Research Proposal

A. PROJECT TITLE	A novel approach to aquaculture in Aotearoa NZ: Growing community wellbeing with Pātiki tōtara
"SHORT" TITLE	A novel approach to aquaculture in Aotearoa NZ
B. THEME / PROGRAMME	Blue Economy Innovation Fund

C. PROJECT KEY RESEARCHERS

Role	Name	Institution / company	Email
Project Leader	Dr Simon Muncaster	University of Waikato	simon.muncaster@waikato.ac.nz
Project Co-Leader	Dr Steve Bird	University of Waikato	
Key Researcher	Dr Kura Paul-Burke	University of Waikato	
Key Researcher	Professor Tim Coltman	University of Waikato	

D. PROJECT PARTNERS

Name	Organisation / company / agency / Iwi / Māori	Role in project
Jason Murray	Matakana Island Marine Club	Iwi involved in overall project
Dickie Farrar	Whakatohea Māori Trust Board	Iwi involved in overall project
Aubrey Te Kanawa	Ahikōmako – Te Wānanga o Aotearoa	WP2: Work alongside iwi and hapū to develop hapū-enterprise model and develop "Aquaculture Ecosystem Canvas"

E. ABSTRACT/SUMMARY

This project applies a unique multidisciplinary approach to develop a 'disruptive' business model, allowing small whānau-owned aquaculture farms with fewer resources to successfully challenge or coexist alongside incumbent operators. We have identified pātiki totara, yellowbelly flounder (*Rhombosolea leporina*) as a strong candidate species with which to achieve this. The project is grounded in kaupapa Māori to reflect value across three key dimensions – social (hauora, oranga), environmental/ecological (kaitiaki) and economic (mana motuhake) and will be undertaken within three complementary work packages. Firstly, by using Mātauranga Māori of the local hapū a better understanding of the distribution, seasonal movement and feeding habits of pātiki will be established. This work provides the platform to guide an understanding of intellectual property, cultural and decision rights. This will also help to assess the potential for pātiki stock enhancement. Secondly, we work closely with local whanau and hapū to co-create a minimal viable product that is acceptable to local communities. This work will advance research by developing a unique 'Aquaculture Ecosystem Canvas' to show how whānau-owned aquaculture farms can co-operate to generate economies of scale and scope. Finally, we will advance the science of pātiki aquaculture to demonstrate how value is created. This work will include refinement of hatchery technology with a particular focus on gamete supply and quality to ensure production of scalable juvenile supply. Throughout the project, there will be opportunities for community members to gain research and work ready skills.

F. PROBLEM DEFINITION/OPPORTUNITY

The NZ government has set the aquaculture industry an ambitious growth target to become a $3 billion industry by 2035. Currently, the aquaculture industry is largely characterised by a small number of corporate enterprises with consolidated resources due to the high infrastructure and operating costs required to farm the two main species that produce approximately 95% of the NZ aquaculture revenue. Thus, access to capital infrastructure determines stakeholder entry into this exclusive industry model, many īwi living in coastal communities unable to contribute despite their strong connection and whakapapa as cultural guardians of the marine environment. These remote communities often suffer high unemployment and socio-economic deprivation, but still own prime coastal land.

Aquaculture is a notoriously difficult industry for new investors, with high risks due to the requirements for expertise, expensive infrastructure and scale of operation. In addition, the nature of working in an aquatic environment with live animals that often have complicated life-cycles adds risk. Historically, the NZ aquaculture industry has sought to overcome these issues using a corporate business model backed by large capital reserves. A common assumption is that future growth of the industry will require investment by large corporates.

We seek to disrupt this industry paradigm and develop a new business model that is grounded in smaller business units with fewer resources that are able to work co-operatively with shared resources to generate value that can challenge incumbent enterprises. However, if this business is wholly framed within the context of a western model it will not necessarily match the values and aspirations of hapū even if it can be demonstrated to be competitive. Therefore, to mobilise regional communities to become empowered stakeholders in this industry requires a unique business approach with values that align with social (hauora, oranga), environmental/ecological (kaitiaki) and economic (mana motuhake) principles.

Lack of diversity has been identified as a key risk to the resilience and growth of the NZ aquaculture industry. Further to this, in the current 'post-Covid' environment, food security, and sustainability are of increasing importance. These challenges should be addressed in a timely manner before crisis or industry strain occur. Global flatfish markets are valued at USD $1.1B and yield 1.2M tonnes of fish of which aquaculture supplies 0.18M tonnes[1] across a diverse range of species (**Table 1**). The NZ yellowbelly flounder (*Rhombosolea leporina*) or pātiki are recognised for their high flesh quality and at approximately $20 - 26/kg gutted-weight, they can command a higher retail value than whole snapper (*Pagrus auratus*) or Yellowtail kingfish (*Seriola lalandi*). Pātiki are currently exported to Australia, South East Asia and Europe with a value of NZD $4M[8]. However, declining wild stocks limits market growth and local companies are supportive of pātiki aquaculture to enable export market growth (Greg Bishop, Lee Fisheries pers. comm.). Flatfish have been shown to be amenable to aquaculture in low-volume, land-based raceways[9]. Therefore pātiki aquaculture could offer a sustainable opportunity to diversify the current industry in NZ.

Table 1: Flatfish that are of interest to the global aquaculture market.

Flatfish currently being used in aquaculture				
Common Name	**Latin Name**	**Family**	**Main producer**	**Ref**
Tongue sole	*Cynoglossus semilaevis*	Cynoglossidae	Asia	2
Olive flounder	*Paralichthys olivaceus*	Paralichthyidae	Asia	2
Summer flounder	*Paralichthys dentatus*	Paralichthyidae	Asia	2
Southern flounder	*Paralichthys lethostigma*	Paralichthyidae	Asia	2
Stone flounder	*Kareius bicoloratus*	Paralichthyidae	Asia	2
Atlantic halibut	*Hippoglossus hippoglossus*	Pleuronectidae	Europe	3
Spotted halibut	*Verasper variegates*	Pleuronectidae	Asia	2
Barfin flounder	*Verasper moseri*	Pleuronectidae	Asia	2
Starry flounder	*Platichthys stellatus*	Pleuronectidae	Asia	2
European turbot	*Scophthalmus maximus*	Scophthalmidae	Europe	4
Common sole	*Solea solea*	Soleidae	Europe	5
Senegal sole	*Solea senegalensis*	Soleidae	Asia	2
Flatfish currently being investigated for aquaculture				
Common Name	**Latin Name**	**Family**	**Main producer**	**Ref**
European plaice	*Pleuronectes platessa*	Pleuronectidae	Europe	6
Winter flounder	*Pseudopleuronectes americanus*	Pleuronectidae	North America	7
Witch flounder	*Glyptocephalus cynoglossus*	Pleuronectidae	North America	7
Yellowtail flounder	*Limanda ferruginea*	Pleuronectidae	North America	7
Brill	*Scophthalmus rhombus*	Scophthalmidae	Europe	7

G. OUTPUT/SOLUTION

Our project will utilise kanohi-ki-kanohi- hui and wānanga to build relationships, facilitate the exchange of local mātauranga, perform structured science-based pilots and co-develop a kaupapa-Māori inspired 'Aquaculture Ecosystem Canvas' to develop whānau-owned aquaculture enterprises. These fora will support building trusted relationships between the haukainga and research team, create the bi-directional exchange of mātauranga and science transfer during the course of the project. In addition, we will give conference presentations and produce papers for publication based on mutually agreed material. This work will be initiated over the summer of 2020/2021.

H. PROPOSED RESEARCH/APPROACH

This project creates a unique multidisciplinary approach that will enable Māori SMEs to compete as alternate stakeholders within the NZ aquaculture industry. The overarching research question we seek to answer is:

> *How can small whānau-owned aquaculture farms with fewer resources successfully create value (social (hauora, oranga), environmental and ecological (kaitiaki) and economic (mana motuhake)) to challenge incumbent operators?*

This will be investigated in three integrated work packages: (**1**) Explore the relevant mātauranga Māori of pātiki in two rohe to inform understanding, (**2**) Work with whānau or hapū enterprises to identify a minimal viable product based on a kaupapa Māori approach; and (**3**) advance the science of pātiki aquaculture and hatchery technology.

Work package 1: Mātauranga Māori of pātiki for stock enhancement

Pātiki is of significant cultural value and have formed an important part of customary fisheries around Aotearoa NZ. They serve as health indicators of the surrounding environment to tangata whenua and are a noted tāonga species to the three Iwi of Tauranga Moana - Ngāti Ranginui, Ngāi Te Rangi and Ngāti Pūkenga. The waters of Tauranga Moana were known for their pātiki abundance. The renowned Chief of Ngai Te Rangi, Hori Tupaea, once quoted at a gathering in reference to this taonga - "Ko au te Patiki, ko te

Patiki ko au" - "I am the flounder and the flounder is me" showing the interconnected relationship local hapu had with this taonga. However, pātiki stocks have experienced a serious decline in the Tauranga harbour and this has been reflected in the local catch numbers over recent decades and has also resulted in the displacement of the local ecology and wider ecosystem. Our plan is to acknowledge and utilize the hapū collective mātauranga of pātiki in this catchment to enable an assessment for stock replenishment of pātiki back into the harbour at selected sites to help balance the displaced mauri. While the success of flatfish re-stocking programs can be ambiguous, studies with European turbot have demonstrated that stock enhancement is viable as long as the appropriate monitoring, site selection and species ecology is understood[10]. Our research question will focus on the movement and feeding of juvenile pātiki in the Tauranga harbour:

1.1 What are juvenile pātiki feeding on around Matakana Island?
Local Mātauranga indicates that pātiki have predictable feeding habits and seasonal movements around Matakana Island in the Tauranga Harbour. However, anthropogenic stressors such as evolving land usage, maritime traffic and modification of navigational channels are likely to influence these patterns. The seasonal feeding patterns of juvenile pātiki around Matakana Island are currently uncertain. We plan to answer this question by collecting sexually immature, juvenile flounder at Matakana Island and analysing their gut content to determine feeding preference in relation to season and location. This will be done using gut content analysis of preserved, wild fish caught monthly over at least one year.

The kaupapa Māori lens applied in this work package allows us to engage stakeholders and develop a unique pātiki story and identity. This work will feed into the development of a business canvas and minimal viable product in work package 2.

Work package 2: Minimal Viable Product

Leading with a kaupapa Māori approach we investigate development of a new disruptive aquaculture business model for whanau-owned pātiki farms.

2.1 What does a minimal viable product look like based on a kaupapa Māori approach?
The research challenge in this phase of work is to identify a minimal viable product based on co-creation of social (hauora, oranga), environmental and ecological (kaitiaki) and economic (mana motuhake) value. This will require the research team to work alongside whānau and hapū to co-develop the core elements for a business model canvas. Key to our kaupapa Māori approach will be our partnership with Ahikōmako who will work alongside whānau and hapū to support early adopters across a rohe or within iwi.

Examples of research work to be undertaken include:

- Market validation to identify what underserved customer segments (markets) exist for pātiki.
- Value chain mapping of the pātiki production system (farm-to-plate),
- Identification of costs and how they can be lowered by deliberately orchestrating co-operative pātiki production systems and infrastructure to create micro scale advantages, and
- Identification of a minimal viable product for pātiki production.

Additionally, the proposition we seek to qualitatively test is that an ecosystem approach will enable greater value creation on all three dimensions: social (hauora, oranga), environmental and ecological (kaitiaki) and economic (mana motuhake). Specifically, we will develop a unique 'Aquaculture Ecosystem Canvas' based on principles of co-creation and shared resources to advance theoretical knowledge in disruptive innovation and entrepreneurship. This will be achieved by comparing and contrasting extant frameworks such as Business Model Canvas[11] and the Kaupapa Canvas[12] An ecosystem perspective will create a unique toolset for Māori and the NZ aquaculture industry that aligns well with a tikanga-based approach to enterprise.

Work package 3: Aquaculture biology of Pātiki

Our aquaculture team has already developed the technology to produce larval pātiki. However, further refinement of hatchery technology is critical for the production of a scalable juvenile supply.

3.1. How can we ensure a predictable supply of quality pātiki gametes?

i) Synchronisation and induction of broodstock spawning:

Our research to date, has indicated that wild-caught pātiki experience chronic stress and reproductive dysfunction in captivity. To secure a predictable supply of gametes we will investigate the use of hormonal therapeutics to induce spawning in wild-caught broodstock. The study will use a gonadotropin releasing hormone analogue (GnRHa) delivered as a sustained release implant. Fish will be caught in May prior to the onset of the winter breeding season. Our work has shown that the majority of sexually mature females have vitellogenic oocytes at this time of year which is necessary for successful induction of oocyte maturation and ovulation. Spawning performance (Number of ovulations & Total egg volume) of hormone and sham (no hormone, control) treated fish will be examined along with an extensive investigation of the reproductive axis (See Tool Development below). In addition, we will develop a specific index to assess the quality of pātiki gametes based on egg blastomere morphology and its relationship to percentage hatch.

These parameters have been demonstrated to be reliable indicators of gamete quality in other farmed fish and are essential tools for reliable and efficient hatchery production[13].

ii) Development of tools to study the reproductive axis in flatfish:

The gonadotropins, follicle-stimulating hormone (FSH) and luteinizing hormone (LH), are key regulators of reproduction across the brain-pituitary-gonadal (BPG) axis of all vertebrates[14,15]. Developing tools to monitor concentrations of these gonadotropins within the blood plasma of pātiki will allow us to accurately assess the action and efficacy of therapeutic interventions to overcome reproductive dysfunction. It will also be important for the assessment of sexual maturity in grow-out and wild fish. In addition it will allow us to better understand potential welfare and economic challenges such as early puberty which is a typical problem in farmed fish. Specific enzyme-linked immunosorbent assays (ELISA) will be developed to measure pātiki FSH and LH protein concentrations in blood plasma. These tools are species specific and have been developed in a range of key fish species[16-19]. To enable this, two monoclonal antibodies will be produced using a peptide approach through Vertebrate Antibodies (VAb) Ltd, which has a proven track-record for developing antibodies to fish proteins[20-22]. These will be subsequently used to develop an ELISA specific for pātiki FSH and LH, which will then be optimised for application to advance pātiki aquaculture research.

Our Team:

Jason Murray (WP 1) is a hapu representative for the Matakana Island community and has set up a number of successful restoration projects with over 15 years experience. Most of his work is involved in wetland and coastal restoration and enhancement projects largely dealing with multiply owned Māori land trusts and organisations. In addition, he manages a number of diverse projects both on and off the island with a firm mindset on supporting and growing communities at the hapū level.

Dr Kura Paul-Burke (WP1) is an Assoc. Professor in Mātai Moana-Marine Research with extensive pragmatic experience successfully combining mātauranga Māori with Western science to assist hapū/iwi kaitiakitanga aspirations and priorities of marine taonga species and space for present and future generations.

Professor Tim Coltman (WP 2) specialises in technology and innovation management. He has undertaken pioneering research for organisations such as the Australian Research Council, DHL, Ports Australia and BlueScope Steel. He uses quantitative and qualitative research methods and has published in leading journals across most of the major fields in business – innovation, strategy, management, information systems, operations management, supply chain management, marketing, finance, tourism, and engineering journals. Tim has leadership experience as Dean, Waikato Management School and has project management experience having worked in private consultancy, government and higher education.

Aubrey Te Kanawa (WP 2) has worked with Ahikōmako – Centre of Māori Innovation & Entrepreneurship since it's inception in 2019. He has worked alongside Māori founders to build capacility and capacity as part of the Pākihi Start-Up Workshops (supported by the Māori Innovation Fund and He Kai Kei Aku Ringa) and Kōkiri Māori Business Accelerator (supported by Te Wānanga o Aotearoa and Callaghan Innovation) enabling whanau transformation through entrepreneurship and innovation. Specialising in working with early stage Māori businesses, Aubrey leads with tikanga Māori in connecting people and place as a mechanism to bring about whānau transformation. His real world experience will be invaluable to the whanau, hapū and iwi of Tauranga Moana and Whakatohea.

Dr Simon Muncaster (WP 3) specialises in fish reproductive physiology, aquaculture broodstock management and hatchery production techniques. Previous work has focussed on a range of marine fish and salmonids. He works in research and has consulted for the European aquaculture industry. Simon has extensive husbandry experience with both broodstock and early life stages of fish. While co-ordinating the overall project he will focus on the live fish work and physiology.

Dr Steve Bird's (WP 3) research is on the isolation of biomarkers to examine the physiological responses of fish, in particular their immune response to changes in their environment, nutrition and disease(s). He utilises new molecular technology for the rapid development of biomarkers and has the ability to understand physiological change in fine detail. He will oversee the development of the ELISA tools.

In addition to our team, we have engaged international experts to advise on flatfish aquaculture. Dr Eva Andersson works at the Norwegian Institute of Marine Research (IMR) and is internationally recognised for her contribution to the field of fish reproductive physiology and spawning induction. Torstein Harbøe (IMR) has extensive expertise in the hatchery production of Atlantic halibut and his research over the last four decades has been instrumental in guiding the Norwegian halibut farming industry..

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I. CONTRIBUTION TO BLUE ECONOMY IN AOTEAROA NEW ZEALAND

The project expands current aquaculture approaches in the blue economy by exploring mātauranga Māori as a paradigm from which to co-develop community-led aquaculture enterprise. We will combine rigorous analysis based on established business theory with recent advances in kaupapa business canvas development developing an 'Aquaculture Ecosystem Canvas'. At the same time, we seek to advance techniques to produce pātiki as a viable aquaculture species and assess the potential to conduct stock enhancement in line with kaitiaki principles. This unique and innovative approach to aquaculture production relies upon cross-disciplinary know-how to identify opportunities for small business operators (largely īwi based), with fewer resources to successfully establish themselves among incumbent businesses.

The principles of this project are rooted in sustainability. Finfish aquaculture is significantly more efficient than terrestrial livestock production. This results in reduced carbon and nitrogen emissions. While fish are metabolically efficient, many farmed species are high trophic-level feeders that require significant marine-derived feed resources. In contrast, pātiki are low trophic-level feeders that consume benthic invertebrates. The utilisation of coastal land for high-value, sustainably produced marine protein will yield a greater economic return per unit area than either crops or livestock. In addition, this model will have a reduced environmental impact compared to similar ocean-based systems.

Our aquaculture model also lends itself to a circular economy approach. Nutrient waste streams can be minimised using macroalgal filtration to remove organic nitrogen and phosphorus. These algae also contain high value bioactive compounds while the remaining biomass can be converted to a potent fertiliser. In addition, future opportunities exist to further improve the circular economy of pātiki production. Aquaculture feed manufacturers are seeking alternate protein sources such as insect meals, in an effort to reduce their dependence on unsustainable wild-sourced fish meal. These insects are ecologically produced using organic waste streams. However, one of the challenges of feeding insect meals to predatory fish can be intestinal inflammation from the chitin within the insect exoskeleton. We anticipate that pātiki should be resilient to this issue due to the high content of chitin in their natural diet of crabs and other crustaceans. In this scenario, spin-off industries could be created to produce sustainable insect protein which utilises organic waste streams produced from other industries.

Finally, this project explores mātauranga Māori as a basis to inform business and aquaculture development. Another important aspect of this mātauranga is to help assess the potential for aquaculture-based restoration of wild pātiki stocks. This concept will be co-developed and executed with iwi. We will, therefore, use land-based aquaculture, as a vehicle to co-develop a bespoke, community-led business model based on minimal viable production and kaupapa Māori principles to enhance community wellbeing. This model is novel and will open up the existing industry to enable new stakeholders who are no longer encumbered by the high entry costs that characterise NZ aquaculture today.

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

This project engages directly with hapū and iwi within the Bay of Plenty who have expressed an interest in developing their position as aquaculture stakeholders. The project seeks to assist the development of a community-led business based on kaupapa Māori principles. In addition, this programme of work has been developed to align with the main themes of Vision Mātauranga, which include:

1) ***Taiao****:* As endemic ika/fish are of great cultural, social and economic significance to Māori, the work packages will contribute to the development of pātiki as a sustainable aquaculture species to uphold kaitiaki and community well-being.
2) ***Mātauranga:*** The work packages acknowledge the importance of mātauranga Māori to understand this taonga resource and enable kaitiakitanga. The mātauranga will therefore form an initial 'staging post' to inform and help guide the entire project.
3) **Hauora/Oranga:** There are increasing concerns around the decline of wild pātiki around New Zealand. Mahinga kai helps bind whānau, hapū and the wider community together, and is an important component of cultural health and wellbeing. This research has the potential to add valuable information for the future management of this species and potentially identify reasons for its decline.
4) ***Indigenous Innovation:*** Leading with tikanga Māori and mātauranga Māori to build a Māori centred business model for whanau transformation.

Aspects of each work package aims to engage Māori MSc students and researchers who have an interest in business development, ecosystem restoration and/or sustainable aquaculture. They will have the opportunity to contribute towards the goals and outcomes of this research, and they will learn research skills in an area of cultural significance. Equally as important, to fulfil these work packages will require co-delivery with iwi members. The essence of the project focuses on community-led action to create an outcome that will enhance community well-being.

Key members within our team are affiliated with iwi and relevant hapū and/or have connections to external Māori organisations that we are partnering with to deliver the designated outcomes. This project will advance and strengthen these relationships and their impact both externally, as well as between those within our team. This will lead to greater and more effective outcomes in the future. The framework that we plan to create will show-case a unique aquaculture business canvas based on kaupapa Māori values. We expect this to be of great relevance and interest to iwi and hapū in the wider region and beyond.

K. COMMUNICATION OF PROJECT RESULTS

Throughout the length of the project, all team members from each work package will engage in a series of Māori centric wānanga/hui-ā-iwi workshops to facilitate the bi-directional sharing of mātauranga and western science between whānau, hapū and researchers involved. Actual outputs from each work package, will include dissemination of important findings in formats that are accessible to all involved. For the general and scientific communities, this will include a wide range of available platforms such as

local newspaper/reporters for Bay of Plenty; Te Wānanga o Aotearoa and Ahikōmako websites; media releases; LEARNZ in conjunction with Sustainable Seas; University of Waikato research profiling/communications and post-graduate lecture series; scientific and indigenous conference presentations and publications; public symposium/seminars. In all cases, outputs will recognise input from kaitiaki who will be acknowledged and/or included in publications relating to the cultural and scientific aspects of this work.

L. CO-FUNDING (Source and amount)

1. Ahikōmako: Start-up programme and supporting resources (typically valued at $10,000 per start-up)
2. Te Wānanga o Aotearoa: Innovation Hub, technology resources (if required)
3. University of Waikato: Analytical laboratory facilities, IT support, meeting rooms
4. Toi Ohomai Institute of Technology: Aquaculture facilities: power, water, plant and equipment

M. RISK & MITIGATION

Treatment of Mātauranga Maori IP:
This will be addressed early and managed by experienced team members who have developed specific protocols to execute similar work requiring discretion in the past. This will be achieved in consultation with the communities engaged with. The Waitangi Tribunal Report on Wai262 Claim, recommendations contained in "Ko Aotearoa Tēnei" (2011) and established IP management plans (i.e. https://www.sftichallenge.govt.nz/assets/Uploads/Download-PDFs/SfTI-IP-Management-Plan-SfTI.pdf) will be used to guide this.

Early stage development of disruptive businesses:
Information on this is lacking, the domain is unfamiliar, and consequences for pātiki farming unclear. To entice whānau-owned property owners to engage in opportunity discovery we have partnered with Ahikōmako, who specialise in kaupapa Māori and develop of new Māori ventures, to support early adopters.

Failure to execute live fish deliverables:
Experimental work uses wild caught pātiki, avoiding dependence on hatchery supplied fish. Our network includes experienced fishers who know where and how to catch pātiki. Also included are experienced international researchers in flatfish aquaculture as advisors and time for sufficient technical support.

N. CONSENTS & APPROVAL required to undertake research	At our initial hui of the whanau and hapū where the key project activities will take place, we will seek approval from their kaumatua and local communities across the breadth of research proposed. Fish collection will be conducted under MPI special permit 593 that allows the collection of up to 400 wild pātiki per annum. Fish will be collected from within our region of study in consultation and engagement of team members and study partners from the relevant iwi. Animal ethics Committee (AEC) approval to conduct the live fish manipulations has been previously granted to the research team for similar studies through Toi Ohomai Institute of Technology and the University of Waikato AECs.