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Empowering indigenous voices in disaster response: Applying the Mauri Model to New Zealand's worst environmental maritime disaster

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ABSTRACT

Just after midnight on October 5, 2011, the MV Rena ran aground on Otāiti, a reef situated 27 kilometers off the coast of New Zealand. The clean-up process has now been underway for more than four years, and is acknowledged as the second most expensive wreck recovery in the world, at more than half a billion US dollars. In October 2015, a resource consent hearing was concluded, and this sought approval to abandon the remaining sections of the Rena wreck on Otāiti. Māori submissions to the hearing process were divided between opposition to the applicant's request and support from others, including the Te Arawa ki Tai tribal grouping. Te Arawa ki Tai have adapted the Mauri Model Decision Making Framework to provide a better understanding of the recovery process, and the holistic understanding it provides is of relevance to other international contexts. This paper shares how the Mauri Model Decision Making Framework, in conjunction with an indigenous based methodology, empowered Te Arawa ki Tai in the recovery process and facilitated an enhanced Te Arawa ki Tai understanding. Since the grounding, Te Arawa ki Tai have co-created indicator sets that are inclusive of all of the relevant scientific and indigenous knowledge available. The impact upon mauri (life force or life supporting capacity) since the MV Rena grounding has been evaluated using the same indicator sets, with quarterly assessments. Reflections on how the concerns of the disadvantaged and marginalized Māori communities have been addressed are included.

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1. Introduction

Just after midnight on October 5, 2011, the MV Rena ran aground on Otāiti, otherwise known as the Astrolabe Reef, situated 27 kilometers off the coast of New Zealand (The Transport Accident Commission, 2014). Fig. 1 provides a map. During the ensuing clean-up, the Minister for the Environment identified the grounding as New Zealand's worst environmental disaster (Sharpe, Johnston, Watkins, Migone, & Cooke, 2011). In December 2011, one of the affected indigenous tribal groups, Te Arawa ki Tai, made submissions on the draft recovery plan, stating that the goal of the plan did not recognize and provide for a Māori (indigenous peoples of New Zealand) cultural perspective to environmental restoration. They suggested that the word "mauri" (life force or life supporting capacity) be inserted, or a new goal added to properly encompass a Māori worldview of environmental restoration. The Ministry for the Environment issued the Rena Long-Term Environmental Recovery Plan on 26 January 2012, with the stated goal to

"restore the mauri of the affected environment to its "pre-Rena" state" (Ministry for the Environment, 2012). This is significant, as it is the first instance in New Zealand that an indigenous concept was given as the goal of a government-led strategy (Morgan, Fa'au, & Bennett, 2015).

The disaster and its associated impacts have been a divisive issue in New Zealand, which historically has had a 'clean, green' image associated with the landscape and coastline. The differences in opinion regarding the recovery and fate of the wrecked vessel and debris have culminated in the resource consent process started by the Rena's owners. In May 2014, the owners of the Rena lodged several resource consent applications under the Resource Management Act (RMA, 1991) to abandon sections of the wreck and associated debris on Otāiti (Beca, 2014). The resource consent application also included provisions for future discharges of contaminants from the remnants of the vessel and remaining cargo, within the period of the ten year consent applied for Bay of Plenty Regional Council, 2014.

The different stakeholder groups with vested interests in the reef and affected areas have varying views on the recovery and resource consent application. These differences are evident in the submissions received by the Bay of Plenty Regional Council, the

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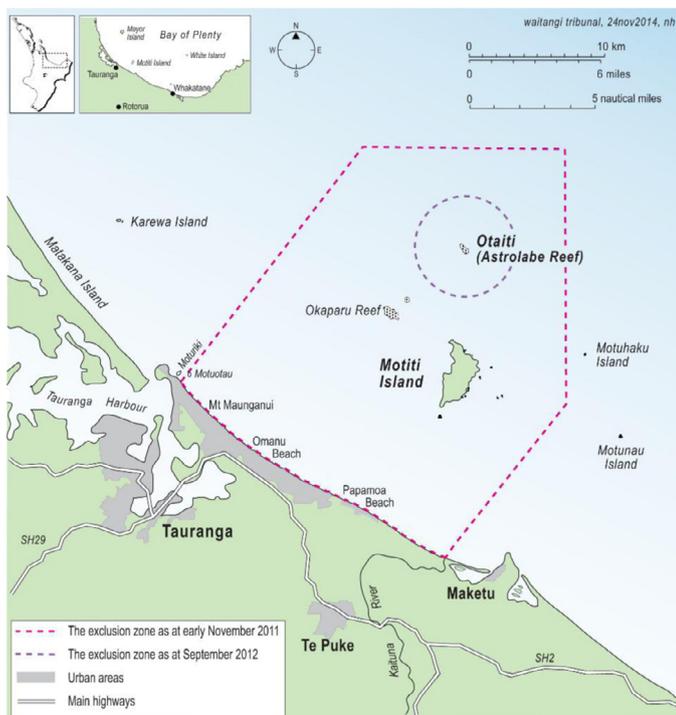


Fig. 1. Location of astrolabe reef and nautical exclusion zones (Waitangi Tribunal, 2015).

local Governmental body tasked with assessing the resource consent application. The submissions received from different affected stakeholders were presented at the resource consent hearing in Tauranga (New Zealand) in 2015, with different groups taking supporting, opposing or neutral stances regarding the Rena owner's resource consent application. The opinions, views and the impacts experienced by/of the different affected stakeholder groups regarding the Rena recovery and associated impacts can be linked to their ontological worldviews. Their differing ontologies are relevant to how solutions are perceived. There are multiple factors that shape these ontological differences, resulting in a wide array of differing and at times adversarial worldviews.

One of these affected stakeholder groups is Maketū-based Te Arawa ki Tai, who have collaborated with a community operational research project using the Mauri Model Decision Making Framework to inform their stance regarding the resource consent process. Te Arawa ki Tai (the coastal branch of Te Arawa) represent the majority of Te Arawa interests impacted by the Rena disaster. The relationships to Otaiti are set out later in this paper, which presents the assessment of the mauri impacts within this community by forming a working relationship and effectively adapting an action research based methodology into a communal, indigenous post-disaster context. Within this methodology, one of the key aspects has been the compilation of the performance indicator sets, to use within the assessment of the mauri impacts. The process to select these indicators is a crucial phase of the community operational research, establishing the criteria by which impacts upon mauri are measured, directly influencing how enhancements or diminishment in mauri are defined. It is therefore important that the methodology dictating this process is sound, as the criteria effectively set the boundaries of subsequent intervention. Within systemic interventions, boundary critique can be applied prior to and during the intervention to help in the process of identifying and placing boundaries, and selecting the appropriate methods (Midgley, 2000).

Boundary critique theory highlights the importance of exploring the boundaries that are being used within an intervention, with emphasis placed on considering the participant's views towards these boundaries (Ulrich, 1983). Foote et al. (2007) defines a 'boundary' as "... a conceptual marker that identifies the people and issues included in, marginalized by or excluded from OR projects" (Pg 1). Therefore exploration of these boundaries, or the 'critique' aspect, can be thought of as consideration of the interconnections of all the relevant factors, different perspectives of stakeholder groups, the interactions between the groups involved (including the researchers) and the overall evaluation of potential points of interest within the system (Foote et al, 2007; Midgley, Munlo, & Brown, 1998, 2007; Ulrich, 1996). This process is undertaken prior to the selection of systems methods to be used, as well as mid intervention, to allow for an appropriate definition of the intervention as well as to avoid superficial diagnoses of issues, which can often result in unnecessary complications during the intervention (Midgley, 2000; Midgley et al., 2007; Ulrich, 1983). More details of boundary critique are provided in the next section.

The Mauri Model Decision Making Framework (Morgan, 2006a, 2006b, 2008) incorporates similar processes, with seemingly parallel goals to boundary critique, in that, as a decision support tool, it provides a framework for practitioners and participant groups to consider and reflect on the views of those groups involved, prompting critical examination of what needs to be included or excluded as well as an exploration of the potential marginalization of people or other factors (Foote et al., 2007). Ulrich (1983) notes the importance of meaningful engagement with affected communities when setting boundaries. This involves providing a 'rational' analysis, rather than allowing external entities to impose boundaries upon affected communities. The boundaries must have some verification from those within the affected community, with these groups identifying the factors and information that will be of most use, thereby providing validity and rationality to the intervention and boundaries used. Providing more 'rational' boundaries through meaningful engagement, as well as ensuring that the set boundaries and outcomes have community verification, have been built into the methodology employed for this study through the use of the Mauri Model, a Kaupapa Māori based community research ethos and culturally relevant community engagement methods. A Kaupapa Māori methodology essentially promotes 'research for Māori, by Māori and with Māori' (Smith, 2005), placing Māori communities at the forefront of the intervention and research formation.

As well as considering who should dictate the placement of boundaries, i.e., deciding what information is important and relevant to the context, Midgley (2000) and Midgley et al. (2007) state that some stakeholder groups can become marginalized within this process: either not included or not fully included. This can result in the devaluing of factors relevant to the marginalized groups, and can be a contributing factor to misrepresentation of information as well as problems within the intervention. Māori communities in New Zealand have often been marginalized within research projects in the past, as is the case with many other indigenous groups globally (Cochran et al., 2008; Midgley et al., 2007; Smith, 1999). With the Mauri Model Decision Making Framework being conceptually rooted in an indigenous epistemology, it empowers the indigenous voice within the intervention and decision making process by providing a conceptual framing consistent with their own, as well as providing an equal footing for inclusion and comparison of culturally and locally relevant factors within the process (Morgan, 2006a, 2006b, 2008).

The results of this assessment of mauri were timely, with the resource consent application being granted in February 2016. With the consent granted, additional conditions have been applied for monitoring, and ensuring that measures to mitigate potential

contamination from the vessel or trapped cargo are in place, including a culturally aligned mauri monitoring programme, which initially proposed (in the consent application) the use of the Mauri Model Decision Making Framework as the monitoring mechanism. The Mauri Model Decision Making Framework's inclusion has since been challenged, but may need to be used regardless, as no other alternative has at this time been identified.

2. Operational research – boundary critique and the Mauri Model

As mentioned earlier, the process of utilizing the Mauri Model Decision Making Framework (Morgan, 2006a, 2006b), whilst working with a community as the participant group, shares close similarities to processes associated with the theory of boundary critique. The term 'boundary critique' was first used by Ulrich (1996), drawing on the previous works of Churchman (1970) and Ulrich (1983, 1987), and was later developed and consolidated by Midgley et al. (1998). A brief summary of boundary critique theory is given here, and for a more detailed examination of the relevant literature see Midgley and Pinzón (2011). Boundary critique is the process of exploring the boundaries of the system being studied, as part of a systemic intervention (Midgley, 2000; Midgley et al., 1998, 2007; Ulrich, 1996). Churchman (1970) notes that the placement and identification of boundaries is significant, as it essentially dictates what factors are considered as relevant and are the result of subjective and inter-subjective processes in the participating group. Therefore, the boundaries placed within an intervention dictate the problem definition as well as how improvements or denigrations within the system are to be measured (Churchman, 1970).

Boundary identification is therefore an important consideration regarding a systemic intervention, as depending on what boundaries are set, how narrow or broad they are, what may have been identified as an improvement in one configuration may rather be viewed as detrimental within another. Churchman (1970) argues that boundaries should be pushed out, to allow for a large amount of relevant information to 'be swept in', therefore providing boundaries that are as inclusive as possible (Midgley et al., 1998). This idea also opens the possibility of expanding who may be considered as a legitimate decision maker (Churchman, 1970). Building upon Churchman's work, Ulrich (1983) states that, whilst inclusivity (i.e., pushing out the boundaries to incorporate the maximum amount of information) is ideal in theory, in practice this process has to be limited. Therefore, a critical issue is how to set boundaries rationally, rather than seeking to be all inclusive. Ulrich (1983, 1996) discusses the process of exploring and defining the placement of boundaries within a system through *debate and dialogue* within and between the affected stakeholder groups, and a boundary is therefore set rationally when it accounts for all relevant perspectives. Ulrich (1983) provides a methodology to support the rational identification of boundaries through dialogue with stakeholders, which is termed Critical Systems Heuristics.

This dialogue aims to ensure that the boundaries of an intervention will be both ethical and useful, and they are more likely to be acceptable to stakeholders than those imposed by an external researcher or authority figure (Ulrich, 1983). Ulrich (1996) also notes that, within the context of a Critical Systems Heuristics dialogical engagement with stakeholders, the input from the affected community (lay people) has just as much validity, if not more, than that provided by 'experts'. This paper suggests that Ulrich's insight is especially important in relation to indigenous peoples who maintain place-based identities with long-term knowledge associated with particular locations.

Building on the preceding works of Churchman and Ulrich, Midgley (2000) notes that, while it is important to identify the right boundaries of the system of concern to use, issues of the

marginalization of particular groups or issues also often needs to be addressed. This marginalization can be the result of conflicting boundary judgments between different groups of people, resulting from the different values and views regarding the system and problem definition (Midgley et al., 1998). The marginalized groups or issues are neither fully included in nor excluded from the system, and are subject to "strong labeling and ritual treatment" (Foote et al., 2007; Midgley, 2000; Midgley et al., 2007). Midgley et al. (1998) explains further that the marginalized elements are often regarded as 'sacred' or 'profane' by stakeholders, and these terms indicate the valuation or devaluation of these elements respectively. Midgley (2000) argues that, although all identified stakeholders may be actively involved in decisions on boundary judgments, there must still be consideration of what will be marginalized within the current boundary configuration.

The Mauri Model Decision Making Framework presents a layered methodology, incorporating a stakeholder analysis of world-views as well as an assessment of performance indicators (Morgan, 2006a, 2006b, 2008), which seems to reflect the theoretical concepts pertinent to boundary critique. Midgley (2000) suggests that interventions informed by the theory of boundary critique most often result in multi-layered interventions, which are customized to the context and employ the mixing of methods in response to the identified boundaries (Foote et al., 2007). Midgley (2000) also implies that an intervention informed by boundary critique is more flexible, adaptable and relevant to the participant communities than many 'off the shelf' methods. Whilst the Mauri Model Decision Making Framework presents a set structure, and may therefore be considered an 'off the shelf' method, it does not easily fit into this category: although there are set processes included within its methodology, the boundaries and assessment criteria within it are customized for each context, to include and accurately represent the relevant information and factors that matter to the affected groups. Just as the Mauri Model Decision Making Framework facilitates the evaluation of impacts on both qualitative and quantitative indicators, it can also provide an understanding of the relevance of boundary identification within wicked problem situations.

3. Māori community research

Māori are the indigenous peoples of New Zealand, comprising 17.5% of the nation's population. The density of the Māori population varies between regions, with Māori being a minority group in larger cities and some areas having Māori as the majority (mainly rural communities). The remaining 82.5% of New Zealand's population comprises mainly those of European descent (the majority being descendants of British and European colonists who came to New Zealand in the 1800s), as well as more recent immigrants from Asia, the Pacific and other parts of the world (Statistics New Zealand, 2013). Māori identify with *iwi* (tribal groupings) and *hapū* (sub-tribal groupings), depending on where in the country they are from, and from whom they are descended.

The epistemologies of indigenous peoples are commonly based on principles of interconnectedness, holism, relevance over long periods of time, inter-generational equity, uniqueness to place and reciprocity (Durie, 2005; Kuokkanen, 2007). Few places in the world still exist where these epistemologies continue to define the dominant reality. Rather, as in the case of New Zealand, Māori have adapted to a colonized societal context where their values and beliefs, the basis of their identity, and their ways of being have been systematically undermined and oppressed over more than one and a half centuries. As a result, Māori have, out of necessity, had to develop ways of retaining their values and beliefs while accommodating the enforced changes associated with destructive coloniza-

tion processes, also experienced by indigenous peoples in many other parts of the world.

Similar to most indigenous groups, Māori have their own language, cultural history and traditions, which can differ slightly between different iwi and hapū groups. Being the indigenous peoples within a colonized context, Māori have been the subject of research interest of non-Māori anthropologists and researchers, as is seen with almost all other colonized indigenous groups globally (Geertz, 1983; Midgley et al., 2007). Generations of colonization and poor treatment from non-Māori researchers of Māori communities as 'objects of inquiry', with uneven relationships of power or benefit from research, has left many Māori communities wary of authority figures, especially those who derive their authority from an identity of 'researcher' (Smith, 1999). In response to this attitude seen within past community-based research involving Māori, and coinciding with Māori development over the past four decades, Māori have been developing their own research traditions. The overarching methodological paradigm, termed Kaupapa Māori, has Māori leading these initiatives and studies, recognizing the importance of the researcher's identity as Māori to their work (Bishop, 1996; Smith, 1999). As well as being led by Māori, Kaupapa Māori based research should seek to advance the aspirations of the participant communities as well as all Māori in general, from a methodological base rooted in Māori values, thinking and culture; i.e., the research should come from a uniquely Māori epistemology, compared to a Western epistemology attempting to measure and represent Māori (Mane, 2009).

Kaupapa Māori research views Māori from a holistic perspective, more consistent with a Māori based epistemology, applying this view to both the individual and the collective community (Smith, 1999). Another key characteristic of Kaupapa Māori research is that it is carried out using culturally appropriate methods, holding the incorporation of the Māori language and cultural values as integral components of successful implementation and development of the methodology (Bishop & Glynn, 1999; Mane, 2009; Smith, 1999). This uniquely Māori research methodology addresses concerns harbored by Māori in the past regarding community-based research projects, which are concerns shared with other indigenous groups globally: who benefits from the research? And is traditional knowledge being represented accurately, within its original context (Bishop & Glynn, 1999; Cochran et al., 2008)? These concerns can be quelled when considering Irwin's (1994) description of a Kaupapa Māori research model, provided by Cunningham (1999): "...research which is culturally safe, which involves the mentorship of kaumātua (elders), which is culturally relevant and appropriate, while satisfying the rigor of research, and which is undertaken by a Māori researcher, not a researcher who happens to be Māori" (Pg 67); or, more succinctly, removing the formalized western academic allusion, described simply as: research by Māori, for Māori and with Māori (Smith, 1995, 1999; Walker, Eketone, & Gibbs, 2006). With discourse regarding Kaupapa Māori approaches being held mainly within the academic realm, there must be constant reassertions and actions to develop and grow the methodology from the Māori world as a collective, especially including the community voice: i.e., those at the grass roots, living and experiencing these issues and impacts being studied (Smith, 1999, 2005; Mane, 2009). This iterative and reciprocal relationship between researcher and participants within Kaupapa Māori methodology is essential to its success and building of capacity, as both researchers and Māori communities need to confidently contribute to this discourse.

It is within this Kaupapa Māori based context that the research team collaborated with a Rena affected iwi group, Te Arawa ki Tai (the coastal branch of Te Arawa, based in Maketū) to assess the impacts of the Rena disaster, and to inform the decision making process regarding the future of Otāiti.

Table 1

Wellbeing criteria and mauri dimension equivalent (Morgan and Te Aho, 2013).

Well-being criterion	Mauri dimension equivalent
Environmental wellbeing	Mauri of ecosystem
Cultural wellbeing	Mauri of hapū/iwi
Social wellbeing	Mauri of community
Economic wellbeing	Mauri of whānau (family unit)

4. The Mauri Model Decision Making Framework

A more holistic and inclusive way to understand the world, compared with just monetary terms, exists in Māori communities (Morgan, 2006a). Firth (1929) observed more than 85 years ago that mauri appeared to be the economic currency of traditional Māori society. Mauri is the binding force between the physical and everything else that makes life possible. It is the life supporting capacity within a thing or collection of things such as an ecosystem. The concept can be likened to gravity: while it may not be observable directly, it explains observable phenomena, being the force that, when sufficiently diminished or denigrated, defines the loss of potential to support life, or the difference between life and death.

The Mauri Model Decision Making Framework combines a stakeholder worldview analysis with an indicator assessment to determine the absolute sustainability of the scenario, option or decision being assessed, using the Māori concept of mauri as the base metric (Morgan, 2006a, 2008). Mauri can be defined as a life force; the force which binds the physical to the spiritual, or the capacity to support life, having similarities with other concepts such as qi, chi or ki in parts of Asia (Mak & So, 2014) and maui, maoli or moui in parts of the Pacific (Best, 1934). This concept of mauri can be used to explain the well-being and potential of phenomena with physical and/or metaphysical characteristics. The capability to measure both physical quantities and metaphysical qualities allows for a widely inclusive range of sustainability indicators that better reflects the defined physical, cultural, psychological and spiritual realities of indigenous peoples than most Western sustainability indicators. The Mauri Model Decision Making Framework is unique as it provides a template within which indigenous values are explicitly empowered alongside scientific data.

Within this framework, mauri, the measure of sustainability, has four constituent dimensions: the mauri of the ecosystem, the mauri of the hapū (sub-tribal grouping), the mauri of the community (non-culturally based community aspects) and the mauri of the whānau (family unit). These four mauri dimensions mirror traditional triple bottom line thinking: environmental, or the mauri of the ecosystem; social, or the mauri of the community; and economic, or the mauri of the whānau. A fourth dimension, cultural well-being (aligned with the mauri of the hapū), is also added, as within New Zealand the indigenous peoples have certain rights and considerations afforded to them legally through The 1840 Treaty of Waitangi, New Zealand's founding document. These four mauri dimensions also reflect the well-beings set out in Part 2, Section 5 of New Zealand's Resource Management Act (1991), which has the purpose of the legislation "promoting sustainable management of natural and physical resources . . . in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural well-being" (Ministry for the Environment, 1991). The alignments between these well-beings and the dimensions of mauri are shown in Table 1.

4.1. Stakeholder worldview quantification

The worldview quantification within the Mauri Model Decision Making Framework uses a modified version of Saaty's (1980)

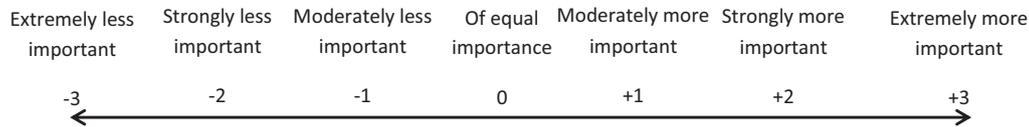


Fig. 2. Pairwise comparison scale (analytical hierarchy process) used in Mauri Model.

Table 2 Analytical hierarchy process example.

Stakeholder	Environmental	Cultural	Social	Economic	Σrow
Environmental	0	a	b	c	a + b + c
Cultural	-a	0	x	y	-a + x + y
Social	-b	-x	0	z	-b + (-x) + z
Economic	-c	-y	-z	0	-c + (-y) + (-z)

Table 3 Analytical hierarchy process calculation example.

Stakeholder	Environmental	Cultural	Social	Economic	Σrow	+9	% weighting
Environmental	0	0	2	3	5	14	14/36*100 = 38.9%
Cultural	-0	0	2	3	5	14	14/36*100 = 38.9%
Social	-2	-2	0	2	-2	7	7/36*100 = 19.4%
Economic	-3	-3	-2	0	-8	1	1/36*100 = 2.8%
						36	100

Analytical Hierarchy Process (AHP). The AHP is a multi-criteria decision making approach, within which factors of importance are arranged in a hierarchal structure. This tool utilizes a pairwise comparison of these arranged factors, using a scale of 1/7th to 7, pivoting about 1, to determine the relative importance of the selected criterion (Saaty, 1980, 1990). The Mauri Model Decision Making Framework utilizes a simplified version of this process (Fig. 2), presenting a pairwise comparison of the Mauri Model's four mauri dimensions, to determine the priority given to each mauri dimension relative to the others, for a particular stakeholder.

An example Mauri Model AHP matrix is given in Table 2. Each cell is scored by comparing the importance of the cell's corresponding column dimension, to the importance of the cell's corresponding row dimension, using the pairwise comparison scale. Due to the layout and order of dimensions being compared, each dimension will essentially be compared twice, with different reference points. Therefore each comparison scored is the inverse of its corresponding opposite comparison, as shown in Table 2.

The outcomes of this matrix can be further processed to better interpret the outcomes and understand the relative importance of each dimension. This is achieved through a normalization process of the sum row totals, by adding nine to the sum score. This normalization transforms all the sum totals of each row, corresponding to each dimension, into a non-negative integer. With all the dimensional totals from the AHP normalized, weightings for the mauri dimensions can then be calculated by dividing by 36 (as the total of the normalized scores will always be 36, due to the inverse scoring in the dimension comparison matrix, and then the normalization process) (see Tables 2 and 3). The weighting can also be converted into a percentage, by multiplying the weighting score by 100.

On their own, these scores can highlight the areas of high and low importance for a particular stakeholder, potentially explaining the reasoning behind certain observed actions, reactions and stances taken. This could be considered to be a reductionist interpretation of the stakeholder's entire worldview, attempting to encapsulate and represent the worldview of a particular group in terms of the four mauri dimensions. However, without modeling of this kind, an attempt to accurately map and represent the subtleties of the entire worldview of a particular stakeholder group would be very difficult to achieve in a way that facilitates compar-

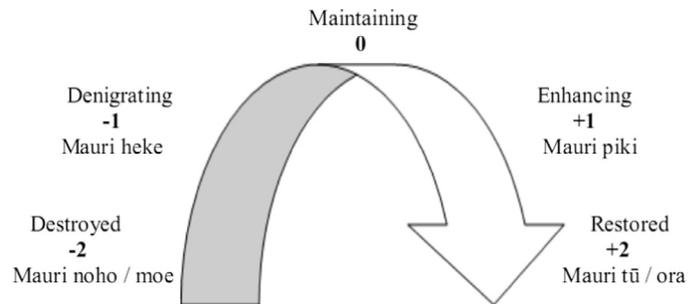


Fig. 3. Mauri meter for performance indicator assessment (Morgan and Te Aho, 2013).

isons between stakeholders and better mutual understanding (see Cronin, Midgley, & Skuba Jackson, 2014, for another example of modeling priorities between values that facilitates improved mutual understanding). Therefore, within the confines of the Mauri Model Decision Making Framework, the representation and assessment of stakeholder worldviews provides a relatively simple measure of the priority placed on the four mauri dimensions, so each stakeholder can easily see how others view sustainability. This numerical representation of a stakeholder's worldview provides a useful lens to review the outcomes of the aggregated mauri meter indicator assessment for each dimension, showing the effect that individual perceptions can have on perceived individual stakeholder impacts.

4.2. Mauri meter indicator assessment

The Mauri Model Decision Making Framework uses an indicator assessment to evaluate the sustainability or impacts of a particular option, scenario or decision in terms of mauri. This is achieved by deciding on a set of indicators for each mauri dimension, which can be considered as influencing factors contributing to the mauri of that particular dimension. Once indicator sets have been compiled for each mauri dimension, each of the different scenarios is scored using the Mauri Meter (Fig. 3). The score given for each indicator reflects the mauri impact of the scenario being tested on that particular indicator. These indicator scores are averaged within each dimension to give the sustainability in terms of the Mauri Meter for each of the four mauri dimensions (see Table 4).

Table 4
Performance indicator scoring example.

Ecosystem mauri/Environmental wellbeing	
Indicator	Mauri meter score
ENV1	X1
ENV2	X2
ENV3	X3
ENVn	Xn

Ecosystem mauri, $M_{ENVIRONMENT} = \sum X_n/n$
(which is then repeated for the other dimensions).
Overall mauri (equally weighted) $M = (M_{ENVIRONMENT} + M_{CULTURAL} + M_{ECONOMIC} + M_{SOCIAL})/4$

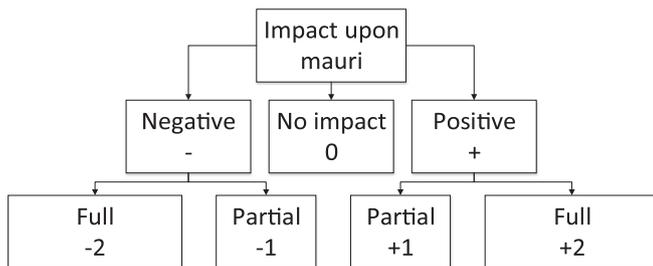


Fig. 4. Mauri Model decision tree (Morgan, Sardelic, & Waretini, 2012).

Table 5
Sensitivity analysis, using AHP calculated weightings.

With the dimensional weightings, $W_{DIMENSION}$ weightings.	
Dimension	Weighting
Ecosystem mauri	$W_{ENVIRONMENT}$
Hapū mauri	$W_{CULTURAL}$
Community mauri	W_{SOCIAL}
Whānau mauri	$W_{ECONOMIC}$

World view weighted ecosystem mauri dimension score,
 $M'_{ENVIRONMENT} = M_{ENVIRONMENT} \cdot W_{ENVIRONMENT}$.
Worldview weighted Overall mauri score $M' = M'_{ENVIRONMENT} + M'_{CULTURAL} + M'_{SOCIAL} + M'_{ECONOMIC}$.

The Mauri meter is used to determine the overall sustainability rating of each option being evaluated against a given mauri dimension. It uses a five point integer Likert scale, indicating possible states of mauri representing a neutral impact ('0'), partial impacts ('-1' or '+1') or full impacts ('-2' or '+2') (Fig. 4). The result is four overall ratings of the mauri of each decision making option being evaluated; one for each of the mauri dimensions.

The dimensional mauri scores can then be multiplied by a weighting, with the default being evenly weighted (25% across all four dimensions), representing the legally consistent position of equally important well-beings. The scoring conditions, dictating what can be appropriated as neutral, partial or full mauri impact, are also defined for each indicator as a set of thresholds. These ensure the repeatability of scoring and remove any uncertainty in the scoring of the indicators. The weightings gained from the worldview quantification can be used to perform a sensitivity analysis of the indicator assessment, replacing the default equal weightings with the defined weightings from the AHP (see Table 5). The sensitivity analysis applies the lens of the stakeholders of interest and can aid in facilitating inter-stakeholder communication, especially in adversarial relationships, providing some understanding and background to particular stances taken and the options/decisions supported.

5. Working with Te Arawa ki Tai

The basis of this study was an assessment of the impacts of the Rena disaster from an indigenous perspective. The unique cultural

factors present within this context have provided an opportunity to assess the impacts of this disaster using an indigenous-based methodology (Kaupapa Māori), with an indigenous-based decision support tool (the Mauri Model Decision Making Framework) as its platform, in conjunction with a partnership relationship with the tribal groups of the Rena-impacted regions. This kind of partnership approach is in line with the thinking of Midgley, Johnson, and Chichirau (2017), who say that the meaningful engagement of the community is essential if a project is to legitimately be considered as Community OR. The approach was designed to ensure that the indigenous voice within this disaster context would be accurately represented, ensuring the ethos of Kaupapa Māori research traditions was upheld: "research for Māori, by Māori and with Māori" (Smith, 1999). This was facilitated through two of the three research team members sharing whakapapa (genealogical links) with some of the affected iwi, as well as the third researcher being Māori, but without genealogical links to any of the impacted iwi (tribes). It is well known in Kaupapa Māori research circles that whakapapa enables the establishment of trust by the community, as people will generally assume that someone who is related to them as part of a large extended family is more likely to act with integrity than someone who is not a relative. The genealogical links between the researchers and participant communities provided a catalyst for the formation of a working relationship, and meaningful participation was enhanced by the fact that the research team was able to understand and comprehend the types of issues that would arise within this context that would be unique to the iwi of the affected region.

In March 2012, a 'cultural framework workshop' was held with representatives from iwi within the five Rena impacted areas (Matakana Island, Mōtītī, Maketū, Mauāo/Pāpāmoa and Eastcape) to potentially form a unified iwi response and submission regarding The 2012 Rena Long Term Environmental Recovery Plan and the proposed recovery processes ahead, with the Mauri Model being used as the basis for the representation of experienced impacts (Morgan, 2012). This workshop ended up being the first 'official forum' in the five months following the disaster that some of the iwi had been given to share their grievances and experiences of the disaster and recovery processes. There was an overwhelming response from the iwi that there were feelings of exclusion within their communities, or inefficient communication from authorities regarding the decision making process following the disaster. Therefore that initial workshop had the unforeseen effect of facilitating the start of the healing process for some of these communities. Following this workshop, all attending iwi were interested in pursuing a unified approach regarding the recovery using the presented Mauri Model methodology. However, due to changes in the project funding arrangements and political tensions, only an iwi from Maketū, Te Arawa ki Tai, continued to participate in this research.

Te Arawa have historical links to Otāiti, the reef which the Rena ran aground on, tracing a cultural and spiritual connection back to when it was first discovered and named. In Ngāti Whakau (a sub tribe of Te Arawa) oral traditions, towards the end of the tribe's waka (canoe) journey migrating from Hawaiiki (the Māori ancestral homeland), when they were rowing along the east coast of the North Island, the travel-weary Te Arawa people sought a moment of respite on a reef, close to Mōtītī Island. Sensing his people's fatigue, the great tohunga (priest) Ngātoroirangi recited a karakia (incantation) imploring the gods to give his people strength to complete their voyage. Immediately, schools of different fish species were seen just below the water's surface. This sight was taken to be a good omen by those on board, giving them the necessary motivation to complete their journey. In commemoration of this event, Ngātoroirangi named the reef 'Te taunga o tā iti o ngā tāngata' or 'the resting place of the people', which is now short-

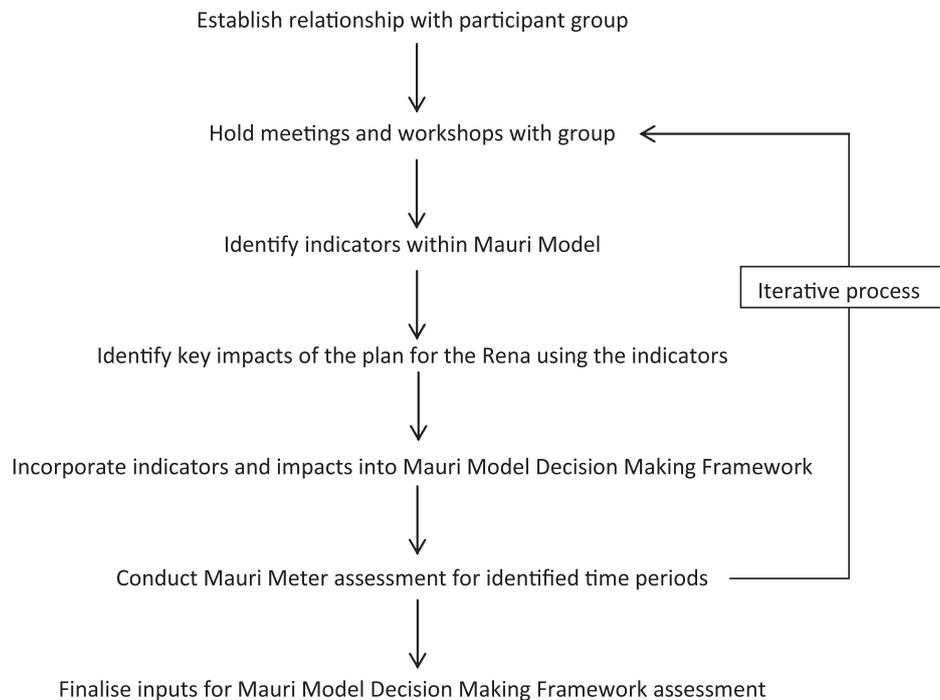


Fig. 5. Simplified overview of Mauri Model decision making framework assessment process.

ened to Otāiti (Te Rūnanga o Ngāti Whakaue ki Maketū, 2015). Other iwi in the surrounding area also have their own oral traditions regarding Otāiti, being prized for its physical characteristics: providing an important fishing ground, as well as being considered an important gateway to the 'spiritual realm' of the gods. It is because of the event associated with its naming that Otāiti is said to be imbued with the mana (prestige or spiritual power) of Ngātoroirangi, thus holding an important position as a wāhi tapu (sacred site), as well as being a place of practical use, providing marine food species for sustenance.

A participatory action research based methodology was used to work with Te Arawa ki Tai to identify the relevant impacts and how these directly affected the mauri of the iwi. The specific process used was adapted from the methodology used by Morgan (2008) to assess the impacts and implications of the 2007 Bay of Plenty spatial plan's management of wastewater (Environment Bay of Plenty, 2007). The methodology uses a combination of workshops, community hui (meetings) and GIS techniques to gather the relevant local and traditional knowledge, and assess the direct impacts upon the mauri of a given area, identifying particular areas of importance. The methodology employed in this context was altered from the 2007 version where necessary due to difference in contexts and different input variables. The flow chart above (see Fig. 5) gives an overview of the process used by the researchers when working with Te Arawa ki Tai.

The establishment of a partnership with the participant group was an important aspect of the process, as it defined the roles and expectations of all who were involved; the participants and researchers alike. One of the first actions as part of this research project in January, 2013, was to charter a launch vessel to take the participant group to the wreck site. This was significant, as it was the first time that any iwi were allowed within the exclusion zone to visit the Otāiti, as the early recovery stages were still underway. Also, this allowed the kaumātua (elders) to recite the appropriate karakia (incantations/prayers) associated with Otāiti, in order for the spiritual recovery of the reef and iwi to begin. This first post Rena visit to the reef provided the necessary cultural and spiritual platform for which the research and work could be completed with the participant iwi group.

With this relationship established, several meetings were held with Te Arawa ki Tai in the following year. These meetings consisted of reviewing the previous meetings findings and outcomes, discussing newly gained information regarding the wreck and recovery, and identifying the key inputs to be used for the Mauri Model impact assessment of the disaster. The researchers utilized a 'top down, bottom up' (Reed, Fraser, & Dougill, 2006) approach, where information would be generated in these meetings by the participants, with contributions from the researchers. Preliminary inputs for the assessment would be discussed (performance indicators, key impacts experienced, important sites and the time periods for assessment) and the researchers would take the generated information, process it and conduct a preliminary assessment of the impacts, with expertise gained from previous experience with using the Mauri Model in similar contexts (Morgan 2006a, 2006b, 2008; Hikuroa, Slade, & Gravley, 2010). The meetings were set up and hosted by the participant group, most often at a marae (traditional Māori communal complex), following the established tikanga (cultural protocols) of that place. Karakia (incantations/prayers), whaikorero (formal speeches) and waiata (song) were incorporated within these meetings, following appropriate kawa (marae protocols). From a Māori perspective, these practices ensured the spiritual integrity of the all participants, as well as the research being conducted, was upheld.

Spiritual and cultural integrity has been at the forefront of all of the work being done with the participant group. These meetings provided participants with an opportunity to contribute to the research, through the sharing of their knowledge, experiences and opinions regarding the disaster, its impacts and the recovery process. The active inclusion of the Te Arawa ki Tai participants, effectively as leaders and partners within the research helped to ensure meaningful participation. A key objective of these meetings was to generate discussion regarding the impacts of the disaster, incorporating the local and traditional knowledge of the Te Arawa ki Tai participants, to compile performance indicator sets which would dictate how assessments would be undertaken for each mauri dimension.

A technique used to facilitate the identification of impacts and Te Arawa ki Tai specific factors, was a GIS based technique, 'cultural mapping' or 'cultural opportunity mapping' (Tipa and Nelson, 2008). This process used large printed maps (A3–A2 size) of the disaster affected areas, upon which participants marked out areas of cultural significance directly on the map. This tool provided a visual prompt to facilitate discussion and visualization of the impacts experienced, as well providing a tangible sense of scale. Information from these exercises and the general meeting discussions were recorded on flip charts, directly onto the printed regional maps and in notes taken by the researchers. Once the indicator sets had been brain-stormed, discussed and chosen, they were also further revised by the researchers to ensure that relevance to the decided scope was maintained. Once the revisions had been presented back to the community and agreed, the indicator sets were used to conduct a Mauri Meter assessment of the plan for the Rena, using the available data to score the impacts using the indicators. The results of the assessment were circulated to the participant group and discussed during the next meeting. Presenting the updated work back to the participants provided an opportunity for them to provide feedback on what inputs were included and what did not accurately reflect their understanding of the context. This dialogue also provided the opportunity for the researchers to explain and share their thoughts on the current iteration of the assessment and information used, allowing for a shared understanding and a gradual growth of both the researchers' and participants' understanding. The sharing of knowledge between the researchers and participants was especially effective as the participants, being tangata taketake (indigenous people), provided the expert insights and interpretations on the cultural and localized impacts, while the researchers provided the expertise regarding the analysis of information and use of the decision support tools.

6. Outcomes

The process of conducting meetings, workshops and preliminary Mauri Model Decision Making Framework assessments with Te Arawa ki Tai was an iterative process, constantly improving on the previous input variables for the Mauri Model and updating and including any new information that had been made available or gained regarding the recovery, always encouraging and allowing for open dialogue between participants within a culturally appropriate setting. Through this process, a preliminary set of input variables were used to conduct an assessment of the post Rena impacts during the first year, seen in relation to a 100 year retrospective assessment of the pre-Rena mauri (Fa'au'i and Morgan, 2014; Morgan, Manuel, & Fa'au'i, 2013). The retrospective analysis was used to identify the pre-Rena state, as defined as the Ministry for the Environment's goal for the recovery process, to be used as the baseline to compare the post-Rena impacts. Continuing to follow the iterative methodology established, the input variables were again revised and updated, reflecting the dynamic and uncertain nature of the research context. The final indicator set and input variables were decided upon in 2015, almost four years after the disaster (Fa'au'i, Morgan, & Hikuroa, 2017). The updated variables therefore required an updated analysis of the 100 year retrospective mauri assessment of the impacted region, which identified the pre-Rena state as +0.48 on the Mauri Meter, indicating that the mauri of the Rena affected area, prior to the disaster, was in a sustainable state. The post Rena impacts assessment was also updated using the finalized indicator set and the timeline extended to cover the four year period post disaster from October 2011–October 2015 (see Fig. 7). The worldview analysis results for Te Arawa ki Tai are also presented below, which were calculated following the process outlined in Tables 2 and 3.

Te Arawa ki Tai

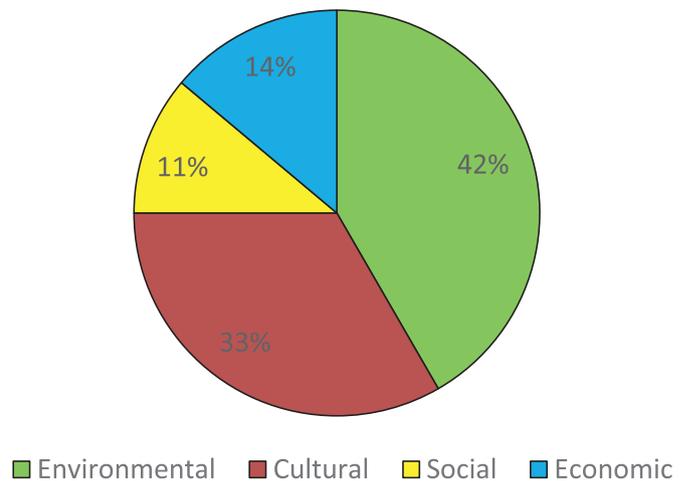


Fig. 6. Outcomes of worldview quantification for Te Arawa ki Tai.

From the data collected during the meetings and workshops with Te Arawa ki Tai, and from the resource consent application process, the Mauri Model Decision Making Framework's process was completed and their worldview was calculated, in terms of the mauri dimensions (Fig. 6). The two dimensions of highest concern were the mauri of the ecosystem (42%) and the mauri of Te Arawa ki Tai (33%). This standing is not consistent with all the iwi within the affected area, some of whom said that the mauri of the hapū, or the cultural considerations within this context, were of the highest importance). These differences in the iwi worldviews have affected their position regarding the application by the Rena's owners for a resource consent to leave the remnants of the Rena on Otāiti, following the required recovery. Te Arawa ki Tai and Mōtītī based Te Kāhui Kaumātua o Te Patuwai, have determined that the mauri of Otāiti can be regenerated, with the remnants of the Rena left in place, and were therefore in support of the resource consent, looking for other avenues to recuperate the mauri of Otāiti and the surrounding area (Ranapia, 2015). Other iwi have likewise determined that, whilst the Rena is on Otāiti, with the possibility of future contamination its mauri can never be recovered, deeming the only fit solution is for the wreck to be removed in its entirety. These iwi were in opposition to the resource consent (Smallman, 2015; Te Rūnanga o Ngāi Awa, 2014; Te Rūnanga o Ngāi te Rangī, 2015).

Te Arawa ki Tai initially had the same mindset as the iwi looking to oppose the resource consent, but through direct consultation with the Rena's owners, insurers and the process of working with the researchers, saw that the most beneficial outcome in this instance required the resource consent to be given. The resource consent covers ten years of potential contaminant releases, but also incorporates monitoring plans, both for the environmental aspects, as well for the cultural aspects (Bay of Plenty Regional Council, 2016). These provisions within the resource consent provide the best possible outcome, in the eyes of Te Arawa ki Tai. The Bay of Plenty Regional Council, as the consenting body, do not have the power to order full removal of the Rena from Otāiti. Therefore, Te Arawa ki Tai have identified (through the process of using the Mauri Model Decision Making Framework) other Rena-impacted factors that can be enhanced, regardless of the continuing contaminant releases, thereby improving mauri despite the legacy of the wreck.

Using the indicator sets developed with the Te Arawa ki Tai participants, the mauri of the Rena-affected environment was

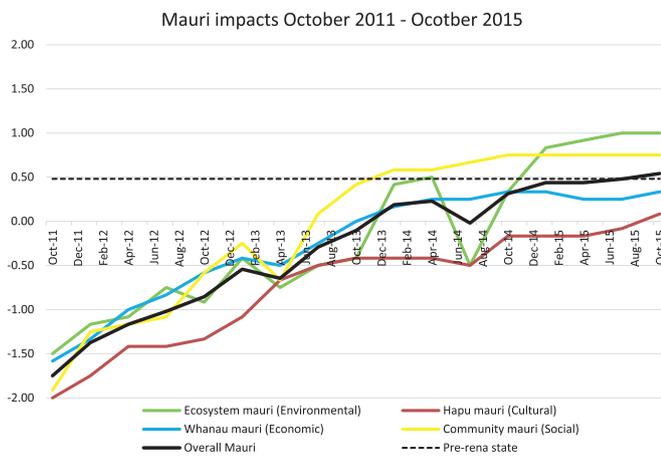


Fig. 7. Mauri Model decision making framework assessments, showing overall impact upon mauri October 2011–2015.

measured across a four year period, in three month intervals. The dashed line in Fig. 7 shows the previously determined pre-Rena state, which is the goal state for the recovery as outlined in the Rena Long Term Environmental Recovery Plan. The black solid line shows the overall mauri across the assessed time period, the equally weighted average of the four mauri dimensions (which are also shown on the graph). In October 2015, the overall mauri pushed above the pre-Rena state, indicating that at that time the environment had actually been enhancing (see Fig. 3 for Mauri Meter scoring).

However, it is not sufficient to consider only the current mauri: there must be some consideration of the cumulative impacts experienced across the assessed time period. An estimation of the cumulative effects can be calculated by finding the area between the overall mauri curve and the time axis, with areas above the time axis being positive and areas below being negative. In this case, as the pre-Rena state was set as the baseline, cumulative effects with reference to this pre-Rena state should be considered rather than the default setting with the mauri meter score axis at '0'. For restoration to this pre-Rena state to occur, there must be an equivalent amount of cumulative mauri effects, equal to or above the pre-Rena state line i.e., there must be a net equivalence or surplus of area that is above the pre-Rena.

The process of using the Mauri Model Decision Making Framework has helped Te Arawa ki Tai to identify areas where it is possible to make some meaningful progress towards furthering their iwi's aspirations regarding the recovery and the future of Otāiti. Looking at the individual dimensional mauri impacts, it is clear that the most negatively affected dimension is the mauri of Te Arawa (cultural wellbeing). There is an opportunity to enhance other culturally affected aspects; i.e., look for opportunities to enhance the other performance indicators within the resource consent process. The diminishment of mauri due to the presence of the Rena on Otāiti could be 'offset' with the enhancement of mauri using other key performance indicators. Enhancing the cultural dimension would provide the greatest increase in the overall mauri, as it is the lowest. There are some 'simple' enhancements to cultural wellbeing that could be contemplated (although these are simple in theory, but more difficult to implement in practice), such as recognition by the statutory authorities of traditional roles as kaitiaki (guardian or custodian) of the affected environment, and/or the effective involvement of tangata whenua (local iwi) within future decision making processes regarding the environment.

7. Reflections

The Kaupapa Māori based methodology utilized in this process provided an avenue where the participants were considered more as partners within the research than people who were merely being involved in a practitioner-led OR project. The idea of working 'with' the community, rather than 'on' the community has been a major part of the methodology, as seen in the 'top down, bottom up' approach, and the iterative process of utilizing each parties' strengths within the research context. Overall, the systemic intervention resulted in positive outcomes, with the participant group having a sense of ownership and active contribution to this research, heavily influencing key aspects of the model's formation and assessment. The resultant co-dependent relationship, between researchers and participants, has provided a meaningful outcome for the participant group who have gone on to successfully pursue their iwi's interests with the Rena's owners regarding the mauri of the reef and their iwi, using the Model as part of their own submissions regarding the resource consent to leave the remnants of the wreck on the reef. With the research team being Māori, with shared whakapapa with the participant group, there was an extra motivation to produce meaningful outcomes, both within the research and for the community also:

"What I was most impressed with was how the process ensures a meaningful link between the researchers and ahikāroa (iwi with long undisturbed occupation of land) . . . that convergence between the academics and those at the 'grass roots' is important for gaining a better understanding of what the communities are experiencing, and the capacity of the community is actually increased also." (Comment from Te Arawa participant at research findings seminar Morgan et al., 2015).

The process of working through the relevant issues with the participants to identify and place the relevant boundaries within the intervention, through the compilation of the performance indicator sets, was incorporated within a culturally familiar setting facilitating the generation of valuable and relevant information. With the use of mauri as the metric (an indigenous concept that encompasses the tangible and intangible), researchers and participants were able to consider both qualitative factors (the majority of the cultural aspects) and quantitative factors of the disaster or perceived impacts, side by side. This ability to consider and adequately represent both the 'soft' and 'hard' has allowed for a holistic assessment of the disaster. The incorporation of both qualitative and quantitative data allows for a representation of the experienced impacts in a way that is understandable to all parties, both 'experts' and lay alike, from all epistemological backgrounds:

"There was an immediate connection and understanding (of the Mauri Model) . . . it accurately and appropriately expresses cultural values in a way that scientists can understand and vice-versa. So the story it tells is a story grown from the tangata whenua experiences, and it can be expressed in a way that everyone understands." (Comment from Te Arawa participant at research findings seminar Morgan et al., 2015)

It must be said that the relationship the research team has built with Te Arawa, born out of the successful outcomes of the project, was not initially foreseen or intended. The ideal situation for this research was to have all the impacted iwi involved as research participants, thereby having a broad representation of the different iwi experiences and worldviews directly influencing the intervention and impact assessment of the disaster and its associated effects. However, due to a myriad of political pressures, changes in funding, internal conflicts within iwi and the dynamic conditions accompanying a disaster of this complexity, there was little interest in joining the study at the time of commencement from iwi

other than Te Arawa ki tai. This was in stark contrast to the interest shown in the initial cultural framing workshop held following the disaster, with the majority of the attendees wishing to participate in a unified response. Therefore the researchers knew that there was at least a seed of interest somewhere within these other iwi that perhaps did not have a chance to germinate within the turbulent circumstances in the months following the workshop. The initial interest from the other iwi prompted Morgan and Fa'au'i (2013) to launch a digitized version of the Mauri Model, maurimeter.com, a free-to-use web-based version of the framework that would allow people to undertake their own (simplified) assessments. The intent was for those who were not currently participating in the research, but were interested, to conduct their own assessments and 'try it out', with the possibility of including these other participants and iwi within the study at a later stage.

With the resource consent to leave the remnants of the Rena wreck on Otāiti being granted in February 2016, there may be an opportunity to make attempts again to include the other iwi within this research. The methods used to form the intervention and its boundaries can be directly adapted for use within these other communities: the process used with Te Arawa for identifying relevant boundary conditions, which are essentially the assessment criteria, can be directly used without much modification. Many of the previously identified Te Arawa indicators would most likely be relevant to the other iwis' views on the impacts and appropriate boundaries. Also their different worldviews can be accounted for and represented with the AHP process, and directly compared using the sensitivity analysis of the results. The challenge in this instance would be to gain a consensus on the use of a single set of indicators, and the thresholds for scoring used in the assessments. It would also be a challenge to get representatives from multiple iwi together at this late stage, as it is approaching five years following the disaster, and stakeholder 'burnout' regarding anything pertaining to the Rena is a likely scenario, especially with many iwi seeing the resource consent outcome as unfavorable, so they are generally dissatisfied with the present course of action being pursued by those managing the wreck.

7.1. Framework applications and recognition

Assessed against the OECD BellagioSTAMP process (Pintér, Hardi, Martinuzzi, & Hall, 2012), and singled out from a short-list of internationally recognized sustainability indicator sets, the Mauri Model Decision Making Framework is the only approach considered relevant regardless of the community it is applied within (Challenger, 2013). The Mauri Model is holistic and culturally derived (Berkett et al., 2013), having a mātauranga Māori (traditional Māori knowledge) conceptual basis. It has now been in use for more than a decade, taught since 2009 as an Engineering post-graduate elective and introduced as a core curriculum component in 2015 in Part II of the BE(hons) at the University of Auckland. The Mauri Model Decision Making Framework has also been acknowledged by the Institution of Professional Engineers NZ through a Furkert award for sustainability and green technologies in 2016, meaning that it has been judged to represent "supreme technical excellence".

Known for a millennia within Polynesia, and having resonance with Asian continental epistemologies (Mak & So, 2014), mauri has now been incorporated as a measure for environmental reporting in New Zealand. The Environmental Reporting Act 2015 (Ministry for the Environment, 2015) provides for te ao Māori (the Māori world) to be an impact category to ensure synthesis and domain reports are informed by a Māori perspective. Mauri is expected to become better understood, as the understanding of mauri presently could be likened to the understanding of gravity prior to Newton's *Principia Mathematica* (Whitehead & Russell,

1962). Mauri is the foundation principle of the Mauri Model, thus enhanced understanding of how mauri is measured provides insights into how it can be better measured into the future, which is fundamentally important to more fully understanding the global survival of humanity.

The Mauri Model Decision Making Framework allows Indigenous peoples to contribute understanding based on their own knowledge so that they can be effectively included in resource management decision making processes. The Framework adds a strengthened decision making context due to its ability to incorporate culturally relevant knowledge seamlessly alongside scientific understandings of a situation, incorporating both quantitative and qualitative data consistently into the same assessment. When mauri is defined as the life supporting capacity of the air, water and soil, the theoretical basis is created for relevance in terms of New Zealand law, and a means to measure and evaluate impacts in a holistic way then exists.

The transferability of the Mauri Model Decision Making Framework identifies it as a potential pathway to more sustainable decisions and actions. Thus, through integrating systems techniques and the indigenous concept of Mauri, the Mauri Model Decision Making Framework creates a new approach to cross-cultural communication and action.

8. Conclusions

While 'boundary may be key' (Midgley, 2000), despite evolving understandings in systems science, there remains considerable uncertainty and indecision about where to place boundaries in relation to complex 'wicked' problems. Boundary definition has been achieved relatively well in the case of the Rena recovery, however, using the Mauri Model Decision Making Framework. The definition of boundaries in the Rena research has been refined throughout, drawing understanding primarily from analysis of the mauri impacts at the boundary, without the boundary, and those evidenced across the boundaries.

The clean-up process has now been underway for more than four years and is acknowledged as the second most expensive wreck recovery in the world, at more than half a billion US dollars. In October 2015 a Resource Consent hearing concluded which sought approval to abandon the remaining sections of the Rena wreck on Otāiti. Māori submissions to the hearing process were divided between opposition to the applicant's request and support from others, with Te Arawa ki Tai included among the latter. The Te Arawa ki Tai position was thoroughly researched and informed by combined knowledge sources: scientific data (including underwater digital recordings) alongside Māori values. Discussions with the resource consent applicant (the owner of the Rena) identified willingness for the inclusion of mauri monitoring using the Mauri Model Decision Making Framework in the consent conditions. Te Arawa ki Tai consider this to be essential to ensure that the impacts upon mauri continue to be understood and influence the management of Otāiti over at least the next ten years. The use of the Mauri Model Decision Making Framework remains a moot point, yet no other alternative has been identified.

How the Mauri Model Decision Making Framework has empowered Te Arawa ki Tai in the recovery process and facilitated an enhanced Te Arawa ki Tai understanding of this 'wicked' problem has been discussed. Since the grounding, Te Arawa ki Tai have co-created indicator sets that are inclusive of all of the relevant scientific and indigenous knowledge available. A retrospective evaluation of impacts upon the mauri of indicator sets representing each mauri dimension over a period of one hundred years prior to the MV Rena grounding was necessary to identify the pre-Rena state. The impact upon mauri since the MV Rena grounding has also been evaluated using the same indicator sets, with quarterly

assessments; thus the current mauri state is known, as is the cumulative impact upon mauri in the 48 months since October 2011.

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