant fibres also has the potential to be developed further for assisting in the restoration of wild mussel beds, for which there is widespread community and iwi interest. The researchers will seek additional funding to pursue this additional goal.

The research will invigorate and apply mātauranga Māori for the management of treasured (taonga) native flora and kuku (mussels) in partnership with western science, providing an exemplar for this approach to solving collective problems in the blue economy.

The aim of the outcome from the research is to use a locally grown and biodegradable product to replace the widespread and ultimately unsustainable use of plastic seed rope in New Zealand's Greenshell™ aquaculture production. Doing so will eliminate the ongoing tonnes of plastic waste entering our coastal waters, and the many tonnes of tired plastic mussel seed ropes being dumped to landfill each year because they are not recyclable.

Devising a mussel seed rope made from harakeke, kuta or tī kōuka fibres would lead to the emergence of a new local industry based on native plant products. Iwi are ideally placed to lead the development of this unique industry given their underlying mātauranga Māori investment and knowledge of the cultivation of these plants. Iwi also have pre-eminent access to coastal plant resources and suitable land-holdings for expanding production and processing for this novel product for Aotearoa. In this regard, the IP for this project will be vested with the iwi initiating and co-leading this research project.

J. BENEFITS AND CONNECTIONS TO IWI, HAPŪ AND MĀORI ORGANISATIONS

The project has been initiated in direct partnership with Ngāti Manuhiri and Ngati Rehua, will be co-led and delivered with a kaumātua who is matatau (expert) in her field of the use of traditional plant fibre products. Also, all final intellectual property will remain with iwi at the end of the project for their development. In addition, the project has strong engagement and direct contribution from a number of key Māori aquaculture businesses, all who have the potential to rapidly adopt the technology emerging from the research project. In this way, the technology transfer from the project can be seamless for our industry partners. There are also potential opportunities for iwi, hapū and Māori organisations around the development of cultivation of native plants as a source of valuable fibres for aquaculture products. The opportunity to use native plant fibres for catching mussel seed to restore mussel beds destroyed

by overfishing, is also being pursued by the iwi – university partnership as an extension of their existing collaboration over restoring mussel beds to the Mahurangi Harbour (https://www.teaomaori.news/ngati-manuhiri-excited-efforts-restore-health-moana).

K. COMMUNICATION OF PROJECT RESULTS

The results of the project will be shared more widely through existing aquaculture networks and communication channels. For example, the University of Auckland researchers currently provide a regular column in the Marine Farming Association Newsletter on the latest developments in mussel spat, and have done so for more than a year. Members of the team have also presented on mussel spat issues at the annual NZ aquaculture conference, and Marine Farming Association annual meetings. Reports from the project will be shared and discussed directly with project industry partners, who are all well connected with Māori mussel aquaculture sector. In addition, the project specifically includes a concluding hui for the research team and project partners to discuss the details of the full results of the project, including the cost-benefit analyses of the sourcing, processing and use of high performing plant fibre for spat catching. The purpose of this hui is to discuss and plan a way forward for developing commercial opportunities that have been identified from the research project. A secondary aim of the project is to provide academic outputs, most likely through papers published through scientific journal outlets.
In addition, the project Leader/s will present on project progress at the Challenge Annual conferences / symposia, once a year.

L. CO-FUNDING (Source and amount)

The project includes a total of $50,000 of in-kind support from project partners. Ngati Rehua & Ngāti Manuhiri will provide unfettered access to their storehouse of plant varieties (pā harakeke) and associated mātauranga Māori that is central to this project. Three Māori-owned mussel aquaculture businesses are also partners in the research, each providing significant access and use of their farm infrastructure, facilities and staff to undertake field experimentation in a realistic industry setting, each within a different setting: 1) Aotea Marine Farms Ltd operates one of the most advanced mussel spat collection operations in New Zealand in Aotea Harbour, 2) Rough Waters Ltd is a pioneer in Greenshell™ on-growing in the sheltered waters of the Hauraki Gulf, 3) Whakatōhea Mussels Ōpōtiki Ltd is a pioneer in Greenshell™ aquaculture in offshore waters of the Bay of Plenty. In addition, Whakatōhea Māori Trust Board will contribute by assisting with experimental deployments.

M. RISK & MITIGATION

The risk to the research from relationship breakdown is minimal as the researchers have existing working relationships including among the partners, with much of these existing relationships centred around aspects of mussel aquaculture and spat handling. This includes the long-standing relationship between University of Auckland and Ngāti Manuhiri whose rohe encompasses the university's Leigh Marine Laboratory. There is some redundancy in the skill base of the project team and industry partners to help to cover any unexpected loss of team members. There is risk that natural plant fibres will ultimately prove unsuitable for commercial production for scale spat catching, however, such a risk is inherent in any innovation project. A number of independent sources of mātauranga Māori have confirmed the effectiveness of some native plant fibres for spat catching, suggesting good prospects for success. Risks of variation in natural spat supply for experiments is mitigated by use of multiple sites.

N. CONSENTS & APPROVAL required to undertake research	No specific approvals or consents are required to undertake this research as the proposed research activities fall under existing approvals for activities. Experiments collecting and growing spat will be conducted on spat collecting and aquaculture space with resource consents for that specific purpose. The removal of the mussels for identification, counting and measuring will be done under the University of Auckland's existing Special Permit under the Fisheries Act which specifically includes mussel spat from existing research work. Access to plant resources is under the control of the iwi who are partners in the research. All IP from the project will be vested with iwi partners to manage as they see fit. This approach is entirely consistent with the recommendations arising from the WAI262 claim, by providing for self-management for iwi of their natural resources.