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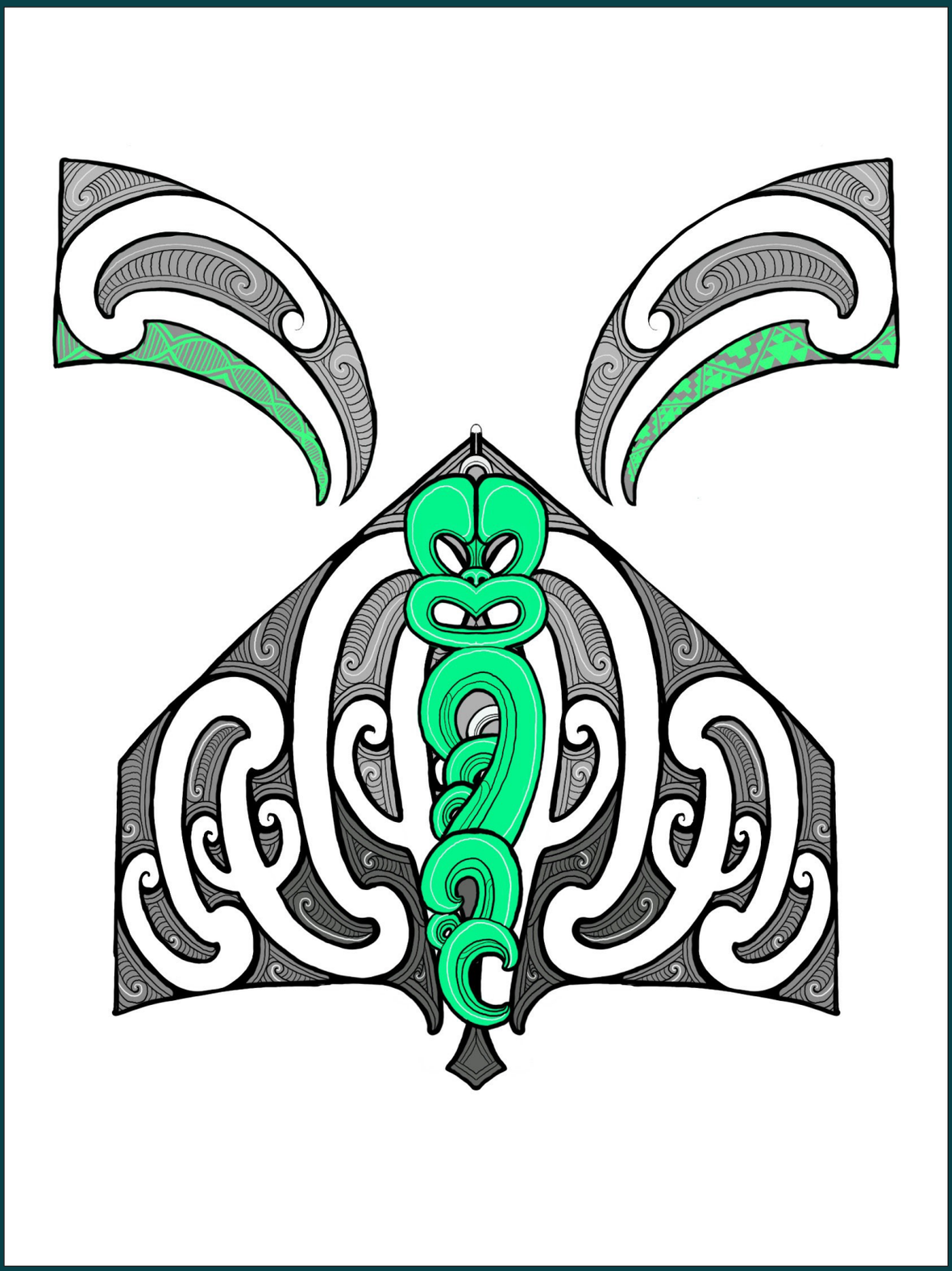
Special issue – Mātauranga and Science – Part 2



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Special issue – Mātauranga and Science – Part 2

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A forum for the exchange of views on science and science policy

Managing Editor: Allen Petrey
Guest Editors: Ocean Mercier and Anne-Marie Jackson
Production Editor: Geoff Gregory

Contents

Cover: From top left there is a puhoro that represents western science with symbols of genes representing laboratory research; on the right side is Indigenous Maori science symbolised with the poutama stairway to the heavens in which Tane gathered the baskets of knowledge. The green pou through the middle represents the ideal person who understands and uses both aspects of culture, unifying them for the good and wellbeing of the people. The grey whare behind the pou is a representation of a whare wananga house of learning, where the knowledge is shared, passed on and embraces peoples' different world views and beliefs into one whare.

Artist: Keanu Townsend (Keanu Arts) a Ngāti Whātua artist raised in the Tauranga and Kaipara regions. His designs, Ta Moko, and painting work can be found across Aotearoa and he has a passion for all Maori arts.

Instructions to Authors

New Zealand Science Review provides a forum for the discussion of science policy. It also covers science education, science planning, and freedom of information. It is aimed at scientists, decision makers, and the interested public. Readability and absence of jargon are essential.

Manuscripts on the above topics are welcome, and should be emailed to the editor (editor@scientists.org.nz).

Full manuscripts (with author's name removed) will be sent for peer review, and authors will be sent copies of the reviewer's comments and a decision on publication. Manuscripts should not normally have appeared in print elsewhere, but already published results discussed in the different, special context of the journal will be considered.

Manuscripts should be accompanied by biographies of not more than 100 words on each author's personal history and current interests. Authors are also expected to supply a suitable high-definition passport-size photograph of themselves. This will be published with the article.

Articles may be submitted in MS Office Word, rich text format, or plain text. Diagrams and photographs should be on separate files (preferably eps, tif, jpg, at 300 dpi), not embedded in the text.

All tables and illustrations should be numbered separately – Tables 1, 2, 3, 4, etc., and Figures 1, 2, 3, 4, etc. – and be referred to in the text. Footnotes should be eliminated as far as possible. Diagrams and photographs will be printed in black and white, so symbols should be readily distinguishable without colour, and hatching should be used rather than block shading. However, colour may be used if the author or the author's institute is willing to pay for the added cost.

References should preferably be cited by the author–date (Harvard) system as described in the Lincoln University Press *Write Edit Print: Style Manual for Aotearoa New Zealand* (1997).

Foreword

Jessica Hutchings[1] and Willy-John Martin[2]

It is with pleasure that we contribute this foreword to *Issue II – Mātauranga and Science in Practice.*

This collection continues the mātauranga- and science-based scholarship presented in Issue I released in late 2019. It further underscores the thrilling contribution that mātauranga Māori makes to understanding and innovating our world in Aotearoa and beyond. Each manuscript unfurls an example of mātauranga-science in practice, displayed as a dynamic, flourishing, expanding and living knowledge system.

The artwork by Keanu Townsend that crowns this edition so clearly illustrates the essence of this academic collection. His artwork on the top left depicts western science, the DNA double helix adorning its puhoro; on the top right Indigenous science is depicted, the puhoro baring the poutama ascended by Tāne to obtain the baskets of knowledge.

Below, the whare wānanga portrays the middle ground, the space where knowledge systems come together in communion. Māori researchers, scientists and traditional knowledge holders find themselves represented in the green pou, possessing the ideal tools to navigate and mobilize both systems for the good and prosperity of people and their communities.

Issue II of Mātauranga and Science in Practice is a manifestation of what Townsend so keenly conveys in his art. The middle space symbolised by Townsend's whare wānanga has also been referred to as Te Pūtahitanga, the 3rd space, the liminal space, the interface – a space between worlds (Baker, 2012, Hutchings, 2012, Rata et al. 2012). This is often seen as a contested space of opposing worldviews; and when this space is interloped by the ignorant, these systems certainly do crash against each other, and conflict is the consequence. However, for the artful and adept, the push and pull of these knowledge systems becomes, instead, as a dance, a duo swaying against each other to the melody of the reo waiata. The authors in the issue have demonstrated what can truly be accomplished in the liminal space: theirs is the reo waiata. Our congratulations to all the contributors and the editors for bringing this collection of writings together in one place.

This collection of writings traverses a diverse array of topics; from history, to epistemology, astronomy, education, capacity and capability development, marine science, strategy, implementation and impact, ethics, Māori sovereignty, environmental decision-making, and colonisation. This array of topics reveals one of mātauranga's true strengths: it does not respect the same boundaries as the western sciences. Instead, it draws resourcefully from diverse areas of thought in order to manifest its impact, and that impact tends to the effective, the sustainable, the complete, the long-term. While the western science system celebrates the discovery that art and the humanities super charge STEM into STEAM, Māori may be forgiven for their roll-of-the-eyes, as they applaud the teina for its discovery that the tuakana had operated from for numberless generations.

This diverse collection also foretells of a future that lies ahead. As mātauranga Māori's ever-expanding potential reaches into new spaces, places, and encounters new challenges to be solved, it may birth new discoveries that may delight, but may also disturb. How mātauranga Māori manifests in the understanding of particle physics may look very different to how it turns up in the protection of Kauri, or the control of environmental pests, or the development of high-value nutrition, and so on. We will need to be aware that an expanding knowledge system will also expand the kinds of practitioners that do its work. We should be prepared to see new kinds of Māori mātauranga-science experts emerge and be ready to challenge our mental barriers to what mātauranga Māori can create, and what its Māori practitioners might look like. That is why the articles in this issue are another very important step in our understanding of the potential and the diversity. We hope there will be many more articles to grace the pages of diverse tomes in the years to come.

A key standout when reading through this edition is the careful consideration that Māori researchers have given to their topics of investigation, the methodological standpoints, and participatory ways of conducting research. Behind the lines of these papers are the longstanding Indigenous connections that the authors have with their kaupapa of investigation as well as the communities they are working with.

To an Indigenous eye, we see the multi-layered textures of relationships, lashing together the timber of the work, holding the project waka together, conveying them to new territory in the mātauranga continuum. The distance of the research journey is dictated by the integrity of the relation-

[1] Dr Jessica Hutchings (Ngāi Tahu, Ngāti Huirapa, Gujarati) is the Director Māori of the Building Better Homes Towns and Cities National Science Challenge. She is a well-known kaupapa Māori research leader trained in the fields of environmental and Indigenous studies and is a widely published author.

[2] Dr Willy-John Martin (Ngāti Wai, Ngāti Whātua, Ngāti Tamaterā) is Science for Technological Innovation's Manager for Vision Mātauranga & Capacity Development Impact at Callaghan Innovation, Wellington.

ships. A non-Indigenous eye has not been attuned to these obligations to working in ways that uphold who we are as Indigenous people, and it is often unseen labour.

Indigenous research is not easy, burdened with the starting point that western science methods were historically hefted as tools for colonisation. These traditions of intellectual violence still try to exert themselves to confiscate or adulterate the liminal space by demoting Indigenous forms of knowing, examining, and sense-making as non-scientific and anecdotal. We honour the austere courage of Indigenous scientists and researchers who exert the right for their indigenous science to be expressed and encourage readers to look behind the lines to see – to make visible – the unseen labor of Indigenous researchers.

This edition exemplifies Māori science excellence and impact in action. The authors have plunged into deep currents of knowledge to reveal old and synthesise new mātauranga in science. They are an envy of conceptualisation to any researcher seeking to use the current tools of the New Zealand science system to realise Māori potential.

We would advocate for more avenues where Mātauranga science like those in this issue can be supported; where research, and its benefits for communities can be amplified. Our recent work as the Rauika Māngai has sought to draw on experts to facilitate collective thinking about the Vision Mātauranga policy, and how the science sector can implement it more effectively (Rauika Māngai, 2020). The collective of Māori researchers provided an embarrassing trove of riches to help guide Māori researchers, non-Māori researchers, and institutions alike. The most significant of these recommendations is for Ministries and research institutions to employ an engaged Treaty relationship in the science sector. We would encourage any reader with interest to read this Guide.

All contributions in this edition amplify mātauranga empowerment. It may be seen as a part of the ongoing reclamation of our right in Aotearoa to express and progress our knowledge traditions; to give our tikanga and mātauranga life in spaces including environmental and marine decision-making; in the science system; in the stars and on the waters; in the structuring of our time from year to year; and in educating our tamariki and rangatahi.

It has been a joy to absorb such a proficient articulation of mātauranga in one collection.

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Mātauranga and Science II – Introduction

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Haere mai te ihi
haere mai te wehi,
haere mai te mana,
haere mai te tapu.

'Draw near o excellent ones,
draw near o awesome ones,
draw near o charismatic ones,
draw near o sacred ones' (Marsden, 2003, p. 3)

This second edition offers additional definitions and examples of mātauranga and science in practice, and advances the basis of such scholarship, across a range of contexts. The papers highlight the relevance, innovation, and dynamism of mātauranga. It questions the taken-for-granted assumptions of scientific thought which are deeply entrenched in modern society and rather encourage us to seek 'a passionate, inward subjective approach' (Marsden, 2003, p. 22–23) as perhaps 'abstract rational thought and empirical methods cannot grasp the concrete act of existing which is fragmentary, paradoxical and incomplete' (Marsden, 2003, p. 22–23). The contributing authors reflect the breadth of experiences in mātauranga and the need for research that is written by those knowledge holders and practitioners of mātauranga. This Special Issue offers a hopefulness to Smith's (1999) caution that, too often, Māori and indigenous peoples were the subject of study as the 'other'. This caution was seen too frequently in scientific study historically, but sadly, still occurs today, at societal, systemic, political, community, and individual levels. Yet, despite these circumstances, we are reminded of a whakatauākī a prominent chief to Ngāti Whātua[1], Ihenga uttered in the context of an ongoing battle:

Me whakapakari ki te hua o te kawariki

'Leave us and we will mature like the fruit of the kawariki'

This is an oft-heard remark at marae in Ngāti Whātua referring to the ongoing strength of our whānau as, like the resilient kawariki, a plant that can survive and flourish in an ever changing environment.

Dr Jessica Hutchings and Dr Willy-John Martin, who are members of Te Rauika Māngai, the strategic Māori leadership group across the National Science Challenges, provide the Foreword to this Special Issue. Both are well respected Māori

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[1] One of Anne-Marie's iwi

Anne-Marie Jackson (Ngāti Whātua, Ngāti Kahu o Whangaroa, Ngāpuhi, Ngāti Wai) is an Associate Professor at the University of Otago School of Physical Education, Sport and Exercise Sciences. She co-directs Te Koronga Indigenous Science Research Theme and Graduate Research Excellence programme. She has a doctorate in Māori studies and physical education, examining rangatiratanga and Māori health and well-being within a customary fisheries context. Her kaupapa is mauri ora (flourishing wellness) and she focuses on hauora (Māori physical education and health), Tangaroa and the marine environment, waka and water safety, and indigenous science.

Ocean Ripeka Mercier (Ngāti Porou) is Head of School at Te Kawa a Māui (the School of Māori Studies) at Victoria University of Wellington, Aotearoa New Zealand. She has a PhD in materials physics. Her teaching and research examine the connections between mātauranga Māori (Indigenous Māori knowledge) and science, particularly in the contexts of education and in cultural mapping. She is a presenter on TVNZ's *Coast New Zealand*, and the presenter of Māori Television's science show *Project Mātauranga*. Her work in science communication saw her receive the New Zealand Association of Scientist's Cranwell Medal in 2017 and the Royal Society: Te Apārangi Callaghan Medal in 2019.

researchers in their own right, and they are at the forefront of leading the strategic implementation of mātauranga, Vision Mātauranga within the National Science Challenges for the benefit of iwi, hapū, whanau, Māori communities, and all New Zealanders.

We bookend this Special Issue with two papers that draw upon arguably one of the greatest Māori scientific feats – the intentional navigation of our voyaging waka to Aotearoa. The kei (stern) of the waka is Kepa Morgan and Robyn Manuel's paper, in which they trace a whakapapa (origin) of Western scientific thought as well as indigenous wisdom. They articulately give voice to commonly held assumptions regarding the divergence of Western science and indigenous wisdom. Two of those assumptions are the isolation and compartmentalisation of the world compared to a more holistic, relationship-based understanding, and the important recognition of spirituality and non-physical attributes of the world around us. Their directive of the need to understand the difference between 'know how' and 'know why' is pertinent for any person interested in the study of science.

Rangi Mataamua, Pauline Harris, and Hemi Whaanga discuss the rise and interest in Māori astronomical knowledge, with a particular focus on Matariki (Pleiades). In Aotearoa, there has been a resurgence in the study and celebration of Matariki. Their paper discusses the astronomical knowledge, mātauranga, and science of Matariki. They dismantle the Gregorian calendar and propose the need to decolonise the calendar and, indeed, modern assumptions of time. They appropriately conclude that a major challenge 'lies in bringing together the collective knowledge, experiences and voices to ensure its authenticity and legitimacy for future generations of aspiring Māori astronomers'. Indeed, this is a take (issue) of significant relevance for many who are navigating similar pathways.

There are major issues in the 'pipeline' for science education. The next two papers highlight solutions in science education: one in a kura kaupapa (Māori medium primary schooling) and the other in tertiary.

Georgina Stewart and Peter Buchanan's paper details their development of a resource called Ngā Hekaheka o Aotearoa for pūtaiao, the science curriculum, in kura kaupapa, which they describe as being in a 'crisis'. Their paper discusses the process of creating the resource and how the team worked together bringing their strengths and perspectives. Their paper serves as an important example for other teams, in how they might create new resources in the primary or any educational setting (whether in schools or elsewhere).

Colleagues of Te Koronga, based at the University of Otago, detail their proposed plan for the introduction of an indigenous science major at the University of Otago. This paper builds off their paper in the prior Special Edition. Growing mātauranga-led curriculum has particular challenges in the mainstream tertiary setting, and more so in sciences. There are limited examples in tertiary science education for training the next generation of researchers. Their paper offers a realistic solution to address this gap within a mainstream setting.

The next three papers describe examples of the application of mātauranga and offer further description that mātauranga is what is known, as well as its application and use.

Kura Paul-Burke, Tuwhakairiora O'Brien, Joseph Burke and Charlie Bluett's paper examines Māori knowledge in the context of marine management. Co-written with iwi leaders, they describe mātauranga in action and highlight the findings of a study in Ngāti Awa. They studied four marine species of importance to Ngāti Awa, and indeed many Māori, through historical intergenerational knowledge alongside quantitative techniques to assess location, the size and number of these species. At times, blending 'mātauranga' and 'science' is criticised, as often one does not do the other justice, or mātauranga is not seen as *real* science, for example. Their approach provides a positive exemplar of how to do this style of research appropriately alongside, and led from within, an iwi context.

Maui Hudson leads a team of University, iwi and business researchers including Hemi Whaanga, Jordan Waiti, Hohepa Maxwell, Kyle Davis, Te Awhina Arahanga, John Proctor, Matt Sword, Thalia Ulrich and Mike Taitoko. Their paper expands definitions of mātauranga and stresses the importance of mātauranga as being 'dynamic, innovative, and generative system of knowledge constituted from mātauranga ā-whānau, mātauranga ā-hapū, and mātauranga ā-iwi'. They also discuss additional mediums for the transmission of mātauranga, with a particular focus on geospatial tools. With the rise of these additional mediums, they discuss the challenges of iwi, hapū, and whānau mātauranga being more accessible and the need to have tikanga that still governs their use.

In light of the need for changes in policy from the whole system, the next paper is led from the Environmental Protection Agency (EPA) Manahautū Kaupapa Kura Taiao Doug Jones' team. The EPA is the 'government agency responsible for regulating activities that affect New Zealand's environment'. They draw upon the metaphor of a waka hourua, which is the symbol of the mātauranga work programme within the EPA, to describe their partnership approach to embed mātauranga into decision-making. As a Crown agent, it is unsurprising the authors bring forward a strong Treaty of Waitangi lens into their work. Their work offers an interesting example of a process, and steps, that institutions and teams within those institutions can follow to ensure their

organisation 'better understands and values Māori perspectives and mātauranga'. These key findings and lessons are critical for all institutions trying to interact with one another.

Our final paper, which is at the ihu of our collection, draws upon concepts of migration. A timely article which interrogates our notions of migration: of people, of scientific thought, and of culture. This paper perhaps has more relevance than ever, as we write this introduction at a time where New Zealand's borders are closed to the world. Arama Rata discusses Cook's legacy in relation to science, migration, and colonialism. She provides an additional narrative to the paper which began this Special Issue, and suggests pathways for the study of migration into the future. Her paper brings about an important, infrequently discussed issue in relation to mātauranga, and opens a space to critically evaluate notions of migration in this new world.

He kupu whakamutunga Final words

We would like to express our sincere thanks and gratitude to the 100 plus contributors and reviewers to these two editions. Collectively the papers add pou (stakes) in the ground in re-defining and re-examining our notions of mātauranga and sciences in practice. We thank Keanu Townsend, who is the Māori artist who designed the covers for the journal issues. We are grateful to Eru Kapa for translating article abstracts into te reo Māori. We also thank the *New Zealand Science Review* editorial team for their support in the editorial processes and in publishing these two editions. We are grateful to funding support from Ngā Pae o te Māramatanga, NIWA, Victoria University of Wellington's Te Kawa a Māui, and University of Otago's Te Koronga Indigenous Science Research Theme. These two editions are a snapshot of a broader re-invigoration of a knowledge system and practice that continues to thrive and flourish.

Me whakapakari ki te hua o te kawariki.

Like the kawariki we shall flourish.

Nō reira,

Ka mutu māua i konei. He mihi whakamutunga ki te runga rawa, nāna nei ngā mea katoa. Āpiti hono tātai hono, rātou te hunga wairua ki a rātou. Āpiti hono tātai hono, tātou te hunga ora ki a tātou nei. Mauri ora ki a tātou.

Nā,

Anne-Marie māua ko Ocean

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Western science and Indigenous wisdom: Is integration possible, practical, plausible?

Kēpa Morgan and Robyn Manuel
University of Auckland

Kimihia katoa ngā pūtake o te kaupapa, ina i kitea, kimihia te rongoā!

Seek out origins and there-in lie the solutions

Abstracts

This article contrasts and compares Western science and Indigenous Knowledge or wisdom, discussing their origins, essential features and how they might engage and speak to each other across cultures. In order to explore this interface, it is necessary to examine the epistemological origins of each knowledge system and the societal drivers that shape them. From this it is possible to examine how science and traditional wisdom have interacted during the processes of colonisation, and how they might better engage entering a time of post-colonisation change. Furthermore, it is possible to see how these knowledge systems might integrate in an on-going way.

Ka whakatauaro, ka whakataurite hoki tēnei tuhinga i te mātauranga taketake ki te pūtaiao Pākehā, me te āta wānanga hoki i ō rāua ake orokohanga mai, i ō rāua ake tino āhuatanga, ka mutu i te huarahi e pōwhiri tahitia ai, e kōrero tahi ai hoki tētahi ahurea ki tērā atu. E wānangahia ai tēnei pōwhiri tahitanga, me tino aromātai ngā orokohanga mai o te mātauranga o tēnā, o tēnā o ngā kete mātauranga me ngā āhuatanga ā-tangata e mirimiri nei i ō aua kete. Mā tēnei e taea ai te āta whakatewhatewha, kua pēhea rānei ngā pōwhiri tahitanga i te wā o te whānako whenua, me te pātai anō ka pēhea rānei ngā pōhiri tahitanga i ēnei rā o muri mai e huri nei te ao. Āpitihia atu ki reira, ka taea te kite ka pēhea rānei te tūhono tahitanga o ēnei puna mātauranga ā haere ake nei.

***Keywords**: Western science, Indigenous Knowledge, societal drivers, post-colonisation change*

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Introduction

This article contrasts and compares Western Science and Indigenous Knowledge or wisdom, discussing their origins, essential features, and how they might engage and speak to each other across cultures. In order to explore this interface, it is necessary to examine the epistemological origins of each knowledge system and the societal drivers that shape them. From this it is possible to examine how science and traditional wisdom have interacted during the processes of colonisation, and how they might better engage while entering a time of post-colonisation change. Furthermore, it is possible to see how these knowledge systems might integrate in an on-going way.

Origins of Western Science

Prior to the seventeenth century, the Western medieval world held a holistic view of nature as God's plan. The holistic worldview interconnected knowledge of the environment, the spiritual world, and culture. Less than 500 years ago, medieval scholars debated how many angels could dance on the point of a pin (Dunphy 2001). The angels represented the metaphysical order, and the pin point, the most precise definition of the physical order. The relationship between the spiritual and the secular, angel and pin point, and ultimately life and death, was considered the central issue to be understood.

A new contemporary worldview replaced the medievalist view during the seventeenth century. Bacon in 1626 (Gauch 2003) introduced scientific rationality, arguing that reliance on scientific truth was more important than the spiritual aspects of life. Descartes in 1641 (Gauch 2003) introduced the idea of objectivity, separating humankind from nature, thereby increasing the emphasis attributed

Te Kīpa Kēpa Brian Morgan (BE, MBA, PhD, FEngNZ) has a bi-cultural background rooted in his cultural identity as Ngāti Pikiao of Te Arawa. Kepa's roles with Iwi and the University of Auckland allowed exploration of the interface between Māori and engineering, with research interests that can be understood broadly as Indigenous engineering and technologies. Specifically, Kēpa has developed alternative construction systems and materials and a decision framework known as the Mauri Model. He is a Principal Investigator on the Ngā Pae o te Māramatanga project, Ngā Ture o te Tai Ao, and the Our Land and Water project, Pohewa Pae Tawhiti.

Robyn Desma Manuel (Te Rarawa and Ngāti Kahu tribes) is a Director of Mauri Oho Mauri Ora Ltd and the General Manager of Hike Bike Ako Waiheke Island, a company that delivers the only hiking, biking and culture tours on Waiheke employing highly qualified, authentic Māori Guides. Dr Manuel also contracts to support Māori university academics and the publication of Māori focused academic journal articles.

to scientific thought and method. Galileo Galilei proved Copernicus's theory of a heliocentric universe, showing that the Earth did indeed revolve around the Sun (Galilei 1642 reprinted 2005). The combination of Bacon, Descartes, and Copernicus outwardly challenged the established authority of religion, discrediting the Ptolemaic ideal, that the Earth was the literal centre of the universe. The concept of the heliocentric universe, that the sun is the centre of our solar system, was developed solely from a scientific standpoint, and challenged the validity and authority of the religious power base of society, including the control of knowledge.

As early as 1597, Bacon demonstrated the *power* of knowledge (Spedding 1872), in the form of his observation and experimentation philosophy, the inductive methodology for scientific inquiry (Baconian method). While ill-regarded by the Aristotelian and religious academies, as well as some contemporary historians (Merchant 2006), this work eventually culminated in the founding of the Royal Society in 1660, enjoying the confidence and official support of the restored monarchy of King Charles II. These advances in knowledge meant that scientific discovery became more important to society than religion.

As rational, scientific thought developed, specialised branches of knowledge emerged, and as this occurred, each branch became separate from the others, and fragmented from the whole body of knowledge (Roberts 1996). Figure 1 depicts the separation of knowledge into specialised branches enabling scientific knowledge to develop generally unencumbered by and separate from religious, legal, or political concerns.

Science, now free of the constraints imposed by morality, ethics and culture, could explore the secrets of the universe, leading to an unprecedented level of detailed knowledge and technological innovation. Technological innovation was an important and attractive area of science, as it offered significant potential for economic benefit, gain and profit, a philosophical direction that perseveres today.

The ability of science to generate new knowledge that transforms society and generates wealth over long timespans in unexpected and far-reaching ways is reflected in the late seventeenth century work of Newton (Walker 1998). Having conceived the concept of gravity, Newton then had to invent calculus to calculate the orbits of the planets and moons in the solar system. The intended application for Newton's work was a system to determine longitude at sea (Sobel 1995), which is largely forgotten due to the more enduring economic and political 'achievements' of the colonisation of Africa, Oceania, Asia, the subcontinent, Pacific and Americas, and their Indigenous populations.

In *Principia*, Newton created an intellectual model of a physical world that was absolutely predictable, a mechanical universe subject to universal mathematical laws. As previously mentioned, the intended application of his work was to devise a system for determining longitude at sea, as the governments of Spain, France, and England understood that this ability would provide the means to safely navigate and therefore control the oceans of the world. A huge reward was offered to the person who could facilitate this.

The Royal Society, follower of Galilei and Newton, applied itself mightily to the task, estimating the weight of the earth and the distance to the stars. Ironically it was an

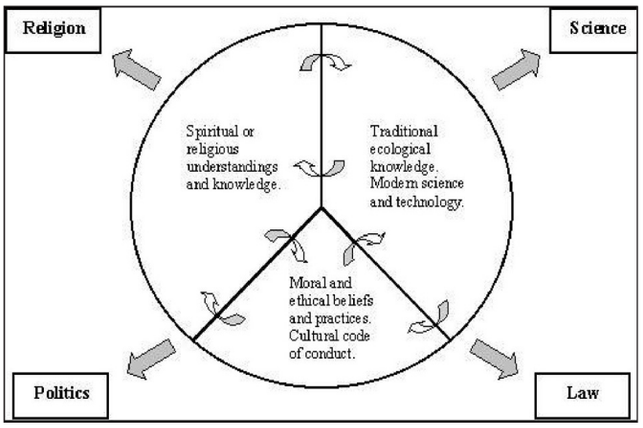

Figure 1: The separation of scientific knowledge (after Roberts 1996).

artisan clockmaker, John Harrison, who invented the dual chronometer that was subsequently tested by Captain Cook on his second and third explorations of the Pacific (Walker 1998). Thus, early science was a willing agent of political and economic gain. Furthermore, although Harrison's chronometer more than met the accuracy specified by the Lords of the Admiralty in England, the Royal Society, which judged his contribution, delayed payment of the £20,000 reward for forty years (Walker 1998). Thus scientific discovery transformed Western Society in far-reaching ways economically, politically, socially, and culturally. However, with scientific endeavour's stated disinterest in religion, morality and ethics, economic power became the primary objective.

The historical lesson is that science has rarely acted independently of politics. Furthermore, the danger of compartmentalising branches of knowledge as shown in Figure 1, is the potential that arises when decisions or recommendations are made from isolated knowledge bases working in self-interest rather than in conjunction with others for a wider societal good. Marsden (2003) identified this danger, observing that science produces 'know how' that is of little value without 'know why', a means without an end. Marsden (2003 p. 27) states that the 'know why' reflects one's values and the motivation for our actions.

Following the work of Bacon, Descartes, and Newton, Darwin's 1859 Theory of Evolution and its child, Social Darwinism, the view that all societies evolved from the primitive (Indigenous) to the civilised (West) completed the initial base 'scientific' intellectual construct necessary to explain the living world in scientific terms. Newtonian reductionism provided the foundations for the contemporary Western worldview, which enthrones analytical thinking, and enables humankind to control, dominate, exploit, and redesign the natural world (Dunphy 2001). Darwin's principles of natural selection (survival of the fittest) were randomly mutated to justify unethical processes such as European expansion, colonisation, racial superiority, elite control (capitalism), and economic rationalism.

Aside from the evident economic and political drivers for knowledge creation, scientific discovery made a huge contribution to the Western world's understanding of the tangible world. As a consequence however; social, cultural, spiritual, and environmental knowledge became less relevant. The chronology in Figure 2 illustrates the beginnings of the scientific revolution.

Origins of Indigenous Wisdom

In contrast, Indigenous viewpoints of sustainable development are based on ideas of reciprocity and giving back to Creation, recognising that which sustains all life. Understanding and acknowledging these inter-relationships with all of Creation is of the utmost importance and involves a tremendous responsibility. This included the First Nations people sharing their knowledge and technology freely to ensure the survival of colonial 'newcomers', who in many instances lacked the capacity to look after themselves at first contact (McGregor 2004).

McGregor (2004) states that 'traditional teachings offer profound guidance about how to work with Creation and not to interfere with other beings' ability to fulfil their duties and responsibilities'. Indigenous scholars argue that Traditional Ecological Knowledge (TEK), a term used to describe Indigenous Knowledge, is inherently sustainable and spiritual, and essential for survival, because it crafts the relationship between the world and her people (La Duke 1997, p. 36). Intellectual, social, cultural, and spiritual learning unfolds within the context of this relationship. It is participative in a way that holds the key to sustainability.

T'Seleie (*in* Blake *et al.* 1977, p. 16) makes an analogy between his people, the Dene Nation, and a great 'river that flows and changes, yet is always the same'. His people take their strength, wisdom, and ways from the flow and direction that has been established by their ancestors for them and future generations. The river is a source of knowledge required for survival and is thus, a 'holistic metaphor for the essential relationship between people and the rest of Creation' (T'Seleie *in* Blake *et al.* 1977, p. 17)

The Indigenous peoples of North America for instance demonstrate an intrinsic spiritual connection and relevance to their worldview. McGregor (2004) states that, to be sustainable is to take responsibility and be spiritually connected to all of Creation, all of the time. Her statement is reinforced with references to Indigenous belief regarding ancestral lands, the 'closest scientific equivalent being the ecosystem without the spiritual component'. She references other literature for the following extracts:

> *When the government people talk about the land ... [they talk] about all the things we use ... I think about the Great Spirit (Elder Annie Catholique in Raffan 1993, p. 49).*
>
> *Spiritual and ethical values are woven into knowledge and regarded as inseparable from the land (Gwich' in Elders 1997, p. 14).*

McGregor (2004) confirms that Indigenous Knowledge is inherently sustainable and spiritual, is based on spirituality, on multiple lifetimes spent enhancing sustainable relationships with the Creator and all of Creation.

Mātauranga Māori

Although now widely understood within Māoridom, when initially introduced in 1998 at a Whakarewarewa hui, mātauranga was an unfamiliar concept to the Te Arawa Koeke present. Te Arawa stated a preference for the concept mōhiotanga which affirms a special characteristics of mōhiotanga for Te Arawa, and mātauranga for other Iwi. Mōhiotanga and mātauranga are the localised bodies of knowledge that underpin Indigenous epistemologies. Mōhiotanga and Mātauranga are location specific and highly specialised,

1859	Theory of Evolution (Darwin)
1798	Finite carrying capacity (Malthus)
1687	Naturalis Principia Mathematica (Newton)
1642	The Sidereal Messenger (Galileo Galilei)
1641	Meditations / humankind separate from nature (Descartes)
1626	The New Atlantis - Scientific rationality (Bacon)
1597	Meditationes Sacrae – knowledge is power (Bacon)
16th C	Heliocentric Universe (Copernicus)

Figure 2: Chronology of the Scientific Revolution.

being informed by the intergenerational relationship of Iwi with their own rohe, their ecosystems of origin. These bodies of knowledge do not delineate between physical and spiritual origins of knowledge. Thus mōhiotanga or mātauranga Māori are holistic ways of knowing that are based on the tikanga and kawa that have endured over time and belong to a specific place.

The potential contribution of mātauranga Māori and other Indigenous Knowledge systems to Western societies is often challenged on the basis of the historic occurrences such as the extinction of the Moa and impact of forest burn-off after Māori first settled New Zealand. This sort of invalidating of mātauranga Māori is an example of how Western Science has been and continues to be an agent of colonisation (Walker 1998). Science itself in different parts of the world has contributed to a larger number of more spectacular environmental failures, e.g. nutrient enrichment of rivers and lakes from farming and sewage effluent, introduction of pests, synthesis and use of agent orange, asbestos, persistent organic chemicals. The impacts of these failures have been 'global, systemic and complex, both in time and space, and have exposed a lack of understanding of the underlying cause-and-effect relationships of scientific applications' (Parliamentary Commissioner for the Environment 2001).

It is useful to continue the examination of the historical record to provide some understanding of the timeframe over which mātauranga Māori evolved as an Indigenous basis of wisdom. An understanding of the timeframe for mātauranga Māori is appreciated by considering the basis for this knowledge system and its transmission. Central philosophy is based on the creation stories and whakapapa. These pakiwaitara (traditions) include mātauranga of genealogies from numerous other parts of the Pacific Ocean and share in common conceptual frameworks that form the basis of Polynesian ontologies and epistemologies.

The specific example used here is that of Mauri (life supporting capacity or potential), a pervasive concept throughout mātauranga Māori. Do similar concepts to mauri exist in cultures located elsewhere in the Pacific Ocean? An equivalent of mauri exists in the languages and cultures of the peoples from other South Pacific Island groups: Tonga has mouri and Nuie has moui (Best 1934 p. 80); Hawai'i (Pukui 2007) and 'Uvea have mauli; Futuna, tamauri; and in Rotuma, Efate (Vanuatu) and the Tuamotu group, mauri

(Best 1934 ,p. 80). Best (1934, p. 80) also describes the physical manifestation of mauri as an 'object that represents the vitality, and general welfare of a place, a forest, river, lake, village, or of people'. The proliferation of the mauri concept throughout the South Pacific, and its continued relevance for the Indigenous peoples of the South Pacific, supports its ancient existence for at least two millennia.

The continued relevance of mauri and the practice of kaitiakitanga (enhancing ecosystem mauri) in many Polynesian cultures indicates the concepts were already important to the ancestors of modern Māori before their journeys to Aotearoa New Zealand, and were significantly important to have been retained throughout the colonisation process. Thus the concept of mauri predates the migration of early Māori to Aotearoa, a feat achieved at least five centuries prior to Tupaia and Cook's arrival in 1769. The adoption of kaitiakitanga in Aotearoa therefore occurred between 800 and 1200 years ago. The significance of this timeframe can be established by considering the century during which much of the Pacific Ocean was explored by Cook and the relevance of his achievements to Western Science.

Captain Cook and the *Endeavour* are recorded as visiting Tāhiti (April 1769), Aotearoa (October 1769), and the Australian east coast (1770), before returning via Torres Strait to Britain in 1771. Cook and *Resolution* returned to the Pacific on a Royal Society commission in 1772 to search for Terra Australis, this time securing another Tāhitian, Omai, to assist on the voyage with his Indigenous Knowledge of the Pacific. On its return voyage, in 1774, HMS *Resolution* landed at the Friendly Islands (Tonga), Rapa Nui (Easter Island), Norfolk Island, New Caledonia, and Vanuatu. Cook's second voyage successfully employed the K1 chronometer, which facilitated the accurate measurement of longitude. Omai also accompanied Cook on his third voyage, again on HMS *Resolution*, and in 1778 Cook and his crew became the first Europeans to reach the islands of Hawai'i. HMS *Resolution* continued on to North America and mapped the coast from California all the way to the Bering Strait, before returning again to Hawai'i, where Cook was killed in 1779 (Salmond 1991, 1997, 2003).

Tupaia and Omai's roles are often made invisible in historical accounts of Pacific exploration by European historians. For more than a millennium before Newton's and Harrison's work culminated in the chronometer, allowing the European navies to map the oceans of the world, the ancestors of the Indigenous peoples of the Pacific Ocean journeyed between the island groups, developing and implementing strategies for their population of the Pacific. Walker (1998) observes that the earliest Māori must have had a systematically organised knowledge of their world to have discovered Aotearoa. The Indigenous Knowledge of those early Māori was essential for survival. Conversely, the knowledge and technology that allowed Europeans to deliberately venture out of sight of land only marginally improved their chances of finding land in an environment that is 99.8% ocean. The chronometer technology alone did not enable Cook's arrival in Aotearoa and the other Pacific Islands, but rather there must have been a reliance on Tupaia and Omai's Indigenous Knowledge to locate the various island groups visited.

The relevance of this example from history is that, prior to and following early European settlement in Aotearoa, European visitors were heavily reliant on the Indigenous Knowledge of Māori to survive (Orange 2004). Initially Cook relied on Indigenous Knowledge to find the various island groups in the Pacific and to communicate with the Māori (Vaggioli 1896, translated 2000). Once the locations of these island groups were recorded on maps, the process of imperial expansion / colonisation could begin, although settlers continued to be dependent on the Māori for their survival.

Comparing Western Science and Indigenous Wisdom

Indigenous Wisdom differs from Western Science in that while Western Science is separated from law, politics, and religion, Indigenous Wisdom is understood and applied as a holistic knowledge system. In both Western Science and Indigenous Wisdom, empirical evidence is based on the systematic accumulation of detailed observation and abstraction of norms from disparate data sets. The similarity ends here, however, as Indigenous Wisdom assesses deviation from the norm in a morally qualitative sense, leading to different conclusions from the economic quantitative nature of Western scientific analysis. Indigenous Knowledge systems are holistic, making no distinction between the material and spiritual worlds. Thus, Indigenous decision-making processes are based on all available indicators.

O'Regan (1984) observed that the historic (Māori) viewpoint is in terms of the environment, and that Māori had the capacity to tie the practical together with their theological beliefs. Conversely, Marsden and Henāre (1992) observed that in rational Western thinking there is rather a disconnection of the physical and spiritual, the secular and the sacred. The separation of knowledge and its compartmentalisation into silos described by Henāre creates tensions between the two bodies of knowledge and has been the basis for Western society devaluing Indigenous Wisdom in the past.

The devaluing of Indigenous Wisdom is evident in written accounts of Māori ethnography. Firth (1929) describes an economic 'magic' of the Māori, classifying it as magic of protection and magic of production. In his view:

> *The object of the protective type of magic is to guard the natural resources on which the Māori depends for his livelihood from the inexplicable and unforeseen accidents due to change in natural conditions. Sometimes birds migrate from a forest for no apparent cause, fish desert their accustomed reefs and shoals, or fail to appear at the usual season, the fruits of trees are lacking in a lean year. Not being equipped with a comprehensive scientific knowledge, primitive man is not apt to attribute such phenomena to the working of natural laws. A simpler reason is always at hand – the conduct of man himself. This postulate of the interference of human agency is one which is in accord with the emotional temper of man's feeling of dependence on his environment. The object of the magic of protection, then, is to obviate any ill results which may be presumed to follow from carelessness or neglect (Firth 1929, p. 254).*

Yet Firth's description of the Māori postulate that the interference of human agency is consistent with the understanding that humankind is dependent on his (sic) environment. This is central to the ethic of sustainability in the context of valuing the environment for its intrinsic value. The use of the term 'magic' rather than spiritual beliefs and also of 'primitive' also appears pejorative.

Despite Firth's biased account of the economic 'magic' of the Māori, his thesis contributes his understanding that mauri was a measure of valuing things with the end objective being protection of valued aspects of the economic life of the Māori:

> *It was the old Māori belief that every natural object or aggregate of objects possessed a spiritual essence, a non-material core, or life principle (mauri), and to this was due their vitality, even their very existence. If it were a forest, for instance, on the maintenance of this vital principle depended its fertility and productive powers. The fruiting of the trees, the abundance of birds and rats, the vigorous growth of the forest as a whole, all hinged upon the preservation of the mauri intact and unharmed. Fisheries too, had their mauri, representing their productivity, as had all other types of natural resources, and man himself. In its nature this mauri was an intangible, imponderable essence, impersonal in character, and not to be confused with any idea of an indwelling spirit (Firth 1929, p. 255).*

While Firth's description of mauri is useful, his separation and rejection of supposed non-scientific attributes of the concept, and therefore his failure to consider the role of mauri in a holistic context, is inconsistent with the field of Indigenous Knowledge from within which the concept has its origins. The scientific worldview is reflected in his purely scientific approach, as is his assumption that the Traditional Ecological Knowledge incorporated into mātauranga Māori has no scientific value.

In isolation, the description of life principle used by Marsden (*also* Best 1924, Williams 1957, and Patterson 1992) can be narrowly construed in Western thinking to imply that mauri only applies to things that are alive. A limited perception of mauri such as this is incorrect and rather reflects the limitations of the English language to convey such a concept as any inconsistency on the part of Marsden or others. Williams' translation equivalent demonstrates this point, including alongside life principle, the thymos of man. Mead (2003) has commented that the Greek word, thymos, mystifies mauri, contributing little to understanding the concept. That the concept thymos also creates confusion for the Western mind is likely a result of its lack of contemporary mainstream use, possibly due to the concept being abolished by Christianity (Scaruffi 2007). Nevertheless thymos is described as spiritedness or the active soul (Plato), and according to Hegel (cited in Zinkin 2011), man's humanity flourishes most when he transcends survivalist (reason), materialistic (desire) inclinations and engages his thymotic side pursuing self-sacrificing higher ends. Thymos is considered to be a very ancient belief, predating civilisations, the equivalent conceptual division of thymos from psyche (immanent soul or spirituality) existing in the ancient cultures of Egypt, China, Judaism, Buddhism, and Zoroastrianism (Scaruffi 2007). Scaruffi describes thymos as pertaining to the active soul that is thought, consciousness, and awareness today. Was Williams then referring to mauri in the context that by binding the physical and spiritual in man, it enables humankind's conscious existence?

The holistic worldview

Indigenous Knowledge systems, conversely, share an integrated and holistic viewpoint. The wisdom incorporated into the creation traditions of Māori, establishes an obligation of reciprocity, founded on the concept of an interrelated natural and supernatural world that is inextricably connected to the Māori by the kinship ties of whakapapa. These ties define a person's identity in the context that the physical condition and spiritual well-being of a geographic region and the person's hapū are one and the same.

The Indigenous worldview is a non-dualistic perspective of an integrated natural environment. Understanding sustainability in terms of Indigenous Wisdom is based on the holistic viewpoint adopted by Māori in terms of the environment, and may have strengths that are absent in the Western scientific approach. The Indigenous worldview of Māori and the inherent obligations that result from this view have many dimensions. The holistic approach of Māori avoids the disjunction between the secular and spiritual, the inherent compartmentalisation and isolation of one institution from another, and the piecemeal approach to problem and conflict resolution (Marsden 2003).

The responsibilities of their descent from the gods and ancestors made Māori guardians of the deities that controlled the relationships among the human, animal, vegetable, insect, fish, bird, mineral, and spirit worlds. These ancestral and spiritual relationships determined that Māori fished, hunted, and cultivated only to the degree necessary to secure their well-being (Sinclair 1975). Thus, before natural resources are allocated for a community's use, propitiatory rites to the appropriate deity must be observed. Their observance ensures that nature is treated with care and respect (Walker 1998).

The holistic worldview, with obligations of responsibility and respect, is a reciprocal relationship between humankind and the gods. Thus the gods and ancestors sustained and protected humans and the other beings of this world (Patterson 1992) reinforcing the inseparability of Indigenous Knowledge and spiritual consideration. For our part, the links between us and the gods are nurtured through ritual. Patterson also summarises earlier writers' attitudes thus:

> *Sir Apirana Ngata and Sir Peter Buck write of the tradition of harmonising with the environment; Te Rangi Mete-Kingi mentions how the ancestors 'inculcated their philosophy of preservation and conservation as a foundation for future generations to build upon' (Patterson 1992, p. 20).*

Mete Kingi introduces the concept of intergenerational equity, an aspect of sustainability thinking, and embodied in the ancient Māori proverb: *Whatungaro te tangata, tū tonu te whenua* (People disappear, the land remains forever).

Rangihau (1981) explained that, in the Māori world, a person is aware of the mauri of the land, and how consideration of this determines appropriate behaviour. He explains that people who live very close to nature apply a feeling of aura to the things around them. In the case of Māori, everything is given a mauri. The acknowledgement of mauri imbues conservation, a strong awareness of their dependence on the environment. Māori strive to maintain balance, due to an intrinsic connection to the land based on the traditional genealogical relationships established in the creation beliefs.

Indigenous Wisdom in a modern postcolonial world

In a postcolonial world, Indigenous Wisdom must be practised to retain its relevance. The ability of mana whenua to continue the application of Indigenous Knowledge is strongly influenced by the way Indigenous Wisdom is perceived within society. Unfortunately, the efforts of hapū as mana whenua to influence common development practice in Aotearoa are often marginalised, the result of dominant Western society's perception of Indigenous Wisdom.

Negative perceptions of Indigenous Wisdom, advanced by the historic denigration of its value in the literature, have resulted in Indigenous Wisdom being ignored, maligned, and depicted as myth or folklore that is primitive, simple, and static. The historic neglect, whether as a result of racism, ethnocentrism, modernism (with its complete faith in scientific method), and postmodernism, has contributed to the decline of Indigenous Knowledge systems, through monoculturalism, and lack of use and application. As Indigenous peoples have adopted Western ideologies, the proffered advances in well-being have been accompanied by impoverishment of culture (Grenier 1998). Furthermore, failures to realise the expected improvements were attributed to the foolish influences of culture. Thus, Indigenous Wisdom was devalued, portrayed as inferior to Western knowledge and blamed when Western knowledge could not provide all the answers. A better situation for the Indigenous peoples would have been to gain access to the benefits of 'modern life' without losing traditional values and institutions necessary to sustain their sociocultural capital (Hooper 2005). This has not happened.

In an about-face, Western Science has more recently started to research the potential value of Indigenous Wisdom, with an increasing awareness that the Indigenous cultures, environments, and peoples that support this wisdom (and Western societies themselves) are being destroyed by the material advances promulgated by westernised societies as driven by the application of Western Science. Thus while Indigenous Wisdom is in danger of being lost through suppression, it has also become vulnerable to exploitation for commercial gain (the basis of the WAI262 claim to the Waitangi Tribunal) as science struggles to remediate its less than desirable impacts. There is therefore a need to develop appropriate mechanisms for the protection of Indigenous Wisdom, and for securing its integrity, but are there more positive ways of looking at Indigenous Wisdom within society?

Indigenous Wisdom is holistic in nature, and it is this characteristic that is synergetic with sustainability aspirations. The report from the Second International Indigenous Peoples Forum on Climate Change includes (2000):

> *Our traditional knowledge on sustainable use, conservation and protection of our territories has allowed us to maintain our ecosystems in equilibrium. This role has been recognised at the Earth Summit and is and has been our contribution to the planet's economy and sustainability for the benefit of present and future generations (Second International Indigenous Peoples Forum on Climate Change 2000, 11–12 November, Part II, 2).*

It follows that much greater value is available from Indigenous Wisdom than that resulting from its commercial exploitation. To realise this greater value, however, it is necessary to forego the purely commercial incentives driving much of the effort made in contemporary society.

Many scientists' rejection of Indigenous Knowledge is on the basis that it does not have the same level of intellectual rigour, is unscientific or scientifically invalid. Walker (1998) identifies this exclusion of other sources of knowledge as a technique designed to ensure science retains its assumed role as producer and keeper of verifiable knowledge of the external world. In the same paper, Walker identifies the appropriation of Indigenous Knowledge through ethnography mining when the reductionist approaches of science are insufficient to address the scale or complexity of the scientific challenge.

Opportunities yet to be realised

An approach inclusive of Indigenous Knowledge could realise greater benefit. Further it would be inappropriate to underestimate the contribution that Indigenous Wisdom will make. It is unlikely that Western Science alone, driven as it is by economic imperatives, could identify solutions as sophisticated as those possible within a holistic paradigm.

An example is the Indigenous Wisdom-based selection of a tree for the creation of a waka. Asymmetry within the natural world is understood within a holistic paradigm and is a desirable characteristic that can be optimised within a holistic design approach such that the eccentric centroid of mass in the asymmetric cross-section provides inherent stability for the waka hull when crafted appropriately to take advantage of this characteristic. The knowledge of the existence of this phenomenon, the knowledge of the location of the trees exhibiting the optimum combination of the most desirable asymmetric attributes, the inherent spiritual processes that support these efforts, and their seamless integration is Indigenous Wisdom that Western Science is unable to replicate. To create a similar result would require significantly greater resource levels with inherent increased levels of uncertainty that would need to be compensated by increased safety factors if attempted from a Western scientific approach. In effect the waka created from a Western scientific paradigm would in all likelihood be too heavy, slow and ponderous due to over-design.

Science practitioners seek predictability and repeatability to ensure very high levels of confidence and as a measure of quality control. However, that approach to gathering knowledge would preclude many of the achievements of Indigenous peoples. Furthermore, much contemporary science and engineering (applied science) is based on statistical probabilities. The assertion of the scientific truth of this knowledge system in this way is on shaky ground, as the statistical means of compliance are rarely absolute, and so repeatability and predictability are not always assured.

Conversely, it can be seen in historic exemplars of engineering (applied science) that Indigenous Wisdom can optimise outcomes by exploiting a holistic understanding of the variability inherent in natural systems, the availability of resources, and the problem context.

Our final example is that of the ocean voyaging waka that surfed to Aotearoa from Hawaiki. The achievement is not conceivable from a scientific paradigm as the basis of this achievement is the combination of specific Pacific Ocean weather conditions in the Northern Hemisphere

that occur on a timescale of several years, combined with highly specialised sail and hull designs, and observation of repetitive natural phenomena over many centuries. Yet this was the basis of exploration and travel throughout the Pacific centuries before the European navies ventured out of sight of land with any confidence of a safe return.

Conclusion

With Copernicus and Galilei came the reign of scientific thought, with highly specialised branches of knowledge continuously examined from a reductionist approach. As each branch of knowledge separated itself further from the others, the whole body of knowledge became fragmented. The necessary present-day integration of the social, economic, environmental, and cultural dimensions for sustainability is a difficult goal for Western scientific approaches that treat knowledge as compartmentalised, separate, and commercial. This problem is a fundamental inadequacy of the rational, reductionist paradigm of scientific endeavour. The reductionist paradigm is unable to understand the complexity of human and natural systems.

Is it wise, then, to isolate and marginalise information, intentionally or unintentionally, that other knowledge systems, such as Indigenous Wisdom, would consider highly relevant and indeed essential for a truly holistic and sustainable approach to the relationship between humans and their ecosystems of origin?

The scientific revolution has significantly contributed to our shared understanding of the physical universe, an understanding underpinned by the concept of the attractive force of gravity. Events associated with the scientific revolution heralded by an enhanced understanding of gravity, influence the way contemporary westernised societies think and act right through to today.

The concept of mauri, equally important to Māori, is also an attractive force, but it provides an understanding of the relevance of the non-physical attributes of our universe that Western Science is as yet unable to comprehend.

Kia aho matuahia te taketake, kia tūwaerea te tau.

When information becomes intuition, knowledge becomes wisdom.

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The science and practice of Māori astronomy and Matariki

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Abstracts

Ki te iwi Māori me ōna tūpuna, ko ngā hua o te noho tahi, o te āta pānui, o te kōrero anō hoki me ngā whetū, he mea āta tuitui ki te pūtaiao, ki te ahureatanga, ki ngā tikanga aho atua, ki te taiao anō hoki. Ko ngā nekehanga o ngā kāhui whetū he mea āta pānui, ka mutu he whakapono, he mātauranga atu anō hoki tō ia iwi, tō ia takiwā puta noa i a Aotearoa nei mō te ao tukupū. Ko te mātauranga whānui mō te kōkōrangi he mea āta whakatō ki ngā āhuatanga o te pāpori Māori o mua, he mea āta whakaora anō hoki ki ngā kōrero tuku iho, ki ngā tikanga hauhake whenua, ka mutu i āta whakaurua ki roto i ngā tikanga whakatū whare tupuna. Tau atu, tau mai, whakanuia ai te rewanga ake me te tōnga iho o ngā whetū hiahira, ka mutu i kaha whakaatuahia ngā kaupapa katoa o te tuarangi ahakoa pēhea. Mā roto mai i tēnei pepa ka kōrerohia te mātauranga me te pūtaiao mātai arorangi e whai iho nei ki a Matariki, ka tahi, ka rua ka wānangahia te whakarauora haeretanga i ngā tikanga tuku iho e hāngai nei ki taua kāhui whetū me tana pānga nuitanga ki te ahurea o te whenua o nāianei, o Aotearoa.

For Māori and their ancestors, the results of living with, studying and talking about the stars were woven into science, language, culture, religious practice and environment. The movements of the celestial bodies were studied in great detail, and all tribal groups and regions throughout Aotearoa maintained their own unique beliefs and understandings of the universe. The extensive knowledge of the night sky was embedded into traditional Māori society, preserved in oral tradition, planting and harvesting practices, and incorporated into the building of ancestral houses. Every year, the rising and setting of important stars were celebrated, and all manner of cosmological events were worshipped. In this paper we will discuss the astronomical knowledge and science associated with Matariki (Pleiades) and discuss how the regeneration of the traditional practice associated with this celestial cluster is playing a significant role in the modern cultural landscape of Aotearoa.

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Māori astronomy

Māori astronomical knowledge was infused across the breadth and depth of Māori society, tradition, knowledge and language (Harris *et al.* 2013; Whaanga & Matamua 2016; Matamua 2017a, 2017b). Connecting observation, cultures, religion, mythology and astrological practices, this knowledge system was transmitted in oral traditions such as *mōteatea* (traditional song), *whakataukī* (proverbs), *karakia* (incantations) and *kōrero tuku iho* (oral tradition). Māori astronomy was also incorporated practically in areas such as the *maramataka* (the lunar calendar), through planting and harvesting practices and the engraving of carving pat-

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terns and paintings that adorn ancestral houses (Harris *et al.* 2013). Māori astronomy was embedded and encoded into these carvings and integrated into the landscape through place names. Most famously, Māori astronomy is most well-known for its application to celestial navigation that helped the ancestors of the Māori to traverse the Pacific Ocean, one of the largest regions of the earth (Matamua *et al.* 2013; Tuaupiki 2017). Utilising the sky as a roadmap, detailed observations and astronomical knowledge supported the 'ancestors of the Māori to undertake arguably the most remarkable voyage[s] in the history of humanity ... [O]nce here, elements of the star-knowledge of the central Pacific were adapted to become relevant to these islands and their climate. ... Over the next 800 years, Māori astronomy evolved with the people to become the situationally specific knowledge base that it is today' (Whaanga & Matamua 2016, p. 60). With a change in location, in particular latitude, new stars became visible and thus new knowledge and understandings about those stars had to be developed.

The movements of the celestial bodies were studied in great detail, their appearance, position, colour and brightness were examined, and their heliacal rising and setting were celebrated. Māori astronomers (*tohunga kōkōrangi*), developed an awareness of the different links between movements of celestial bodies and seasonal patterns in order to ensure food security, and all manner of cosmological phenomena were worshipped, studied and correlated to terrestrial events, and connections were drawn between them (e.g. seasonal changes, the timing of ocean tides, and the nature of comets, eclipses, meteors, and other transient celestial phenomena) (Harris *et al.* 2013; Matamua 2017b). This knowledge was regionally specific and while the stars gave a broad indication as to the season and event, more detailed understanding of the environment was deduced through the lunar calendar, such as the management and harvesting of species and the migration and spawning of animals around the cosmological cycle and seasonally timed rituals (Tāwhai 2013; Timoti *et al.* 2017).

During the 19th century and the early parts of the 20th century, the documentation of Māori traditions, life style, language and customs of the Māori was a preoccupation for many early European ethnographers, missionaries, and historians, with the likes of George Grey (1853, 1857), William Colenso (1868, 1878, 1879), S. Percy Smith (1898, 1913, 1915), John White (1887–1890), members of the Williams family (1906, 1844), James Cowan (1910, 1930), Edward Treagar (1904) and Elsdon Best (Holman 2008; Sissons 2010), leading the way.

Regarded as one of the most important early ethnographers in Aotearoa, Elsdon Best (Te Pēhi) spent much of his time interviewing Māori elders, researching Māori tribal history, and collecting mātauranga Māori (1922a, 1922b, 1922c, 1923, 1924, 1929, 1972). While in the Urewera, Te Pēhi formed a close working partnership with his key informants Tutakangahau of Maungapohatu, Paitini Wi Tapeka, Tamarau Waiari, Te Whenuanui of Tūhoe, and Hamiora Pio of Ngāti Awa, while maintaining his longstanding relationship and roles with the Polynesian Society and the National Museum. Te Pēhi produced a number of important works on various aspects of pre-European Māori life and tribal history, Māori religion and mythology, Māori forest knowledge, wānanga Māori, but his publication '*The Astronomical Knowledge of the Maori Genuine and Empirical*', has been widely considered, for a long-time, as the leading work on Māori astronomy (Orchiston 2016b). In this publication he pronounced that 'the available data concerning Maori sky-lore is now exhausted, and this account must be closed. The knowledge gained by us of this subject is meagre and unsatisfactory, but it is now too late to remedy the deficiency' (Best 1922a, p. 64). This statement, however, was much too presumptuous, for unbeknown to Te Pēhi, the informants that he had interviewed had only shared with him a small portion of knowledge on Māori astronomy.

Over the past three decades, there has been a renaissance in the scientific study of Māori astronomy in a range of areas including reviews on Māori astronomy (Harris *et al.* 2013; Williams 2013; Tuahine 2015; Orchiston 2016b), lists on Polynesian and Māori star names (Johnson *et al.* 2015), accounts on the development of astronomy and emergence of astrophysics in Aotearoa (Hearnshaw & Orchiston 2017), histories of astronomy in New Zealand (Orchiston 2016a), critiques of Polynesian, aboriginal and Māori astronomical perspectives (Orchiston 1996, 2000), the use of astronomy as a cultural experience (Austin 2009), comparative cultural studies of astronomical knowledge (Selin 2000), a discussion on supernovas and meteors (Green & Orchiston 2004; Britton & Hamacher 2014), the application of portable planetariums in the teaching of Māori astronomy (Harris 2017), horticultural and ethnopedological praxis (Roskruge 2011), *waka* navigation (Matamua *et al.* 2013; Tuaupiki 2017), the *maramataka* (Ropiha 2000; Roberts *et al.* 2006; Smith 2011; Tāwhai 2013; Clarke & Harris 2017), *Matariki* and *Puanga* (Matamua 2013; Williams 2013; Rerekura 2014; Matamua 2017a, 2017b), together with a number of popular publications and resources on Māori astronomy (Leather & Hall 2004; Hakaraia 2006, 2008).

The science and practice of Māori astronomy: Matariki

The renaissance in the scientific study of Māori astronomy has developed out of the burgeoning development of Māori-led cross-cultural celebrations and ceremonies of celestial events such as the heliacal rising and setting of *Matariki* (Hakaraia 2006, 2008; Hardy 2012; Matamua 2017a, 2017b). This star cluster, known as the Pleaides elsewhere, has found new status within the cultural and societal landscape of Aotearoa (Hardy 2012). The revival of the *Matariki* celebration had a humble beginning, with small gatherings of people associated with Pipitea marae and Te Papa Tongarewa in Wellington in the 1990s (Hardy 2016). However, by the beginning of the 2000s, *Matariki* celebrations transformed into larger gatherings and events moving from a celebration of Māori culture to one associated with growth, development, and identity (Hardy 2012; Hardy 2016; Whaanga & Matamua 2016). Now, numerous *Matariki* events are held throughout Aotearoa in both the larger cities and smaller communities where 'people are once again using the pre-dawn rising of this star cluster to foster unity and togetherness. *Matariki* has become part of school curriculum, is included within the structure of city councils and other organisations and is promoted on television, via radio and in print' (Whaanga & Matamua 2016,

p. 67). We are also seeing *Matariki* embedded into a wide range of art, from *tā moko* (traditional tattooing) to modern art to large scale museum exhibitions.

The *Matariki* cluster is of great significance to many cultures worldwide, is known by many names such as the Pleiades, Seven Sisters, or Messier 45. It is an open star cluster located within the constellation of Taurus with several hundred stars of which only a handful are visible with the naked eye. *Matariki* is often mistakenly translated as little eyes or small eyes, *mata* 'eyes' and *riki* 'small' or 'little', which originates from Te Pēhi (Best 1972) where he describes a literal translation of the word '*Matariki*'. Matamua (2017a; 2017b) describes another account of *Matariki* as a truncated version of the longer name, *Ngā mata o te ariki Tāwhirimātea*, or the eyes of the god *Tāwhirimātea*. He recounts that, in the beginning, *Ranginui* (the Sky Father) and *Papatūānuku* (Earth Mother) were bound together in a tight embrace, where their children were cloaked in perpetual darkness. The children, the pantheon of Gods, eventually agreed, apart from *Tāwhirimātea* the god of winds and weather, to separate their parents as a course of action. *Tāwhirimātea* sought retribution from his siblings and he set forth on a series of attacks against them. His brothers cowered before his wrath except *Tūmatauenga*, the god of war and humanity: a warrior. Following an epic battle, *Tūmatauenga* triumphed, banishing his brother to the sky. Defeated and overcome with sorrow, *Tāwhirimātea* plucked his eyes and cast them into the heavens in a display of rage and contempt towards his siblings and *aroha* (love) for his father. These eyes became the stars of *Matariki*, *Ngā mata o te ariki Tāwhirimātea*. This understanding of the origins of *Matariki*, or *Ngā Mata o te Ariki o Tāwhirimātea* is now gaining traction in mainstream New Zealand consciousness, however much misrepresentation of the names' meaning is still perpetuated nation-wide.

Matariki is also known by other names including *Te Huihui o Matariki* (the cluster/ assembly of *Matariki*), *Te Tautari-nui-o-Matariki* (*Matariki* fixed in the heavens), *Tāriki* (an abbreviation of *Matariki*), *Aokai* (denoting its connection with food), *Hoko/ Hokokūmara* (describing its influence over the growing of *kūmara*), and three further names (*Mataroa*, *Matarohaki*, and *Matawaia*), which were suggested by Te Pēhi as possible names (Best 1910). The name *Matariki* is used to describe the entire star cluster, with nine of the major stars in *Matariki* having their own individual names. They are *Tupuānuku* (*Pleione*), *Tupuārangi* (*Atlas*), *Waitī* (*Maia*), *Waitā* (*Taygeta*), *Waipunarangi* (*Electra*), *Ururangi* (*Merope*), *Pōhutukawa* (*Sterope*), *Hiwa-i-te-rangi* (*Calæno*) and *Matariki* (*Alcyone*). *Matariki* was taken by *Rehua* (Antares) as a wife and she gave birth to eight children (five daughters and three sons). *Rehua*, a paramount chief, is connected with medicine and healing and *Matariki* to well-being, good fortune and health, and 'it is within both Rehua and Matariki that knowledge of well-being and medicine exists, and both have the power to heal' (Matamua 2017b, p. 26). Although there are a number of accounts that recount *Matariki* as a mother to seven daughters, seven sisters, or a flock of birds, these are thought to originate from Greek myth where Māori understandings of *Matariki* over time have merged with Greek myth (Matamua 2017b) and perpetuated as fact.

Within Māori astronomy, many stars not only had an identity associated with them but also had a specific purpose or role intrinsically connected to the Māori world. Within *Matariki,* each of these stars represented either a food, a source or a weather occurrence, the dead or the promise of a prosperous year (similar to the notion of making a new year's resolution or wishing upon a star). *Pōhutukawa* is a female, the eldest and she is associated with the dead who have passed since the last heliacal rising of *Matariki*. *Tupuānuku* is female and she is connected with food grown in the earth. *Tupuārangi* is male and he embodies the food that comes from the sky, including the fruit from trees and birds. *Waitī* is female and she holds the essence of food found in fresh water and *Waitā* is male and he holds the essence of the food in salt water. *Waipunarangi* is female and she is connected with rain and *Ururangi* is male and he is connected to the nature of winds for the year. *Hiwa-i-te-rangi* is female and the youngest of this celestial family. She is associated with the promise of a prosperous year. *Matariki* is the mother and the conductor of the entire cluster (Matamua 2017b).

Overlapping with the growth in *Matariki* celebrations is the regeneration, by a small group of practitioners, in a number of traditional ceremonies that coincide with the heliacal rising of *Matariki*: '*Te taki mōteatea*' (reciting of laments) and '*Whāngai i te hautapu*' (to feed with a sacred offering). These ceremonies, led by Professor Rangi Matamua at Waikato University, are being analysed and reinvigorated by a group of young *tohunga* called *Te Matapuenga*, a group established by the language, *tikanga* and *karakia* expert, Professor Pou Temara. Since 2017, practitioners and followers of the ceremony ascend before dawn in the *Tangaroa* lunar phase of the month *Pipiri* to view the heliacal rising of *Matariki*. Once ascended, the practitioners prepare food that corresponds to each of the domains of *Matariki*. The food is placed at an altar and ceremony is conducted with *karakia* and chants. During this ceremony a reading of the bounty of the year is conducted, the names of the dead of the year are recited and released (*Te taki mōteatea*), and the smoke from the food is offered to the cluster as sustenance (*Whāngai i te hautapu*). The regeneration of this practice associated with *Matariki* ceremony is in stark contrast to many of the celebrations that continue to be conducted nation-wide. The direction of this ceremony towards an honouring of *Matariki* via ceremony is a direction that many Māori are signalling favourably towards (Hardy & Whaanga 2019).

Matariki: Systems of time, the politics of time, and calendrical systems

There are a number of beliefs, ideas and applications associated with *Matariki*. *Matariki* is many things for many people: it has a spiritual dimension, it has a community and cultural dimension, but what is often overlooked and misunderstood, more than any other element, is its association with time; in particular, its connection to Māori divisions of time. The Māori division of time follows a stellar lunar calendar, whereby predominantly heliacal risings of stars or sometimes settings are used as indicators of specific times of the year, with a lunar cycle playing another layer of time increment. These stars could indicate, for example, a month or season of the year. For *Matariki,* probably the most crucial

element missing from its application in a modern context is its role in regulating our yearly cycle, especially because we no longer follow a traditional lunar calendar for our everyday activities.

Indigenous concepts of time, calendar systems, seasonality, rituals, and the rhythms of nature are intrinsically intertwined. Māori, similar to other Indigenous peoples, developed a complex time system integrating celestial, environmental and ecological occurrences to track time and seasonality. The movement of the sun, moon and stars, were used as clocks to regulate the timing of agricultural, fishing and hunting activities, and rituals. This division of time falls under the calendar system known as *maramataka* (Roberts *et al*. 2006; Best 1922b; Ropiha 2000; Tawhai 2013). The *maramataka* is a multilayered time system that utilises observations from the celestial such as the phases of the Moon and the sightings of certain stars, to ecological and environmental indicators such as the flowering of certain plants and occurrence of particular weather patterns (Clarke & Harris 2017).

The use and practice of the *maramataka* has changed as part of the process of colonisation. The move to reform Indigenous time was part of a broader agenda to interrupt 'the cycles of Indigenous and local seasons and calendars, and replacing them with the coloniser's rituals and routines, along with a new calendar for counting the days, months and years ...' (Nanni 2012, p. 3). This colonial-settler agenda sought to alter time as one of the fundamental tenets of Indigenous culture. Calendar reform is closely aligned with geopolitical movements, the role of empire, ecclesiastical control and power (Nanni 2012). As the Gregorian calendar was introduced by Pope Gregory XIII in 1582 to replace the Julian calendar, the same calendrical system was used by European settlers and missionaries in Aotearoa as a colonial act to target the minds, culture and the timing mechanisms of Māori. Māori soon shifted away from following and celebrating traditional Māori months and started to apply and even infuse Māori time within the Gregorian cycle of 365¼ day calendar system including its months, the seven-day week, and the 24-hour clock. The observation of the movements of the celestial bodies and ecological indicators was replaced by colonial timekeepers such as clocks and watches and a calendar based on the movements of the sun (Roberts et.al 2006).

Accompanying the demise of the use of *maramataka* and astronomical knowledge, was the devastating loss of land, language, and cultural practices led by successive polices of assimilation and integration, urbanisation, and restricted access to key resources (Walker 2004). These factors impacted profoundly on Māori cultural norms, collectivism, language, and the knowledge systems that were woven into the practice of Māori astronomy and the *maramataka* (Whaanga & Matamua 2016). As a result, the celebration of *Matariki* had almost disappeared as a recognisable part of the cultural landscape of Aotearoa by the middle of last century. Driven by the impending threat to the future of Māori, a series of Māori-led campaigns, petitions, and claims were undertaken in the late 70s and 80s to revitalise the Māori language, its knowledge and cultural systems, focusing on issues such as the Treaty of Waitangi, Māori land rights, language and culture, and racism (Harris 2004; Walker 1984, 2004).

As part of the cultural renaissance of reinvigorating the use of *maramataka* and Māori astronomical knowledge with star and lunar indicators, the recovery has had many challenges. In particular, in order to decolonise the calendar system and return to a traditional calendar system we have had to step away from the need to resolve and merge the Gregorian calendar with the *maramataka*. This has been due to how the Gregorian calendar has evolved away from its traditional origins. The evolution of this calendar has involved adding and subtracting days to the original true lunar months, giving 28–31 days in the Gregorian months, which could then be added to give a solar year of 365 days. In addition, the leap year is used to readjust the calendar to fit the solar year approximately every 4 years. Also, what is not commonly known is that additional seconds are added where needed to keep Coordinated Universal Time (UTC) in alignment with the actual length of time it takes the Earth to rotate (Frankston 2017). With such a number of adjustments, the reconciling of the Gregorian calendar with the *maramataka* is somewhat futile and what is needed is to understand the *maramataka* as its own independent system.

The stellar component of the *maramataka*, which includes *Matariki*, is a regulator for the Māori year and it was a cyclic indicator that determined when the Māori year commenced. Māori also traditionally followed a lunar component of the calendar, which is 354 days long and is based upon the cycles of the moon phases (synodic months). Thus, there is an 11-day difference between the Māori lunar calendar and the 365 day year, 12 months western solar calendar that we currently follow. Over a two-year cycle this difference becomes 22-days, over three-years it results in 33-days and therefore there becomes a full month variation between a lunar and solar calendar.

Māori understood the subtleties and importance of this relationship and they practised a system to ensure that they harmonised with the cycle of the year and the seasons. This was done every three years, when they would insert an extra month into their calendar system. This month was known as *Ruhanui* or the listless or lazy month. The use of what is known as an intercalary month was a common practice world-wide. Early uses of an additional month can be found in calendars of the Greeks (Van der Waerden 1960), Hebrews (Segal 1957), and Chinese (Aslaksen 2010; Martzloff 2016) amongst many others. These calendars place the insertion of a 13th month at various stages during their calendars with varying degrees of accuracy. For Māori, however, the intercalary month was more approximate and precision was less of a concern with a focus more on what works. Other systems around the world have adopted the metotonic scale that places 7 extra months over a 19-year time scale.

For Māori, the indicator of when to place the intercalary month was related to the appearance of the constellation *Pipiri*, which are two stars in the constellation of Aries known as Sheratan and Hamal. These two stars for Māori are called *Pipiri* and *Ruhanui*. For many Māori constellations the name of one particular star in the group will also be the name of the entire constellation. Hence *Pipiri* is the name of the constellation and also the name of a particular star (Sheratan) in the constellation. These two stars are referred

to as twins, as they appear in close proximity to each other and rise very near each other in the night sky. In the Māori calendar system, the months also often carried the names of stars. For example *Pipiri* rises in the eastern-sky in late May. When the first star in the constellation of *Pipiri* rose, it was taken as a sign that the winter month was upon us and the year was about to start, it also indicated that the following month after the sighting would be *Pipiri*, which is named after the constellation. As the *maramataka* is a solar-luni calendar, many events would also coincide with a particular moon phase. In the case of the new year, as soon as *Matariki* was seen in the sky during the month of *Pipiri* our ancestors would wait until its sighting coincided with a particular lunar phase of *Tangaroa* (the last quarter). Thus, the Māori new-year begins when *Matariki* is seen in the sky on the last quarter of the first month of the year, called *Pipiri*.

When following both a lunar and stellar cycle, as described earlier, 12 lunar months will add up to only 354 days and will leave a remainder of 11 days till the solar year is completed. The implication of this is that the lunar phase *Tangaroa* will be occurring 11 days earlier than the previous year. When observing the night sky, the 11-day shift between lunary and stellar cycles across the year will thus mean that each year *Matariki* would appear lower and lower in the sky on the horizon at the time of *Tangaroa* (last quarter phase) as the years progress (see Figure 1).

As heliacal risings of stars occur early in the morning before the sun rises, the closer the star is to sun below the horizon, the more difficult it is to see. Given that *Matariki* is a 3rd magnitude star, in order to view its heliacal rise with the naked eye, the cluster will need to be at least 5 degrees above the horizon while the sun is at least 16 degrees below (Matamua 2017a). As Matariki is supposed to occur during the month of *Pipiri* in *Tangaroa*, eventually the 11-day slippage will be so far out that *Matariki* will not be visible at that time. When *Matariki* was not visible during the *Tangaroa* phase of the month of *Pipiri*, *Pipiri* would become a double month. This is when the intercalary month known as *Ruhanui* would be applied and Māori would follow the second star in *Pipiri* to determine when our new year would commence. Figure 1 shows the position of *Matariki* in the early predawn sky in the month of *Pipiri* on the first phase of *Tangaroa* for the years 2018 (Fig 1a), 2019 (Fig 1b), 2020 (Fig 1c) and 2021 (Fig 1d). In order to ensure visibility, the times chosen were for when the sun is at least 16 degrees below the horizon. For 2018, 2019, and 2021 *Matariki* is clearly seen above 5 degrees; however, for 2020, *Matariki* is below the 5 degree limit and thus is not visible. Therefore in 2020 an intercalary month needs to be inserted following *Pipiri* and is called *Ruhanui*. Thus, when *Matariki* is not visible because of the ongoing 11-day slippage every year, an additional month is added in the first month of the Māori new year and the whole cycle resets itself.

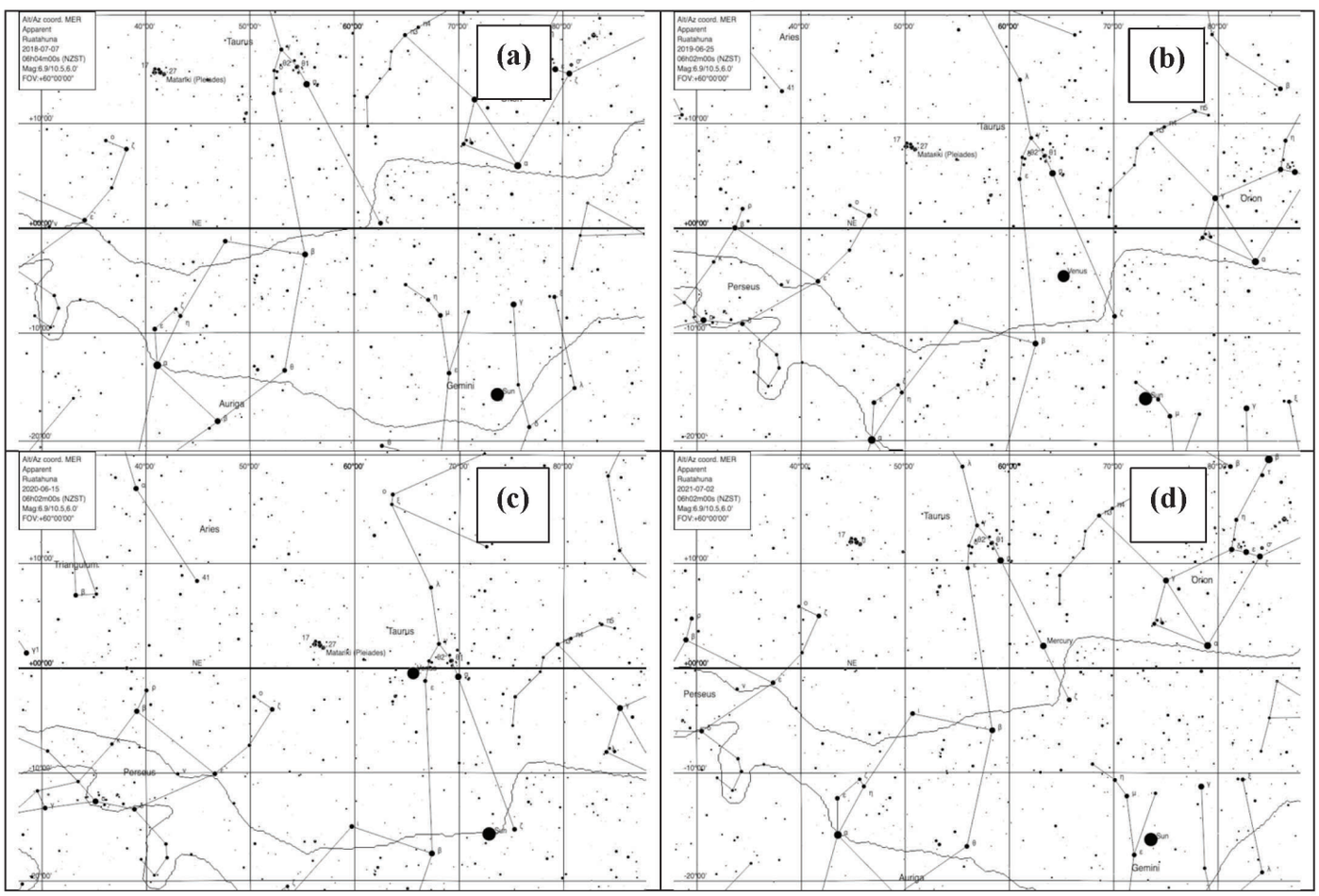

Figure 1a–1d: Star maps where *Matariki* is present in the pre-dawn sky in the moon phase *Tangaroa-a-mua* in the month of *Pipiri* for 2018–2021 (after Matamua 2017a). The sun is located at approximately 16 degrees below the horizon in each map.

With many people wanting to engage in *Matariki* celebration, much of the understanding around this concept has become muddled and confused in the public domain. As many try to fit the timing of *Matariki* within the Gregorian system, these two completely different time-keeping systems clash and there remains much confusion about when *Matariki* is visible and when it should be celebrated. Without the understanding of such intricacies of the intercalary month information regarding the timing of *Matariki* becomes incorrect. Attempting to reconstitute and reconfigure our sighting of *Matariki* with a Gregorian calendar is fundamentally flawed and continues to cause confusion when trying to understand the internal workings of a Māori system of time.

Conclusion

This paper has highlighted a small portion of the extensive scientific and astronomical knowledge base that our ancestors infused across all facets of Māori society. Over the past three decades, there has been a renaissance in the scientific study of Māori astronomy, with the celestial cluster of *Matariki* playing a significant role in the regeneration of Māori astronomy, science and traditional practice in Aotearoa. A key area that has enabled the growth of this knowledge has been government funding that has supported the myriad of projects and initiatives driven by Māori astronomy practitioners and organisations. In the past 15 years there has been a shift to engage with policies such as Vision Mātauranga (VM) and Mātauranga Māori more effectively in the research, development and economic space (Ministry of Research, Science and Technology, MORST 2007). The VM policy was developed in 2005 by MORST to engage and include Māori aspirations into these spaces, with its aim being to unlock the innovative potential of Māori knowledge, resources, and people in order to assist New Zealanders in creating a better future (MORST 2009). For many years, however, the way in which Māori have been engaged with via the VM policy has been tokenistic. Nonetheless, in more recent times, a number of initiatives and accountability to strengthen Māori inclusion and leadership have been implemented through placement programmes and research funding such as Curious Minds from the Ministry of Business, Innovation, and Employment (MBIE), which has opened up the door to enable Māori science to begin to grow and flourish. From these foundations the Māori astronomy space has grown, supported by funds such as the Royal Society of New Zealand Marsden Fund, MBIE, Te Puni Kōkiri, Te Taura Whiri, Te Māngai Pāho, and Ngā Pae o te Māramatanga.

The power of Māori astronomy is that it connects in a multifaceted way; from outreach into communities working with *rangatahi* (youth) to inspire them to realise their potential and imbue ancestral knowledge that has been hidden from them, to the development of new practitioners in rituals and practices around *Matariki*, to the creation of practitioners of *maramataka* to monitor the environment, ecological systems and well-being of themselves. The breadth of reach of Māori astronomy now is reaching millions of people and is growing in popularity every day. With over 20,500 followers for the *Living by the Stars* series, and over a million views of the popular series, the phenomenon that is occurring is unprecedented. Over the past 20 years researchers and practitioners have been actively sharing and growing the navigation, Māori astronomy and *maramataka* space by engaging the public in over 1000 talks, roadshows to over 8000 people, outreach to over 10,000 Māori and Pacific *rangatahi* and museum exhibitions that attracted more than 315,000 visitors.

Nevertheless, as this renaissance and revitalisation continues, *tohunga kōkōrangi*, navigators, Māori researchers, practitioners, and Māori communities face a number of challenges to decolonise and reconcile many facets of this knowledge base. The challenge for these groups lies in bringing together the collective knowledge, experiences, and voices to ensure its authenticity and legitimacy for future generations of aspiring Māori astronomers.

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Developing a Pūtaiao resource: *Ngā Hekaheka o Aotearoa*

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Abstracts

He aha ngā āhuatanga e eke ai tētahi rauemi Pūtaiao mō te rūma ako? Ka whaiwhakaaro tēnei tuhinga ki tēnei urupounamu mā te hoki atu ki te tukanga whakawhanaketanga i Ngā Hekaheka o Aotearoa, koia tētahi rauemi i whakairohia ai hei tautoko i te whakaako me te ako i roto mai i ngā kura kaupapa Māori mō te hekaheka o Aotearoa Niu Tīreni. I toko mai te hiahia ki tēnei tuhinga i ngā wheako o te kaituhi tuatahi e whakaako ana i te pūtaiao, e whakawhanake ana hoki i ngā rauemi Pūtaiao mō te hiatau te roa. Ko te whāinga ia ka puta mai he ārahitanga whaitake mō te whakawhanake tonu i ngā rauemi ā-ruma ako mō te Pūtaiao me ērā anō wānanga kaupapa Māori hei ngā rā ki tua.

What are the characteristics of a successful Pūtaiao classroom resource? This article considers this question by reflecting on the process of developing Ngā Hekaheka o Aotearoa, a resource designed to support teaching and learning in Māori-medium schools about the fungi of Aotearoa-New Zealand. The motivation for this article originates in the first author's decades of experience teaching Pūtaiao and developing Pūtaiao resources. The aim is to provide useful guidance for the development of future classroom resources for Pūtaiao and other Māori-medium learning areas.

***Keywords**: Hekaheka (fungus), Kura (Māori-medium school), Pūtaiao (Science), Te reo Māori (the Māori language)*

Introduction

Primary school science remains an area of intense concern for education researchers, given its foundational role in the education of future scientists and science-literate citizens, and since primary teachers often lack confidence in teaching science (Buntting et al. 2017; Stewart & Buntting 2015). In today's primary schools, science can easily be buried under an ever-growing pile of expectations placed on teachers.

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Difficult as it is for English-medium primary schools to adequately teach the science curriculum, the situation for Pūtaiao, which is the equivalent of the Science learning area in the curriculum for Māori-medium schools (kura) is more like a 'crisis' (Stewart 2017).

A complex set of intersecting reasons impede the im-plementation of the Pūtaiao curriculum, over and above the difficulties for primary science education in general, including: the philosophical conflicts between science and Māori knowledge (Stewart 2019); the ongoing residual effects of historical misuse of science to justify racist attitudes by Pākehā towards Māori people and culture; the abyss between scientific genres of English and te reo Māori; the widespread lack of engagement of Māori students in science education, impacting on those cohorts of people who are today's teachers in kura; and a severe lack of classroom resources for teaching and learning Pūtaiao (Stewart 2005, 2007, 2010). The focus of this article is on the last of these factors: the acute need for high-quality materials fit for the purpose of teaching and learning the Pūtaiao curriculum in Māori-medium classrooms.

There is only a very limited financial and human resource available for producing Pūtaiao classroom materials. It is therefore essential to the interests of Māori-medium students and their teachers that this limited resource is used well, based on sound understandings of the divergent demands in-volved. The dominant approach has been to send a finished English-medium resource to a translator, who may have no background in classroom teaching, the development of the Pūtaiao curriculum, or the accompanying Pūtaiao lexicon. When an already-published English-language story, de-

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signed to appeal to children by being embedded in a 'typical' everyday context, is translated into Māori, the connection to science is easily obscured. The resulting Māori text risks becoming almost meaningless, and such texts are invariably of limited educational, scientific or cultural value/validity. Class sets of such resources – usually consisting of several short, illustrated stories, collected together in student booklets, or school journals – are sent out to every kura in the country, where they end up sitting on shelves, seldom if ever to be opened. The government counts the cost of producing such resources as demonstrating their commitment to the retention and revitalisation of te reo Māori, and those involved in producing the resources benefit by being paid for their work, but the intended end-users receive no help, and Pūtaiao teaching and learning continues to stall.

Pūtaiao education is inherently complex and (largely due to the above effects) still embryonic. Cognisant of these limitations and the position of Pūtaiao in relation to science education in general, this article considers what is involved in developing a successful Pūtaiao classroom resource by narrating the story of one example: the award-winning book Ngā Hekaheka o Aotearoa (Buchanan et al. 2017; Copy-right Licensing New Zealand 2018). Before turning to this story, however, some methodological remarks are in order.

About the approach taken to writing this article

This article is unusual in the following three senses: firstly, to write an article about developing a classroom resource challenges dominant ideas of what counts as research in science education. The above paragraphs, however, explain the rationale underpinning this work; the apparently superficial focus provides an opportunity to explore serious educational issues concerning the resourcing of Pūtaiao, a discussion that is also relevant to other subject areas of Māori-medium education. Secondly, this article utilises self-study methods (Lassonde et al. 2009) in being written by the authors of the resource in question, and drawing on the first author's background in Pūtaiao education. Like other auto-methods in educational research, self-study prefers the validity of concrete examples over the quest for scientific objectivity, recognising the socially constructed nature of education practice. Thirdly, each author's voice is visible and separate in the section that follows. This dialogical element is a methodological device for keeping in play the productive tension of different perspectives on knowledge questions, which are evoked by writing a science classroom text in te reo Māori. Accordingly, the first-person voice is used to narrate the book's story, with sections attributed by name to each author.

Having set the scene for the article and commented on its approach, the main section below presents the story of how the resource was developed, narrated mainly in the voice of the first author (Georgina). This story provides a context for considering key practical and theoretical questions that arise in Māori-medium education resource development projects. The last sub-section switches voice to present a response and commentary from the second author (Peter). The conclusion summarises the key points as useful guidance for future resource development projects

A narrative: developing *Ngā Hekaheka o Aotearoa*

Georgina

In August 2016 I received an email from Peter setting up an initial meeting, at which he explained that he had been funded for a six-month project to produce a Pūtaiao classroom textbook written in te reo Māori about the fungi of Aotearoa-New Zealand. Peter expressed his wish to restore to Māori children the traditional Māori knowledge about fungi, which he had collated over the course of his career as a research scientist (mycologist) specialising in these indigenous species. While interested in being involved, I immediately told Peter my past experience suggested six months would be insufficient time to produce the finished resource. I was mindful of the risk of promising more than we could deliver, having once been contracted to write for a large Pūtaiao digital resource development project, very ambitious in scope and technology, but ultimately only partially completed, despite consuming a large budget. In my experience of teaching in kura, even today, books can be more dependable and therefore more valuable classroom teaching tools than computers.

Peter explained that he conceptualised the project as consisting mainly of translating into Māori a chapter on Māori knowledge of fungi, previously published in a science monograph on New Zealand fungi (Fuller et al. 2004). He had therefore already involved expert translator Hēni Jacob, which was fortuitous, since no other translator has more experience than Hēni with te reo Pūtaiao (the language of Pūtaiao), and she and I had worked together before on various Pūtaiao projects over the years. Peter is a senior scientist and expert science writer, but at the beginning of the project he had no experience of writing for the primary classroom, and lacked knowledge about teaching the material to non-scientists and children, or how teaching considerations affect how the material could be presented.

I helped Peter render his scientific knowledge of indigenous fungi into simpler terms suitable for a Māori-medium classroom book. I worked on the English text with Peter before it was sent to Hēni, and worked on the Māori text Hēni sent back. I wrote the classroom activities and teacher guide material, arranged for the draft book to be trialled, and facilitated the launch event. Since we all worked on the text, in different but overlapping roles, the three of us agreed that we would all be named as co-authors of the book.

We decided to produce the book in two versions, one for students and the other for teachers. The student booklet is smaller and in te reo Māori only. This booklet was printed in numbers sufficient for sets of 30 to be provided free of charge to every kura in the country. The teacher booklet is slightly larger; it includes all the material in the student booklet, with full translations into English. It also includes teacher guide material and copy masters for the classroom activities. This version of the book was printed in smaller numbers, and a few were sent out with each set of student booklets. A pdf version of the teacher book is available at the publisher's website: www.huia.co.nz/huia-services/resources-for-teachers/nga-hekaheka-o-aotearoa. The whole resource is also available on the Science Learning Hub: https://www.sciencelearn.org.nz/images/3711-nga-heka-heka-o-aotearoa.

In the months following that initial meeting, as our drafts began to take shape, Peter negotiated for more time and funding to complete the project, keeping the funders updated on progress. In the end, it took about 12 months to get to first full-draft stage, and the book launch was held in early December 2017, i.e. 17 months after my first meeting with Peter, and as the copies were in the process of being distributed to kura around the country.

Knowledge content

Our early discussions mainly concerned exactly what content would be included, and in what form. I was aware there was little or nothing in the way of Pūtaiao resources on fungi. Peter's enthusiasm for fungi was infectious, and the information about traditional Māori uses was fascinating. We decided the best way to organise the material was to write the text in two main sections: the first section would give an overview of introductory science relating to fungi, and the second section would be about the traditional Māori knowledge and uses of fungi. Peter and I developed an efficient way to work: we wrote comments in tracked changes on each other's electronic drafts exchanged by email, and mostly used the telephone for discussions and decisions. We never met in person with Hēni, but email proved efficient for communicating between the three of us.

I edited Peter's drafts for the first section, to level the material and break it up into manageable sub-sections. For the second section, I also ordered the material according to Māori perspectives, for example, promoting the tapu (sacred) and culturally significant uses of fungi for tāmoko (tattooing) and carrying fire. That Māori would see such sequencing decisions as significant is related to the gap or 'hyphen' between Māori and Pākehā worldviews (Jones & Jenkins 2008).

Voice

As agreed, after our initial meetings, Peter sent me the first draft piece of text for the introduction section of the book. Peter's first draft was written in the typical anthropolog-ical style: 'Early Māori uses of fungi...' The phone rings. "I wouldn't refer to Māori uses of fungi like that." "How would you refer to them, then?" "Probably as 'our tūpuna (ancestors) . . .' or something like that."

This kind of negotiation over the positioning of the text was the most obvious clash of 'voices' wherein what Peter the scientist thought of as 'normal' was jarring in the context of a Māori education project. Peter never used that kind of term again: he learned quickly and was always appreciative of the opportunity to learn about Māori perspectives.

A more subtle disjunction of perspective came up in discussing the section on the species pukurau (puff ball). Peter remarked "Waipukurau is the only Māori placename that includes a fungus name" to which I replied that such names are not 'Māori placenames' in a Māori-centred sense. Waipukurau is the only fungus placename that has been appropriated into the standardised set of placenames in use today. So we should say that Waipukurau is the only placename in English that includes a Māori fungus name.

Bringing it all together

Everything continued to fall into place as Peter contracted Huia Publishers to produce the book. A graphic design based on fungi, previously created for Manaaki Whenua–Landcare Research, was used to anchor the booklet design. I looked for a suitable illustration for the section on the use of fungi in tāmoko, and quickly decided on a famous Lindauer painting held by the Auckland City Art Gallery. We obtained permission to use the image, which visually enriches and adds mana (cultural power) to the book. It is important not to underestimate the work required to finalise the draft, which Peter mostly shouldered. Hēni and I continued to check and provide feedback on each version, with three-way discussions of tricky points. In this way, the inevitable hundred-and-one wrinkles were slowly but surely ironed out, one at a time.

The contract required the draft book to be trialled, and we discussed how this might happen. Eventually we negotiated for Peter to bring photocopies of the draft book to a Professional Learning and Development meeting for Pūtaiao and Pāngarau teachers, held during school holidays in early October 2017. I introduced Peter and the project to the teachers, and Peter spoke about the book's content. There was a good level of interest and some useful feedback from the group. Later, I followed up with one tumuaki (principal) from the trial group to organise an event for the book launch, which took place in the last few weeks of the 2017 school year. We held a hui (formal gathering) at the kura, at which the book was blessed, then after morning tea break, Peter and I taught the children using slides made from the book's pages, and ran a practical exercise making spore prints from mushrooms. A video about the resource was produced (Manaaki Whenua–Landcare Research 2018).

Different knowledges in the project

Conflicts between different forms of knowledge have already been mentioned above. In early meetings with Peter, we discussed the language medium requirement of the contract, and I pointed out the small percentage of Māori children who attend kura, the project's intended beneficiaries. Based on my past experience and knowledge of the sector, I recommended making the teacher version bilingual. This enlarges the book's potential range of users, and increases the possibility of its content being adequately taught.

In the book launch video, Peter mentions his belief that Māori had 'lost' their knowledge about fungi, saying this knowledge 'didn't seem to have been maintained' and that he had conceived the project as a way to 'reintroduce' this knowledge to Māori through schools (see 0.40 – 1.00 of video footage). Yet the teachers who attended the lesson that day countered this notion, mentioning traditions from their own families, and adding extra details to those recorded in the book. Afterwards I reflected on how Peter's notion about returning 'lost' Māori knowledge to Māori children aligns with dominant myths of national identity in this country. It is widely promulgated and regarded as 'scientific fact' that Māori have lost their traditional knowledge, and Peter naturally reflects that belief. Like other truth-myths held by Pākehā about Māori, it seems designed to subtly reinforce Pākehā feelings of security and superiority. Yet a counter story can often be found to challenge the dominant view.

The scientist's viewpoint

Peter

This project was highly motivating, taking me well outside my comfort zone as a (Western) scientist, and becoming feasible only once Georgina and Hēni came on board. Georgina's leadership of the educational aspects of this project and links to relevant personnel in Māori-medium education were indispensible. I was also indebted to earlier studies by Rebekah Fuller, who used literature and oral interviews to document Māori knowledge and uses of fungi for her MSc thesis, co-supervised by Mere Roberts and me, and published as Fuller et al. (2004). Rebekah's research found that few kaumātua (elder) interviewees recalled ancestral uses of fungi, which led to my motivation to provide students in kura with access to at least a basic consensus of the knowledge recorded by certain early European writers.

I was attracted to first contact Georgina because of her extensive research publication record concerning Pūtaiao, and her progressive role in its development. Hēni's involvement followed her earlier specialist translation of abstracts and popular summaries for scientific papers on invertebrates and fungi written by various colleagues. Other key insights by Georgina included her advice about the age range for the student audience, checking the appropriateness of language and voice for these students, and identifying and writing classroom activities (questions, a crossword, research activities) to assist student learning.

An important language point that arose early in the project concerned the Māori word for fungus, since the concept of Kingdom Fungi (also Kingdom Animals, Kingdom Plants, etc) is a Western science construct, and equivalent terms are not found in the traditional Māori lexicon. Previous publications on fungi by Manaaki Whenua–Landcare Research, on which Hēni had been consulted, had chosen to use 'harore' to mean fungus; hence the title of a series of publications, *The Fungi of New Zealand–Ngā Harore o Aotearoa*. Harore is a traditional Māori name for a well-known indigenous species of edible mushroom, and has become adopted in modern Māori as the standard word for mushrooms used as food. In the intervening period since those earlier publications, however, lexicon development to support the Pūtaiao curriculum had assigned 'harore' more specifically to mean 'mushroom' and adopted the word 'hekaheka' as a generic term for all fungal forms including moulds. Also, since previously published Pūtaiao resources had largely focused on plants and animals, several Māori terms for fungus-specific words needed to be found, such as fruitbody (ropihua) and hyphae/mycelium (torohihi). The prior combined experience of Hēni and Georgina in developing Pūtaiao terms was extremely helpful in relation to these tasks.

Another early lesson for me, alluded to above, was the need to get over my hesitation to embrace Tāne Mahuta as god of the forest, presiding over all forest organisms. Georgina helped me understand that my intention to communicate effectively with Māori-medium students required me to use the appropriate voice for the audience and learn-ing context. Once over that mental hurdle, composition became easier.

Hēni's language expertise ensured the Māori text was clear and of excellent quality. Georgina provided advice on the formatting of the book and assisted in formulating the glossary. Artist Ann Gale's labelled diagrams were important for helping students grasp the material about fungal life cycle, feeding and reproduction, and contributed to producing a scientifically accurate and visually appealing resource. Huia Publishers were instrumental in turning the draft resource into a published book with high production values. As with many successful outcomes in science, contributions came from a broad team of collaborating experts in various fields.

Next steps? Our hekaheka resource has been widely distributed and welcomed, but is it being effectively used? Future plans include workshops to assist kaiako (teachers) become more confident in using the resource to teach about hekaheka, including cultivation of one or two edible fungi (stop press: these courses began in 2019 through partnering with Ako Pānuku: www.akopanuku.tki.org.nz). Longer term, it is hoped that an understanding of the biology, ecology, and traditional uses of fungi will encourage hapū to consider cultivation of traditional edible fungi as kai (food sources).

Conclusion: learning from the project

To return to the motivating question for this article, the following list summarises 'what worked' in this project to produce a successful Pūtaiao classroom resource with high educational, scientific and cultural values:

- A bounded science topic aligned with the Pūtaiao curriculum, on which existing resources were lacking;
- A topic suited to classroom teaching but not dependent on specific curriculum links, ensuring the resource would not become outdated by future curriculum revisions;
- A topic from the natural world based on a set of indigenous species, about which there is a well-preserved body of traditional Māori knowledge;
- A topic from a scientist's area of specialist expertise and personal interest/passion;
- The 'x-factor' of collegiality and teamwork between the co-authors of the book;
- Contributions from people with a range of complementary skills in science, te reo Māori, teaching practice, art and design, book production, and knowledge of the kura community;
- A clear project concept that was not overwhelmed by complexities of design or technology.

These factors meant the entire resource could fit within a Māori framework. It is written in clear te reo Māori suitable for primary and early secondary classrooms, and incorporating mandated Pūtaiao vocabulary (www.paekupu.co.nz). Science knowledge and traditional Māori knowledge are each accorded equal significance in the book. Intrinsically interesting material, excellent translation into te reo, good illustrations, high production values, and above all a significant quantity and quality of basic science about fungi, combine to mean this resource makes a useful exemplar for developers of future classroom resources to support Māori-medium education.

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generously brought to the project. Furthermore, related to the purpose of this article, it is important to acknowledge the collaborative spirit that developed between the three co-authors; a special interpersonal quality, based in aroha for the aims of the project and trust in each other, which cannot be generated or replaced by standard project management approaches, and from which the resource greatly benefited.

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Towards building an Indigenous Science Tertiary Curriculum (Part 2)

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Abstracts

Ko te Koronga tētahi kaupapa mō te rangahau Māori kounga nei, e tū nei i Te Whare Wānanga o Ōtākou (https://www.otago.ac.nz/te-koronga/index.html). E rua ōna wāhanga: ko te Graduate Research Excellence tētahi, ko te Indigenous Science Research Theme tērā atu. I Aotearoa nei, e ai tonu i te Whare Wānanga o Ōtākou, he āputa nui e tohu nei me whakatipu ō te Māori pūkenga, ōna āheinga hoki, ā-rangahau nei, ki ngā pūtaiao. He tauira, i Ōtākou ko tōna 3% o ngā pouako katoa i te Division of Sciences he Māori, ka mutu, ehara i te mea ka rangahau ngā pouako Māori katoa i ngā take whakawhanake Māori. Mō Te Koronga, ko tō mātou whāinga matua ā-rautaki ko te whakatipu i te tokomaha o ngā pouako Māori e hāngai ai ki te taupori, me te aro kehokeho pū ki te whakapakarihia o te mātauranga me te pūkenga Māori. E tutuki ai ngā whāinga e pā ana ki te whakawhanakehanga Māori i tā Te Whare Wānanga o Ōtākou Māori Strategic Framework 2022 (MSF), ngā whāinga ā-kaupapa here o te motu, ka mutu ko ngā whāinga o te hapori Māori anō hoki, kua whakatauria e Te Koronga kia whakatipu i te hunga pouako Māori kia hāngai ki te taupori (ko tōna 15%), kia whakapakari hoki i te mātauranga me te pūkenga Māori i ngā pūtaiao. E whakatinanahia ai ēnei whāinga, e rua ngā rautaki e horaina nei: ko te waihanga mai i tētahi kaupapa matua hou mō te pūtaiao taketake, mō te mauri ora rānei, nō roto mai i te Division of Sciences ka tahi, me te whakawātea mai i ētahi tūranga mahi mauroa mō te pouako Māori ka rua. Ka aro pū tēnei tuhinga ki te rautaki tuatahi. Ko tēnei kauapapa matua hou mō te pūtaiao taketake: ka whakangungu i ngā atamai, Māori mai, Pākehā

mai hoki, ki ngā rohenga o te ('ngā' rānei) pūtaiao taketake; ka whakapakari i ngā āheinga ā-pouako puta noa i ngā momo akoranga mā roto mai i te waihangatia o tētahi wāhi ake hou mō te whakaako i te pūtaiao taketake/mauri ora; ka waihanga i tētahi marautanga hou kaupapa Māori nei, ka aro tonu hoki ki ngā 'ōritehanga' o te mātauranga taketake me te whakaaro Pākehā; ka takoha atu ki ō te hapori Māori hiahia, ki ōna wawata hoki mō ngā pūtaiao e whirinaki nei ki ngā hoahoatanga Māori o nāianei, ki ngā āheinga hou hoki ka puta, ka whakatutuki anō hoki i tā Te Hīkina Whakatutuki rautaki ko Vision Mātauranga Policy, Diversity in Science, me ō Te Whare Wānanga o Ōtākou whāinga i te Māori Strategic Framework.

Te Koronga is a Māori research excellence kaupapa (mission) based at the University of Otago (https://www.otago.ac.nz/te-koronga/index.html). It is composed of two parts: Graduate Research Excellence and the Indigenous Science Research Theme. In New Zealand, there is a significant need to grow Māori research capability and capacity in sciences and particularly at the University of Otago. For example, at Otago approximately 3% of all academic staff in the Division of Sciences are Māori and not all Māori staff necessarily research on Māori development issues. For Te Koronga, our top strategic priority is to grow Māori academic staff numbers to population parity with a clear focus on building Māori expertise and capability. In order to meet the objectives related to Māori development for the University of Otago Māori Strategic Framework 2022 (MSF), as well as national policy goals, and importantly Māori community aspirations, Te Koronga has set an aim to increase Māori academic staff numbers to population parity (approximately 15%) and to increase Māori academic expertise and capability in sciences. To realise these aims, two strategies are offered: firstly, to create a new indigenous sciences or mauri ora (flourishing wellness) major within the Division of Sciences and secondly to create Māori academic tenure track positions. This paper will focus on the first strategy. A new major in indigenous science will: train Māori and non-Māori scholars in the fields of indigenous science(s); build staff capacity across the disciplines through creating a new dedicated teaching area of indigenous sciences/mauri ora; create new curriculum that is kaupapa Māori-led as well as at the 'interface' of indigenous scholarship and Western ways of thinking; contribute towards Māori community needs and aspirations in sciences that build on current Māori networks as well as new opportunities that emerge and will address Ministry of Business, Innovation and Employment's Vision Mātauranga Policy, Diversity in Science strategy and Otago University's Māori Strategic Framework goals.

Introduction

In this companion paper we focus on an Otago-based solution, which is the creation of a new postgraduate major of indigenous sciences in the Master of Science. The proposed pedagogies that can be drawn upon within the new major are described. The core kaupapa (underlying focus) of the previous paper was to highlight the systemic issues and realities of Māori academic staffing in sciences in Aotearoa (New Zealand), and this paper offers a solution that is locally based but may have implications for other institutions nationally and internationally.

An Otago-based solution: Towards an Indigenous Science Curriculum

A solution to grow Māori research capacity within sciences at the University of Otago is through a proposed indigenous sciences major at the postgraduate level. Currently this proposal is being socialised amongst academics and senior leadership within the Division of Sciences. Indigenous science refers specifically to mātauranga (Māori knowledge; both what is known and how it is known (Jackson, Mita, & Hakopa 2017)) as a localised representation of indigenous knowledge. Of the 31 major offerings in the Bachelor of Science (https://www.otago.ac.nz/courses/qualifications/bsc.html) a quick search of the term Māori highlights one offering as a recommended paper. Of the 15 majors in the Bachelor of Applied Science there are two papers offered (https://www.otago.ac.nz/courses/qualifications/bappsc.html). These papers are hosted in the School of Physical Education, Sport and Exercise Sciences taught in Te Koronga. Furthermore, there is a paper taught in the Department of Marine Science by Te Tiaki Mahinga Kai (http://www.mahingakai.org.nz/) and Te Koronga academics. Māori content is sprinkled throughout other papers such as in the School of Surveying. While there are aspirations for an increase in Māori content, there are limited meaningful opportunities for this to occur, as well as a lack of expertise for staff in academic positions to be able to teach the content, as highlighted in the various University of Otago strategic documents (University of Otago, 2017, 2018, 2019).

In Māori communities there are increasing concerns relating to environmental degradation, water, and their effects on hauora (health). Underlying these issues are the impacts on Māori knowledge systems, practices, and language (Jackson, Mita, & Hakopa 2017). We are not advocating to 'do away' with the disciplines of science, but rather to propose a way forward to create academic positions focused on indigenous science, in which the research and teaching activity is derived (a) from the importance of mātauranga (mātauranga-derived), (b) at the interface (mātauranga and the specific discipline), and (c) from areas which are not mātauranga-based but in which Māori have an interest. It is important to state here that Māori have an interest in all aspects of Te Tai Ao, The Natural World.

To understand the potential for indigenous science within the Western academy is to highlight how te ao Māori (a Māori world) is science. We suggest a working definition of science as 'learning through observation over time related to phenomenon'. We acknowledge that there are multiple ways to view science and the philosophy of science, but there is not scope in this paper to explore these in further detail. Mātauranga in action is based within a Māori worldview. Marsden (2003a) describes worldview as

> *the central systemisation of conceptions of reality to which members of its culture assent and from which stems their value system. The worldview lies at the very heart of the culture, touching, interacting with and strongly influencing every aspect of the culture (Marsden 2003a, p. 56).*

We borrow the definition of mātauranga from Jackson, Mita, & Hakopa (2017), who contended that

> *mātauranga viewed in the context of Māori worldview, and the organising principles of whakapapa, whanaungatanga and kinship relationships, is both what is known… and how it is known. [They were] specifically interested in mātauranga in karakia (incantations), mōteatea (chants), pēpeha (tribal sayings), whakataukī (proverbs), and pūrākau (stories) (p. 10).*

A way to understand science in a Māori world is through the different domains of the atua (deities). For example, in the separation of Ranginui (Sky Father) and Papatūānuku (Earth Mother) there were over 70 deities who held dominion over certain environments: Tangaroa (God of the ocean), Tāne (God of the forest, trees, and birds), Tāwhirimātea (God of the elements), Rūaumoko (God of earthquakes), Haumiatike-tike (God of uncultivated foods), Rongomātāne (God of cultivated foods), to name a few. There are certain tikanga (protocols) within each domain to maintain the balance of tapu (restriction) and noa (unrestriction).

As humans were created, as junior in the whakapapa (genealogy) and then populated the world, they were tasked with ensuring the delicate balance between mana atua (mana of the gods), mana whenua (mana of land), mana moana (mana of the ocean), and mana tanagata (mana of people). Through physical creation, humans were imbued with the ira atua (godly essence) and ira tangata (human essence) (Jackson, Baxter, & Hakopa 2018). This meant that, through time, Māori held and continue to hold and practise localised knowledge from the gods, to the present as well as into the future. This, in an English word, is 'science'.

The previous sections have highlighted the opportunities and realities of Māori research capacity within the University of Otago. Many predecessors and current colleagues have offered solutions such as strategic planning, advocacy, letters, and hui at all levels of the institutions. To draw upon the defiant response by Ngāti Maniapoto leader Rewi Maniapoto in 1864 at the battle of Orakau and repeated by the late Professor Ranginui Walker, 'Ka whawhai tonu mātou' or, translated for the purposes of this paper, 'We continue to fight' (Walker 2004). The reality is that, for our communities, the issues for local people are worsening and we are in a continual state of seeking mauri ora (flourishing wellness). The role of academics and universities is to be the critics and conscience of society; it is difficult to do so where the institutions do not reflect the society from which we may come and serve.

There are other issues which we do not have the space to discuss in detail, such as the growing number of Māori undergraduate students (McAllister *et al*. 2019) as a driver for the need for new curriculum areas and more Māori academics/academics with tikanga and Te Reo knowledge. Another significant issue we face is the notion of science excellence on the international stage versus what is needed to strengthen what is unique and excellent about New Zealand, i.e. strong indigenous research. Hiring faculty who understand the unique challenges and opportunities in New Zealand and celebrate the funding opportunities that follow that expertise, should be given higher priority – at least to balance the international reputation that currently exists.

Thus, we offer a further solution to realistically grow research capacity and capability within sciences whilst addressing issues of importance for Māori. We are not attempting to reproduce the *status quo*; otherwise we will create the same outcomes, which do not work. There are a few examples of Māori content across some of the mainstream institutions in New Zealand. Some of these courses are listed in Table 1.

Table 1. Examples of current papers related to Indigenous Science/Mauri Ora at New Zealand Universities.

University	Paper Code	Title
Otago	SPEX206	Te Pū o te Ora Māori Physical Education and Health
Otago	SPEX306	Te Pou o Te Koronga Advanced Māori Physical Education and Health
Otago	AQFI301	Field Methods for Assessment of Fisheries and Aquatic Habitats
Otago	MAOR 303	Ngāi Tahu and the Natural World
Canterbury	MAOR172-17S2	Science, Māori and Indigenous Knowledge
Lincoln	MAST319	Te Kaitiakitaka (Māori Environmental Management)
Lincoln	MAST603	Mana Kaitiaki (Māori Resource Management)
Victoria	MAOR202	Te Putaiao Māori/Māori Science
Victoria	MAOR203	Te Taunaha Whenua/Mapping Whenua
Victoria	MAOR302	Te Pumoto o te Tangata Whenua, o te Taiao/Indigenous Knowledge and Science
Massey	235.311	Māori Policy and Agribusiness
Massey	235.211	Māori Agribusiness Systems
Massey	235.701	Māori Values and Resource Management
Massey	235.702	Māori Resource and Environmental Management - Whenua
Massey	235.703	Māori Resource and Environmental Management - Freshwater
Massey	235.704	Māori Resource and Environmental Management - Flora and Fauna
Massey	235.705	Māori Resource and Environmental Management - Foreshore and Oceans
Massey	235.706	Maara kai - Traditional and Contemporary Māori Food Production
Massey	119.170	Māori Value Systems in Science
Massey	132.304	Tuhono Taiao: Māori and Planning
Waikato	GEOG515	Māori Geographies
Waikato	ENVP505	Māori Environmental Management
AUT	MAOH501	Māori Health, Development and Environment
AUT	MAOH701	Māori Health Promotion
AUT	MAOH801	Māori Health Research Practice - Te Rangahau Hauora Māori
AUT	MAOH802	Māori Health Practice - Taunga a Mahi Hauora Maori

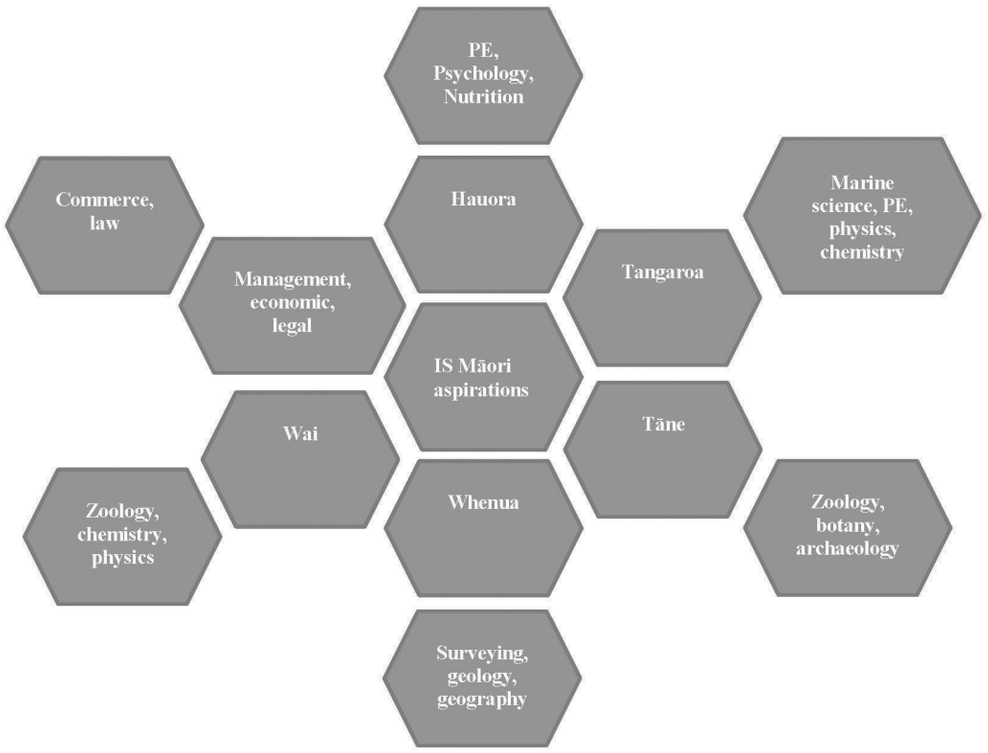

Figure 1. Proposed Master of Science in Indigenous Science/Mauri Ora Version 1.0.

To provide an example within the current structure at the University of Otago, we propose to create a new major in indigenous science/mauri ora that has linkages with each School/Department within the Division of Sciences. This will be introduced at the postgraduate level, with a keen focus on the development of undergraduate curriculum in the future. We acknowledge findings from Kidman *et al*. (2015), who stated that:

> *'the scientists in [their] study drew on examples from their own disciplines about how an understanding and awareness of Māori empirical knowledge about the natural world had provided them with particular insights into the knowledge base of their disciplines that were not immediately available to their colleagues in the sciences who assumed that indigenous knowledge was merely a 'superstitious' repetition of myths and legends' (Kidman et al. 2015, p. 78).*

At the centre of the curriculum design are indigenous science (IS) and Māori community aspirations. This would include offered papers that focused on Māori research methodologies, methods, and content related specifically to mātauranga *as* science. There would be opportunities for collaborations with Māori studies papers that include language, tikanga, and Treaty of Waitangi content. Many of the current papers in the sciences include field-based activities; as such, we would continue to privilege Māori fieldwork opportunities through papers such as AQFI301 Field Methods for Assessment of Fisheries and Aquatic Habitats, SPEX206 Te Pū o te Ora Māori Physical Education and Health, and SPEX306 Te Pou o Te Koronga Advanced Māori Physical Education and Health, which include noho marae (Jackson, Hakopa, & Jackson 2017).

The second, outer grouping, is a potential grouping of curriculum areas based on the Māori worldview and current needs in whānau, hapū, iwi, and Māori communities which are highlighted in Table 2.

Table 2. Proposed curriculum areas and focus for Master of Science in Indigenous Science/Mauri ora.

Curriculum area	Focus
Hauora	Tangata, wellbeing, mental health, nutrition, physical education, physical wellbeing, genetics, whakapapa
Tangaroa	Ocean and marine focus, fisheries management, aquaculture, climate change, marine mammals/creatures
Tāne	Flora and fauna, agriculture, terrestrial animals
Whenua	Land based, maunga, pā, wāhi tapu, outdoor education, surveying, management
Wai	Freshwater, freshwater species, environment, rivers/lakes, pollution
Management/ economic/legal	Governance, economic futures, legal

The third, outermost grouping, is the specific department or school where there would be a possible curriculum alignment. There may be other alignments into the second grouping that reflect the broad scope of research within a department. This would provide a pathway for the creation of new academic positions, in which a staff member would teach one paper in the new indigenous science major and then teach a second paper based on their particular discipline. At Otago, a common teaching model for a fulltime academic staff member is a two-paper teaching model for the approximately 40% of time allocated to teaching. Thus,

new academics in these positions would still fulfil their 40% allocation, as well as contributing to a new major, and also undertake their research (40%) in relation to indigenous science and their specialised field. The further 20% is service, and this could include Māori development for example.

Through our Te Koronga-grown approach, this would create new academic positions in an area of significant importance locally, nationally, and internationally. There would be flow-on effects such as increasing quality postgraduate supervision, addressing issues for Māori communities, and creating linkages with other indigenous peoples internationally. In the next section, we discuss our proposed teaching pedagogies for the successful implementation of this new major.

A pedagogy for the implementation of a new curriculum

Three years of research has led to a model of Māori language revitalization in New Zealand, the ZePA model, which acronymises three critical positions, Zero – Passive – Active, and presents factors that enable or disable language maintenance and acquisition. The ZePA model is an approach towards language revitalization that extends beyond the people to whom the language belongs and raises the issue of a language being valued by the greater nation. Where language provides a foundation of identity, acknowledgement of the language catalyses Indigenous existence and, therefore, affords the delivery and receptivity of Indigenous knowledge within mainstream and Indigenous forums (T. Rewi & Rewi 2015, p. 136).

It is important to design the curriculum around a grounded pedagogy. This section will outline the pedagogical foundations of the proposal to provide context to the aspirations of the curriculum. In keeping with the language imperatives described above, the curriculum design and method of delivery within the new major would also need to reflect maatauranga Maaori[1] and Indigenous knowledge relevant to the topics being taught. Maaori Marsden (2003b) identified that maatauranga was learned in waananga and that from te kaakano, *'the seed of thought' came moohio 'ways of knowing' which gave us maatauranga 'knowledge'* (p. 31–32). When we think about teaching, we acknowledge and identify that teaching is not only a complex, organic and experiential endeavour, but that the practice of teaching Maaori students should, inherently, be based on applying experiences that reflect our Maaori worldview. As Pihama *et al.* (2004) explain:

> *The complexity of Maaori pedagogy is evident but...is not to be viewed, however, as limiting or restrictive. Rather it presents a multitude of possibilities for those that are willing and committed to bringing about positive change for Maaori within education. What is clear is that there have always been a range of pedagogical forms that have been a part of Maaori experience (Pihama et al. 2004, p. 53).*

Clearly evident are the words of Bishop (1999) below, exemplifying how traditional research methodologies were once devoid of Maaori cultural preferences, but a new indigenous sciences or mauri ora major developed by, and for the advancement and benefit of, Māori students (and for that matter, all students) at the University of Otago, is long overdue. Bishop (1999) outlines

> *Traditional research epistemologies have developed methods of initiating research and accessing research participants that are located within the cultural preferences and practices of the Western world as opposed to that of Maori people themselves (Bishop 1999, p. 2).*

Key ways of learning noted from participants in a study carried out by R.T. Rewi (2018) observed the following points:

Te Ako maa te Kite me te Whakarongo – Learning through Observing and Listening or Titiro, Whakarongo

This pedagogy is not a new practice within Maaoridom, but reflects how knowledge was passed on from our tuupuna (ancestors) before us (Best 1923; Metge 2015; P. Rewi 2010; Whatahoro & Smith 1913). Moreover, other indigenous people of the Pacific and elsewhere have also been known to use similar pedagogy to transmit their cultural knowledge inter-generationally. Robert Borofsky, who studied the techniques Pukapukans used to acquire traditional knowledge, gives one such example (Borofsky 1987). Pukapuka is one of the fifteen islands that make up the group known collectively as the Cook Islands. In this example, Borofsky (1987) used an illustration of canoe lashing to describe how observation as pedagogy was used to pass on traditional knowledge from an elder to two students. Borofsky (1987) had spoken with both parties the day before and understood they both had the same expectations, that the elder would teach the students how to make and then lash the old-fashioned canoes. From what Borofsky (1987) observed, there was actually very little direct teaching involved. The elder rarely gave explicit instructions about what to do and, in Borofsky's (1987) opinion, the students learned more from the practical work they did, and from their own intuition about what to do and observing, rather than any actual advice or instruction from the elder.

Learning by exposure / Learning by part of living (Metge 2015)

A distinction that is important to note here, and commented on by all of the participants in the Rewi (2018) study, was the important learning that came naturally to them as part of their daily lives at home and growing up at the marae, particularly for those who also came from rural, Maaori communities. Metge (2015) describes in her book, *Tauira, Māori methods of learning and teaching,* how the reflections of her participants rated their childhood learning in their homes and at the marae as the most important kind of learning they experienced. The marae was also the other place most of their learning outside school occurred. For some, this was the only place learning occurred. Metge (2015) originally called this phenomenon 'learning by exposure' before renaming it 'learning as part of living'. Her participants took this learning for granted and did not perceive it needed to be named.

Metge's (2015) description of this mode of learning, taken from participants who were children in the mid-twentieth century, helped T. Rewi appreciate what her own pakeke

[1] This section utilises the Waikato dialect of double vowel sounds.

(adults/senior family members) were saying to her when she first approached them to participate in her project. They kept saying they had nothing to offer when she first approached them to participate in this project – they had no special names for any types of learning they did. Like Metge's (2015) participants, they took their learning for granted. They simply learned what they had to do and went on their way. They either understood something or they did not. If they did not understand, then the person would be shown again. Whether this happened would depend on their tutor's patience and commitment to teaching the student. If the student still did not understand, then it was likely they had missed their opportunity and would have to move on. Rewi recalled her father or her uncle commenting, *Only the mentally fit and the tough survive. Listen carefully, watch what I'm doing, I'll only show you once*.

Role modelling

People often base their own practice on the actions of someone else they hold in high esteem, someone they trust and respect deeply. No matter whether acting in a personal or professional capacity, most of the time a person's actions emulate those of an individual admired for their ways of being, their demeanour and actions when in the same position. This learned behaviour could have been acquired in this way through role modelling. Cruess *et al.* (2008) wrote about role modelling in their field, the medical profession, stating that 'Teachers need to be aware of the conscious and unconscious components of learning from role modelling, so that the net effect of the process is positive' (p. 718). The key points they note from their research into role modelling are:

> *Role modelling is a powerful teaching tool for passing on the knowledge, skills, and values of the medical profession, but its net effect on the behaviour of students is often negative rather than positive ... By analysing their own performance as role models, individuals can improve their personal performance ... Strategies are available to help doctors become better role models (Cruess et al., 2008, p. 721).*

Other important considerations from a Western context include:

Contextualising learning

Some people now believe that learning a language is building a map of meaning in the mind. These people believe that talking may indicate that the language was learned, but they do not believe that practice in talking is the best way to build up this 'cognitive' map in the mind. To do this, they feel, the best method is to practice meaningful listening (Norton in Nation, 1993, p. 11).

Nation (1993) continues the discussion by way of explaining that meaningful listening is not having to understand each word in isolation, but rather the need to make sense of the entire message. Therefore, messages must be interesting and involve the learners so that listening becomes a 'truly active process' (p.11). Vandenbosch (2007) elaborates further by saying that: 'contextualisation of learning occurs when the content of the curriculum, and the methods and materials associated with it, are related directly to the experience and environment of the learner' (p. 2). The example given here demonstrates that the aim of contextualising language is to help learners notice and understand meaning. This is an active process in which the learner is actively creating the context rather than just passively registering the context. Similarly, with the new major, contextualising learning is critical to the success of the programme and exemplifies how the environment and experience, not just the content, contribute to successful outcomes for the learner and are a critical part of the learning experience.

Experiential learning

Beard and Wilson (2006) report experiential learning as 'the insight gained through the conscious or unconscious internalization of our own or observed experiences, which builds upon our past experiences or knowledge' (p. 43). This is quite similar to observing and listening, and also to learning by exposure or learning as part of living, but it is also different. It can be described simply as learning whilst experiencing, another critical learning style synonymous with a Māori worldview. Classrooms or learning situations that provide opportunities for experiential learning create direct interactions with the study focus itself deliberately, instead of abstract presentations. Kohonen (2003) supports how learning is viewed as 'a cyclic process integrating immediate experience, reflection, abstract conceptualization and action' (p. 14). From a language perspective, for example, Kohonen (2003) justifies the inclusion of experiential language learning as part of cooperative learner education within language programmes, as learners are provided with activities that encourage the use of real-life language where there are relevant or significant reasons for the communicative activities. Within a wānanga programme, for instance, experiential language learning examples could be intentionally co-planned for, so that both students and teachers maximise the wānanga environment. This style of learning could be easily incorporated within the new major.

The physical environment

Already experiencing success in connecting with community for some programmes (for example within the School of Physical Education, Sport and Exercise Sciences), Kyle & Murray (2008) point out that the physical environment is a key factor in building quality learning situations:

> *There are many factors that affect the integrity of the learning environment ... the learning environment is a complex but critical educational construction borne of essentially three components: the physical, actions and resources of the teachers as well as the response of the learners (Kyle & Murray 2008, p. 154).*

Van Lier (2004) takes a socio-cultural perspective and provides many examples of ways in which 'the physical world...has a number of obvious and not so obvious connections with language use, and the ties between word and world are deep and numerous' (p. 46). This acknowledges the fact that the physical environment is fundamental to the language development of the people and cultures that exist within that environment. Flaherty in Brucato (2005) provides a good summary of the need for educators to focus on creating optimal environments, explaining how:

human beings are affected by their heredity and their environment. The former is beyond the scope of even the most determined theorist. It is, therefore, in the latter area that educators can do the most to provide the best possible start in life to those entrusted to them (Van Lier 2004, p. vii).

The quotations listed here may only focus on language, but from a Māori worldview, language and tikanga are synonymous, so speaking of one invariably describes the benefits for both. From a curriculum perspective, the new indigenous science or mauri ora major is significantly enhanced from working with community where relationships forged are more likely to outlast the years the students are enrolled at the university.

Conclusion

In this paper, we have focused specifically on our own university through highlighting a potential solution. This solution is the introduction of a new major of indigenous science/mauri ora in the Master of Science. We also discussed the pedagogical approaches that we would draw upon for this major to be a success. The solution we have provided is Otago-focused and, although it is locally created based on our specific needs, it may have applications for others nationally and internationally.

Tēnei anō tātou te koronga

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Mapping Māori knowledge from the past to inform marine management futures

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Abstracts

E aro whānui nei tēnei tuhinga ki ētahi rangahau i whakamahi i te mātauranga moana kia whakamōhiotia, kia hāpaitia hoki ngā tukanga rangahau ā-papa me ngā rūritanga o te pūtaiao Pākehā. I whakatau te mātauranga Māori ā-wāhi nei, ā-moana nei hoki, i te tikanga tuku me te tikanga ine i ngā taonga hirahira nei ki te ahurea Māori pēnei me; te Kina, te Koura, te Kūtai, te Pāua anō hoki, i ngā ākau i hī ngohi ai ngā whakareanga maha, i whakahaerehia rā hoki e rātou. Kātahi taua mātauranga ka whakamaheretia, ka whakamahia hoki hei taumata ine i ngā rūritanga rangahautanga ā-papa o te pūtaiao mō te takutai moana. Ko ngā kitenga i hua mai i te rangahau matarau mō te moana i whakamahia rā kia whanake ake ngā mahi whakahaerenga ki te hāpai i ngā umanga Māori me ngā umanga Kāwanatanga kia pai ake, kia tiketike ake, kia whakahaumarutia ake anō hoki ngā taonga a Tangaroa ā haere nei te wā. Ka āta wetewete, ka whakatauira hoki tēnei tuhinga i te whaipānga me te kōkiri tahitanga i waenga i te mātauranga Māori me te pūtaiao Pākehā, me te hiranga o ngā rautaki kaupapa Māori nei kia whakamanahia ai ko te mahi tahi me te Māori, ka tahi, ka rua ko tō te Māori reo i te whakawhanake takirua nei, i te whakatinanahanga, i ngā whakawhiti kōrero anō hoki i roto i ngā rangahau ā-moana.

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This article provides an overview of research which used mātauranga moana (Māori marine knowledge systems) to inform and assist Western science field research methods and surveys. Place-based Māori marine knowledge identified the traditional distribution range and sizing of taonga (culturally important) species in traditional coastal areas which had been fished and managed by consecutive generations of Māori; kina, Evechinus chloroticus*, sea urchin; koura,* Jasus edwardsii*, red rock lobster; kūtai,* Perna canaliculus*, green lipped mussel; and pāua,* Haliotis iris*, abalone. This knowledge was then mapped and used as the baseline for sub-tidal marine science field research surveys. Findings from the transdisciplinary marine research was used to develop management actions to assist Māori and Government entities for improving, enhancing and safeguarding marine taonga species into the future. This article critically discusses and demonstrates the relevance and complementarity of mātauranga Māori and Western science, and the importance of kaupapa Māori strategies for empowering Māori collaboration and voices in marine research co-development, implementation and communication.*

Keywords*: mātauranga Māori, Western science, mapping, traditional knowledge, marine management, Māori knowledge systems, rohe moana.*

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Glossary

Mātauranga Māori, Māori knowledge systems;
Kina, *Evechinus chloroticus*, sea urchin;
Koura, *Jasus edwardsii*, red rock lobster;
Kūtai, *Perna canaliculus*, green lipped mussel;
Pāua, *Haliotis iris*, abalone;
Moana, marine environments;
Mātauranga moana, Māori marine knowledge systems;
Hapū, sub-tribe;
Iwi, tribe;
Taonga, culturally treasured/important;
Māori, Indigenous peoples of Aotearoa New Zealand;
Tangata whenua, people of the land;
Kaimoana, seafood;
Mahinga kai, harvesting areas;
Tikanga Māori, cultural practices;
Rohe moana, traditional oceanic territory of a coastal hapū/iwi.

Introduction

The ocean and its resources are of significant cultural importance and value to Māori. In pre-European times, the ocean provided coastal hapū and iwi with a key food resource, a means of transportation, cultural identity, and ecological connectivity (Ministry for the Environment 2010; Royal 2010; Brake & Peart 2013). However, for over one hundred and twenty years, a significant number of legislative Acts, policies, and plans actively enforced the exclusion of Māori from participating in management decisions and actions for their traditional territorial land and oceanic areas. Over time this resulted in traditional fisheries knowledge, activities, and decision-making capabilities being replaced by non-Māori fishing perspectives and practices (Hooper & Lynch 1999; Leach 2006). These actions severely interrupted the intergenerational transmission of ecological knowledge and marine management activities for taonga species and their associated ecosystems.

Today, many Māori entities have substantial concerns regarding the degeneration of marine species and spaces and want action to prevent further degradation and to allow recovery in multi-use ecosystems.

This article provides an overview of a research project conducted in 2009/2010 which used mātauranga Māori with western science to map the distribution and abundance of four taonga species at three traditional sites of significance in te rohe moana ō Ngāti Awa (traditional oceanic areas of Ngāti Awa). The information from the research was used to assist the development of a Ngāti Awa marine management plan and formal application to Fisheries New Zealand for the establishment of a mātaitai reserve under the Fisheries (Customary Kaimoana Fishing) Regulations 1998. Mātaitai are marine management tools which recognise and provide for traditional fishing through local management. They allow customary and recreational fishing but usually do not allow commercial fishing (NZ Legislation 2019). Mātaitai provide legislative ability for Māori to establish management regimes for their rohe moana, permitting recreational and customary fishing management practices while prohibiting commercial fishing activities.

Ngāti Awa Customary Fishing Authority

Situated in the Eastern Bay of Plenty region of Aotearoa New Zealand, Ngāti Awa are a coastal Māori iwi (tribal authority) made up of 22 hapū or subtribes. In 2005, a Deed of Settlement was signed between Ngāti Awa and the Crown (Ministry of Justice 2005) which resulted in the establishment of the Ngāti Awa Customary Fishing Authority (NACFA) in 2007. The NACFA encompasses the development of management actions and kaitiaki (tribal fisheries officers) for te rohe moana ō Ngāti Awa (Te Rūnanga ō Ngāti Awa 2009).

Overview

The purpose of the project was for Ngāti Awa to know the state of our rohe moana. Ngāti Awa had no ready access to resource information about the customary fisheries and the environmental and harvesting impacts upon marine resources within the rohe moana. The four identified taonga species (kina, kūtai, pāua, and koura) surveyed in this project were selected by the NACFA as the species considered most likely under stress due to a history of consistent harvesting pressure by commercial, recreational, and customary fisherpeople (O'Brien 2010). It was further suspected that exposure to environmental degradation of waterways through land runoff and pollution (Environment Bay of Plenty 2006) was also impacting the health of taonga species.

The three sites of significance were all located in the rohe moana and include the rocky shore coastline of Kohi Point to Ōtarawairere (hereafter Site A), the inshore island of Moutohorā (Whale Is.), (hereafter Site B) and the islets of Rūrima, Moutoki and Tokata jointly referred to as Rūrima (hereafter Site C). All three sites were geographically positioned within a maximum twelve nautical miles from the mouth of the Whakatāne river (Figure 1). The rohe moana also includes the soft-bottomed Ōhiwa harbour and the islands of Whakaari (White Is.) and Mōtītī. Both islands have overlapping historical interests with multiple neighbouring iwi. Motunau (Plate Is.) is a site of interest for Ngāti Awa, although it is understood that Motunau is under the full and direct management authority or mana moana of Ngāti Whakahemo, a kin relation to Ngāti Awa. The three rocky reef sites have been easily accessed and frequented by Ngāti Awa for the procurement of kaimoana over many consecutive generations.

The three sites were identified by the NACFA as having important cultural, spiritual, historical and environmental significance in the traditional fishing grounds of Ngāti Awa (Te Puni Kokiri 1996; Ministry of Justice 2005).

Mātauranga Māori

Mātauranga Māori or Māori knowledge and experiences of the natural world encompasses not only what is known but how it is known (Paul-Burke et al 2018), and the connection of inter-generational knowledge with the environments from which it is derived (Jackson et al 2018; Mercier 2018). Māori epistemologies or ways of knowing, being and doing, take for granted that all elements of the natural world are related, and it is upon those relationships that survival depends. This ideology suggests that the natural world is an intricate and intimate system, composed of many interacting and adaptive structures and components. All elements move and interact within a complex holistic framework of relationships both human and non-human, tangible and intangible, each supporting and benefiting the other (Rameka & Paul-Burke 2015).

Ngā tohu o te taiao (hereafter tohu), or the signs and symbols of the natural world, are often referred to as en-

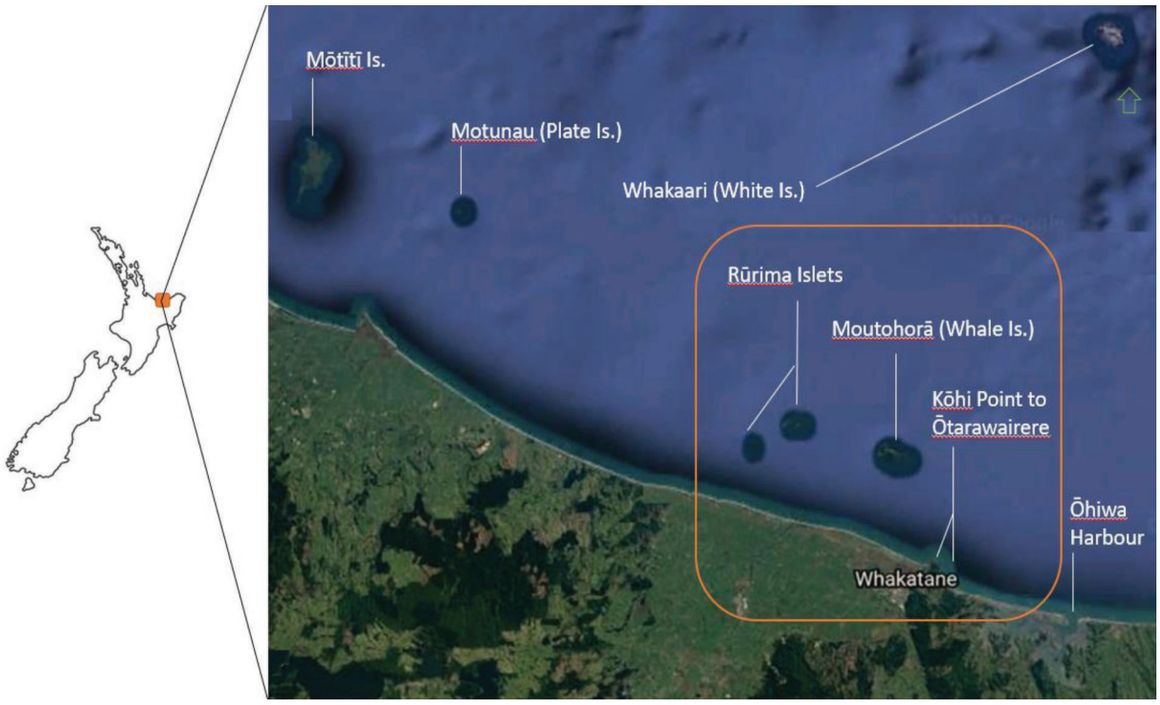

Figure 1. Map identifying traditional coastal islands and marine areas of interest for Ngāti Awa. Orange box identifies the sites that were surveyed as part of the mātauranga Māori and Western marine science field research project discussed in this article. Map Data @ Google, Imagery @2019 Google TerraMetrics.

vironmental indicators and are widely used by Māori environmental practitioners to identify trends or changes in the state or health of marine environments (Paul-Burke 2017). Tohu show if ecological systems are getting better or worse and recognise social/cultural/environmental declines and changes as precursors to ecological tipping points. Māori carefully scrutinised the natural world, they took special note of seasons, circumstances and habitual cycles. All forms of knowledge were directly or indirectly sourced from the environment. The act of observation and information gathering was integral to a range of established sustainable management practices that governed the harvesting, use and protection of natural resources (Kerr & Grace 2017). Attention was given to recognising, interpreting, and responding to tohu and the cumulative effects, causes and events associated with the natural world (Paul-Burke 2017). In time, this information became common knowledge and was conveyed from one generation to the next.

Individual hapū and iwi have their own localised understandings of tohu which are specific and relative to their environmental contexts, experiences, observations and understandings of species interactions and patterns of use. These accumulated intergenerational understandings, practices and knowledge transmission are grounded in the existence of Māori, who are intimately bound to residing in one place for many generations (Cheung 2008). Māori worldviews consider the wellbeing of natural resources to be directly related to the wellbeing of the people. Using mātauranga Māori to co-develop understandings of ecosystem stability, recoverability, and resilience across consecutive generations, including coordinated managerial approaches, is increasingly recognised as an important tool for contemporary marine management (Forster 2012; Lyver *et al* 2016).

Methodology

Kaupapa Māori research methodologies have arisen out of mātauranga Māori as a theory and analysis of the approaches to research which involve Māori (G. Smith 2009). It does not exclude a wide range of other methods but rather signals the interrogation of methods in relation to cultural sensitivity, cross-cultural reliability, and meaningful outcomes for Māori and their wider communities (Cram 2002; Pihama 2010). Kaupapa Māori is formative (Cunningham 1998) as it creates an awareness of another worldview. It legitimises Māori epistemology which is meaningful to Māori and seeks to empower and honour the research participants by ensuring that they have access to the research and ownership of their intellectual property, which helped shape and inform the research project (L. Smith 1999).

Kaupapa Māori research is positioned to address the concerns of Māori and in so doing provide a construct for informing the wider community (Mane 2009; Keer 2012). This can be achieved by actively including the participants in all stages and at all levels of the research design and implementation of the project, to ensure that their 'voice', perspectives, and knowledge were accurately represented and communicated in a language and cultural context that was appropriate, understandable, and made clear links to the research outcomes for Māori. Kaupapa Māori seeks to shift the traditional power dimension from the researcher to the researched. This position locates research which is grounded in the material existence or experiential reality of the participants (Freire 1970), for as Marx discerns, it is not the consciousness of men that determines their existence, but their social existence that determines their consciousness (Marx 1958).

Methods

The aim of the research was to gather traditional intergenerational knowledge alongside contemporary quantitative information regarding marine taonga species and sites of significance within te rohe moana ō Ngāti Awa to assist decision making for the NACFA. This was to be achieved by answering the following questions:

1. What/where are the traditional harvesting sites of kina, kūtai, koura, and pāua in te rohe moana ō Ngāti Awa?
2. What is the current distribution (location range), sizing (how big or small), and abundance (how many), of the four species at identified sites in te rohe moana ō Ngāti Awa?

The methods used in the study were in three stages. Stage one involved ethical approval and qualitative interviews, stage two involved a boat field trip with participating kaumātua (elders) and pūkenga (experts), and stage three involved quantitative dive surveys.

Stage one included semi structured, small-group focus interviews with kaumātua/pūkenga who are or have been active users of marine resources, and/or were identified as those most likely to have traditional ecological knowledge of customary species distribution patterns and/or socio-cultural knowledge of identified sites across time and space. The information shared by the participants was based on their experiential observations and knowledge accumulated over fifty or more years (Pauly 1995). Other ecological knowledge such as the depth range of harvesting (dive) sites, sizing, abundance estimates, coastal water, weather patterns, and habitat information was also discussed. Thirteen participants aged between 58 and 80+ years were interviewed for the project (O'Brien 2010).

Stage two involved a boat field trip to enable participants to physically identify the traditional distribution, abundance, and sizing of the marine species using inter-generational harvesting landmarks and ngā tohu o te taiao or Māori environmental indicators (Paul-Burke *et al*. 2010). The information was then recorded on the main research vessel using Global Positioning Satellite (GPS) coordinates as well as a Garmin 78sc handheld GPS system as a data backup precaution. Mapping traditional distribution areas affirmed mātauranga Māori as having value in its own right while also communicating and informing research and decision making for a variety of ecological systems (Lyver *et al*. 2016). Mapping the seascape through participatory research strengthens the management of marine resources through the use of local, place-based intergenerational knowledge and values within a system that integrates as equivalents, Indigenous and Western forms of knowledge (Aswani & Lauer 2006).

During the boat field trip, participants were asked to determine their start and end boundaries and/or specific spots of distribution for each of the four identified species. The information shared by participants was based on their experiential harvesting knowledge and practices as kaitiaki (environmental guardians) and food gatherers. This information was then substantiated by other participants when recounting conversations, observations, and practices of their people having harvested the same species from the same marine areas for many consecutive generations (Paul-Burke *et al*. 2018). To assist participants with recollections of sizing the identified species, different sized samples of the species had previously been gathered and placed in size class orders as a visual reference (Figure 2). Information from interviews and the boat field trip was used to determine the commencement of all Western science sub-tidal (underwater) dive mapping and surveying across the rohe moana. This approach actively positioned mātauranga Māori alongside other knowledge systems as a 'normal' approach to research (Mane 2009; Paul-Burke & Burke 2016).

The information obtained during the boat field trip was verified and approved by participants before being recorded using WGS84 marine GPS system for future replication monitoring surveys and for comparability purposes (MacDiarmid 2008). The GPS coordinates of the four identified species were then translated into visual representations using a free online mapping tool in cohesion with a satellite imagery tool. The combined mapping tools were selected to allow Ngāti Awa independent access to easy-to-use, accessible, and affordable mapping systems for any future monitoring or replication efforts.

Stage three included subtidal surveying of the identified marine taonga species. All surveys were commenced on the traditional start and end distribution boundaries identified by kaumātua/pūkenga. Surveying kina required research divers to swim along a 25 metre transect line placing a $1m^2$ quadrat on every odd number along the transect. All kina within the quadrat were counted and measured (Freeman 2006 MacDiarmid 1994; Kayes 2009) (Figure 3). Kūtai were surveyed by placing a $1m^2$ quadrat on the substrate, reef rock or pinnacle to take percentage assessments 0–100% in multiples of five. The sizes of five individuals in the top right-hand corner of the quadrat were then measured (Dytham 2003; MacDiarmid 2008; Morrison 1996). All measurements of kūtai were taken across the widest part of the shell as opposed to the industry measurement of farmed kūtai which utilised shell length. Measuring across the posterior (widest) end of the kūtai was used to inflict the least possible impact on the mussels (Paul-Burke 2007). This was consistent with baseline survey research studies undertaken by Paul-Burke (2007, 2008, 2009) on kūtai populations in Ōhiwa harbour. Kick cycles were used to determine quadrat placement and to provide an estimation of the sizing of the reef/rock pinnacle surveyed. Koura and pāua were surveyed using the 10-minute timed count method (McShane *et al*. 1994; Kingsford & MacDiarmid 1998). The count started from when the first koura or pāua was located. If it took one minute or more to locate the first koura/pāua the time was recorded, and the ten-minute time count then commenced. If no koura/pāua were found within the ten-minute timeframe a nil count was recorded. The diver then ascended to the surface. At the surface the position of the diver in correlation with traditional landmark bearings was recoded and geographical coordinates were marked by the research boat person using a handheld GPS (Paul-Burke *et al*. 2013). All koura located were measured along the carapace length (body cavity) (Kingsford & MacDiarmid 1998), using rulers marked with pre-determined size classes (Roberts 2007), if individuals were able to be caught without being damaged. However, if koura were unable to be caught, an estimate of the carapace

Figure 2. Images 1 & 6, participants identifying marine taonga species distribution, sizing and abundance at identified sites of significance during the boat field trip. Image 2, a rocky reef site in the rohe moana ō Ngāti Awa. Images 3 & 4, examples of species size classes used to assist sizing recollection during the boat field trip. Image 5, mapping workshop with participating kaumātua and pūkenga. (Images by Waka Paul and Tuwhakairiora O'Brien, 2010.)

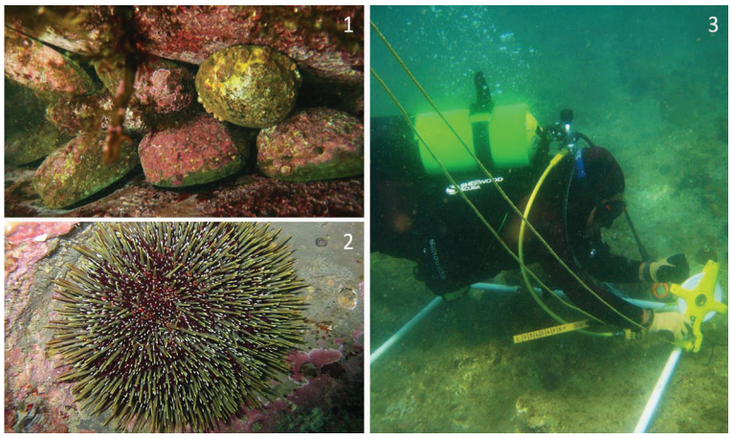

Figure 3. Images of (1) pāua; (2) kina and (3) Ngāti Awa researcher conducting dive surveys in te rohe moana ō Ngāti Awa.

was made (Kayes 2009; Kingsford & MacDiarmid 1998). Every pāua measured was carefully removed from the rock surface, measured along the length of the shell (Freeman 2006; Kingsford & MacDiarmid 1998) with a flat, blunt pāua iron and then placed back in its original position. If for any reason pāua were difficult to remove, they were left undisturbed and an estimated sizing was made. All species were measured in size classes. All survey dive locations were determined by the intergenerational mātauranga Māori identified by participating kaumātua/pūkenga.

Results

Part One – Mapping mātauranga Māori

Part one included the qualitative interviews/workshops and boat field trip, with participating kaumātua/pūkenga identifying intergenerational understandings of marine taonga species distribution, abundance, sizing, and customary fishing sites and harvesting practices within te rohe moana ō Ngāti Awa. The sharing of mātauranga Māori by the participants in support of the research project was imparted with serious and thoughtful reflection. Participants openly shared their ecological and cultural understandings of tohu and species lifecycles, relationships, habitats, and patterns of distribution. They also shared their 'secret' intergenerational whānau (family) fishing boundary parameters and harvesting spots with the researchers, trusting that their traditional experiential knowledge would 'truly' benefit the following generations and the natural world in which we live.

As a result, the researchers were left with an overwhelming sense of responsibility to get the research 'right' (Mead 2003) not only for future management of the rohe moana, but also the implicit sense of honouring the participants' wisdom, cultural guidance, and support for the research. Irwin (1994) postulates that kaupapa Māori research is about cultural safety undertaken by Māori researchers who are guided and/or mentored by kaumātua/pūkenga. This ensures that the research approach is both culturally relevant and appropriate, while at the same time satisfying the rigours of academic research (Bishop 2008, Forster 2012).

As two of the three researchers were also descendants of Ngāti Awa, it was automatically assumed that we would

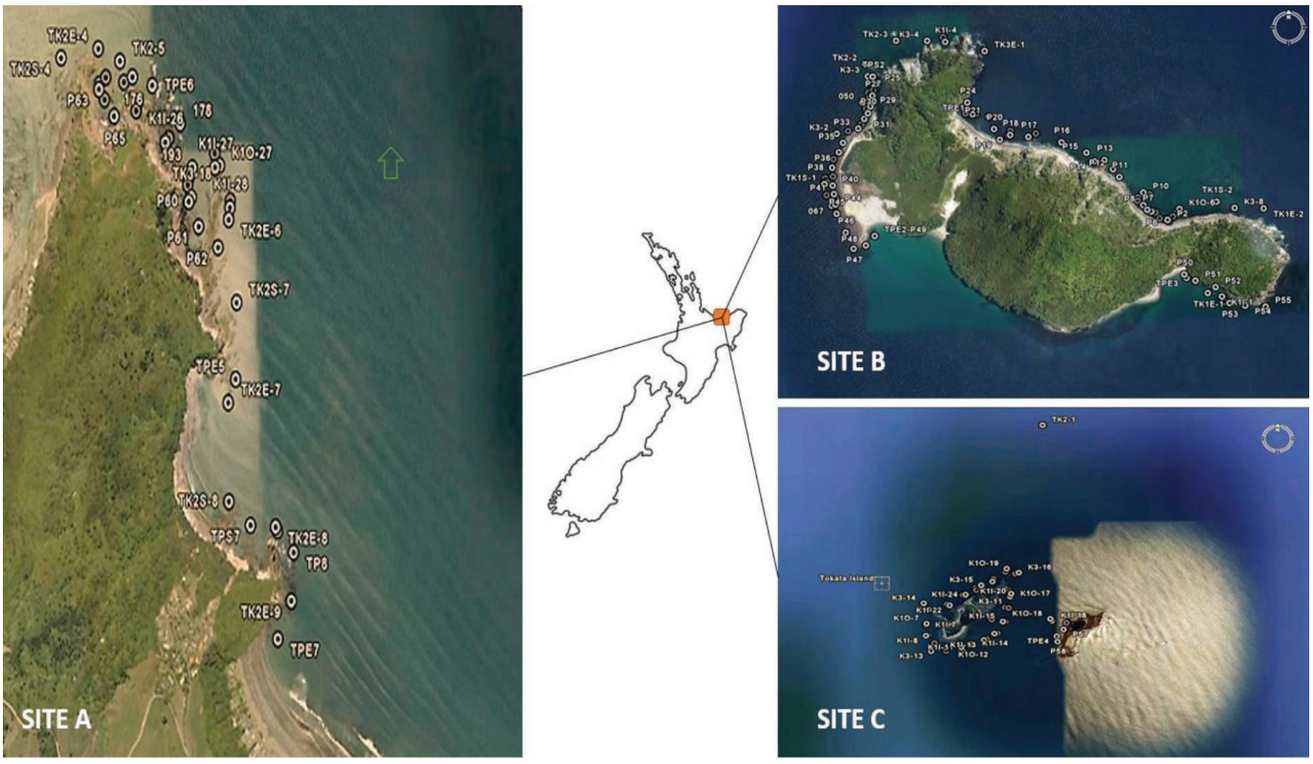

Figure 4. Public map of traditional and contemporary distribution of four identified marine taonga species in te rohe moana ō Ngāti Awa. Map Data @ Google, Imagery @2009 Google TerraMetrics.

'naturally' protect the knowledge imparted to us (L. Smith 1999). While kaumātua /pūkenga never once said 'don't tell anyone where my grandparents' dive spots are', it was an unspoken agreement that certain aspects of the knowledge shared were not intended for public consumption; and when the project ended, particular private dive 'spots' identified in the research would remain the private intergenerational dive spots of kaumātua/pūkenga and their whānau. The research study honoured that unspoken agreement.

From a Māori worldview it is understood that not all cultural knowledge is open or accessible to everyone (Mead 2012). To promote and protect intergenerational mātauranga Māori of traditional customary fisheries information, all GPS waypoint coordinates identifying the exact distribution locations of the four taonga species were omitted from public reports. All species traditional and actual distribution locations were coded. No legends explaining the codes were provided nor included in public maps (Figure 4), documents, reports, appendices, or power-point presentations. All information pertaining to kaumātua/pūkenga intergenerational 'private or secret' family dive spots were omitted from all documentation both public and private. This format is consistent for all distribution maps of all species surveyed. The GPS coordinates with exact dive site locations across all sites surveyed were provided to Ngāti Awa in a separate report, entitled: Private and Confidential Document Two: GPS Coordinates of Actual Taonga Species Distribution in the Rohe Moana ō Ngāti Awa (Paul-Burke *et al*. 2010). If external individuals wished to access the culturally sensitive knowledge, it is understood that they must make direct contact with the knowledge holders of Ngāti Awa.

Protecting the cultural and intellectual property of participating kaumātua/pūkenga is supported by Royal (2006, p. 25) when he asserts: 'like all bodies of knowledge of this kind, there are aspects that are common to the community and there are aspects which are held by specialists'. Smith (2012, p. 72) adds: 'Māori society valued knowledge highly, to such an extent that certain types of knowledge were entrusted to only a few members of the whānau... there were sanctions that ensured that it was protected, used appropriately and transmitted with accuracy'. The specialists in this research study are the participating kaumātua/pūkenga, and their knowledge shall remain with them.

Part two – Quantitative surveys

Sub-tidal baseline surveys of the identified customary species at each of the three sites of significance was undertaken between January and March 2010. Baseline surveys refer to the data collected to provide an indication of the present state of the species at each specific dive site (Kingsford & Battershill 1998.) All actual dive survey locations for this research study were determined from the findings of qualitative interviews and the boat field trip with kaumātua/pūkenga. A combined total of two hundred and eleven (211) GPS dive survey marks were recorded, identifying the distribution of identified taonga species – kina, kūtai, koura, and pāua – across the three sites in the rohe moana (Figure 4).

Kina, *Evechinus chloroticus,* sea urchin: A total of 364 × 1 m^2 quadrats and 18 × 25 m transect lines for kina abundance counts and size measurements across all sites surveyed was recorded. The most frequently occurring measurements of kina diameter were recorded in size classes 50–69 mm and 70–89 mm. The largest kina diameter

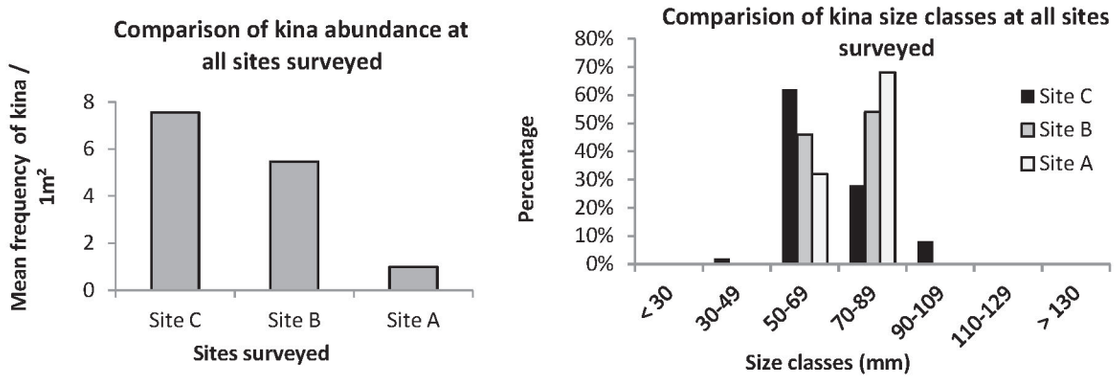

Figure 5. (L) Comparison of kina, *Evechinus chloroticus*, mean frequency /m² and (R) size classes (mm) measurements across all sites surveyed in te rohe moana ō Ngāti Awa 2009-2010.

measurements across all sites surveyed were found at site C, which also recorded the largest number of kina presence with a mean frequency of 8 per m^2 (Figure 5). This was consistent with the traditional intergenerational harvesting knowledge by kaumātua/pūkenga of kina abundance and sizing provided across all sites surveyed.

Kūtai, *Perna canaliculus,* green-lipped mussel: Kūtai percentage and sizing counts were achieved by using 283 × 1 m^2 quadrats. Consistent with kaumātua/pūkenga information, it was found that an important traditional intergenerational kūtai rock identified as being 'covered 100% with kūtai right down to the sand on the bottom' measured an estimated 64 m in circumference with 10% of the total area populated by kūtai. Site B recorded the greatest number of kūtai (51%) in size class 41–60 mm in width. Over all sites surveyed, site B recorded the widest range (four of the five pre-determined size classes were represented) and the largest kūtai measurements (Figure 6). The results of this survey found kūtai present at all three sites surveyed. However, in some areas of site A and site C the recorded measurements were substantially smaller than those recalled by kaumātua/pūkenga in the 1960s. Some areas of site A also recorded nil kūtai present. In site B it was found that kūtai sizes were significantly larger than previously estimated by kaumātua/pūkenga (Paul-Burke *et al*. 2010). Kaumātua/pūkenga identified site A and site C as traditionally the most preferred places for gathering kūtai due to their prolific abundance (O'Brien 2010). The results of the research suggested that a marked decrease in abundance of kūtai both in site A and site C may have occurred. A significant presence of the reef star, *Stichaster australis,* was observed at Site A.

Koura, *Jasus edwardsii,* red rock lobster: Across all sites surveyed 96 × 10 minute timed koura counts were conducted. The highest number for koura were found in a 'secret koura hole' identified by one kaumātua as the 'family heirloom'. Kaumātua/pūkenga recollections of where, when, how to dive, what landmarks and underwater features used to locate 'secret' sites were consistent with the findings and recorded the largest koura with an average 9 koura counted and measured every 10 minutes. The most consistently occurring measurement of koura across all three sites surveyed was recorded in size class 71–90 mm with site C recording 29% and 33% recorded in both sites B and A. The largest koura carapace length measurements across all sites surveyed were recorded in site C (figure 7).

Pāua, *Haliotis iris*, abalone. A total of 2524 individual pāua were counted and measured across all sites surveyed, of which 3 individuals were recorded in the legal take size of 125 mm or over. Participating kaumātua/ pūkenga had asserted that 99% of pāua were under the legal-size limit, with one site in te rohe moana known to have consistent legal sized pāua in small numbers. Their recollections were consistent with the quantitative findings. The greatest abundance of all pāua counted across all sites surveyed was recorded in Site B with site C recording consistently larger sized shell length measurements and the only site to record individuals in the legal harvest size of 125 mm or larger (Figure 8).

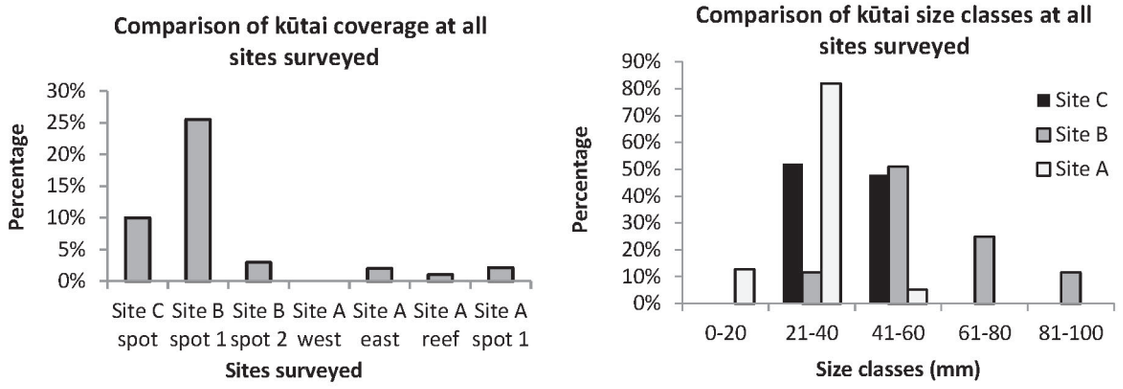

Figure 6. (L) Comparison of kūtai, *Perna canaliculus,* percentage coverage and (R) size class (mm) measurements across all sites surveyed in te rohe moana ō Ngāti Awa 2009–2010.

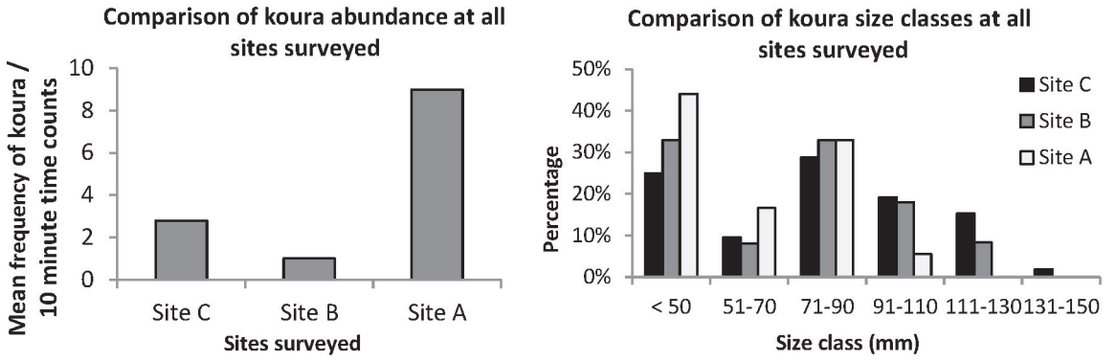

Figure 7. (L) Comparison of mean frequency of koura, *Jasus edwardsii,* and (R) comparison of size classes at all sites surveyed.

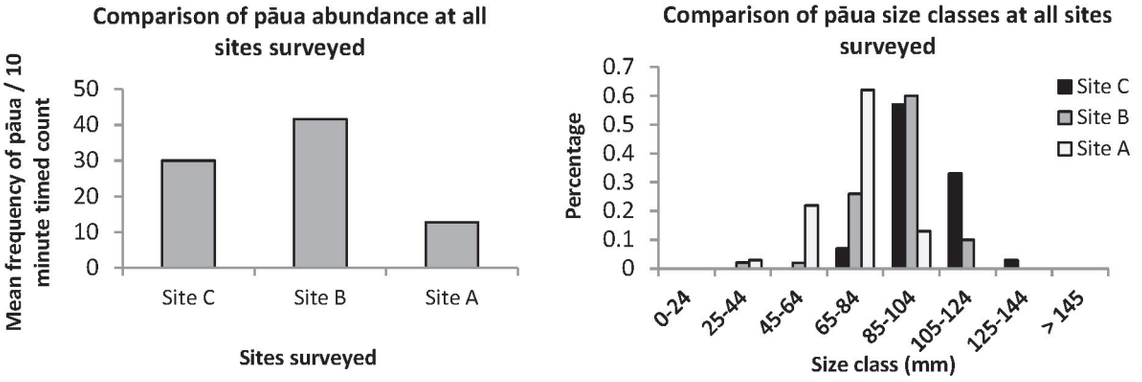

Figure 8. (L) Comparison of mean frequency of pāua, *Haliotis iris*, and (R) comparison of sizing (mm) width measurements across all sites surveyed.

Discussion and conclusion

In this study, mātauranga Māori was pivotal in identifying and determining all dive survey sites of the four marine taonga species within te rohe moana ō Ngāti Awa. With over two hundred mapped distribution GPS marks, it was found that all taonga species were located where kaumātua/pūkenga said they would be. Kaumātua/pūkenga knowledge regarding the sizing and abundance of taonga species in sites surveyed were consistent with the findings of the research, for example: kaumātua/pūkenga observations suggested that there were small pāua in large numbers in site B and the highest numbers of kina would be found in site C. This was also consistent with information pertaining to 'secret family' koura spots which was given with detailed intergenerational instructions such as location, depth, above and below water navigational marks, and tohu. Kaumātua/pūkenga observations also indicated that kūtai populations at site A and C had declined over the years (O'Brien 2010).

Positioning place-based mātauranga Māori alongside Western science to assist decision-making for marine taonga species and spaces helps mitigate issues of shifting baselines, in which each generation of scientists accepts as a baseline the stock size and species composition that occurred at the beginning of their careers and uses this to evaluate changes (Pauly 1995). The result is a gradual decreasing shift of the baseline, aggravated by the lack of personal, long-term intergenerational experience in localised marine spaces (Ray & McCormick-Ray 2014). This approach to marine management is supported by Butler (2006, p. 4):

> *We have reached a moment when fisheries managers are realising that their knowledge of the ocean resources is inadequate, and they are looking to resource users for information about particular resources. Practical knowledge is being recognised as a necessary supplement to scientific knowledge. Therefore, when we ask about a resource, we have to ask about the resource use – knowledge must be related to experience.*

This research arose from the needs, issues, aspirations, and priorities of Ngāti Awa. It employed a collaborative, transdisciplinary approach, with kaumātua/pūkenga and researchers to answer specific questions co-developed and designed by the NACFA. This included the collaboration of mātauranga Māori and Western science to better understand the state of taonga species in the rohe moana; and to assist decision making, promote recovery, and ensure a sustainable food basket for present and future generations. To that end, the findings from the mātauranga Māori mapping and quantitative field surveys were used to support an application to the Ministry of Fisheries for the establishment of a Mātaitai reserve in te rohe moana ō Ngāti Awa.

For coastal Māori there is a growing demand to investigate alternative ways of engaging with Western science to better understand degradation and assist recovery initiatives for culturally important species in marine environments. Māori aspire to live in sustainable communities with access to up-to-date evidence-based information to assist decision-making and marine management actions. Identifying ways in which hapū/iwi driven scholarship

and place-based participatory practice can be captured and incorporated through co-developed transdisciplinary mapping tools to assist culturally important rohe moana, is a high priority. Research on ways in which mātauranga Māori can be captured, in accordance with tikanga Māori (culturally appropriate practices) and incorporated into marine monitoring, mapping, and management frameworks, is immensely important and would strengthen Aotearoa New Zealand's knowledge of the impacts of change on local ecosystems and communities (Ministry for the Environment & Statistics NZ 2019). Cultural diversity is related to biodiversity, and both may be important for improving the sustainability of the world's ecological systems for present and future generations (Berkes & Folkes 1994; WWF 2014; Diaz *et al*. 2019).

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Visualising Mātauranga Māori for Iwi Outcomes

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Abstracts

Ko te Mātauranga Māori he puna nō te katoa, he mea āta whakatipu hoki e ngā whānau, e ngā hapū, e ngā iwi hoki o tēnā, o tēnā o ngā whakareanga maha. He mātauranga nō te hapori, he mea āta whakatō hoki ki roto i ngā wheako o te ia rā, he mea kawe ki te pūrakau, ki te waiata, ki ngā karangahanga whenua, ki te kani, ki te kawa, ki te whakapapa, ki te pūmahara, ki te whakakitenga, ki te matakite, ki te whakaakoranga me te tohu pūtake, hei tirohanga, ka mutu he mea āta ako mā te tirohanga, mā tāngata kē atu rānei o te hapori. Tēnei mea te Mātauranga Māori, he pūnaha whakatipu mōhiohio, he nukurau, he nanakia anō hoki, kua hangā mai ki te mātauranga ā-whānau, ā-hapū, ā-iwi anō hoki.

Kei te whakatau tikanga, kei te whakamahere, kei te whakamahi hoki ētahi hunga tangata i te Mātauranga Māori, ka mutu kei tēnā ōna anō whaihuatanga. Ko te aho e whakakotahi nei i ngā rōpū kāwanatanga me ngā kaunihera ā-rohe, ko te whakaaro e hāngai pū ana te mātauranga Māori ki te Māori, he mea whakahāngai hoki, ka mutu he rerekē i tēnā, i tēnā o ngā rohe. Ki tā te nuinga o ngā hunga tangata, ko te whakapakarihia o ō rātou ake māramatanga ki te mātauranga Māori tētahi tino whāinga ā-rautaki, kei reira hoki he āwhina i te ārahi whakataunga, i te whakahaerenga, i te tikanga mātai anō hoki, me te takoha atu ki te nanakia e taea nei e te mātauranga Māori, kia waihangatia mai ai he tatauranga tika mā tēnei whakareanga.

He maha ngā kauwaka e kawe atu nei i tēnei mea i te Mātauranga Māori. E kōrero nei ngā mana whenua i ō rātou hiahia ki te whakamahinga o ngā taputapu wāhi ā-nuku hei whakakitenga atu i te mātauranga Māori i te taha o te raraunga pūtaiao, kia tautokohia ai ngā whakataunga ki ngā hua ā-taiao nei. I tēnei pepa, ka kōrerohia e mātou ko Takiwa, koia he Geo-spatial Visualisation Tool e whakatakoto nei i te papa whakatū mō Takiwa Lakes, e hāngai nei ki ngā kaupapa wāhi ā-nuku e toru. Kua whai hononga te taputapu ki ētahi kaitiaki, e tika ai te horopaki, ngā kiko, me te whakahaere o te mātauranga Māori i tōna papa whakatū. He tino take ēnei i tēnei wā e aro pū nei ngā ohu tangata kia nui ake te whakamahinga o te mātauranga Māori i ngā whakataunga. Ko te whāinga o ngā hononga kaitiaki ko te whakatinana ake i ngā mahere whakahaere mā roto anō i te whakamatihiko i ngā raraunga me ngā kōrero i ngā mahere, me te whakaatu i ērā i te taha o ngā raraunga pūtaiao. E whakamana nei tēnei papa whakatū i ngā mana whenua mā roto i te whakaatu i ngā tohunga pūtaiao pēnei me te kounga, te nui rānei o te wai (te wāwahi rānei) i roto i te horopaki o te raraunga mātauranga Māori, pēnei anō me ngā whenua hirahira ki te Māori me ngā mahinga kai. Heoi, he take whakatū pihi te whakamahinga o te mātauranga Māori i ētahi wā, nō reira me whai whakaaro ki te whakangungu i te mana, i te tūturu, i te ngākau tapatahi ā-ahurea nei anō hoki o ngā hapori ka whai wāhi mai.

Mātauranga Māori is the shared intellectual capital generated by whānau, hapū and iwi over multiple generations. It is community knowledge embedded in lived experience and carried in stories, song, place names, dance, ceremonies, genealogies, memories, visions, prophesies, teachings and original instructions, as learnt through observation and via other community members. Mātauranga Māori is a dynamic, innovative, and generative system of knowledge constituted from mātauranga ā-whānau, mātauranga ā-hapū, and mātauranga ā-iwi.

Mātauranga Māori is being defined, framed, and operationalised with varying success by a range of institutions. The general premise is that government agencies and regional councils acknowledge mātauranga Māori as Māori-specific knowledge that is adaptive and regionally distinct. For most institutions, improving their understanding of mātauranga Māori is an important strategic aim that can help guide their decision-making, management, and monitoring procedures as well as contribute to the innovative potential of Māori knowledge in order to create culturally appropriate data for this generation.

Mātauranga Māori is transmitted through a number of mediums. Mana whenua are expressing interest in how geospatial tools can visualise mātauranga Māori alongside science data to support decision-making for environmental outcomes. In this paper we discuss Takiwa, a geospatial visualisation tool that provides the platform for Takiwa Lakes, in relation to three geospatial initiatives. This tool has developed kaitiaki layers to provide an appropriate context, content and control of mātauranga Māori within its platform. These are critical factors as agencies focus

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on increasing the use of mātauranga Māori for decision-making. The aim of the kaitiaki layers is to bring iwi management plans to life by digitising the data and information within the plans and presenting them alongside scientific data. This platform empowers mana whenua by presenting scientific indicators such as water quality and quantity (e.g. allocation) within the context of mātauranga Māori data such as sites of cultural significance and mahinga kai. However, the use of mātauranga Māori can be a sensitive issue and it is important that consideration is given to protecting the cultural authority, cultural authenticity, and cultural integrity of the participating communities.

***Keywords**: Mātauranga Māori; Indigenous Knowledge; Traditional Knowledge; Geospatial visualisation; Mana Whenua; Takiwa tool; freshwater monitoring; cultural authority; cultural authenticity; cultural integrity*

Indigenous Knowledge

Every society, culture and language has developed its own knowledge system for describing the world grounded in traditional understandings and enriched through local experience and practical use. These knowledge systems are known by a range of terms including Indigenous Knowledge (IK), Traditional Ecological Knowledge (TEK), Traditional Knowledge (TK), and Local Ecological or Environmental Knowledge (LEK). Castellano (2000, p. 24), describes IK as knowledge that:

> *has been handed down more or less intact from previous generations. With variations from nation to nation, it tells of the creation of the world and the origin of clans in encounters between ancestors and spirits in the form of animals; it records genealogies and ancestral rights to territory; and it memorialises battles, boundaries, and treaties and instils attitudes of wariness or trust toward neighbouring nations. Through heroic and cautionary tales, it reinforces values and beliefs; these in turn provide the substructure for civil society.*

Embedded in lived experience and carried in stories, song, place names, dance, ceremonies, genealogies, memories, visions, prophesies, teachings and original instructions, IK is a shared-community knowledge (Smith *et al*. 2016). It has high intrinsic value and tends to be context-dependent and localised to particular communities, places and regions (see, for example, Berkes 1995, 2008; Cajete 1999, 2000; Grenier 1988; Houde 2007; Isaac 2015; Latulippe 2015; Menzies 2006; Reo 2011; Sillitoe *et al.* 2005; Smith *et al*. 2016; Wehi *et al*. 2009; Whaanga & Wehi 2015; Whyte, 2013).

IK is used interchangeable with TK and often reflects the positioning of the authors who 'operate under differing sets of assumptions and towards particular ends (Latulippe 2015, p. 118). While descriptions are not fixed or mutually exclusive, they tend to cluster in four general categories: ecological, critical, relational, and collaborative (Latulippe, 2015) (see Table 1).

Table 1. Typology of traditional knowledge (TK).

Orientations	Description
Ecological	TK supplements Western science, offering unique insights into ecological processes
Critical	TK is embedded in uneven, colonial relations of power
Relational	TK emphasises the relationship between knowledge, place, and practice, recognising the kincentric relationship with the natural world
Collaborative	TK holds a position of empowerment for Indigenous peoples that enable Indigenous peoples to create conversations, spaces, institutions, and mechanisms across knowledge systems in order to protect their own knowledge systems.

Mātauranga Māori

Mātauranga Māori has been defined as 'the unique Māori way of viewing themselves and the world, which encompasses (among other things) Māori traditional knowledge and culture' (Waitangi Tribunal 2011, p. 6). Mātauranga Māori is a cumulative body of knowledge that has accrued over millennia. It carries meaning for Māori communities as it continues to be applied and adapted to a variety of contemporary contexts (Durie *et al*. 2012; Smith *et al.*, 2016). There are many manifestations of mātauranga Māori from its historical origins in Polynesia to its evolution in Aotearoa (Royal 2009), and over the past 20 years the term has become:

> *increasingly important as more and more people are engaged in efforts to understand what it means. Put simply, the term refers to Māori knowledge. However, once efforts are made to understand what the term means in a wider context it soon becomes evident that Mātauranga Māori is a lot more complex. (Mead 2012, pp. 9-10)*

At an epistemological level Hardy *et al*. (2015, p. 48–49) present four overarching features of mātauranga Māori:

(i) *The interconnectedness of people and nature*: Whakapapa places Māori within an ecological sphere at the same level and linked to the natural world. A whole-of-system approach takes into account the human-ecology relationship and their influence on each other.

(ii) *Sacredness of nature*: All things have a life force of their own, and as such have their place in the order of things. All living things and natural resources are taonga derived from the supernatural world, which evokes ethical concepts of reverence for creation as a whole including kinship, and reciprocity.

(iii) *Guardianship/ kaitiakitanga*: Māori ancestral connections to the natural world confer the responsibility to sustain and maintain the well-being of people, communities, and natural resources. Kaitiakitanga is the active practice of spiritual and physical guardianship based on tikanga to support the wise management and care of natural resources.

(iv) *Intergenerational passage of knowledge*: Māori possess a rich knowledge of ecological systems and relationships with the natural world, accumulated through their long history of resource use in specific locales, spanning many generations. The inter-generational connections between people and nature is strengthened as mātauranga is passed down through generations, combining practice, knowledge, and belief systems.

Use of matauranga Māori in research

The interface of mātauranga Māori and science has become increasingly relevant as the Vision Mātauranga policy (VM) is being implemented across a range of research funders[1] in Aotearoa (MoRST 2007). At a practical level the interdis-

ciplinary interface provides opportunities for knowledge exchange, innovation, and the creation of both mātauranga Māori and science (Durie 2005; Hudson *et al.* 2012; Smith *et al.* 2013; Hikuroa 2016). Mātauranga Māori is gaining a more visible presence within the research environment, as it is being used in an increasing number of practical contexts to support environmental management and ecological restoration (Bernhardt *et al*. 2011; Uprety *et al.* 2012; Hudson *et al.* 2016; Landcare 2016). However, as researchers and institutions become more open to the potential value of mātauranga Māori, there are a number of important factors that should be recognised so that communities do not feel like their knowledges are being misappropriated (Whaanga *et al.* 2017; Williams *et al.* 2017)

1. ***Acknowledging contemporary relevance and application*:** Iwi partners value mātauranga Māori not only for its historic significance but its contemporary relevance.
2. ***Acknowledging cultural validity*:** Mātauranga Māori informs not only traditional practices but also Māori and iwi participation within Council activities.
3. ***Accepting epistemological difference*:** Mātauranga Māori brings a different value set and way of understanding phenomena to the table.
4. ***Acknowledging mana whenua responsibility for mātauranga Māori*:** The management and use of mātauranga represents a core responsibility of mana whenua.
5. ***Developing a more nuanced understanding of mātauranga Māori*:** Developing a more nuanced understanding of the different disciplines and content that exist under the broad definition of mātauranga Māori is necessary.
6. ***Exploring the interface of mātauranga Māori and science*:** Recognising the difference between science as a content, science as a process, and science as a community is vital for understanding mātauranga as a body of knowledge, mātauranga as a system of knowledge, and mātauranga as a community of knowledge.
7. ***Incorporating mātauranga Māori within institutional workstreams*:** Institutions have a diverse range of responsibilities and programmes of work which are expected to incorporate mātauranga Māori. Relationships with mana whenua, recognition of cultural intellectual property, and processes of knowledge management are all significant issues that should be addressed in partnership with mana whenua.

A key consideration for using mātauranga Māori is understanding that it is a body of knowledge comprising a range of different types of knowledge. The usefulness of any particular type of knowledge or specialist disciplinary information will depend on its relevance to the activity being undertaken. The table below outlines the how different dimensions of mātauranga Māori could align with different components, for example, in a freshwater management regime (Hudson *et al.* 2016a).

Table 2. Dimensions of mātauranga Māori relevant to freshwater management.

Governance	Treaty relationships, *mana whenua* status
Goals	Māori values, *whakataukī*, Māori environmental concepts
Objectives	Māori aspirations, historical accounts, Māori conceptual frameworks
Actions	Traditional Ecological Knowledge, cultural management practices, Māori modelling tools
Limits	Traditional Ecological Knowledge, Cultural protocols (*Tikanga*), Māori assessment frameworks
Monitoring	Cultural indicators (*Tohu*), Māori monitoring tools

Implementation challenges

Knowledge translation, dissemination, implementation, and uptake are becoming increasingly important to transitioning innovative research into policy and practice. The institutional drivers, such as VM, for incorporating mātauranga into research, policy, and/or decision-making processes arise in part from Treaty responsibilities with mana whenua. Mana whenua is a term used to describe hapū or Iwi with decision-making rights and kaitiaki responsibilities across specific areas and domains in the environment. Relationships with mana whenua require a better understanding of mātauranga Māori both to support the interface with science and its use within decision-making. This context creates specific implementation challenges to ensure programmes are delivered in a culturally appropriate manner, maintain their social licence[2] and their cultural licence[3]. Key elements of a recently developed implementation framework for Māori communities are community engagement, cultural centred approach, systems thinking, and integrated knowledge translation (Oetzel *et al.* 2017). The components of the framework are consistent with kaupapa Māori approaches and enhance implementation by prioritising both mātauranga Māori and rangatiratanga (self-determination). The core implementation challenges that have emerged from efforts to incorporate mātauranga Māori into policy and practice are:

1. **Ethics of engagement:** ensuring engagement processes are consistent with cultural expectations and ethical codes.
2. **Māori data sovereignty:** recognising the inherent rights and interests that Māori collectives have in mātauranga Māori and Māori data, and the importance of Māori governance of Māori data.
3. **Knowledge management:** having clear processes and rules about the collection, storage, and use of mātauranga Māori, especially secondary use.
4. **Modelling with mātauranga**: ensuring participation of any communities that use their mātauranga as inputs into modelling exercises. (Hudson *et al.* 2017)

[1] Royal Society of New Zealand, https://royalsociety.org.nz/what-we-do/funds-and-opportunities/marsden/application-process/submitting-a-proposal/vision-matauranga/; Health Research Council, http://www.hrc.govt.nz/funding-opportunities/maori-development; MBIE, https://www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/vision-matauranga-policy/

[2] Ability of an organisation or industry to undertake business in a socially and environmentally acceptable way with confidence from society (MPI 2017).

[3] Ability of an organisation or industry to undertake business in a culturally acceptable way with confidence from Māori Treaty partners and iwi (MPI 2017).

Actively planning for these implementation challenges is vital for building trust and accountability into relationships with mana whenua and ensuring mātauranga is used in ways that maintain;

- te mana o te tangata (cultural authority),
- te wairua o te korero (cultural authenticity), and
- te mauri o te kaupapa (cultural integrity).

Case studies

Muaūpoko geospatial platform

Located in the western side of the Rimutaka and Tararua ranges to Te Whanganui-a-Tara (Wellington), Porirua, Kapiti Coast, Horowhenua, Manawatu to Rangitikei, Muaūpoko are the descendants of Tara, the eponymous ancestor of the Ngāi Tara tribe. Muaūpoko developed as a separate and unique iwi over time and established its own hapū, areas of occupation, use and access to resources from this region (Muaupoko Tribal Authority 2015–2017). One of the key sites of significance within the rohe is Punahou or Lake Horowhenua.

As part of a programme of monitoring and restoration, the Muaūpoko Iwi Authority developed a project, funded by Te Wai Māori Trust, to build a cultural indicators framework. The framework was to identify relevant targets and indicators that support the Trust and Muaūpoko to lead the restoration, maintenance, and preservation of their lakes and rivers. While numerous data-sets and indictors exist in the scientific communities and with regional councils and government, there are very few documented indicators that help to articulate the cultural values that are important to iwi.

The project made use of the Takiwa Geospatial Platform to organise the range of public and private datasets that the iwi identified as being relevant to freshwater decision-making. The geospatial platform provided easy access to the wide range of publically available datasets as well as the ability to store restricted datasets including mātauranga Māori. A series of workshops were conducted with kaumātua and mana whenua to identify cultural values and other dimensions of mātauranga Māori. Organising mātauranga in a way that both made sense to the iwi and was coherent in the context of the scientific data was an important step. Aligning iwi observations and narratives with indicators and models to support Muaūpoko-based decision-making was a key step. Not only was this consistent with the data–information–knowledge–wisdom framework (Mercier *et al*. 2012), it also built on a proposed organisational schema for layers relating to *mana* (cultural sites of significance – consistent across time and space), *mauri* (cultural indicators – vary across time and space), and *wairua* (cultural aspirations – reinforce identity across time and space). This schema is illustrated in Figure 1.

Tapuika: The importance of creating new Māori data

Tapuika is a tribe of Te Arawa that extends from coastal Western Bay of Plenty inland towards Rotorua. Its interior boundaries were formed as the *tupuna* Tia made his way inland discovering the Lake Taupō nui a Tia. His son Tapuika remained in the lands and, through *noho tuturu*, Tapuika claim *mana whenua* and *mana moana*. The Tapuika Claims Settlement Act 2014 created the Te Maru o Kaituna River Authority as 'a co-governance partnership mandated to restore, protect and enhance the environmental, cultural and spiritual health and well-being of the Kaituna River' (Bay of Plenty Regional Council, BOPRC 2019). Protecting and enhancing the wellbeing of the Kaituna river is a core responsibility of the Tapuika Iwi Authority and as a consequence they have engaged in research relationships and projects to better understand and coordinate scientific data and mātauranga about the health of the river (Waiti *et al*. 2017a & b). This included projects investigating current

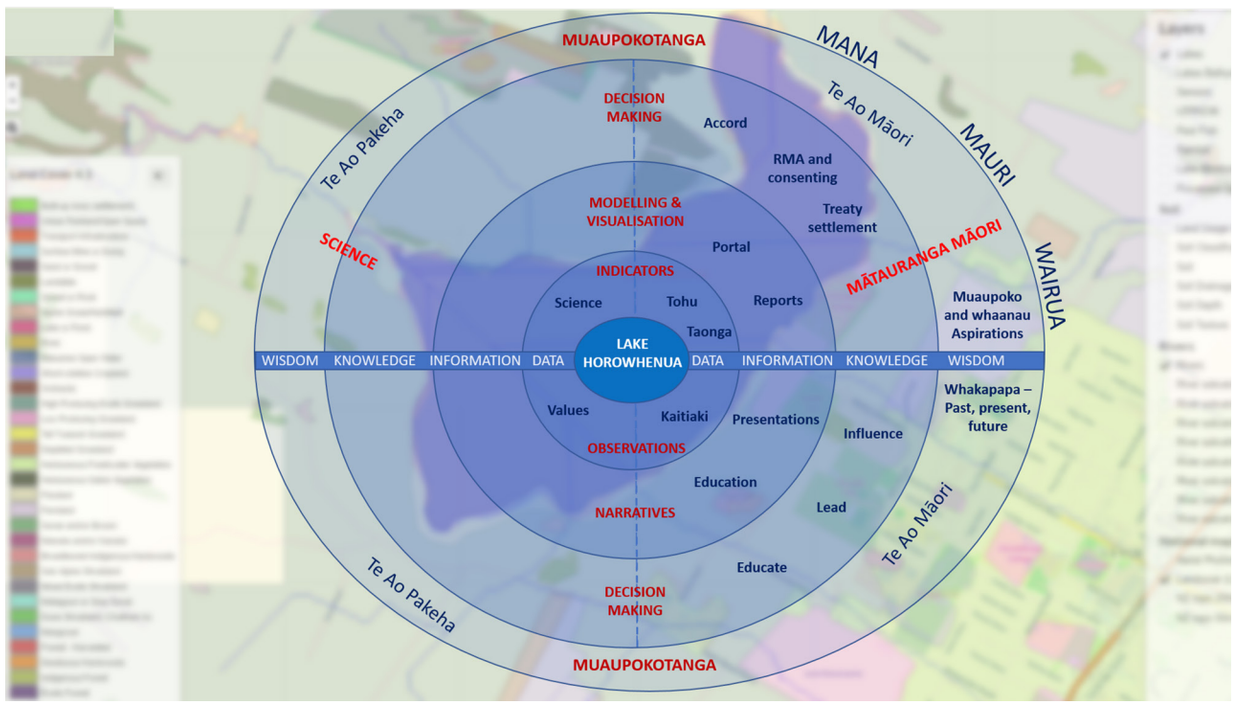

Figure 1. Muaupoko framework for a geospatial platform.

monitoring and historic data for five sites on the Kaituna river (see Table 3), in addition to Tapuika mātauranga (described thematically in Table 4).

Table 3. Attributes monitored by BOPRC each month at five different sites along the Kaituna River.

Dissolved oxygen	Flow	Specific conductivity
Temperature	Turbidity	Calcium
Suspended solids	Magnesium	Dissolved reactive phosphorus
Biochemical oxygen demand	pH	Ammonium
Potassium	Total Kieldahl nitrogen	*Enterococcus*
Chloride	Sulphate	Total phosphorus
E. coli	Faecal coliforms	

(Waiti *et al*. 2017b)

Alongside the research projects a decision was made to make use of the Takiwa geospatial platform to visualise a range of scientific data as well as Tapuika-specific mātauranga. The project team realised that, while Tapuika members retain important knowledge about their *whenua* (land) and *awa* (river), much of it was historical and experiential. As this mātauranga is in a different format to the scientific monitoring data, visualisation and analysis of the two forms of information alongside each other is more challenging. As a result, the team has since been working with Landcare Research to adapt a Kaupapa Māori Assessment Tool for Wai Ora Wai Māori. The tool is made up of '*qualitative and quantitative measures for stated attributes consistent with the National Objectives Framework (NOF) bands for assessing and reporting standards and condition of selected attributes*' (Landcare Research, 2016). The aim of this new component is to ensure that more consistent and regular mātauranga-based observational data can be collected and analysed alongside the scientific monitoring data.

Mahaanui Kurataiao: Visualising an Iwi Environmental Management Plan and collecting freshwater data

Mahaanui Kurataiao (MKT) is the environmental management unit for the *rūnaka* based around the Greater Canterbury region. As part of a project to better understand the groundwater resource MKT worked with Waiora Pacific to utilise the Takiwa geospatial platform and adapt it to locate scientific datasets within an *atua* (diety) based framework aligned to the Mahaanui Iwi Management Plan (Jolly & Nga Papatipu Runanga Working Group, 2013). In addition to visualising various publicly available datasets they have been able to add additional data about consents across their rohe (region) including volumes and lengths of each consent. This has provided the foundation for increasingly sophisticated analyses of water allocation and use and how this relates to issues of water quality for Te Waihora and the wider catchment (see Figure 2).

Discussion

As access to data increases, the way in which that data is contextualised and visualised is important. Framing data within an iwi worldview allows iwi to make sense of different types of data whether it emerges from a scientific inquiry or a mātauranga-based inquiry. The brief descriptions of the case studies outlined above demonstrate how mana whenua have orientated the scientific datasets within iwi value-based frameworks, layering them alongside mātauranga-related content. Each iwi chose a framework which made sense to their context, and subsequent discussions have been held to see whether it is possible to switch views between different contextual frameworks to allow iwi to consider the data through a different lens (i.e., capitals approach v. mana whenua approach).

Table 4. Definitions of themes for Tapuika mātauranga.

Theme	Definition
Kaupapa	Principles and values that guide the management and usage of mahinga kai.
Tāngata	Iwi members who use, co-manage, and co-govern mahinga kai resources.
Tuku Iho	Using the past to inform the future. Significant historical kōrero, text, whakataukī (proverbial sayings), etc., that describe a past environmental state.
Take	Issues that impact the health and well-being of mahinga kai.
Tikanga	Practices and methods implemented in the field by kaitiaki and kaimahi (those doing the work).
Whakakitenga	Field observations by experienced kaitiaki and kaimahi (those doing the work).
Tohu	Signs and indicators used to interpret and monitor what is happening in the environment.

(Waiti *et al*. 2017a)

In each case researchers have been working with iwi to visualise different sorts of Māori content. They have used the concepts of *mana*, *mauri*, and *wairua* to conceptualise different types of content that can be generated from mātauranga Māori. Content in the *mana* domain relates to cultural sites of significance that represent the ongoing associations (both spiritually and culturally) that iwi have with their environment. Content in the *mauri* domain relates to assessments of the state of the environment (i.e., cultural health indicators). Content in the *wairua* domain relates to the historic associations with place, and how these can inform restoration activities to enhance relationships with the environment. Mātauranga tends to be information rich but data poor, so the generation of new Māori data is necessary for enhanced monitoring and modelling. Tools like *Cultural Health Indicators* (Tipa & Tierney 2006) or the *Wai Ora Wai Māori App* (Awatere *et al*. 2017) support the collection of new Māori data.

However, as the use of mātauranga Māori can be a sensitive issue for mana whenua groups, it is important that consideration is given to protecting the cultural authority, cultural authenticity, and cultural integrity of the participating communities. Few organisations have specific policies or protocols in place to manage the collection, use, and management of mātauranga Māori, a situation which contributes to the discomfort experienced by mana whenua groups. Recent literature around Māori data sovereignty has focused iwi attention on the need to establish clear protocols around the secondary use of data (Kukutai & Taylor 2016; Hudson *et al.* 2016b). It is important that discussions and agreements are made with mana whenua groups that clarify these boundaries and responsibilities so that information can only move from private spaces to public spaces with appropriate permissions. Data access should be determined

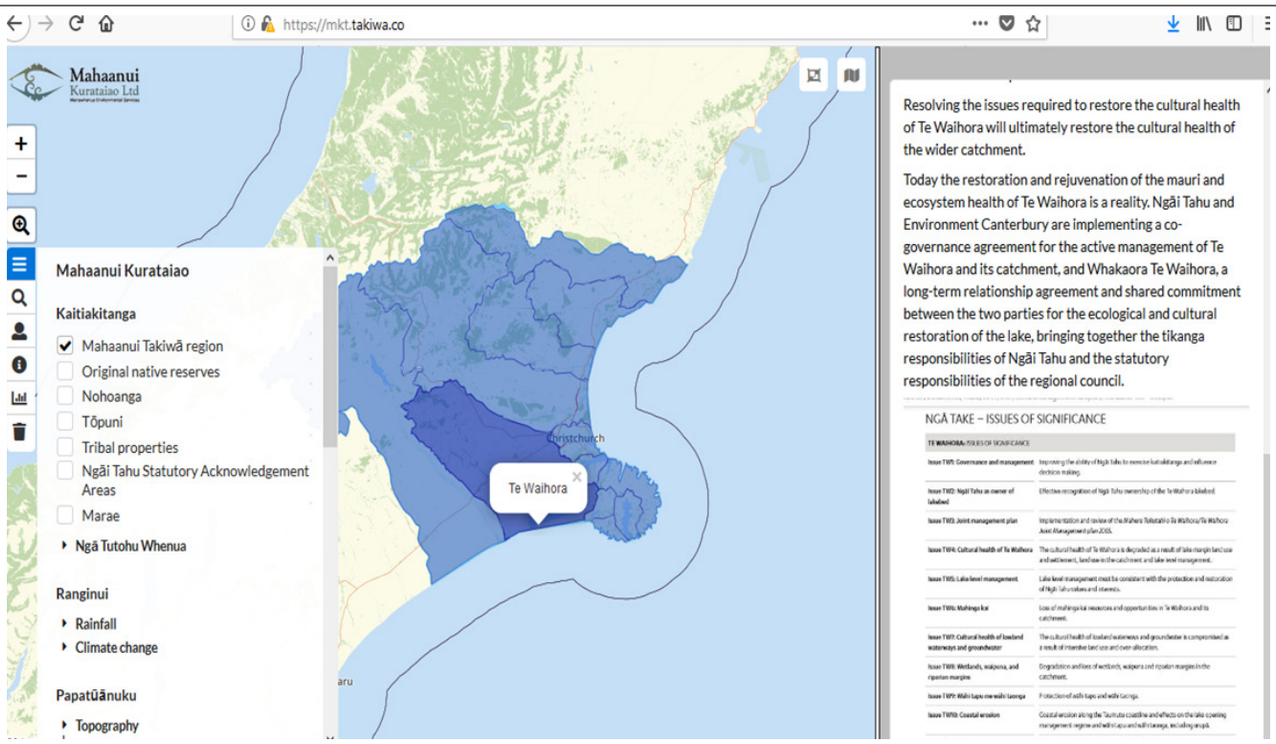

Figure 2. Screen capture from Mahaanui Kurataiao.

by the owner/provider of the data and managed by a mandated kaitiaki.

Data management is not a term normally associated with mātauranga Māori (Whaanga & Wehi 2015). Nonetheless, as the knowledge economy continues to grow and society shifts towards open data environments we have to be much smarter about creating tools that will allow us to utilise mātauranga Māori in culturally and ethically appropriate ways (Boulton *et al*. 2014; Hudson *et al.* 2018). Data infrastructures will only be useful if we have the ability to adequately use them so improving technical skills and building capacity in this key area will be an important activity. Similarly, Māori communities have to assume responsibility for the governance of data (both mātauranga-based and science-based) and sustain a 'response ability' around data for governance if we are to shift our capacity to use mātauranga Māori and Māori data from a 'reactive inquiry' space to a more proactive one focused on creating insights and initiatives.

Conclusion

Mātauranga Māori was traditionally transmitted through a number of mediums. Now mana whenua are expressing interest in how geospatial tools can visualise mātauranga Māori alongside science data to support decision-making for environmental outcomes. The key challenges for iwi entities in making their mātauranga Māori more readily accessible and usable is to develop platforms that provide the appropriate context, content, and control over the use of mātauranga Māori.

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Weaving mātauranga into environmental decision-making

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Abstracts

Ko te pūtaiao me te taunaki te tūāpapa o ā Environmental Protection Authority (EPA) whakataunga. Kua whakataurangi ake a EPA ki tētahi kaupapa mahi tau tini nei e aro pū ana ki ngā huarahi kia whītiki tauātia ai te mātauranga Māori taketake nei ki āna tukanga whakataunga. Mātua rā, me whai i te mārama kehokehotanga ki ngā kaupapa o roto, me ngā hīraunga ka pā ki ngā tukanga whakataunga a EPA. Ko te whāinga ia, kia tuia te māramatanga ki te mātauranga ki ā EPA mahi o te ia rā, me te whakakaha i ngā houruatanga Māori anō hoki. Kua whātoro atu a EPA i runga i ōna ake hiahia ki Ngā Kaihautū Tikanga Taiao – koia ko te kōmiti tohutohu Māori ā-ture nei o EPA, ki Te Herenga – koia ko te whatunga kaitiaki o ngā takiwā e hāpaitia nei e EPA, ki Ngā Parirau o te Mātauranga anō hoki – koia ko te kāhui kaumātua kua kōwhiria mai i te whatunga o Te Herenga. Ko tētahi tino wāhanga ā-mahi nei o tēnei kaupapa mahi o te mātauranga ko te waihangatia o tētahi mahere hei whakamahi mā ngā kaiwhakatau, kia aromātaihia te pono o te mātauranga ka whakatakotoria ana hei taunaki. Ka kōrero tēnei pepa i tā EPA haerenga kia rite ai ki te waihanga mai i tētahi mahere mātauranga.

Science and evidence form the foundation of decision-making at the Environmental Protection Authority (EPA). The EPA has committed to a multi-year mātauranga work programme that focuses on ways of weaving mātauranga, indigenous knowledge, into its decision-making processes. The first step is to develop a deeper understanding of the concepts involved, and their implications for the EPA's decision-making processes. The aspiration is to weave an understanding of mātauranga into the daily work of the EPA, and to build on Māori partnerships. The EPA has engaged proactively with Ngā Kaihautū Tikanga Taiao, the EPA's statutory Māori advisory committee; Te Herenga, the EPA-supported kaitiaki network centred in the regions; and Ngā Parirau o te Mātauranga, the kaumātua group drawn from the Te Herenga network. One of the most critical strands of work of the mātauranga work programme will be to create a mātauranga framework for decision-makers to use to examine the veracity of mātauranga when presented as evidence. This paper explores the EPA's journey towards being ready to create a mātauranga framework.

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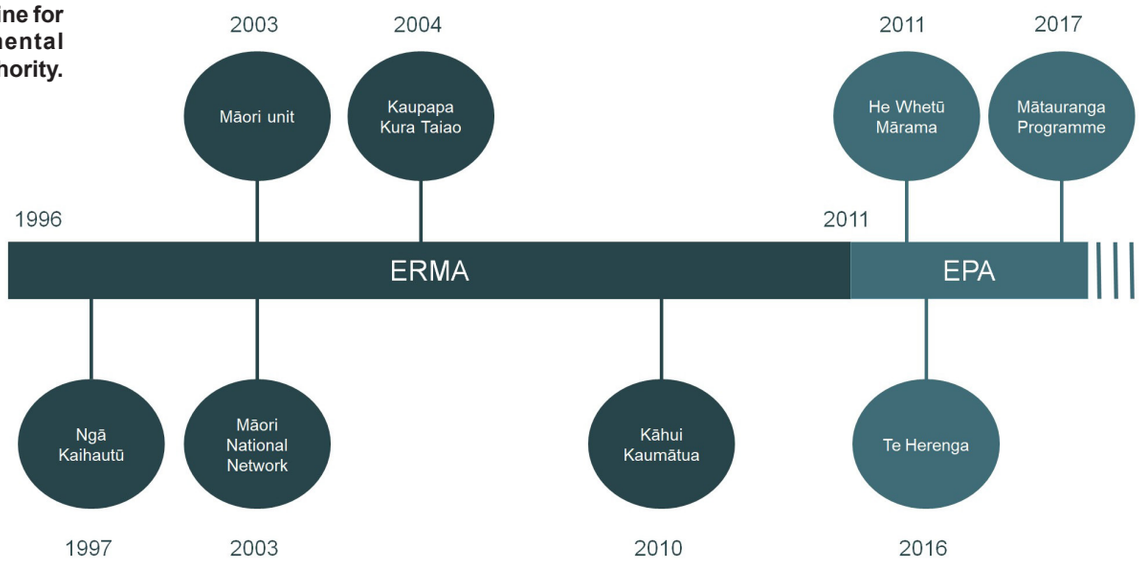
Figure 1. Timeline for the Environmental Protection Authority.



Introduction

Mātauranga[1] is broadly defined as a body of knowledge, experience, values, and philosophy of the indigenous peoples, Māori, in Aotearoa, New Zealand.[2,3] Mātauranga can be described as 'the pursuit of knowledge and understanding of Te Taiao (the natural world), following a systematic methodology based on evidence, incorporating culture, values and worldview'.[4] The development of cultural models and frameworks that incorporate indigenous knowledge and science are increasingly used to inform environmental management, policy, processes, and decision-making.[5,6]

Te Tiriti o Waitangi, The Treaty of Waitangi, has provided a foundation for recognising the rights and interests of Māori, which is reflected in national legislation. Understanding and realising how to best give effect to Māori rights and interests has taken considerable time and resources for agencies and institutions to grasp.[6]

In the broader context, the incorporation of mātauranga into environmental decision-making has largely been driven from rights-based environmental pressure by Māori largely based around the Resource Management and Local Government Acts,[7] a growing recognition and understanding of Māori rights and interests by institutions and agencies,[6] and, as a means to inform sustainable environmental management, using a more holistic understanding of the relationships among Te Taiao.[4]

The Environmental Protection Authority New Zealand (EPA) has commissioned a multi-year mātauranga work programme which focuses on weaving mātauranga into its decision-making processes. The EPA is a government agency responsible for regulating activities that affect Aotearoa New Zealand's environment, while balancing social, economic, cultural, and environmental factors.

The EPA recognises the unique relationship of Māori with the environment in Aotearoa New Zealand, their place as the people of the land, tangata whenua, and the important role they play in New Zealand's economic, environmental, social and cultural wellbeing.[8] The EPA also recognises that, as land managers, owners, guardians, and governors of significant natural resources, Māori contribute a range of knowledge, skills, and experience, which, through the incorporation of mātauranga, are invaluable to robust and effective decision-making and provide for a holistic approach to environmental management.

This recognition is not new; an evolving discussion on the relationship of Māori to the environment has occurred over many years between the EPA (and its predecessor, the Environmental Risk Management Authority), Ngā Kaihautū Tikanga Taiao ('Ngā Kaihautū').9 Te Herenga, a network of Māori environmental practitioners centred in the regions and Ngā Parirau o te Mātauranga ('Ngā Parirau'), the kaumātua (elders) group drawn from within Te Herenga.

In recent years, the EPA has taken further steps to help decision-makers and staff incorporate Māori perspectives into their work. This includes *He Whetū Mārama*, developed in collaboration with Ngā Parirau, a framework that provides EPA staff with guidance on how to meet the EPA's statutory and other obligations towards Māori. The vision of this framework provided the foundation statement for the EPA strategy. The strategy also includes a strategic intention to *increase the trust of the nation, Māori, and business through decision-making based on science, evidence, mātauranga, and risk assessment.*[10]

In collaboration with Ngā Kaihautū the EPA has also developed the *Incorporating Māori Perspectives into Decision-making* protocol to help decision-makers incorporate Māori perspectives appropriately into decision-making.

The mātauranga work programme is the next step in the evolution of the EPA towards an organisation that better understands and values Māori perspectives and mātauranga. The EPA formally committed to its mātauranga work programme in 2017. The programme aims to increase the understanding of mātauranga across the EPA, enable well-informed decision-making and support the EPA to understand the issues, implications and benefits that mātauranga raises for the EPA's decision-making processes.

This paper provides an overview of the EPA's journey (Figure 1) in weaving mātauranga and science in environmental decision-making, using a *Waka Hourua-partnership* approach in line with the Te Tiriti o Waitangi, Treaty of Waitangi principles in the EPA's He Whetu Mārama framework and organisational strategy. It also explores the EPA's key findings and lessons learned to help inform others embarking on a similar journey.

Example 1. Pūrākau represent a type of codified mātauranga Māori[12,13]

One example of mātauranga relevant to the EPA is taniwha, which can mean different things to different whānau, hapū and iwi. A common widespread understanding is that taniwha are kaitiaki, guardians. When used in that sense, as kaitiaki, taniwha serve as a warning of danger. In 2002 the Waikato expressway was being constructed. Ngāti Naho expressed concerns that a section near Meremere would encroach upon the lair of Karu-tahi, a taniwha. After consultation with Transit New Zealand the section was re-designed and the route slightly altered. Almost 14 months after construction, a flood inundated the lair of Karu-tahi, but the re-design ensured that the expressway was not threatened. In this case, it can be argued that Karu-tahi is an explanation of observed potentially dangerous flooding events, explained according to a Ngāti Naho worldview. Heeding Karu-tahi, as Transit New Zealand did, is a form of risk reduction and accordingly it acted as guardian of the expressway.

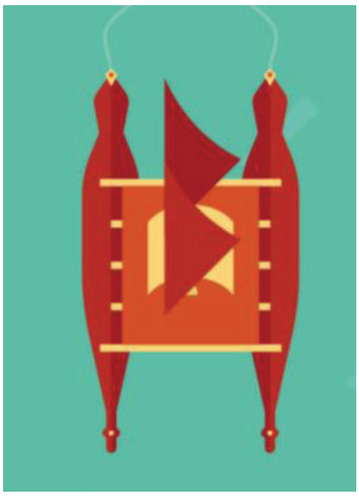
Weaving mātauranga and science

The EPA has decision-making powers under two pieces of legislation, the Hazardous Substances and New Organisms Act 1996 (HSNO), and the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ).[11] Decision-making powers are delegated to either individuals, or committees of decision-makers. EPA decision-makers rely on evidence, amongst other things, to help them form a view on all of the issues contributing to a decision they have to make, including both scientific and mātauranga evidence.

As an environmental decision-maker the EPA considers both mātauranga (Example 1) and science in its decisions and day-to-day work. It was noted by a kaumātua on Ngā Parirau, that decision-makers and staff are capable and confident to query, test, and assess matters pertaining to science; metaphorically, they are able to turn over the stones of familiar knowledge systems. By comparison, their ability to turn over the stones of mātauranga is limited. In order to enable a partnership approach, decision-makers and staff need to be able to turn over the stones of both mātauranga and science to make better-informed decisions.

Building on conversations with Ngā Parirau, it was identified that there was no clear pathway or framework for decision-makers to effectively assess mātauranga when it is presented as evidence, and that there could be greater understanding within the EPA of what mātauranga is and its relevance. In addition, there was limited understanding that mātauranga as a knowledge system has its own veracity and rigour – rather, any testing or probing of mātauranga tended to be from the frameworks that decision-makers were familiar with. Furthermore, at various hui over a number of years, Te Herenga members have frequently raised concerns about thepotential for third parties to misuse mātauranga in ways which could compromise its integrity. While the EPA has no evidence of this happening, we acknowledge the importance of building trusting relationships between kaitiaki (guardians), regulators such as the EPA and third parties.

Figure 2: Image of a waka hourua.



Ngā Kaihautū and Ngā Parirau have discussed with the EPA to aspire to a paradigm where evidence from a mātauranga knowledge system is capable of being given equal weight to evidence from a science knowledge system, and where the veracity and rigour of mātauranga is evaluated from a mātauranga framework.

In 2016 the EPA's Chief Executive, Dr Allan Freeth requested that Kaupapa Kura Taiao, the Māori Policy and Operations unit at the EPA, develop a work programme to increase the understanding of mātauranga across the EPA and to ensure that understanding of mātauranga becomes embedded as business-as-usual.

Complementary to this request, significant investment was made into concurrently increasing Māori capability across the organisation. The investment was matched by an enthusiasm of EPA staff to understand Māori worldviews and engage with mātauranga, including though te reo Māori and waiata. The culture change and commitment within the EPA as a result was recognised in 2018, when the EPA was a finalist in the government category for the Ngā Tohu Reo Māori awards.

The EPA has adopted a partnership approach based on the concept of a waka hourua to ensure that the mātauranga work programme draws from both knowledge systems, mātauranga and science, and is developed in a way that aligns with the mutual aspirations of Ngā Kaihautū, Te Herenga, Ngā Parirau and the EPA. We refer to this as the Waka Hourua-partnership approach to recognise that both knowledge systems are vital to understanding of what is needed to protect and foster our New Zealand way of life.

A Waka Hourua–partnership approach

The Waka Hourua, a doubled hulled canoe (Figure 2), is the symbol of the EPA's mātauranga work programme. The two hulls represent two knowledge systems, mātauranga and science working and moving together in the same direction. The analogy of woven sails represents the information, evidence, advice, and risk assessment that inform EPA decisions. This approach will enable the weaving of mātauranga and science through the use of a mātauranga framework (potentially a series of respectful questions) that will sit alongside frameworks already familiar to decision-makers. In combination, decision-makers will be able to test, probe, and weigh evidence using the most appropriate

framework for the knowledge system. This will acknowledge the contribution both knowledge systems make towards environmental management and recognise the privilege it is to receive both.

A critical aspect of successful navigation is to have a clear image of one's destination before embarking on a journey.[14] The EPA is guided by Ngā Kaihautū and Te Herenga and together provide leadership to encourage and explore the place for mātauranga within EPA decision-making processes. Te Herenga supports the EPA's moves to improve the effectiveness of Māori engagement in EPA decision-making.

In adopting the Waka Hourua–partnership approach, the EPA places a high level of importance in having the trust and confidence of Māori. The aim of the approach is to ensure that the aspirations for improved Māori participation in EPA processes and understanding of mātauranga by EPA decision-makers that have been discussed with Ngā Kaihautū and Te Herenga over a number of years are realised. A way to do this, and to maintain the integrity of the programme, is to ensure that relationships fostered over many years continue to be honoured.

Key findings

The experience of the EPA has led to the conclusion that successful development of a mātauranga work programme that weaves mātauranga and science into decision-making involves two key components working together.

First, weaving mātauranga and science into decision-making requires an alignment of aspirations, willingness, and expertise between all parties involved.

Second, the Waka Hourua-partnership approach needs to ensure that the programme maintains the alignment of the aspirations and expectations of Ngā Parirau, Ngā Kaihautū, Te Herenga, and the EPA. Both components acknowledge the critical role that everyone has in creating a well-rounded, robust, and rigorous programme which has the ability to weave two worldviews. This will be tested as the EPA moves towards implementation of its mātauranga work programme.

Alignment of aspiration, willingness and expertise were key elements to success

In order for the EPA to embark on the journey of weaving mātauranga and science into its decision-making processes, there needs to be an alignment of aspiration, willingness, and expertise between all parties involved. For the EPA, the Waka Hourua partnership approach enables aspirations of Ngā Kaihautū, Ngā Parirau, and Te Herenga to be set for mātauranga that aligns with the willingness and courage of EPA leadership to formally adopt and invest in a multi-year mātauranga work programme.

The willingness also extended to the EPA staff who were eager to learn more about Māori worldviews and perspectives, to incorporate into their own day to day work. The investment by the EPA to increase Māori capability alongside the willingness of staff, and the culture change as a result should also be acknowledged in terms of alignment. The role of Kaupapa Kura Taiao in maintaining open communication and incorporating feedback on the programme, while increasing Māori capability within the organisation is important.

A Waka Hourua–partnership approach is required to weave two knowledge systems into decision-making

The Waka Hourua partnership approach is broader than weaving together two knowledge systems in and of themselves. For this to be successful, the design of, and communication about, the mātauranga work programme needed to ensure all partners, Ngā Parirau, Te Herenga, and Ngā Kaihautū, were successfully brought on this journey. In addition, the tikanga guidance provided by these partners has been essential to enabling the EPA to embark on this journey with cultural integrity. In the development of the mātauranga work programme, Kaupapa Kura Taiao focused on maintaining open lines of communication in multiple directions: with Ngā Parirau, Te Herenga, Ngā Kaihautū, and EPA governance, leadership and staff. A deliberate balance is maintained throughout to ensure that all parties involved could see their views reflected in the programme. Similarly, Kaupapa Kura Taiao is responsible for ensuring that the programme stays on track, delivers on the aspirations of Māori for mātauranga, and has integrity from a tikanga perspective.

An effective strategy to bring EPA leadership, governance, and staff on the journey of creating a programme that weaves mātauranga and science into decision-making is to demystify mātauranga, making concepts relatable and building connections between different worldviews. Ngā Kaihautū impressed upon the EPA that mātauranga has its own unique characteristics, which are different from, but equally valid to, other forms of knowledge (e.g. conventional science). Mātauranga has been disregarded by some due to a perception that it is myth and legend. when in fact mātauranga knowledge can be generated using techniques that are consistent with a scientific approach, but explained according to a Māori worldview.

The EPA has facilitated a number of presentations and symposia to expose its staff and leadership to academics, scientists, and thought-leaders who have a depth of experience and understanding of mātauranga. For Māori scientists, there is a critical role in communicating the interface between mātauranga and science. Ngā Kaihautū also has direct engagement with the EPA Board and staff to provide advice at governance and operational levels.

Next steps

The EPA has prioritised the development of a proposed mātauranga framework to help decision-makers understand, test, and probe the veracity of mātauranga when presented as evidence. This will be the focus of the next phase of the mātauranga work programme. It will require an understanding of the EPA's current legislative requirements as a baseline of what we must do, and conversations on the appetite of the organisation to move beyond those requirements to successfully implement such a framework. Implementation of the mātauranga framework will require investigation into EPA processes which are critical to encourage the transmission of mātauranga evidence, as well as, cultural capability building of EPA decision-makers and staff to use the framework and understand the concepts being presented as evidence.

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Dismantling Cook's legacy: Science, migration, and colonialism in Aotearoa

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Abstracts

I Aotearoa nei, ko te tau 2019 tērā i tohu mai kua 250 tau i te taunga mai o Kāpene James Cook, i runga i te Endeavour, i tana haerenga ki te 'rapu mātauranga pūtaiao'. Kia whakanuia ai taua kaupapa, i tuku ngā kāwanatanga, ā-motu, ā-rohe anō hoki, i te $23 mīriona neke atu hei whāngai i ētahi anō kaupapa, ko tētahi ko te kāhui waka i haere ai ki ngā wāhi hirahira o te motu. Hākoa te hiahia o ngā kaiwhakahaere kia maumaharatia ngā 'hononga tuku iho', otirā ko ngā tūtakihanga o mua a te Māori me te Pākehā (Manatū Taonga 2018), tino kore nei te nuinga o ngā hapori Māori i hurō i te kitenga ake o te tāruatanga o te Endeavour i te paerangi. I kaha te whakahēngia o te kaupapa whakamaumahara i tōna wairua whakatarapī, ka mutu i ngā mahi kino rawa atu a Cook nōna i konei (arā, ko te kahaki, me te kōhuru i ētahi Māori; tirohia tā Ranford 2018). Ko tō Cook noho ki Aotearoa tētahi tino wānanga mō te whakakotahitanga mai o te pūtaiao, o te nuku tangata, o te whānako whenua anō hoki i tēnei motu. Mā tēnei tuhinga, ka taki ahau i te hītori o te pūtaiao me te nuku tangata i Aotearoa (mai i te taunga mai o ō ngā Māori o nāianei tūpuna tae noa ki te taunga mai o te Pākehā, ā neke atu), ka kōrero hoki he pēhea ngā kaupapa here me te pūtaiao o nāianei, ā-nuku tangata nei, i te inenga o ngā hua ki te ōhanga i tēnā o ngā tūraru e whakapaengia nei ka puta i ngā rāwaho kua whakaiwingia, me te huna tonu i ngā hanganga kaikiri whānako whenua nei i tūāpapa ai i a Niu Tīreni, ka mutu ka tohu i ētahi huarahi hou o te rangahau ā-pūtaiao i te nuku tangata ā haere ake nei.

In Aotearoa, 2019 marked the 250th anniversary of the arrival of Captain James Cook, aboard the Endeavour, on its voyage of 'scientific discovery'. To mark the occasion, central and local governments commited over $23 million to fund events including a flotilla that travelled to sites of significance around the country. While organisers intended to commemorate our 'dual heritage' and in particular the early 'encounters' of Māori and European peoples (Ministry of Culture and Heritage 2018), the sight of a replica Endeavour on the horizon was not a cause for celebration for many Māori communities. Strong objections to the commemorations were raised because of the imperial intentions and violent actions of Cook while here (which included abducting and murdering Māori; see Ranford 2018). Cook's presence in Aotearoa is an interesting case study of how science, migration, and colonialism have converged in this country. In this essay, I sketch a history of science and migration in Aotearoa (from the arrival of the ancestors of modern Māori through to the advent of the European and beyond), and outline how migration policy and contemporary migration science weigh economic benefits against the presumed 'risk' posed by racialised migrants while obscuring the racist settler–colonial structures New Zealand was founded on. I suggest new pathways for the scientific study of migration to move forward.

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Science and migration

In Aotearoa, the story of science *is* the story of migration. The ancestors of modern Māori, through science and innovation, constructed the fastest seafaring vessels in the world (Walker 1994), the waka hourua, and through their extensive knowledge of ocean environments, of swells, of weather systems and atmospheric conditions, of marine life, and of astronomy, were able to navigate the largest ocean in the world –Te Moana nui a Kiwa – and populate every major island throughout (see Howe 2003). In doing so, our ancestors created the largest 'culture sphere' in the world, spanning 25 million square kilometres, and occupying approximately one-fifth of the Earth's surface – at a time when European ships were 'still hugging the coastlines of continents for fear of the open ocean' (Davis 2009, p. 41).

On reaching Aotearoa, our ancestors encountered an environment vastly different from the tropical islands they had formerly called home. Once again, they applied scientific rigour as they migrated throughout these islands, studied the natural environment, and adapted the culture and technologies they brought with them from tropical East Polynesia to allow them to thrive in much cooler climes (see Walker 1994). Within a relatively short time, Māori had explored the length and breadth of Aotearoa, naming and categorising new species of flora and fauna as they went, and had found uses for all the raw materials that would continue to be to be of value for the next five hundred years (Adds 1998).

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The story of science is the story of migration for Pākehā in Aotearoa too, as migration provided Pākehā with opportunities to develop and exchange knowledge. The first European explorer to reach these shores was the Dutchman Abel Tasman in 1642. However, the only thing that was exchanged in this encounter was blows (Belich 1996). The next invader was Captain James Cook, who arrived aboard the *Endeavour* in 1769. Although framed as a mission of 'scientific discovery', the presence of the *Endeavour* in our part of the world was more about empire-building than science, and is seen today as the antecendent of British colonisation. Under the direction of the Royal Society (London) and the Admiralty, the *Endeavour* had dual intentions: to observe the transit of Venus, but secretly (and more importantly) to seek out the great mythical southern continent 'Terra Australis' and identify resources of value, in order to claim them for the British Crown by 'right of discovery' (Frame & Walker 2018). In his efforts to do so, Cook routinely abducted, maimed, and murdered Indigenous people (as his journal of the *HMS Endeavour* voyage attests).

Seventy-one years after Cook reached these shores, and despite the subsequent signing of the Treaty of Waitangi with Māori, the Crown claimed sovereignty over Te Waka a Māui (the South Island) and Te Punga o Te Waka a Māui (Stewart Island) by 'right of discovery' (Binney *et al*. 2014). Yet Cook's claim of discovery cannot be justified. Māori were already here, Abel Tasman arrived before Cook, and written records from the *Endeavour* show that Cook found his way to Aotearoa aided by Tahitian navigator, Tupaia (Davis 2009), who had drawn from memory a map of seventy-four islands in Te Moana nui a Kiwa (Di Piazza & Pearthree 2007).

It's clear that, prior to Cook's arrival, these islands had been discovered, were mapped, and were inhabited. Yet, in claiming to 'discover' Aotearoa, this knowledge was denied. Our ancestors were not afforded the right to know. Our independence as sovereign peoples was ignored. We were viewed as animals: able to occupy territories, but unable to own them. Through the European lens, these lands lay 'undiscovered'.

The Doctrine of Discovery

The European tradition of denying the sovereignty, and indeed, the humanity of Indigenous peoples elsewhere has a long history that can be traced to the Doctrine of Discovery, birthed in late medievil Europe, at the tail-end of the Crusades (religious wars sanctioned by the Roman Catholic Church to advance the religious, political, and territorial interests of the papacy; Jotischky 2004). The Doctrine consisted of offical letters issued by successive Popes between 1452 and 1493 (see Grewe 2000). The Papal Bull, *Dum Diversas*, issued in 1452 by Pope Nicholas V, granted King Alfonso V of Portugal permission:

> *to invade, search out, capture, vanquish, and subdue all Saracens and pagans whatsoever, and other enemies of Christ wheresoever placed, and the kingdoms, dukedoms, principalities, dominions, possessions, and all movable and immovable goods whatsoever held and possessed by them and to reduce their persons to perpetual slavery* (Doctrine of Discovery, 2018).

Like many Papal Bulls encouraging Christians to 'take the Cross' and join the Crusades before it, *Dum Diversas* offered spiritual rewards to those who supported King Alfonso in his campaign. Thus, in the European imagination, invasion became synonymous with righteousness, honour, and glory – an end in and of itself: a practice that existed beyond economic motive (see Jotischky 2004). As military campaigns into Islamic territories wound down, European monarchs sought to expand their territories into the 'New World', where the Doctrine sanctioned mercantilism and colonialism. The Middle Ages drew to a close and 'The Age of Discovery' – an age of unrestrained genocide – began.

Scientific racism

While early European campaigns to eliminate, dispossess, and replace indigenous peoples in the 'New World' relied on a religious justification, by the time lands were claimed by 'right of discovery' here in Aotearoa, European colonists had a new oppressive ideology in their arsenal – 'scientific racism'. The history of this new 'science', too, cannot be separated from migration. Theories dividing humankind into distinct 'races' had been circulating since the late 17th Century. Yet racism as we understand it today – the idea that certain groups of people, distinguishable by phenotype, are innately superior to others – were popularised by a misreading of Charles Darwin's (1859) *On The Origin of Species*, a text based largely on observations of biodiveristy made while he circumnavigated the world aboard the *HMS Beagle*.

Darwin's theory[1] was misapplied to support the belief that individuals and groups accrue power and privilege because they are innately superior to others: retrospectively, it was labelled 'Social Darwinism' (Hodgson 2004). Through this lens, the survival of certain groups and the annihilation of others is framed as inevitable, even desirable: a scientific justification for imperialism and colonialism that was not unlike 'manifest destiny', the religious justification that preceded it. Through the development and application of scientific racism, migration informed 'science', which was then used to justify oppressive forms of migration: imperialism and colonialism.

Darwin himself was reluctant to apply his theory of natural selection to social relations (Hodgson 2004). However, the belief in human racial heirarchies is evident in his journal entries while aboard the *HMS Beagle*. While docked in Aotearoa in December 1835, Darwin's (1845) assessment of Māori was as follows:

> *Looking at the New Zealander, one naturally compares him with the Tahitian; both belonging to the same family of mankind. The comparison however tells heavily against the New Zealander. He may perhaps be superior in energy, but in every other respect his character is of a much lower order. One glance at their respective expressions, brings conviction to the mind that one is a savage, the other a civilized man.*

[1] [Darwin's theory] was that certain individuals within a species had observable traits making them better suited to an environment, and therefore more likely to survive and reproduce, passing advantageous traits to their offspring; and that incremental changes over successive generations could lead to the evolution of new species.

Crown migration policy

By the time the *HMS Beagle* arrived in Aotearoa, the flow of ideas, technologies, and capital in and out of Aotearoa was well established, and Māori had solidified their international identity through *He Whakaputanga o te Rangatiratanga o Nu Tireni* (*The Declaration of Independence 1835*). *Rangatiratanga* (independence) was again affirmed by *Te Tiriti o Waitangi 1840*, which allowed for the Queen of England to exercise a limited form of governance over her subjects who had migrated here, and others yet to come. Thus the Treaty can be viewed as New Zealand's first immigation policy document (Walker 1993; *see also* Kukutai & Rata 2017). But the Crown immediately, grossly, and consistently violated the Treaty. Violations included assuming absolute sovereignty, stipulating who could and could not migrate here, and dictating the rights that would be afforded to migrants once they arrived.

The initial mass immigration of European colonists far exceeded Māori expecations. At the time the Treaty was signed, Māori outnumbered the semi-permenant Pākehā resident population by at least 40:1. Yet within only two decades the Pākehā population had reached parity (Pool 1991). No longer a numerical minority, and with access to an inexhaustable supply of imperial troops, the Crown abondoned diplomacy and invaded Taranaki, and full-scale war ensued.

A decisive military victory eluded the Crown (Belich 1986). In the 1870s, frustrated by the economic cost of the previous decade's wars, then-Premier Julius Vogel ramped up immigration once more. In his view, demographic swamping was 'the sole alternative to a war of extermination with the natives' (Vogel 1893; cited in Dalziel 1986). By the early 1880s, the Crown project to usurp *tino rangatiratanga* (Māori sovereignity) appeared complete, and Pākehā settlers outnumbered the Māori population (which had been halved by war and Pākehā-introduced diseases) by 10:1 (*see* Pool 1991). Commenting on Māori population decline, a prominent scientist of the time, Alfred Newman, expressed the white supremacist view that, 'the disappearance of the [Māori] race is scarcely subject for much regret. They are dying out in a quick, easy way, and are being supplanted by a superior race' (Newman 1882, p. 477).

By no coincidence, as the 'threat within' appeared to have been neutralised, the Crown turned its attention to keeping non-British subjects out. *The Chinese Immigrants Act 1881* was the first in a flurry of legislations passed around the turn of the 20th Century to restrict the entry of Chinese, Indian, and other racialised 'aliens', through poll taxes, limits on the number of immigrants per ship based on the vessel's weight, and English language requirements. The result was a 'White New Zealand' immigration system, designed to create a 'Britain of the South'. The irony of Pākehā anxieties over foreign invasion was not lost on legislator The Honorable Henry Scotland, who, in parliamentary debate, noted the following.

> *When we first came to New Zealand did the Maoris ever impose a tax upon us? No: and I will venture to say that we have done a great deal more harm to the Maoris than the Chinese are ever likely to do to us. I think the people who come after us will be thoroughly ashamed and thoroughly astonished at what their progenitors have done, for it is simply an inhuman and barbarous measure* (Scotland 1881, p. 210).

By the mid-20th Century, following the 'world wars', the Western science community could not ignore the horrors enacted in service of White supremacy (as on this occasion many of its members had found themselves on its opposite side). Social Darwinism was widely repudiated. The United Nations Educational, Scientific and Cultural Organisation (UNESCO) was founded in 1945 to combat, 'the doctrine of the inequality of men and races' (UNESCO 2018). In 1950, UNESCO tasked a committee of scientific experts (including New Zealander Ernest Beaglehole) to issue a statement debunking scientific racism (UNESCO 1950). The statement itself was not removed from the Western imperial roots of racism, however, as the committee described their 'hope that the struggle against the misdeeds of racism will become a *crusade* to be carried out in common by all the peoples of the earth' (*emphasis added*).

Despite international efforts to eliminate racism, the 'White New Zealand' immigration policy persisted until the late 20th Century. During a period of agressive neoliberal reform, the automatic entry rights guaranteed to predominantly White, English-speaking nations (such as Britain) were abandoned in favour of policies designed to benefit business by filling labour shortages (Bedford *et al*. 2002). By the mid-1990s, however, anti-immigration political rhetoric exacerbated widespread fears of an 'Asian invastion', and policy to limit Asian immigration closely followed (Simon-Kumar 2015).

More recently, in the early 2000s, the Crown made further, similarly motivated changes, resulting in a sharp and sustained increase in the number of migrants arriving on temporary visas (Immigration New Zealand 2016). Of particular concern is the high proportion of temporary workers whose visas are attached to their employer, exposing migrants to increased risk of labour exploitation and modern slavery. New Zealand currently has the unfortunate distinction of the highest proportion of temporary labour migrants in the labour force (5 per cent) of any state in the OECD (Carey 2019). Through this system, the Crown is able to maximally exploit migrant labour to benefit the economy, while mitigating presumed risks by forcing migrants to leave.

The primacy of risk management also features in refugee policy. In 2009, the Crown introduced the family link policy, banning refugees from the Middle East and Africa unless they already had family in New Zealand, which former refugee and community advocate Guled Mire described as a racist policy that must be stopped (Mitchell 2019).[2] Additionally, the Crown's most recent budget included $25 million allocated to prevent asylum seekers accessing New Zealand via boat (Manch 2019) – a strategy that violates the intentions of The Universal Declaration of Human Rights 1948, which includes seeking asylum as a fundamental human right.

[2] The Crown announced an end to the family link policy on 4 October 2019.

Contemporary migration science

Contemporary science in Aotearoa is dominated by a Western tradition that has not decoupled itself from White supremacist ideological foundations fortified by the Doctrine of Discovery and scientific racism. Thus, in scientific research produced here, the sovereignty presumed is that of the Crown, and the interests centred tend to be those of the Pākehā majority. Contemporary migration research often involves assessing the impact of immigration on the New Zealand economy. Examples of this approach include studies that assess the impacts of immigration on GDP and GDP per capita, and the benefits of temporary immigration to fill labour shortages, for example in healthcare and agriculture (*see* Fry & Glass 2016 for an excellent review).

Underpinning this type of research is a series of assumptions, including: the existence of a border around a territory defined as New Zealand; power to control the border resting with the New Zealand Government; borders between peoples who have a right to enter and those who do not; dividing lines between those who arrive determining rights granted (e.g. between those on temporary visas and those given permanent residency; or between those who arrive as refugees and those who arrive as asylum seekers); and immigration equating to aberrant behaviour that poses a risk to New Zealand and must be justified in terms of economic benefits to the 'host society' (in contrast to emigration, viewed as an expected freedom). These assumptions are aspects of Western border imperialism (see Walia 2013) and are contestable.

Other scientific studies of migration focus not on whether migrants should be accepted, but on how the state can 'manage' increasingly ethnicly diverse populations once they are established. These studies include those focused on the 'acculturation' of migrants into New Zealand society and associated outcomes (*see* Ward & Mak 2016, for a review), along with those comparing the attitudes of New Zealand's ethnic groups towards immigration and each other (e.g. Leong & Ward 2011; Grbic 2010; Asia New Zealand Foundation 2014).

These avenues of scientific exploration position ethnic diversity as a 'problem' that must be managed, and the Crown as the solution (see Rata & Al-Asaad, forthcoming). They further assume that there is a mainstream New Zealand culture that migrants should be expected to be a part of (which is not the Indigenous- but the settler–colonial culture). Migrants' experience of 'acculturative stress' and associated negative outcomes are attributed to the 'acculturation strategy' migrants choose to adopt. Yet the problem in the case of unequal migrant outcomes could alternatively be framed as deriving from the monoculturalism of New Zealand institutions that have not responded to our 'super diverse' demographic reality.

Finally, and perversely, these studies may be predicated on the assumption, or draw the conclusion, that the causes of racism in New Zealand are minoritised ethnic communities themselves. However, lateral violence (or racism within and between minoritised ethnic groups) could better be understood as settler–colonial structural racism opperating *through* communities of colour (see Saranilio 2013).

As outlined above, while the unofficial 'White New Zealand' immigration system has been overhauled, biases that run along national and therefore racial lines are ubiquitous. This racialising approach to 'risk' management is now being automated – shifting racist decision-making from human cognition to algorithms. Immigration New Zealand now uses data on the 'harm to New Zealand' caused by migrants to predict the harm their compatriates *might* cause, or as Immigration New Zealand's compliance and investigations area manager Alistair Murray explained:

> *So then we might take that demographic and load that into our harm model and say even though person 'A' is doing this, is there any likelihood that someone else that is coming through the system is going to behave in the same way and then we'll move to deport that person at the first available opportunity so they don't have a chance to do that type of harm* (Bonnett 2018).

This approach is nothing short of racial profiling, and provides a clear example of the way in which structural racism is embedded in our institutions, serving to produce and reproduce White supremacy.

Dismantling Cook's legacy

Here in Aotearoa, the story of science is the story of migration. Science and innovation allowed for migration, and migration led to scientific innovation through contact with new territories and biodiversity, and new cultural knowledge systems, resulting in the generation of new ideas. But religion and science have also been used to justify imperialism and colonisation, and produce and reproduce White supremacism, first through the Doctrine of Discovery, and then through scientific racism.

Ideologies glorifying conquest and upholding racial hierarchies are foundational to New Zealand, and are embedded in our institutions. These racist foundations were celebrated in 2019 on the 250th anniversary of Cook's invasion of Aotearoa. The government's framing of the event as acknowledging early 'encounters' and of celebrating our 'dual heritage' (see Ministry of Culture and Heritage 2018) marginalised non-Māori communities of colour from the national narrative, and obscured colonial violence, prompting Indigenous rights activist Tina Ngata to lay a complaint at the United Nations 17th Permanent Forum for Indigenous Issues (Ranford 2018). In addition, Contemporary New Zealand science and our immigration system tend to frame ethnic difference as a 'problem' or 'risk', and often reduce migrants to exploitable labour for the benefit of the national economy.

In researching this paper, I was reminded byof a short speech given by Linda Tuhiwai Smith in accepting the inaugural Te Puāwaitanga Award from the Royal Society Te Apārangi, the New Zealand equivalent of the very group responsible for funding Cook's first voyage here (Vimeo 2018).

> *Like many of you in this room I'm descended from a proud people, who navigated the Pacific and used knowledge to do that. When Cook arrived what began was the systematic destruction not only of what we knew but the value of knowledge to us. And I hope in my work I've rebuilt confidence of Māori in our own knowledge. In our ability to know. To know well. To know deeply. And to know in ways that advance our future.*

In attempting to advance our future through science, we must challenge assumptions around who has the right to know, and interrogate the premises of our research questions. When researching migration, a radical shift is

required. Instead of asking, 'how does immigration impact New Zealand', as if migrants should be expected to justify their presence here, let's start asking new questions: What value do we place in freedom of movement across borders? How can we ensure our immigration system is free of national/religious/ethnic/racial discrimination? How can we end New Zealand imperialism abroad, and ensure our foreign policy (e.g. trade deals) does not displace people? In addition, instead of asking: 'How do we manage ethnic diversity?', we need to start asking: How do we dismantle monoculturalism and Pākehā supremacy? How could the nation be imagined as plural? And what constitutional arrangements would ensure full expression to Te Tiriti o Waitangi, and full rights regardless of immigration status?

Settler–colonial racism, and Western border imperialism have not always existed; They are social structures created by people, requiring constant maintenance, that can also be undone by the people. Imperialism, colonialism, and White supremacism arrived in Aotearoa 250 years with the arrival of Cook. It's well past time to dismantle his legacy and begin a new era of hope and freedom in Aotearoa for all.

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Public science policies in Aotearoa New Zealand present an expectation to researchers and educators that their practice will engage with mātauranga Māori.

The primary objectives of Science Review are to inform and stimulate. It gives us great pleasure to do just this by giving voice to those who see the enormous potential and significance of mātauranga Māori.

The two part issue of *Mātauranga and Science in Practice* draws together the experiences of Māori, Pākehā and tauiwi scientists, researchers and educators. The issues present a variety of cases that span institutions, disciplines and domains. The collective experience forms a resource that helps us all to better understand how this work can advance Aotearoa NZ's public knowledge ecosystem.

More than 100 people have contributed to this work. The Association of Scientists congratulates all who have contributed to both parts of the special issue and acknowledges the superb effort of guest editors Drs Ocean Mercier and Ann-Marie Jackson especially in the present troubling times of the COVID-19 pandemic.

Mātauranga and Science in Practice is a tribute were we, in New Zealand have got thus far in this endeavour.

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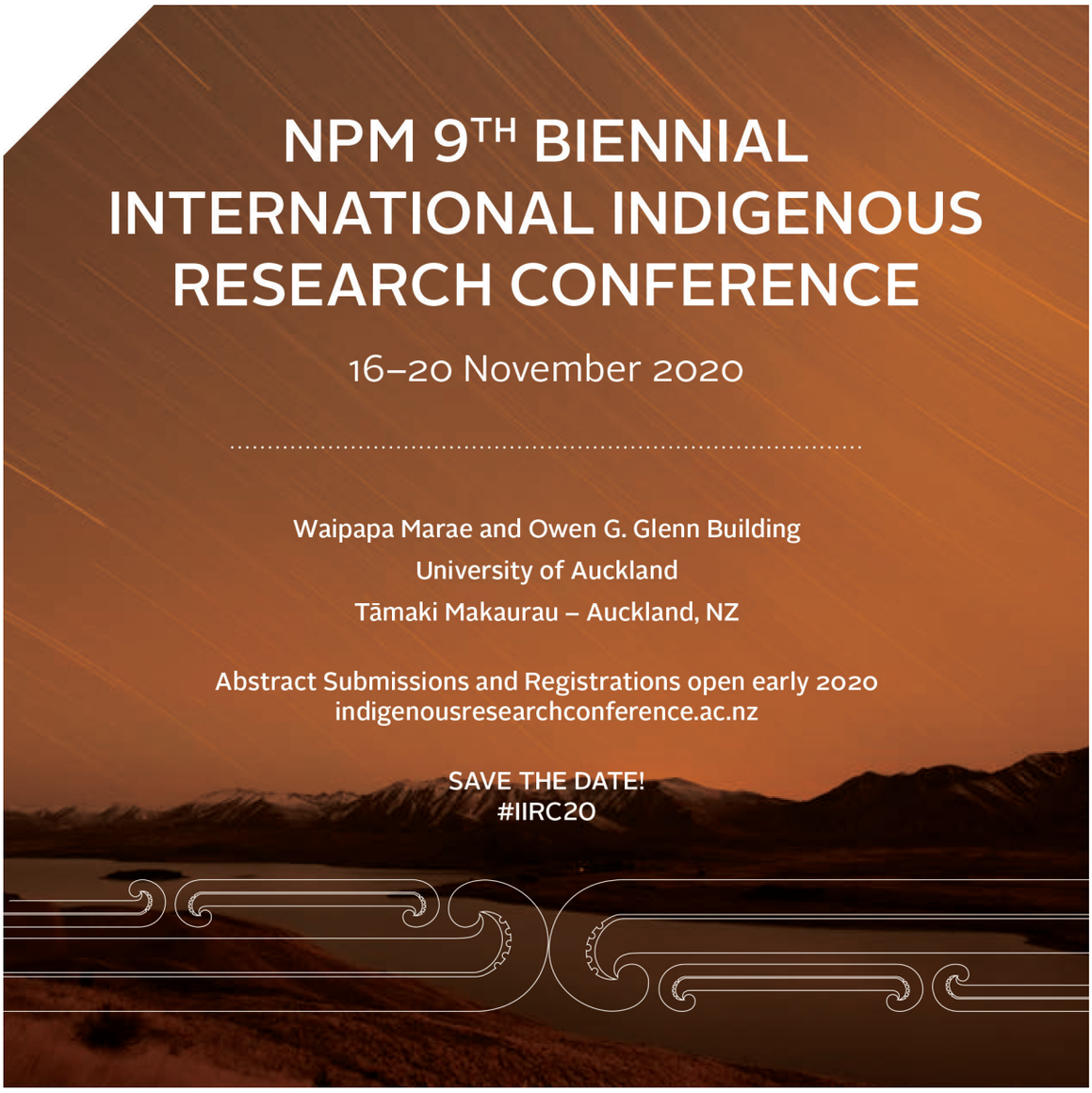

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