National SCIENCE Challenges

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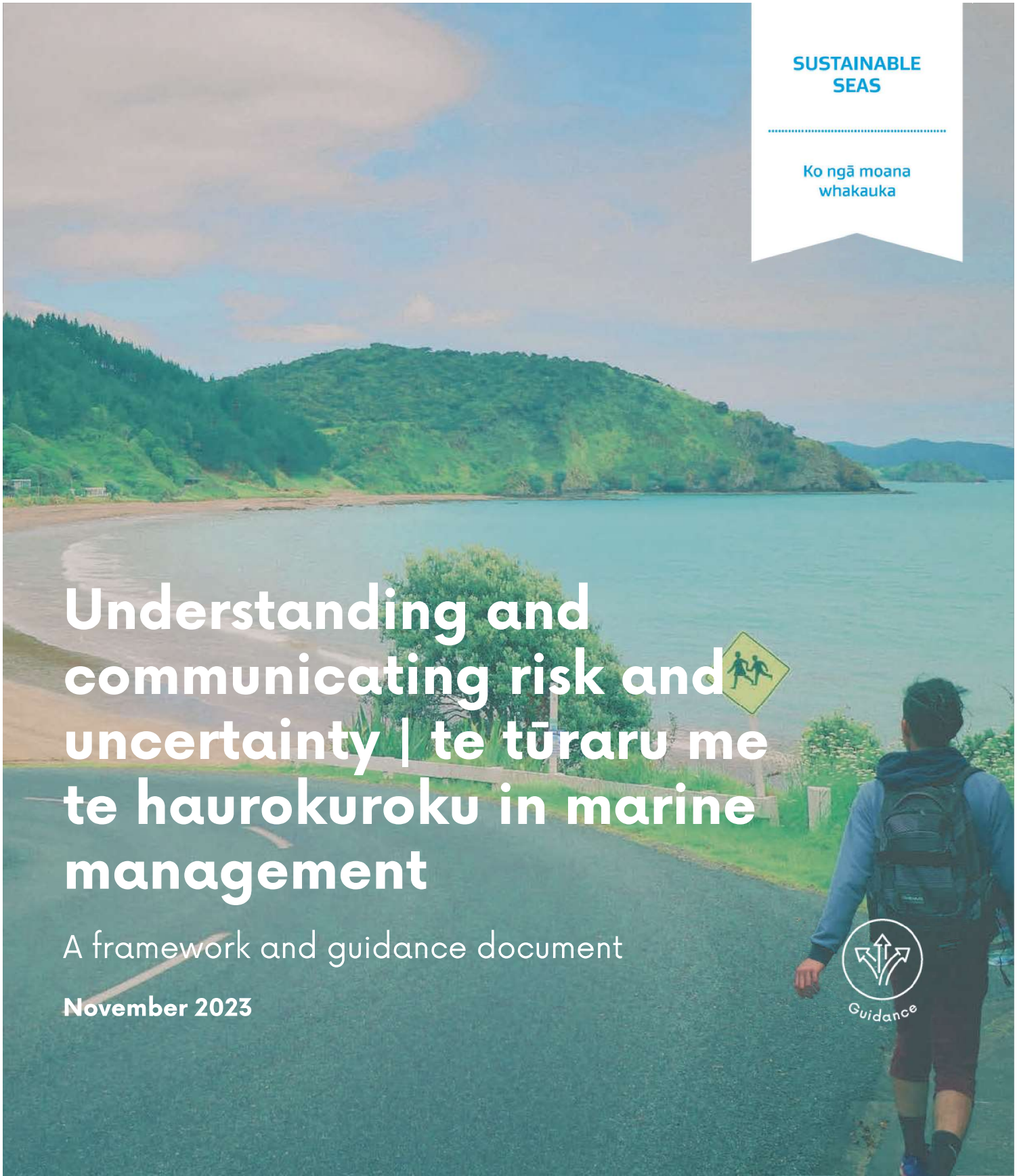

# Understanding and communicating risk and uncertainty | te tūraru me te haurokuroku in marine management

A framework and guidance document

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Guidance

**Project 3.1 Perceptions of Risk and Uncertainty**

Paula Blackett (NIWA)
Shaun Awatere (Manaaki Whenua Landcare Research)
Erena Le Heron (Le Heron Leigh Consulting Limited)
Richard Le Heron (University of Auckland/Le Heron Leigh Consulting Limited)
June Logie (University of Auckland)
Jade Hyslop (Manaaki Whenua Landcare Research)

**Project 3.2 Communicating Risk and Uncertainty**

Joanne Ellis (University of Waikato)
Fabrice Stephenson (University of Waikato)
Judi Hewitt (NIWA/University of Auckland)
Ilze Ziedins (University of Auckland)
Maria Armoudian (University of Auckland)
Richard Bulmer (NIWA)
Dana Clark (Cawthron Institute)
Rebecca Gladstone-Gallagher (University of Auckland)
Ani Kainamu (NIWA)
Vera Rullens (University of Waikato)

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# About this document

This guidance document introduces findings and recommendations from our research on risk and uncertainty. It covers the work of two Sustainable Seas National Science Challenge projects: *Perceptions of Risk and Uncertainty* and *Communicating Risk and Uncertainty to aid decision making*.

The document is structured around five recommendations from the projects. It also includes case study examples, frameworks, scenarios, and diagnostic tools.

## A series of quick guides to support this document

We've also written five quick guides as practical summaries of key parts of this framework and guidance document. You can find them on our website, and they are linked below.

Quick guide 1: Perceptions of risk and uncertainty influence marine management decisions

This guide explains why perceptions of risk and uncertainty matter in marine management and summarises the main research findings.

Relevant part of this document — summary of recommendations.

Quick guide 2: Worldviews influence their perceptions of risk and uncertainty

This guide explains what worldviews are and why they matter when making decisions for the long-term good of the marine environment.

Relevant part of this document — Recommendation 2: expose worldviews, discipline, and positionality to unpack perceptions of risk and uncertainty.

Quick guide 3: Te Ao Māori understanding of tūraru me te haurokuroku (risk and uncertainty)

This guide introduces a Te Ao Māori lens on risk and uncertainty.

Relevant part of this document — Recommendation 2: expose worldviews, discipline, and positionality to unpack perceptions of risk and uncertainty.

Quick guide 4: Tools to help navigate perceptions of risk and uncertainty

This guide introduces tools to help navigate different perceptions of risk and uncertainty in decision-making.

Relevant part of this document — Recommendation 3: think about implications of worldviews, positionalities, and disciplines and negotiate a pathway for enacting ecosystem-based management and incorporating Te Ao Māori in 'risky' decision-making.

Quick guide 5: How to incorporate risk and uncertainty in ecosystem-based management

This guide explains what an ecosystem-based risk assessment should be able to do and has a decision tree to help choose the right method.

Relevant part of this document — Recommendation 4: select a risk assessment method that is capable of meeting ecosystem-based management requirements and Māori needs and aspirations.

## Ecosystem-based management and Te Ao Māori knowledge is reshaping thinking about risk and uncertainty

We hope this document will help practitioners and decision-makers find pathways for working with risk and uncertainty and inform any future decision-making about risk.

Throughout this document we have recommended ways to engage with risk and uncertainty in the current Aotearoa New Zealand context. Understanding how Māori knowledge is reshaping risk is an important part of this.

We point to Sustainable Seas National Science Challenge Waka Taurua framing as our starting point. This framing interweaves Te Ao Māori and Te Ao Pākehā in Aotearoa New Zealand and could flow directly into future environmental legislation and decision-making. This inclusive, collective approach has great potential to break short-termism and re-imagine thinking, especially about intergenerational outcomes.

Our focus is also on ecosystem-based management — manging marine ecosystems in a holistic, inclusive way. A Te Ao Māori-centred approach to risk and uncertainty also honours obligations under Te Tiriti o Waitangi and can help Aotearoa New Zealand transition to ecosystem-based management.

Overall, a greater awareness of where the differences regarding risk and uncertainty perception lie will support a more nuanced approach to dealing with conflict in decision-making and with applying tools and practices to enact ecosystem-based management and including Te Ao Māori principles and processes.

## About the risk and uncertainty projects

This section gives an overview of the purpose of each project, how this document supports the purpose, and summarises some of the methods.

The *Understanding perceptions of risk and uncertainty project* identified the need to conceptually step back to engage with available knowledge on the subject.

Describing different perceptions of risk in and of itself is not enough – so we asked the wider contextual question, 'why are we always arguing about risk and uncertainty?'. This question gets at the heart of why differences in perceptions and understanding of risk and uncertainty occur, and what can be done about these differences in decision processes.

In this document[1] we:

- unpack, *'why we do we always argue about risk and uncertainty'* when making decisions about natural resource use in Aotearoa New Zealand
- provide insights and guidance for practitioners to help navigate the often-invisible differences between people and interests that lead to conflict in decision-making processes
- argue that once these invisible forces are illuminated and their influence on practice are considered, a decision-maker is better placed to choose what tools, approaches, practices, and methods might be useful in their context
- provide tools of thought to help decision-makers explore their own perceptions of risk and uncertainty, including risk to what, for whom, where and when, before attempting to make decisions in various settings
- highlight that gaining awareness of how you think about risk and uncertainty is a necessary step in engaging with others who are likely to have differing risk and uncertainty perceptions.

The *Communicating risk and uncertainty to aid decision-making* project focused on the utility of present risk assessment methods to support ecosystem-based management and the needs and aspirations of Māori, as a major way in which risk and uncertainty could be communicated within the decision-making process.

Risk assessment initially involved the concept that risk is comprised of the likelihood of an event occurring and the consequence of the event on something of importance. This frames the starting point of a risk assessment as thinking about, *'risk to what value?'* and *'risk from what stressor?'*. These two simple questions still underly most risk assessments, and most still focus on one activity (risk from what stressor) influencing one species or habitat (risk to what value).

We suggest that this simplistic view is no longer enough.

- To support ecosystem-based management and Te Ao Māori principles, especially in the current proposed Aotearoa New Zealand management landscape, risk assessments for decision making need to include looking forward to restore rather than just protect, and to assess risks to success associated with a range of possible actions (scenario testing).
- Risk assessments need to deal with cumulative effects from multiple stressors as very few marine areas in Aotearoa New Zealand are affected by only one stressor.
- To support ecosystem-based management, risks to multiple social (including economic), cultural, and ecological values all need to be assessed.

[1] This document is a compilation and summary of other works, designed to be easily accessible. References are found throughout.

In this document we provide a decision tree to assess common risk assessment methods currently used in Aotearoa New Zealand and show the application of three risk assessment methods in three case studies. We also show the application of different methods using four case studies.

## Ngā tikanga | our methods

The projects explored several streams of evidence and information.

*Table 1: Research methods across projects*

| **Key questions** | **Methods** | **Activity** | **Outputs that discuss the methodologies** |
|---|---|---|---|
| How are Māori worldviews around risk articulated to other professionals, via existing frameworks? | Literature reviews | Mātauranga Māori frameworks and approaches to risk and uncertainty | Hyslop et al, 2022; Le Heron et al, 2023j, 2022 |
| How do various disciplines know and understand risk and uncertainty?<br>What are the critical influences on perception of risk and uncertainty? | | Disciplinary positions on perception of risk and uncertainty | |
| What mātauranga is there around risk and uncertainty?<br>What are the successes and difficulties associated with enacting Te Ao Māori worldviews in different decision settings? | Interviews and document analysis | Interviews with (12) Māori experts | |
| How do different (conflicting) perceptions of risk and uncertainty play out in decision-making in Aotearoa-NZ?<br>How do these perceptions enable maintenance of existing worlds or creating new ones?<br>The emphasis is on making highly visible the investment pathways that are presented, implicitly and explicitly, by the different worldviews being championed. | | Document analysis of historical case studies (3): Chatham Rise phosphate mining, Okura Development, and mangrove management around Aotearoa | |
| What are the practical realities of the influences of different perceptions in a consenting process? | | Interviews with key informants (8) associated with the case studies | |
| What risk assessment methods are presently used and are they capable of considering recovery strategies, ecological dynamics, ecological, social, cultural and economic dependencies and desired outcomes?<br>Can they include mātauranga and local knowledge? | Literature reviews | Assessment of present methods and creation of a decision tree to allow quick comparisons | Clark et al, 2021, 2022, this document |
| What are the values in 'risk to what values'?<br>What kind of risks are government stakeholders concerned about? | Workshop and survey with co-development partners | Analysis and report | Clark et al, 2021 |
| Can we improve our risk assessment methods? | Case studies | Ōhiwa mussel restoration, Cumulative effects modelling, Development of principles for Cumulative effects assessments that can be used in areas with sparse western science data, Comparison of two methods by Moana and ICP | Bulmer et al in review, Rullens et al, 2022b, Gladstone-Gallagher et al, in review, this document |

The combined methods and lines of research allowed unique issues to be pursued and a deep understanding to evolve of nuances of risk perception in decision choices and practice in Aotearoa New Zealand (for more detail see E. Le Heron et al 2022b and R. Le Heron et al, 2022) and those involved in decision making to select methods that will support the broadest participation base (Clark et al 2022). From this knowledge base, we developed this guidance document.

Work conducted for *'Communicating Risk and Uncertainty to aid decision making'* outside this particular document includes example applications and methodological developments for accounting for risk and uncertainty in spatial planning (Stephenson et al, 2021; Mouton et al, 2022; Reichelt-Brushett et al, 2022; Watson et al, 2022; Lohrer et al, 2023), developing methods for better understanding, visualising and communicating changes in ecological risk with cumulative impacts (Rullens et al, 2022b; Armoudian, 2023; Gladstone-Gallagher et al, in review), applying methods for assessing the impacts and risks from climate change (Anderson et al, 2022; Rullens et al, 2022a; Stephenson et al, in review), and exploring novel methods for combining outputs and tools for interdisciplinary risk assessment (Bulmer et al, in review; Rullens et al, in review).

## Kia rima ngā huanga matua | five recommendations — a summary

Our research offers five important recommendations to implement ecosystem-based management alongside Te Ao Māori to improve risk management decision-making and the wellbeing of the environment.

This section summaries these recommendations, and the rest of this document explores them in more detail. Quick guide 1: perceptions of risk and uncertainty influence marine management decisions also summarises the findings and recommendations.

1. **Reconceptualise risk and uncertainty for ecosystem-based management and Te Ao Māori in Aotearoa New Zealand — Māori knowledge is reshaping risk thinking**
   The way risk and uncertainty is now used for environmental decision-making in Aotearoa New Zealand does not work well for ecosystem-based management or Māori. To broaden practices, a shift is needed in investment decisions from prioritising the economic in to prioritising the environment as the overriding frame for organising decision pathways. Also needed is a recognition that what's risky depends on your perception.

2. **Expose worldviews, discipline, and positionality to unpack perceptions of risk and uncertainty — decision makers need to understand these invisible shapers of risk perception**
   Decision-makers must position themselves in both their professional and individual roles and become aware of the hidden influences that impact risk and uncertainty framing in different situations.

   Knowing the main active worldviews in Aotearoa (Dominant Social Paradigm, New Environmental Paradigm, and Te Ao Māori) means acknowledging that some worldviews hinder progress towards ecosystem-based management (EBM). An EBM and Te Ao Māori approach represents a way forward to decision-making for longer term, wider ecological aspirations.

   **Relevant references**
   Diagnostic tool 1: Unpacking perceptions of risk and uncertainty
   Quick guide 2: Worldviews influence people's perceptions of risk and uncertainty
   Quick guide 3: Te Ao Māori understanding of tūtara me te haurokuroku (risk and uncertainty)
   Quick guide 4: Tools to help navigate perceptions of risk and uncertainty
   Appendix 3: What data is needed for flourishing futures?

3. **Think about the implications of worldviews, positionalities, and disciplines and negotiate a pathway for enacting ecosystem-based management and incorporating Te Ao Māori in 'risky' decision-making**
   Decision-makers can take steps to go beyond the existing dominant perceptions of risk and uncertainty, to help open possibilities for new directions.

   Regardless of the resource-change issue, Aotearoa New Zealand decision-makers are left without much guidance on weighing claims, rights, and obligations. The cascading steps format of the *Diagnostic Tool 2* assigns Tiriti issues and partnerships top priority as they affect what is imagined as environmental and economic futures, and what risks and uncertainties might be attached to them. The Guidance for *Diagnostic Tool 2. HUAT Working with risk* that follows in this document adds detail and a wealth of examples.

**Relevant references**

Diagnostic tool 2: Working with risk and uncertainty
Quick guide 4: Tools to help navigate perceptions of risk and uncertainty
Appendix 3: What data is needed for flourishing futures?

4. **Select a risk assessment method that is capable of meeting ecosystem-based management requirements and Māori needs and aspirations — different practices can create different futures**

   While an application that a risk assessment is for may not need an assessment that that can deal with all ecosystem-based management and Te Ao Māori principles, choosing a method that does include them has b one real benefit. It allows the risk assessment process to theoretically be able to incorporate all interests, and clarifies that interests, stressors and values left out of the risk assessment have been done so deliberately by those involved in the risk assessment process.

   **Relevant reference**

   Quick guide 5: How to incorporate risk and uncertainty in ecosystem-based management

5. **Re-engage continually with diagnostic tools to assess the 'success' of 'risky and uncertain' processes**

   Evaluation, reflection, and learning are key to implementing and improving processes. Diagnostic tools are not one-stop tools. At key points in any process, decision-makers should revisit and re-use them. Being open to re-engaging with tools means being in a stronger position to make sense of achievements and any barriers to not taking risk dimensions for granted.

   **Relevant references**

   Rubric 1: what does success look like when 'working with risk and uncertainty'?
   Diagnostic tool 1: Unpacking perceptions of risk and uncertainty
   Diagnostic tool 2: Working with risk and uncertainty
   Quick guide 4: Tools to help navigate perceptions of risk and uncertainty

## A conceptual overview of the projects and outputs

The figure below shows an overview of the project concepts and outputs.

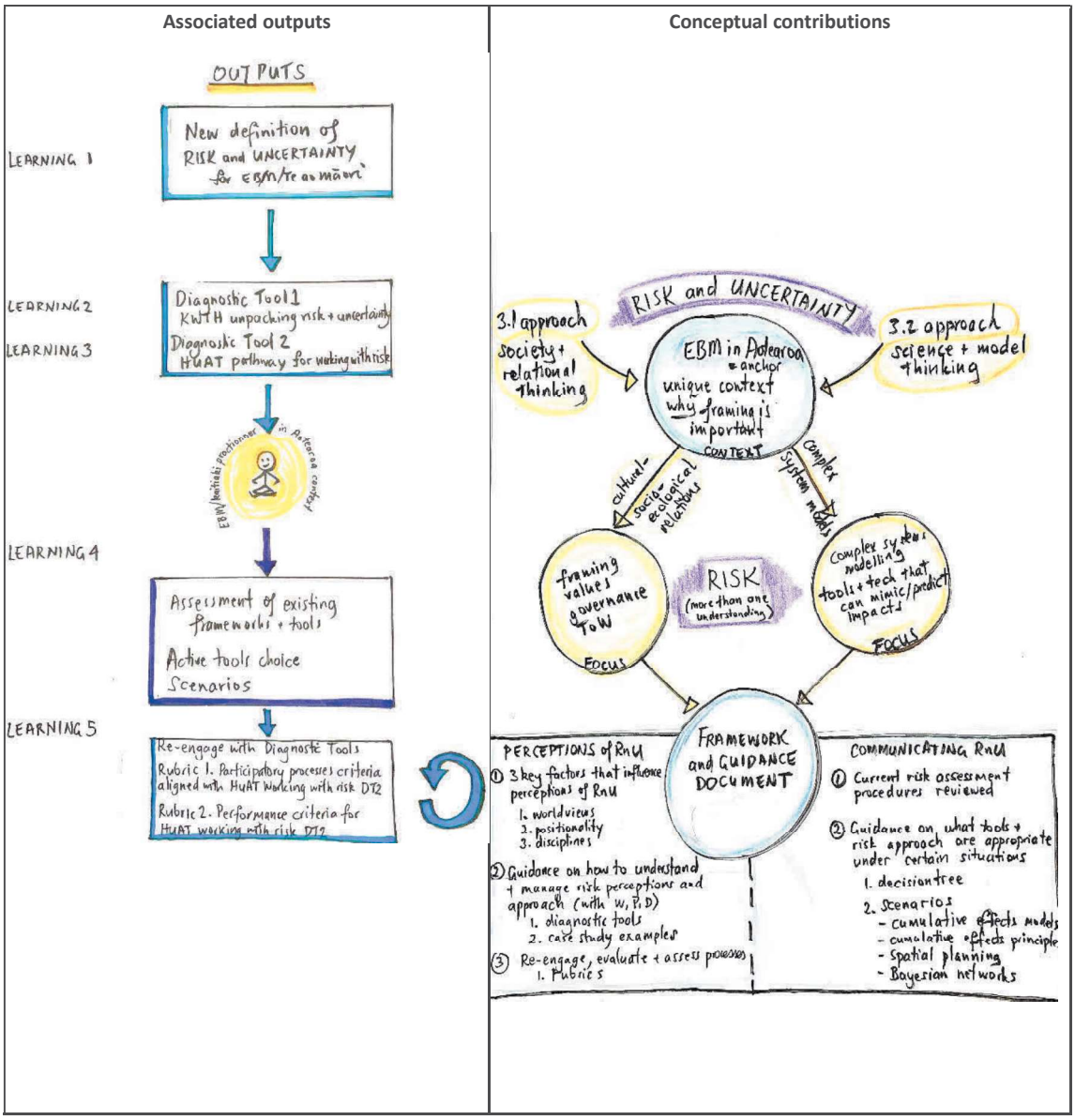



*Figure 1 A conceptual overview of the projects and outputs*

# Recommendations and guidance in detail

In this section we expand on each recommendation and give guidance, examples, case studies, and tools where appropriate to support each recommendation.

# 1. Reconceptualise risk and uncertainty for ecosystem-based management and Te Ao Māori in Aotearoa New Zealand

In this section we've included insights and guidance on the following findings.

- Multiple understandings of risk and uncertainty exist.
- Risk and uncertainty are entangled.
- We must reconceptualise tūraru me te haurokuroku | risk and uncertainty.

## Multiple understandings of risk and uncertainty exist

The outcomes of decision-making processes are likely to be very different depending on perceptions of risk and uncertainty.

The social and cultural context in which risk is decided, understood, and experienced is all important. Acknowledging the 'invisible' factors (worldviews, disciplines, and positionalities) influence[2] on what is seen as risky and uncertain, is a pioneering approach that better frames risk towards the application of ecosystem-based management and Te Ao Māori goals.

Changing decision-making processes to include multiple understandings of risk and uncertainty is necessary. This means understanding that individuals, institutions, communities, groups, hapū and iwi, understand and expect to experience the impact or implications of an event or change or action to or on something they value in different ways, using different words and concepts.

A Te Ao Māori-centred approach has much to offer 'risk and uncertainty thinking' in natural resource management and is well aligned with current environmental policy directions and aspirations of ecosystem-based management.

Dominant, more narrow, perceptions of risk and uncertainty can be compared with broader perceptions of risk and uncertainty that include a Te Ao Māori worldview and a 'new environmental paradigm' worldview.

**Dominant perceptions of risk and uncertainty** are a product of the Dominant Social Paradigm worldview and heavily influenced by the disciplines of economics, law, and sciences. These perceptions of risk and uncertainty are usually about loss, change and financial cost-benefit analysis, focusing on trade-off rather than new directions of action. They can also be about not achieving or partially achieving the outcome aimed for. Dominant perceptions of risk and uncertainty are about hazards and probability, about 'reducing risk' and 'reducing uncertainty', and they can be modelled.

These dominant perceptions can hinder change because they embed key 'reduce risk' views in societal structures, legislation, governance, and industry practices and are embedded in science research and methodological practices.

[2] Much can be said about the influence of worldviews, positionalities, and disciplines on conceptions of risk and uncertainty. Recommendation 2 discusses this in more detail. Please also see our published papers for a deeper explanation of why these are so important.

Having one dominant understanding of risk and uncertainty reduces the scope of possibilities or of identifying new options, a factor often overlooked.

In Aotearoa New Zealand, the dominant understanding of risk is couched predominately in economic terms when making decisions with available information. This understanding cultivates an ethos of self-interest and maintains the status quo of power relationships and privileges.

Dominant perceptions of risk and uncertainty are about 'reduce risk' thinking. This means thinking about reducing the risk of financial cost, or about reducing degradation — instead of focussing on enhancement or recovery and elevating environmental goals and actions.

But there are other ways to engage with te taiao | the environment. Ecosystem-based management practices and Te Ao Māori focus on enhancing mana, restoring mauri, and managing the marine environment in a holistic and inclusive way, with principles of sustainability, co-management, and partnering.

The Sustainable Seas National Science Challenge explicitly endorses and seeks to encourage ecosystem-based management and Te Ao Māori practices.

**Broader, more inclusive perceptions of risk and uncertainty** work towards ecosystem-based management and Te Ao Māori goals. These perceptions are a product of New Environmental and Te Ao Māori worldviews and are about 'enhancing the mana' of a localised environment and environmental conditions.

Broader perceptions of risk and uncertainty align with ecosystem-based management thinking and Te Ao Māori goals. Broader perceptions are not yet embedded, but an appetite for change enlivens thinking towards a holistic view of risk and uncertainty that includes, but goes beyond, known outcomes, restricted economic thinking, or probability calculations.

This broader thinking about desired futures links to Te Ao Māori considerations of longer timeframes and future generations.

## Māori perspectives focus on mana-enhancing practices

Māori perspectives on tūraru me te haurokuroku are fundamentally different to dominant euro-centric and techno-centric perspectives. Māori perspectives focus on mana-enhancing processes and practices rather than prevailing risk assessment and mitigation strategies.

Enhancing the mana, or the intrinsic value of natural resources, provides an alternative to more reductionist approaches of standard risk assessments and reducing uncertainty in current natural resource management decision-making. Decision making parameters must shift to support the mana o te taiao, not just reduce risk in conventional terms. At first this shift may seem hard to fathom, but steps are available to make this transition.

> 'Māori perspectives of environmental risk are inherently holistic, multi-dimensional, interconnected, and values based, and can be used to guide more ethical and moral risk assessment as an alternative.' (Hyslop et al, 2022)

A Te Ao Māori perspective also lengthens the time for evaluating risk and uncertainty, which extends the values that are considered to be 'at risk' to future generations.

Māori take a holistic approach to natural resource management decisions and strive to achieve balance in all things, between competing economic, sociocultural, and environmental drivers, and in

the relationship between whānau/hapū/iwi and te taiao more generally. Recognising this, a general 'appetite for change' exists within Aotearoa New Zealand's current natural resource management policy space.

Many policymakers are willing to incorporate Māori perspectives and mātauranga into natural resource management (NRM) policy. However, to date, implementation of policy responsive to mātauranga Māori has been imperfect and partial.

To ensure that Māori worldviews are considered adequately within decisions concerning risk and uncertainty, these steps below are essential.

- Frame environmental issues from a Te Ao Māori perspective.
- Avoid the gratuitous co-option of Te Ao Māori in natural resource management
- Provide adequate resources for Māori participation in natural resource management.

We need to carefully and collectively navigate these challenges to put in place and realise the benefits of the Te Ao Māori approach of mana-enhancing natural resources alongside more technical and scientific approaches.

## Te Ao Māori values and tools that can link to risk and uncertainty practices and processes

| |
|---|
| **Whakapapa**: provides a place or whenua baseline for assessing responsibility and environmental risk. |
| **Kaitiakitanga**: describes the interface between the spiritual and the physical dimensions of natural resource management (NRM). Is a process that regulates human activity with te taiao. |
| **Mauri**: the form of value that indigenous risk management responds to. |
| **Mana**: fundamental importance of natural resources for well-being of the wider environment, not just for humans. (Hyslop et al, 2022) |
| **Some tools** |
| **Rāhui**: allows hapū to push 'pause' until there is less uncertainty. |
| **Maramataka**: intimate knowing of environmental processes that helps to predict environmental impacts, reduces uncertainty, and maintains balance. |

*Figure 2 Mātauranga concepts in terms of risk and uncertainty.*

In terms of how tūraru and haurokuroku work with core Te Ao Māori principles and concepts regulating behaviour, Hyslop et al (2022) offer definitions that describe mana, mauri, whakapapa and kaitiakitanga *in terms of risk and uncertainty.* This goes a crucial step further than the usual more generic definitions of mana, mauri, kaitiakitanga, whakapapa, and is useful in terms of interlinking conceptions of risk and uncertainty with practices and processes.

People will likely identify themselves as having a mix of dominant social paradigm, new environmental paradigm and Te Ao Māori worldviews, as the world is messy and complicated (see Recommendation 2 for more on worldviews). However, dominant understandings that are embedded in practice are difficult to shake, even when individuals may wish otherwise (see (Hyslop et al, 2022) for excellent examples of this tension in the TAM context)[3].

[3] For further guidance see Appendix 1: What is my worldview? A short self-reflective exercise, and Appendix 2: Worldviews and legislation

## Risk and uncertainty are entangled

Perceptions of risk and uncertainty are inextricably bundled and considering them as separate components that can be quantified and known requires careful attention and consideration in a decision-making process.

Whakaaro Māori does not separate uncertainty from risk. The idea of uncertainty arises because of the compartmentalisation of knowledge in western science thinking, where complex issues are dealt with in this way. However, Te Ao Māori perspective understands and prioritises the connections between ecosystems. The lessons learned from hazards over time has created a database of potential risk (maramataka) and behaviours about looking after the environment (manaakitanga[4]). A whakaaro Māori perspective is about interconnections, and risk and uncertainty are perceived together.

When communicating with the public, similar entanglements of risk and uncertainty occur because risk is often considered to include uncertainty.

Conceptualising risk-and-uncertainty together, means that progress past siloed definitions can be made, moving into how risk and uncertainty operates in the world, for different circumstances, worldviews, and people.

Overall, uncertainty tends to be debated in detail when choosing an action regarding a value or desired future 'at risk'. However, different kinds of uncertainty exist in risk discussions[5]. For example, political uncertainty and process uncertainty are very different from scientific uncertainty.

In the environmental policy world, risk is the framing of known uncertainty. Unknown uncertainty (unquantifiable) is ignored, although its dimensions are increasingly being researched. For example, work on extreme events, events that are outside the realm of our present experience and beyond our expectations. 'Surprising, extreme events have been labelled "black swan" events' (Taleb, 2007). 'They differ from high consequence events with low probability in that "black swan" events cannot be predicted from our present knowledge, understanding or beliefs' (Aven, 2013).

Importantly, uncertainty exists in all disciplinary endeavours and within all decisions but is rarely acknowledged. It's more helpful to explore the different perspectives regarding uncertainty, than try to produce a single definition of certainty. This moves the ground towards forward-looking decision-making where alternatives are foregrounded.

[4] Gail Tipa's NZGS presentation showed the possibilities of obtaining a rich base of data at micro-local levels (Tipa, 2022).

[5] For a discussion on the types of uncertainty and how they compound see Hanna et al (2020)

**Uncertainty influences how people *process* risk**

> Example A: if risk can be given a 'certain' number, it can then be perceived as risky; if the risk is uncertain, then it is seen as less because it might not happen.
>
> If geologists are certain that there will be a 7.1 earthquake in Wellington at a depth of 5m in the next 10 years, then the risk of (or from) an earthquake in Wellington, can be quantified. If geologists were uncertain about this happening, then the risk would be seen as less.

> Example B: in a contrary example; if risk can be given a 'certain' number, it can also be perceived as less risky; and if it is uncertain, then the risk is seen as greater (which is the opposite of example A)
>
> Quarry bosses want to know in quantifiable terms what the risk of hitting an isolated patch of highly carcinogenic rock (causing airborne pollutants). In this case, if the risk is known (certain) they can act to mitigate against it, and the risk becomes less 'risky.'

> Example C: a home on a coastal cliff. A high value house with a one hundred percent chance of cliff collapsing and taking house with it in the next year – no one will build or buy. But if there is an eighty percent chance of this occurring in the next 50 years, a person might take engineering measures such as building a retaining wall, might reflect on their memories of weather and remember conditions favourably, might think it's far in the future, might very much want to have a home with a spectacular view – and decide to proceed in a 'high' risk and uncertainty situation, often by not acknowledging it (rather than accepting it), or by transferring the responsibility of risk to others (eg to the council who give a permit or engineers who provide mitigation measures).

The project was tasked with *perceptions* of risk and uncertainty – and these are thoroughly entangled. The severity of consequences or desirability of a certain outcome often influence perceptions of risk and the uncertainty involved. Time horizons also play a factor in assessing risk and uncertainty ("it's in the future, ie too far ahead to worry about") and time horizons vary with worldview. In short, people can behave very oddly around risk and uncertainty, often disregarding them both if desire for a certain outcome is high, or downweigh unexperienced risk if an outcome is favoured.

Uncertainty and risk, as seen in the above examples can be confusing and understood differently.

## We must reconceptualise tūraru me te haurokuroku | risk and uncertainty

Project 3.1 has identified that, conceptually and empirically, the dominant understandings of risk and uncertainty do not work to further ecosystem-based management or Te Ao Māori goals. We know that there is contestation in multiple settings, unresolved conflict, and degradation of the environment, and that a dominant social paradigm (DSP) understanding of risk compounds the difficulties of stepping towards sustainability, co-management, and co-governance.

**Reconceptualised perceptions of risk and uncertainty**

**Perceptions of risk and uncertainty are:**

> *the way that individuals, institutions, communities, groups, iwi and hapū* ***understand and expect to experience the impact/implications of an event or change or action to/on something they value*** *eg a place or activity, or relationship)* ***or a desired future outcome****.*
>
> (Le Heron et al, 2023j)

Perceptions of risk and uncertainty are understood in terms of relationship to a change in value and desired futures.

**A Te Ao Māori lens on risk and uncertainty:**

> ***thinking instead of how an activity can 'enhance the mana' of a natural resource*** *in the first instance (rather than being limited to reducing adverse risk).*
>
> (Hyslop et al, 2023)

Uncertainty itself isn't a criterion that kaitiaki focus on, rather the approach is one that is principles based ie restoring the mana or mauri of an ecosystem.

A Te Ao Māori perspective also lengthens the time horizon for evaluating risk and uncertainty, and extends the values that are considered to be 'at risk' to future generations.

Risk and uncertainty are defined differently in different circumstances and worldviews

One dominant understanding of risk and uncertainty often frames decision-making, to the detriment of other possibilities

Understandings of risk and uncertainty that work towards ecosystem-based management and Te Ao Māori goals can shape different futures, because these conceptualisations of risk and uncertainty include:

- **mana-enhancing** approaches (principles based)
- an understanding that risk and uncertainty are **bundled**
- a **holistic** view of risk and uncertainty that includes but goes beyond outcomes, economics or probabilities uncertainty
- thinking about impacts on desired futures linking to Te Ao Māori consideration of **longer timeframes and future generations.**

*Figure 3 Reconceptualised perceptions of risk and uncertainty*

A shift is needed from prioritising the economic in investment decisions (allowing vested interests to steer the direction of investment and the relations between economy and environment), to prioritising the environment as the overriding frame for organising decision pathways. It means implementing new paradigms (ecosystem-based management alongside Te Ao Māori) to improve decision-making to improve risk and uncertainty management and wellbeing of the environment.

This new concept of risk and uncertainty as multiple and grounded is needed to further ecosystem-based management and fulfil Te Tiriti partnership commitments. Today, the perceptions of risk and uncertainty, and the practices, processes and tools often applied to describe risk and uncertainty are frequently dominated by a particular view. Decision-making processes and future agendas are dominated by monocultural worldview thinking. This dominance generates detrimental outcomes for those holding contrasting perspectives.

We invite readers to undertake a risk and uncertainty journey with the broad future-oriented reconceptualisations of perceptions of risk and uncertainty in mind. Through undertaking a risk and uncertainty journey the reader will begin to reflect on what positions underpin legislation, how and

why some outcomes are privileged over others, and consider the nature of the transitions in processes, practices and actions may be required to implement new paradigms. An important, but bold transition is required at the national scale.

# 2. Expose worldviews, discipline, and positionality to unpack understandings of risk and uncertainty

How do you become aware of hidden influences that impact risk and uncertainty framing in different situations? This section and *Diagnostic Tool 1 Kia whakahura te tūraru me te haurokuroku (KWTH) Unpacking perceptions of risk and uncertainty* provides guidance on situating and positioning ourselves in both professional and individual worlds and unpacking what risk and uncertainty mean in decision-making situations and processes.

In this section we've included insights and guidance on the following findings.

- Three invisible factors influence risk and uncertainty.
- Worldviews underpin perceptions of risk and uncertainty.
- Positionality means where you stand matters.
- The impact of disciplinary training influences perceptions.
- A diagnostic tool can help unpack perceptions of risk and uncertainty.

## Three invisible factors influence risk and uncertainty

Our research shows that decision-making processes are influenced by the three 'invisible' factors of worldviews, disciplinary training, and positionalities. Worldviews are the key factor: the most extensive and invisible influences on uncertainty and risk perception, although disciplines and positionalities have surprising roles to play.

Here we integrate research findings from three sources: a benchmark study (Thomson, 2013) focusing on two worldviews (DSP and NEP) prominent at the time; Māori research into Te Ao Māori where a case is made that Te Ao Māori is place-based (Hyslop et al, 2022; Rout et al, 2021); and the synthesis and analysis of the current project. Our research showed that a significant synthesis could be achieved, however, if we began, with an illustrative self-reflective conversation in which a person ponders their encounters with risk and then proceeds to explore risk and riskiness.

Our research quickly showed that mainstream views on risk are not suitable for the societal shift of enabling ecosystem-based management and integrating Te Ao Māori principles and processes. Our findings point to many taken-for-granted assumptions about risk by people, and the inability to conceptualise multiple influences on which decision-makers decide and judge risk features and consequences (Le Heron et al, 2022b).

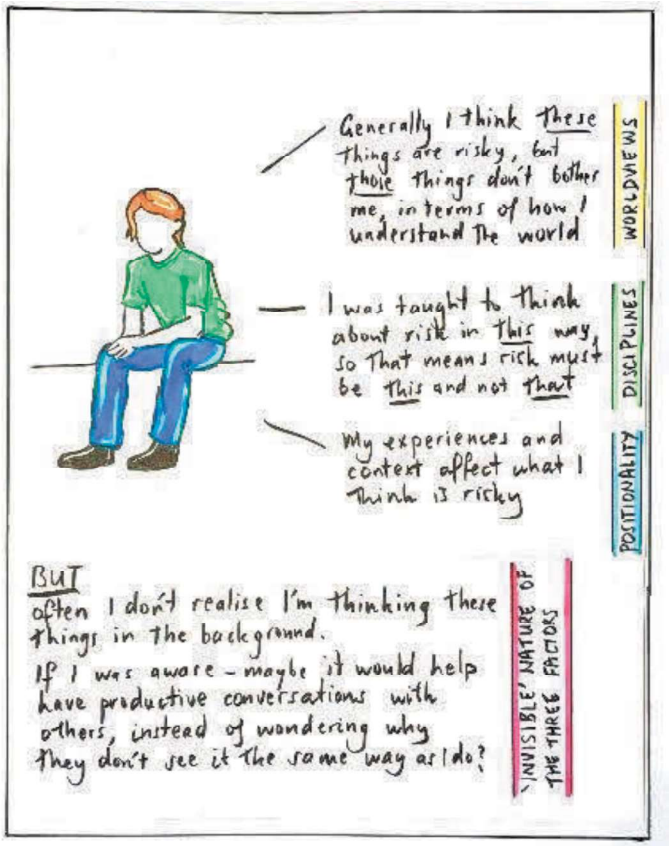



*Figure 4 Identifying three (often invisible factors influencing perceptions of risk. Source (Le Heron et al, 2023a)*

## Worldviews underpin perceptions of risk and uncertainty

A worldview is how an individual believes the world works or should work.

According to psychologists, worldviews underpin environmental attitudes and behaviour and can provide insight into the different perspectives an individual brings into a decision-making environment or collaborative or policy process. Essentially worldviews underpin peoples' intentions to behave in certain ways or to support certain viewpoints (Le Heron et al, 2023a) (Le Heron et al, 2023a). The potential collision and almost inevitable co-existence of the worldviews is apparent in the figure below.

Three dominant worldviews are in Aotearoa New Zealand

- Te Ao Māori
- New environmental paradigm
- Dominant social paradigm

The invisibility of these factors leads to conflict, because often the origin of the disagreement is hidden by unacknowledged or unexpressed differences. By making these differences visible, we can begin to identify where disagreement occurs and more importantly, why it occurs, and what the implications of differences and potential similarities might be.

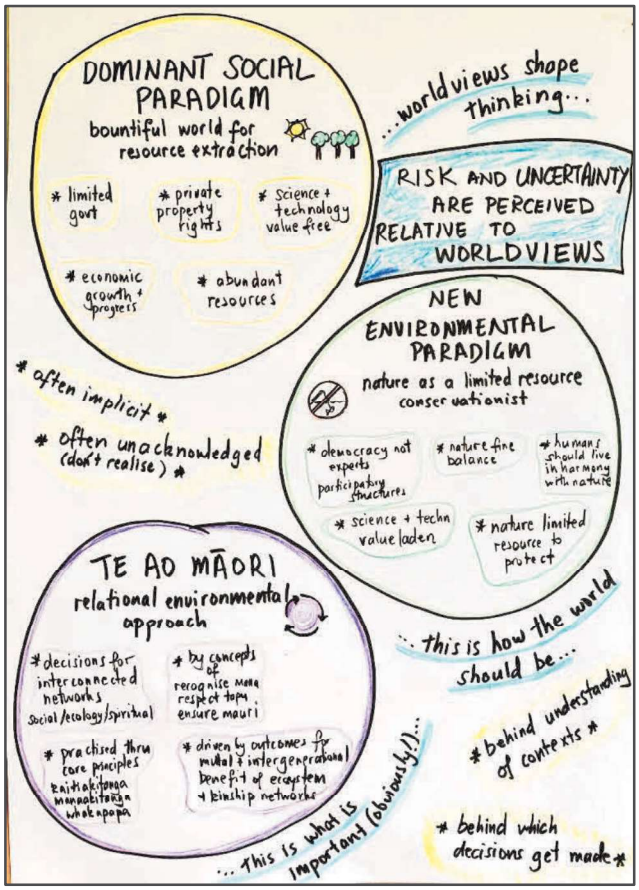



*Figure 5 Risk and uncertainty are perceived relative to worldviews. Source (Le Heron et al, 2023j)*

As organising frameworks, worldviews structure beliefs of what the world **does** look like, and what the world **should** look like. These organising beliefs about the world help people make sense of events, make moral judgements, and align practices to what is regarded as 'right'. What is seen as 'risky' therefore, will alter depending on what worldview is engaged. Seen in one worldview, environmental degradation may be an acceptable risk. In another, economic loss is more acceptable. In a third, it may be risky to think in non-holistic ways. These simple examples acknowledge the influence of worldviews on the everyday, and on everyday decision-making.

Worldviews can be both individually held and held by societies at large. It is useful to think about an individual living by the premises of *several* worldviews instead of having a single worldview, and often being in places where they are subconsciously trying to resolve tensions amongst worldviews. It is important to recognise that parts of any worldview are shared by many people in the community, other parts differ for individuals, and so worldviews (of different people) are shared yet unique and influenced by power relations and politics. What therefore becomes important is finding ways and tools to lay out the differences and points of connection.

This table shows key aspects of each worldview. It shows differences and similarities of focus that have risk implications, but it also acknowledges by association their co-existence (E. Le Heron et al, 2022b).

| Dominant social paradigm (DSP) | New environmental paradigm (NEP) | Te Ao Māori (TAM) |
|---|---|---|
| Bountiful world for resource extraction | Nature as a limited resource, protectionist | Relational environmental approach |
| 1. Economic growth and progress are paramount<br>2. Abundance of resources, resources are to be exploited.<br>3. Government interference is limited<br>4. Private property rights and business-as-usual is supported<br>5. Faith is placed in science and technology (view that science is value free) | 1. Protecting the environment is more important than resource use<br>2. Nature is seen as a delicately balanced limited resource<br>3. Non-materialism favours participatory structures & safety<br>4. Trusts democracy rather than experts<br>5. Humans should live in harmony with nature<br>6. Science and technology are limited (and value-laden) | 1. Priority is given to outcomes of mutual benefit to kin groups and ecosystems<br>2. Extracting resources is okay if it builds intergenerational benefits<br>3. Conceptualises ecology as social relations, ie te taio is *always in-relation-to humans* as humans *actually are relatives/related to/descended from* the environment<br>4. Behaviour is regulated by concepts of mana (power, authority), tapu (sacredness) and mauri (lifeforce)<br>5. Core principles are: kaitiakitanga (sustainable management), whakapapa (connectedness) and manaakitanga (reciprocity) |

*Table 2 Key aspects of Aotearoa worldviews. Adapted from (Le Heron et al, 2023j)*

In Aotearoa New Zealand three worldviews are strongly present – the Dominant Social Paradigm (DSP), the counter New Environmental Paradigm (NEP), and the increasingly recognised Te Ao Māori paradigm (TAM). DSP and NEP are well established in the literature (Dunlap, 2008; Dunlap and van Liere, 1984; Hawcroft and Milfont, 2010; Thomson, 2013) and a growing literature supports TAM (Rout et al, 2021; Salmond, 2014).

The DSP and NEP approach risk as something to be minimised, whether to aid earnings from resource use or reduce environmental impacts. However, TAM is fundamentally place based and whakapapa centred. It seeks to enhance mana relating to the moana and whenua.

It follows that taking seriously the research on three key paradigms active in Aotearoa, means acknowledging that some paradigms hinder ecosystem-based management progress because they frame investment goals and prospects differently. An ecosystem-based management and Te Ao Māori approach represents ways forward to decision-making for longer term, wider-sense ecological aspirations.

## Ngā pou o Te Ao Māori — pillars of Te Ao Māori

Most people will be familiar with the Dominant Social Paradigm (DSP) as it is the context in which most institutions, business and individuals organise and operate in Aotearoa, and it is embedded into practice. Equally, the New Environmental Paradigm (NEP) is well known and adhered to by many. A Te Ao Māori worldview may be less familiar.

Below is an overview of key concepts and principles in Te Ao Māori. For a more detailed, nuanced, and entangled description of the pillars of Te Ao Māori see Rout et al (2021) and Hyslop et al (2022). A strong message from the diagram is that Te Ao Māori is a form of place-based circular relationships with resources. This is not an isolated determination. It is instead ongoing 'living' relationships with resources in their widest sense.

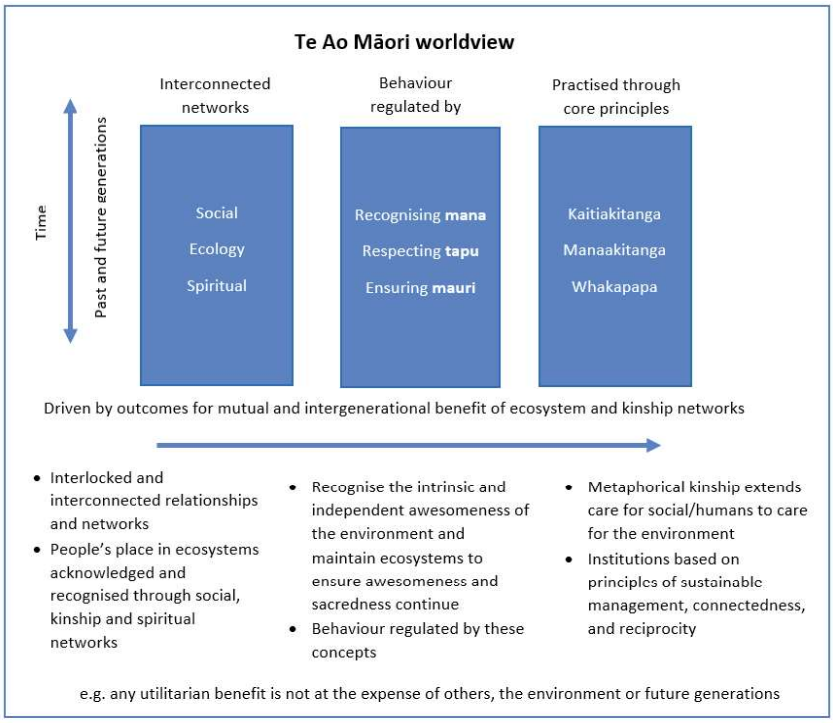



*Figure 6 Ngā pou o Te Ao Māori*

**For further guidance** see Appendix 1: What is my worldview? A short self-reflective exercise, and Appendix 2: Worldviews and legislation.

**For more detailed information on the three worldviews introduced here see** (Le Heron et al, 2023j) *Why do we argue about risk? The invisibility of worldviews in marine decision-making* **and** *Quick guide 2: Worldviews influence people's perceptions of risk and uncertainty*.

## Positionality — where you stand matters

Understandings of risk and uncertainty have traditionally dealt with a 'universal self', that is a self who is static and whose perceptions are fixed and knowable; this means calculations can be based on stable assumptions about behaviour. We argue there is no 'universal self' from which to understand risk and uncertainty. Instead, there is a complex myriad of interactions involving roles, experience, aspirations and so on. In practice, positionality means that 'where you stand' matters, the situated knowledge and experience of place and attachment to place that an individual may have in a given situation. This idea has been overlooked in many disciplinary literatures and in most applied studies.

This complexity is well illustrated by Figure 7 which illustrates differing situated reactions to a rain forecast (Blackett et al, 2017). A person's knowledge set, circumstance and situation dramatically influence how 'rain' will be perceived and experienced; and this of course feeds into risk perceptions. If a person is inside, the rain will not affect them the same as someone taking their baby to the park who is concerned for their baby's welfare should they get wet, or a fisher wishing they had paid attention to the maramataka and who is concerned about storms.

Of course, this figure is a simplification, though importantly an illustrative proof that different kinds of positioning exist and what they might mean. In decision-making about competing resource uses, those involved in debate may occupy multiple positions. Our invitation to the reader is to note the different backgrounds of those in a meeting. How are official positions or background training and experience impacting on their arguments? Are they concerned with professional or financial risks rather than considering the merits and demerits of evidence? Are there other hidden influences 'in the room'? (E. Le Heron et al, 2022b).

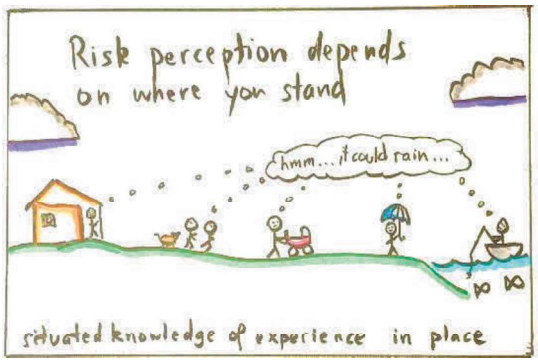



*Figure 7: Rain explanation of positionality. Source (E. Le Heron et al, 2022a)*

## Disciplines — the impact of disciplinary training influences perceptions

Disciplinary training frames risk and uncertainty assessment in any given situation. Disciplines and professions offer a panorama of perspectives on what risk might seem to be. They teach ways to think, critique, and scrutinise the world. However, identifying disciplinary differences towards risk is one thing; recognising the effects of disciplinary hierarchies in decision-making contexts is another.

Unfortunately, little attention has been given in most disciplines to 'what thinking tropes' are internalised from instruction. What do disciplines know about their frameworks of abstraction? This impacts on the profile of 'this is our territory' or 'these are the organising principles we live by' thinking and what is excluded as a result.

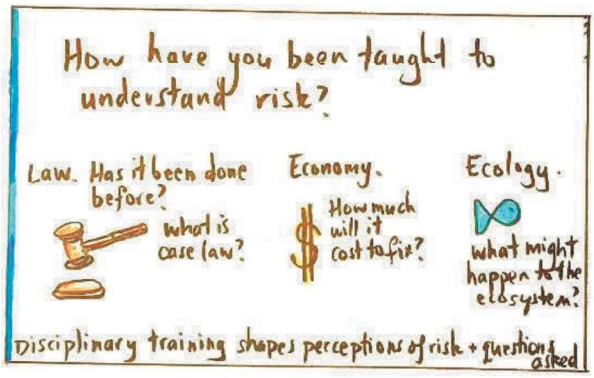



*Figure 8 Role of disciplinary training on perceptions of risk. Source (E. Le Heron et al, 2022a)*

Insights from our research suggest that in a consent process, how disciplines think about risk and uncertainty is different; desirable outcomes and 'riskiness' are seen through the lens of disciplines. For example, lawyers may approach consent processes on a 'fair to each case' basis, seeing risks as procedural. Physical scientists may focus on the risk of a stressor occurring. Ecologists' interests in maintaining ecosystem function and integrity, mean risks might be framed in terms of ecosystem responses. Social scientists may consider socially just and equitable elements, so risks may be constructed around ideas of inequality, access, or socio-economic factors. Māori researchers may

desire outcomes that maintain relationships between themselves and ecosystems and future generations, retaining or enhancing mauri, so risks are considered in terms of responsibilities.

Natural hazard specialists understand risk as a product of exposure to a hazard and the consequences of that hazard. In essence, each discipline thinks about risk and uncertainty and how we can come to know and explain risk in, subtly different ways. Even within disciplines, thinking may vary, for example biochemists and ecologists may differ in their positions, as may neoclassical and environmental economists. Which of these is given priority or weighting? How does this matter for choice of tools or processes, decision-making and outcomes?

## A diagnostic tool can help unpack perceptions of risk and uncertainty — kia whakahura te tūraru me te haurokuroku

Figure 9 below — *Diagnostic tool 1 Kia whakahura te tūraru me te haurokuroku Unpacking perceptions of risk and uncertainty* has a package of complementary questions that ask about worldviews, disciplines, and positioning.

- What risks make sense in my worldview? What risks might make sense in another worldview?
- How does where I stand affect my perception of risk? What might other people think is risky because of their situation?
- How does my training affect what I think is risky? What might people who have trained in different disciplines think is risky?

These questions are directed at outlining context and circumstance, which are important in probing risk. What has struck the audiences at our research presentations is the *relationality and connections* of the influences. Seen together they both assemble and unpack grounded perceptions of risk and uncertainty. Different spatial and temporal scales of the risk journey will demand deeper interrogation and analysis.

This diagnostic tool takes the reader on a journey from the realisation of hidden influences on understandings of risk and uncertainty, to thinking through what those influences (worldviews, positionalities, disciplines) mean for risk decision-making and outcomes.

**Diagnostic Tool 1. Kia whakahura te tūraru me te haurokuroku (KWTH) Unpacking perceptions of risk and uncertainty**

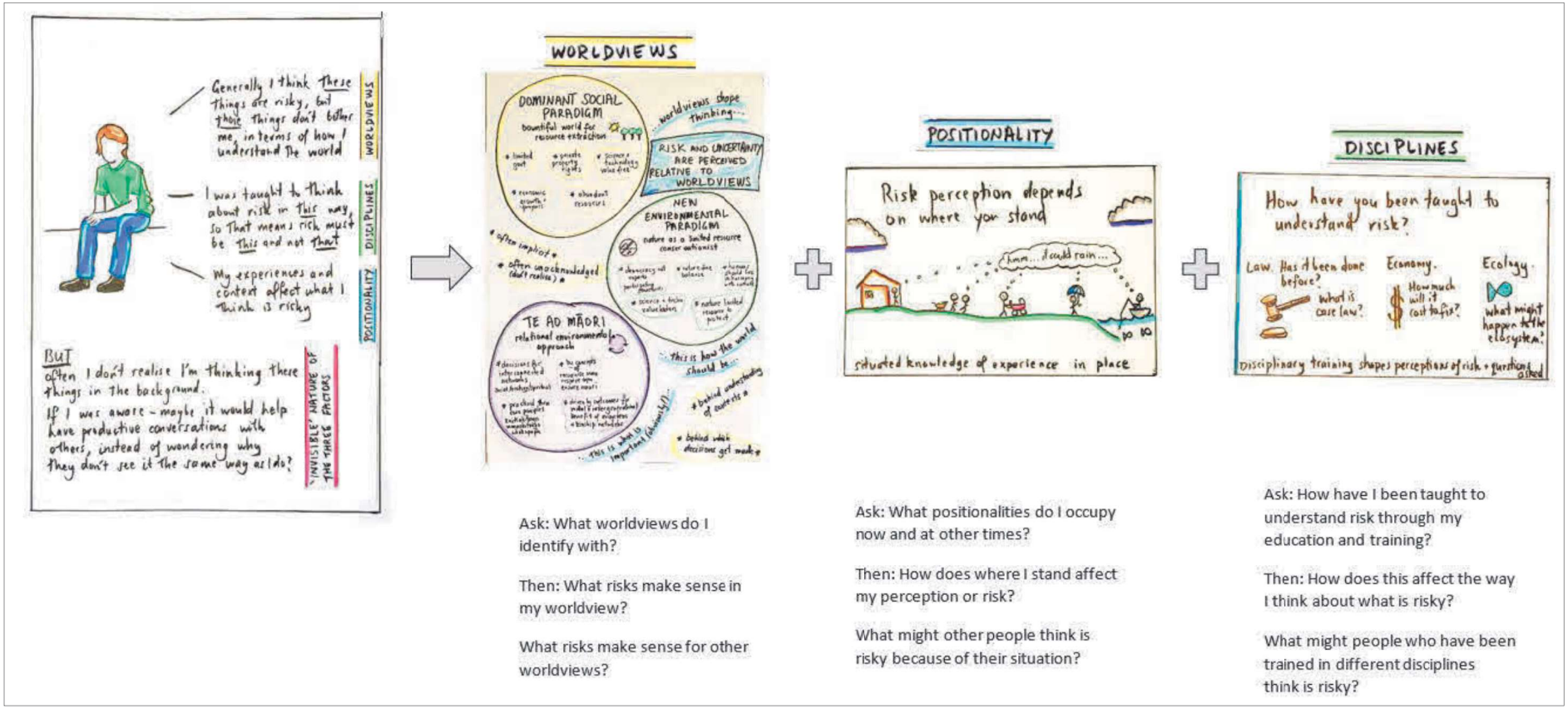



*Figure 9 Diagnostic Tool 1 helps unpack the three 'invisible' components of risk and uncertainty*

# 3. Think about implications of worldviews, positionalities, and disciplines and negotiate a pathway for enacting ecosystem-based management and incorporating Te Ao Māori in 'risky' decision-making

Many hidden influences and their ramifications can be identified on how risk and uncertainty can be framed in different situations. Steps can be taken to go beyond dominant social paradigm risk formulations.

In this section we introduce another diagnostic tool with steps and questions to help work with risk and uncertainty in marine decision-making. We also explain how to use the tool. In this section:

- *Diagnostic Tool 2 He Uiui Aromatawai Tūraru Working with risk and uncertainty*
- Case study guidance on how to use *Diagnostic Tool 2 He Uiui Aromatawai Tūraru Working with risk and uncertainty*

## He Uiui Aromatawai Tūraru | diagnosing and working with risk and uncertainty for ecosystem-based management and Te Ao Māori futures

We identified five priorities present in risk and uncertainty disputes in the country (see the diagnostic tool in figure 10 below). Regardless of the resource change issue, in Aotearoa New Zealand decision-makers are bound into Tiriti obligations. Decision-makers face competing evidence claims relating to futures, are assailed with many procedural options, encounter legislative constraints, and dictates, and are left without much guidance on weighing claims, rights, and obligations.

The cascading steps format of this diagnostic tool assigns Tiriti issues and partnerships top priority (step 1) as the nature of their resolution in context and place affects what are imagined as environmental and economic futures and what risks and uncertainties might be attached to them.

Steps 2 and 3 are next, as once ideas of evidence and tools/frameworks/approaches have been worked through, it's easier to recognise how process constrains what's happening (step 4), and what is allowed 'in the room'. Step 5 is about balancing rights.

The multi-directional questioning (down and across) in the figure is intended to trigger new, focused thinking and to help decision-makers be constantly mindful of the opportunities for relationship building.

## Diagnostic Tool 2. He Uiui Aromatawai Tūraru Working with risk and uncertainty

| Get ready: warm up! | Ko te mahi (Step) 1 | Ko te mahi (Step) 2 | Ko te mahi (Step) 3 | Ko te mahi (Step) 4 | Ko te mahi (Step) 5 |
|---|---|---|---|---|---|
| **Use Diagnostic Tool**<br>Kia whakahura te tūraru me te haurokuroko (KWTH)<br>**Unpacking perceptions of risk and uncertainty**<br>  <br>Apply these questions across steps | **How are Tiriti partnerships enacted?**<br>Through process (engaging with and empowering the right group) and ethics of practice. | **What is evidence?**<br>Evidence is information presented in a way that is seen as credible to base decisions on.<br>Reconsider what is allowed as evidence. | **What are the 'right' tools?**<br>Tools are used to order information in a way that enables decisions to be made. What are the 'right' tools in this situation?Are there others? | **How does process constrain content?**<br>Legislation influences how issues are presented, discussed and weighted. Often things can't be weighted properly because they 'don't fit' or aren't legislated for. | **What balance of rights is supported?**<br>There is a continual tension between collective rights and private property rights. What mix of rights is negotiated and adopted in any given situation? |
| **What is 'risky' in different worldviews?** | Multiplicity of worldviews needs to be acknowledged right up front, including Te Ao Māori.<br>Anchor people back in Aotearoa setting – Tiriti, principles, ethics, co-governance. | There are multiple versions of what is credible depending on worldview, positionality and discipline. | There is a diversity of tools, approaches, and frameworks*, and how they are used. Who is involved impacts the tools used, and access to tools differs. | Legislation and courts have rigid processes which constrain the evidence, tools, Te Tiriti partnerships, and how conflicts are framed for consideration. Legislation and courts are direct product of worldviews (mostly DSP). | Worldviews crucially affect how rights are perceived, and what risks may be taken with the balance of rights.<br>Dominant worldviews have the most influence on how rights are distributed, eg private property wins in economic growth model. Shifting the balance of rights means exploring the worldviews behind them. |
| **How does your positionality change risk?** | People have been taught different ways to approach 'truth' and 'knowing', and power relations. This has huge impact on their ability and capability in the processes of enacting co-governance. | Positionality matters because often one assessment of 'credible' dominates the evidence, locking out other ways of knowing, eg Te Ao Māori. | How do your experiences in place affect what you consider to be a suitable tool? Mātauranga Māori is often little understood or used. Seek out guidance, eg EPA Mātauranga Māori assessment tool. | Ability to produce content for the decision-making framework varies depending on role and life experience. | Are you in a position to enable or advance a particular set of rights? How does this affect risk decisions? |
| **How does your discipline teach you to think of risk?** | Be willing to learn, reflect and evolve positions. Focus on ethical decisions – equity, justice, power. What are (currently) suitable Te Tiriti partnership approaches? | What is and isn't considered evidence? Why might that be? What do I think is evidence? How do I rank these? Is the evidence place-based not universalised? | Tools help shape the world. Lobbying, local experiences, disciplinary approaches all influence the tools picked, which then changes what is done and known. | Expand the content that is 'allowed' and the ways issues are discussed as risky or uncertain and important or not. Mandate taking other knowledges into consideration. How can you expose other perspectives? | What is (currently) considered as an acceptable balance? Where does this weighting come from? Are the interests (that provide the weighting) being served by this, or are others? |

*Tools 'perform or facilitate operations,' aiding decision-making, while frameworks can be considered 'a basic structure, plan or system, as of concepts, values, customs or rules'. However, these definitions are not rigid, as frameworks are also tools of a sort, when they are used to facilitate decision-making.

*Figure 10 Diagnostic Tool 2 sets out a pathway for working with risk and uncertainty*

# How to use *Diagnostic Tool 2. He Uiui Aromatawai Tūraru Working with risk*

This section uses case studies to help show how to use diagnostic tool 2.

## Three case studies show the influence of worldviews, positionalities, and disciplines on ecosystem-based management decision-making

The guidance here offers a way to navigate the complexities of risk perception (and differing viewpoints) in decision-making contexts (Le Heron et al, forthcoming).

Case study examples show how worldviews, positionalities, and disciplines *matter* in the Aotearoa New Zealand ecosystem-based management decision-making context. We use examples to highlight the presence of these factors and issues in *already existing* situations – to make visible some of the hidden influences at work. These influences will be at work in any given setting and this tool will help identify them so they can be examined. Careful examination of the underlying influences will highlight some of the reasons for difference (and conflict) and provide signposts for practitioners as to how to structure more productive dialogue.

*Table 3 Quick summary of case studies*

| **Example explores** | **Worldviews**<br><br>**Disciplines** | **Positionalities**<br><br>**Disciplines** | **Positionalities**<br><br>**Worldviews** |
|---|---|---|---|
| **Case study** | **Chatham Rise deep sea phosphate mining application**<br><br>● Mining permit granted 2013<br>● Mining consent applied for by TRP 2014<br>● Declined by EPA 2015<br><br>**Mining not permitted** | **Okura development application**<br><br>● Urban limit between Long Bay and Okura catchments (decisions in 1996,1997,2014)<br>● Auckland Unitary Plan IHP recommended zoning be changed, rejected by Planning Committee 2016<br>● Landowner Okura Holdings appealed to EC, dismissed by EC 2016<br>● Okura Holdings appealed to High Court, then withdrew appeal 2018<br>● **Land zone remained unchanged**<br><br>Developer's proposal to subdivide 1000ha at Auckland City's northern boundary not allowed | **Mangrove removal consents (around Aotearoa)**<br><br>● Many removals requested at local and regional council level (date range)<br>● Removals approved, removals denied, depending on local area<br>● Changes to RMA sought by one council to allow removals, not passed (year)<br><br>**Inconsistency in decisions** |
| **Why?** | Deep sea mining for phosphate in the Aotearoa New Zealand context initially seemed unproblematic. It was a clear example of mining interests being able to assert a social licence based on export earnings and Chatham Rock Phosphate's experience in mining at depth. This relied on DSP prevailing.<br><br>However, the apparently simple steps connected with seeking a mining consent hide a very complex consenting situation.<br><br>Te Ao Māori worldview came into play, in a manner that exposed the | Okura should be seen as a clash of two trajectories – a succession of development proposals across Auckland City and a localised environmental movement that galvanised around impacts on the marine reserve.<br><br>Disciplinary influences intruded on many levels. Instead of engaging around environmental claims per se the arguments and stories assembled were re-phrased into technical discussions about the adequacy of models used by experts. Model choice, structure, application domain, findings and errors at every stage were debated in technical terms.<br><br>The decision was eventually made in terms of the Unitary Plan framework which rephrased the | The range of removal decisions over time and space highlights that what is a 'risk' around mangroves depends dramatically on where, when and who is involved.<br><br>Clash of worldviews – economic (property value) versus protectionist or relational (aesthetics and recreation, connections)<br><br>Impact of positionality – those able and resourced to lobby for the council differed greatly, and influenced decisions made. |

| | | | |
|---|---|---|---|
| | limits, in the current context, of the prevailing DSP and NEP worldviews.<br><br>Clash of worldviews – economic, extractive versus protectionist or relational. | argument into a pan-Auckland narrative. The 'right' of a subdivider to seek consent anywhere without cognizance of city-wide matters (DSP) was challenged. | |

## Questions and examples can guide each step of diagnostic tool 2

*Diagnostic Tool 2 Working with risk and uncertainty* offers helps link different perceptions of risk to the key interrogating questions that investigate and document priorities.

The following section steps through the tool with three case study examples from table 3 above.

- Chatham Rise phosphate mining application
- Okura development application
- Mangrove removal consents

Each step has its own one-page guidance, including questions to ask, examples, and suggested tools and frameworks.

### Ngā whakaaro takatū | Get ready: warm up!

**Guidance on unpacking perceptions of risk and uncertainty**

Use this part of the diagnostic tool 2 to go on a risk journey: from the realisation of hidden influences on understandings of risk and uncertainty, to thinking through what those influences (worldviews, positionalities, disciplines) mean in terms of risk decision-making and outcomes.

There is detailed information on how to understand the role of 'invisible' factors with the full version of *Diagnostic Tool 1 Unpacking perceptions of risk and uncertainty*.

**Invisible factors**

What is risky in different worldviews?

How does your positionality change risk?

How does your discipline teach you to think of risk?

When 'warmed up' use the five steps of the diagnostic tool 2 to ask how worldviews, positionalities and disciplines contribute to the key aspects in decision-making processes.

### Ko te mahi tuatahi | step 1: How are Treaty partnerships enacted?

The principles of Te Tiriti can be enacted through process (engaging with and empowering the right group) and ethics of practice. If this is done well, many other issues can be smoothed over. The Tiriti o Waitangi principles (partnership, participation, protection) provide a foundation for developing meaningful and enduring partnerships between government and iwi or hapū, setting the scene for successful collaborative decision-making processes.

To ensure that iwi or hapū are adequately represented in collaborative processes, it's important to include as many individuals as iwi or hapū deem is necessary to represent their status, values, perspectives, and interests. Adequate resourcing for all partners involved is essential for successful collaboration (Harmsworth et al, 2016).

## Ko te mahi tuatahi | step 1

**Guidance for engaging and developing relationships with iwi and hapū**

**How can this situation be improved?**

- Continually anchor ourselves back in Aotearoa NZ setting – Te Tiriti, principles, ethics
- Desire to learn and reflect on personal positions and what assumptions and limitations that brings
- Moving forward needs to focus on ethical decisions – equity, justice, power, historical making guidelines
- Accept multiplicity of worldviews as the norm
- Pursue diversity – how do we begin to accommodate others' worldviews
- Acknowledge difference between diversity and co-governance

Māori advisors for ERMA (pre-EPA) have advocated in the past for a Treaty-based partnership decision-making model, such as the Waitangi Tribunal, whereby Māori and non-Māori commissioners could reflect on applications independently before coming together, but this has not yet happened. It was suggested that the current Resource Management Act reforms could provide an opportunity to see whether these Treaty-based models might be palatable for the Crown.

Ask the questions:

- What are considered (currently) suitable Tiriti partnership approaches?
- What does this mean in decision-making processes?

**Frameworks:**

These are frameworks where Māori values, perspectives and mātauranga Māori inform and support partnerships, collaborative processes, and desired outcomes (worldviews)

- **Tikanga Process Model**: A tikanga-based model for collaboration with Māori. The model outlines an eight-step process for optimal freshwater planning and management outcomes, starting with a Treaty-based framework for engagement and policy development. (Harmsworth et al, 2016)
- **Te Mana o te Taiao – Aotearoa NZ Biodiversity Strategy** (2020): upholding the ToW is an essential foundation of this strategy: "*working together in partnership towards a shared vision for nature will ensure that rangatira (chief) and kaitiaki (guardian) obligations, as well as mātauranga Māori, are actively protected."* (Department of Conservation, 2020)
- **Mātauranga Māori Framework (EPA):** The EPA's Mātauranga Framework is described as 'partnership in action'. The framework, which is designed to enable decision-makers to consider mātauranga from a Māori point of view, is

informed by Treaty principles, which sit diagrammatically at its core. (Environmental Protection Authority Te Mana Rauhi Taiao, 2020)

- **NPS-FM – National Policy Statement of Freshwater Management (2014):** recognises the importance of the Treaty, stating: *"The Treaty of Waitangi (Te Tiriti o Waitangi) is the underlying foundation of the Crown-iwi/hapū relationship with regard to freshwater resources. Addressing tangata whenua values and interests across all of the well-beings, and including the involvement of iwi and hapū in the overall management of fresh water, are key to meeting obligations under the Treaty of Waitangi."*(Ministry for the Environment, 2020)

**Disciplinary influences**

- Social scientists (including geographers and economists), natural scientists, planners, lawyers etc will have been taught different ways to approach 'truth' and 'knowing', and power relations.
- This will have a huge impact on their ability and capability in the processes of enacting co-governance.

**Positionality of individuals and groups**

- Personal experience on marae, in schools/kura, with iwi, at home, will all influence how individuals and groups approach Treaty partnerships and relationships.
- Flexibility matters.

**Ko te mahi tuarua | step 2: What is evidence?**

Evidence is codified knowledge presented in a way that is seen as credible to base decisions on. In other words, knowledge is a set of ways of knowing and understanding how the world works, while evidence is the physical measurable (qualitative or quantitative) aspect of the application of knowledge. For example, knowledge is the understanding that the earth moves around the sun, but evidence is the ways that we know and can measure or observe this to be true. Underlying knowledge can be scientific (obtained through scientific method), mātauranga Māori or experiential local. Evidence is given different weightings by decision-makers depending on the legislative context and the worldviews/disciplinary training/positionality of decision-makers. Evidence is also presented in particular ways by different parties to seem most credible in any given context, and according to worldviews, positionalities, and disciplines. This may mean much knowledge is not included, which is why the ability to incorporate multiple knowledge types into risk assessment methods is important.

## Ko te mahi tuarua | step 2

**Guidance on expanding what is evidence**

**How can this situation be improved?**

While legislation is unlikely to be changed in the short term, decision-making bodies and individuals can be supported to acknowledge, learn about and champion different types and sources of evidence. It takes engaged and motivated individual decision-makers to make the extra effort to look past the legislation in front of them that does not make it easy to give weight to other evidence.

> *'So often I remember workshopping with some of our decision makers and they would say, often we wanted to add a condition or to decline an application because of the weight of evidence coming from Māori, but to be able to do that we had to find other mechanisms to justify that decline.'*

Ask the questions:

- What is and is not considered evidence? Why might that be? (to help with this, think positionality, worldview, discipline)
- What do I think is evidence? How do I rank these?
- What does this mean in decision-making processes? What information is being rejected?
- How does process constrain content? (for example, fitting answers to context narrows what is presented)
- What work do the different types of evidence do for the collective/society?
- Is the evidence place-based rather than universal or general evidence?

Examples: **EPA decision-makers**

- Have traditionally given unequal weighting to different types of evidence, with technical or western science evidence given prominence over mātauranga Māori-based evidence.
- This has implications for hapū or iwi groups not wanting to provide mātauranga as evidence because it has not been given the same regard as techno-scientific evidence.

  '*a lot of the regulatory policy provides the opportunity to identify what the issues, what the interests might be that Māori have, and to talk about them in terms of risks and benefits but then the specific criteria that decision-makers actually have to use, that are outlined clearly in the Act, none of them refer to any of that, they are all very quantitatively based criteria.'*
- The EPA's new Mātauranga Framework will help decision-makers to better probe mātauranga Māori-based evidence and therefore encourages hapū and iwi to present mātauranga as evidence (although the success of utilising mātauranga as evidence remains hampered by the existing legislative requirements).

**Okura development**

- Disciplinary training affected what was considered evidence at different times
- Treated some evidence as more credible or important than others
- There was a mix of experts involved. But who was missing? And why?

**Chatham Rise phosphate mining**

- Positionality of interests affected their concerns and arguments
- Everyone was asking 'does it affect my interests?'
  - Commercial fishing: mining affects fishing breeding grounds; bring in fishing models and evidence for argument
  - Submitters who believe in the intrinsic value of the benthic environment: argue that there is not enough evidence in the models that mitigation is possible. those with local interests (Crown and iwi) were more concerned with place-based impacts.
  - Applicant: argues mining will bring jobs, GDP, also employer positionality; economic modelling is used as evidence. Applicant was not locally based, so universal concepts and general mining evidence were applied.

See also *Appendix 3 What kind of data is needed for a flourishing future?*

### Ko te mahi tuatoru | step 3: What are suitable tools?

Tools and frameworks are simplifying procedures that enable us to operate and make decisions in the world. However, they must be contextualised, recognising assumptions, strengths, and limitations. It is key to be aware of and consider the (assumed) worldviews, disciplinary training and positionalities that underpin the selection, utilisation and outputs of any given tool or framework[6]. The makeup of those involved will impact what appropriate tools might be, as access to tools differs.

## Ko te mahi tuatoru |step 3

**Guidance for using the 'right tools'**

**How can this situation be improved?**

- Review what tools and frameworks are available and to whom.
- Keep looking for newly developed tools and frameworks, eg, Waka Taurua, EPA mātauranga Māori framework. Also, MWLR policy brief (Māori Values and Perspectives to Inform Collaborative Processes and Planning for Freshwater Management).
- By improving decision-makers' awareness of the 'invisible' assumptions that underlie different tools/frameworks, they can better understand how different tools can have different impacts: who is involved in data collation decisions, what data/information is being collated, how data is used/perceived/weighed, and the impact of these on NRM decisions.

Ask the questions: What are (currently) considered as suitable tools? Whose tools are these (ie, from what discipline or worldview) and what does this mean in decision-making processes?

| Tools | Worldviews | Disciplines |
|---|---|---|
| LGATPA S156(1) of Local Govt (Ak Transitional Provisions) Act 2010 | DSP (Dominant Social Paradigm) | Planning, Economics, Law |
| The Unitary Plan<br>The proposed Auckland Unitary Plan | DSP, NEP (New Environmental Paradigm) | Planning, Law, Ecology |
| RMA (Resource Management Act 1991)<br>*Clause 15 of Schedule 1 | NEP | Planning, Law |
| RMA Section 7 Archaeological Assessment – Pa site – cultural landscape | TAM (Te Ao Māori) | Anthropology, Archaeology |
| RUB identification (in Table B 1.6.1 (a provision of the Regional Policy Statement in Unitary Plan) | DSP | Economics |

[6] Tools 'perform or facilitate operations', aiding decision-making; while frameworks can be considered 'a basic structure, plan or system, as of concepts, values, customs or rules." However, we do not hold these definitions rigidly, as frameworks are also tools of a sort, when they are used to facilitate decision-making.

**Disciplinary influences on what is risky and what is the 'right' tool.**

| | | |
|---|---|---|
| CLZ (Countryside Living Zone) | NEP, DSP | Biology, Economics |
| FUZ (Future Urban Zone) | DSP | Economics Modelling |
| GLEAMS model (sediment) | DSP | Modelling science |
| Models of single species | NEP | Modelling science |
| Case Law | NEP | Law, Science expertise |

Example: **Okura development**

Reasoning based on legislation, plans, policies, and case law seen as less risky and most fair by lawyers

Modelling estuarine sediment and systems – applying models comes with assumptions, risks, and uncertainties

Applying Unitary Plan as least risky by council officers.

**'Tools' used in the Okura example**, each tool linked to worldviews and disciplines.

**Tools and frameworks that are underpinned by Te Ao Māori worldview:** or that are cognisant of multiple worldviews, that can be used to incorporate mātauranga Māori, or Māori values, into NRM (Hyslop et al, 2022).

- **Arotakenga Huringa Āhuarangi: National Climate Change Risk Assessment Framework** A "how to" bicultural framework towards the development of a NCCRA. Guided by 8 key Māori values and combines scientific, technical, and expert information (including mātauranga Māori), across multiple domains (Ministry for the Environment, 2019)
- **Mātauranga Māori Framework (EPA)** A mātauranga Māori framework based on ToW principles and the concept of a waka haurua (double-hulled canoe), used to elevated mātauranga Māori and help decision-makers to better understand, test and probe mātauranga as evidence, through a Te Ao Māori lens. (Environmental Protection Authority Te Mana Rauhi Taiao,2020)
- **Waka Taurua** A dual worldview framework to examine and develop marine co-management - provides an interface between mātauranga Māori and western science approaches. (Maxwell et al, 2020)
- **Mauri Compass** A tool for assessing and restoring the mauri of oceans, rivers or lakes, accounting for the health of tangata whenua (people), whenua (land) and taonga species (important species). Based on Te Ao Māori principle of mauri, enabling hapū or iwi to monitor the environment in a way that encompasses mātauranga Māori. (Ruru, 2015)

*Diagnostic Tool 1 Unpacking perceptions of risk and uncertainty* and *Diagnostic Tool 2 Working with risk* can be applied to processes, models and other evaluation and situations. It is intended to provide questions that allow analysis of the status quo, and equitable and just interrogation of assumptions at play.

Conceptually, the tools link with the governance level framings developed by Sustainable Seas. The Waka Taurua framework uses a double-hulled voyaging canoe to set expectations for how decisions are made. The diagnostic tools are *for use in the papa noho/deck space-between*, to aid in negotiating in complex risk and uncertainty decision-making contexts.

### Ko te mahi tuawhā | step 4: How does process constrain content?

The applicable legislation under which decisions are made has a large influence on how issues are presented, discussed, and weighted. The RMA, EPA, and Environment Court all have rigid processes, and these each (differently) constrain the evidence, tools, Treaty partnerships, collective/individual rights tensions and how conflicts are framed for consideration.

## Ko te mahi tuawhā | step 4

**Guidance on how process constrains content**

**How can this situation be improved?**

- Mandate (through policies, plans, and practice) the taking of other knowledges into consideration. This will expand the content that is 'allowed' and the ways issues are discussed as risky or uncertain and important or not.

Ask the questions:

- What influence does framing have?
- What does this mean in decision-making process?
- How can we improve this situation and expose other perspectives?

For Māori, this might link to co-management/co-governance arrangements etc – discussed and referenced in Step 1.

Natural resource management and policy is framed in a way that **reflects worldview**. Existing NRM policies and legislation largely **relate to the dominant risk discourse** concerned with reducing risk, or reducing the adverse impacts of an activity (i.e., it is related to DSP not TAM/NEP, and regards growth as a given priority).

Examples: **The RMA** is the regulatory overseer of land and resource use

- administered by regional councils and local authorities
- *through plans* that focus on managing the effects of the activities rather than restricting activities
- only indirectly recognized Māori interests, epitomised by the relatively weak wording 'take account of'
- Drafting the plans has always been political, the particular politics varying up and down the country.

In contrast **the EEZ** zeros in on non-fishing marine uses, alongside the Fisheries Act 1996

- overriding concern is about intrusions into the marine environment.
- minimal guidance on linking risks and consequences.
- explicitly framed in keeping with Te Ao Māori. The act was 'to develop credibility and relations with Māori' and includes in its regulatory organ, the EPA, a statutory Māori Advisory Board.

**The EPA is**

- legally mandated to obtain information from relevant sources to perform its duties.
- contrasts starkly to the regional council situation where issue specific policy development occurs
- implicit power is conferred to applicants. Applicants are in the position to screen out relevant contextual matters, which steers the decision-making focus to the specific request and its 'limited' risks.
- includes provision for the applicant to propose adaptive management options, a 'second chance' provision that enables applicants to modify their initial case to meet criticisms of other submitters.
- EPA's decision-making tool is compliance based, involving consents, compliance, prevention, prosecution.
- Rather than thinking *"how does what we do add value to or enhance the mana of the river or harbour",* this compliance perspective "*forces you to think about the lowest common denominator, rather than the highest" (interview* (Hyslop et al, 2022)*)*

**Disciplinary influences**

- In the Okura example, arguments were framed tightly in the litigious Environment Court context [lawyers].
- The issue of development was framed as 'fair' as in the past similar development had been allowed.
- The issue was also framed by the Unitary Plan [planners] and the careful attention to controlling city expansion.
- Framed by which models seen as appropriate evidence (by planners, environmental consultants, lawyers, developers…)

**Positionality of actors**

- The ability to appropriately produce content/input for the current decision-making framework will vary depending on a person's role in the process
- Life experience and views on what is seen as risky or uncertain

- Resourcing and capacity

### Ko te mahi tuarima | step 5: What balance of individual vs collective rights are supported?

There is a continual tension in decision-making contexts between supporting collective rights and supporting individual rights, usually in the form of private property rights. Some interests will be well funded to lobby their rights and others will have little capacity or capability to make their view on collective or individual rights heard. What is the right balance in any given situation?

## Ko te mahi tuarima | step 5

**Guidance on intersecting worldviews and the balance of rights**

**How can this situation be improved?**

Ask the questions:

- What is (currently) considered as an acceptable balance?
- Where does this weighting come from?
- Whose interests are served and whose are not?
- What does this mean in decision-making processes?

**Worldviews** crucially affect how rights are perceived, and what risks may be taken with the balance of rights.

Examples: **Chatham Rise phosphate mining proposal**

- Collective responsibility of current generations to protect future generations against uranium contamination (through the application of phosphate fertiliser on to farms) was eloquently argued by Ngai Tahu (TAM's relational worldview prioritises collective rights and responsibilities).
- The precautionary principle was applied (due to EPA requirements around uncertainty and the commercial fishers' need for protection of nursery areas) as harm to benthic communities was certain, but mitigation and recovery were deeply uncertain (NEP protectionist desire to separate/protect natural areas for the non-economic benefit of all, and avoid harm to the function of valuable ecosystems)

**Mangrove removal decisions**

- Diversity of decisions around the country highlights the extent to which individual property rights are a key component of the DSP and are enshrined and protected in legislation.

**Disciplinary influences**

- Social science disciplines (e.g., geography, sociology, anthropology) look for interactions and ways to understand societies as wholes, often highlighting the need for collective solutions.
- Other social science disciplines like economics, and others such as law (focusing as it does on European based law), focus on the individual rights, benefits, and accruals that individuals or individual companies may be entitled to.
- Ecologists focus on understanding ecosystem function(s) and impacts of human activities on species, systems and aspects that underlie human well-being and values

Example: **Okura**

- The argument in the Environment Court was based primarily on sediment management and the risks or benefits of development to sediment runoff.
- Obscured the underlying conflict of whether development should be occurring at all.

- Often the opposing roles of disciplines were also obscured – to fix and define, to model and predict, to see unknown uncertainties as a need to evoke the precautionary principle for the environment, and to consider cumulative effects.

**Positionality of actors** influences the balance of rights that are supported

Example: **Mangrove removals**

- Individuals concerned with sinking property values associated with mangrove encroachment were highly motivated to lobby for mangrove removal.
- Those who did not have property near affected beaches were not pro removal.
- Others who remembered beaches without mangroves and were nostalgic for that, were often pro removal.
- Those who thought in terms of whole ecosystems understood why mangroves were spreading (changes to land use further up catchment) and did not see mangroves themselves as threatening.
- Scientists who applied tropical mangrove knowledge to New Zealand mangroves often initially wanted protection of mangroves.
- Place matters also, as different regional councils had different legislative interpretations and drives (eg the Thames-Coromandel District Council and Hauraki District Council Mangrove Management Bill 2017 to change RMA for mangrove removal, subsequently rejected).
- Local experiences and knowledge in place make some more passionate and vocal
- Lobbying and pressure from interest groups has a particularly significant impact in local government settings

It became clear that mangroves themselves were not the underlying subject of argument, but rather it was about property rights versus environmental protection; holistic ecosystem-based management versus bay by bay tactics (worldviews); nostalgia and evolving knowledge (positionalities).

# 4. Select a risk assessment method that is capable of meeting ecosystem-based management requirements and Māori needs and aspirations

Earlier sections in this guidance document point out that we must recognise the assumptions, strengths, and limitations of any risk assessment method. They also make the point that people need to be aware of the makeup of those people involved (worldviews, disciplinary training, and positionalities) as these factors will underpin the selection, utilisation and outputs of any given method.

In this section we discuss present risk assessment methods commonly used in Aotearoa New Zealand. We take a slightly different approach and define the factors that allow a risk assessment method to support ecosystem-based management and Te Ao Māori principles and processes. We consider that while the application the risk assessment is intended for may not need to deal with all these factors, utilising one that can, has one very real benefit. It allows the risk assessment process to be theoretically able to incorporate all viewpoints, and by doing so clarifies that worldviews, positionalities, interests, stressors, and values left out of the risk assessment have been done so deliberately by those involved in the risk assessment process.

This approach by-passes the need to ask the questions: What are (currently) considered as suitable tools? Whose tools are these (ie, from what discipline or worldview) and what does this mean in decision-making processes? These questions instead become appropriate during the selection of desired outcomes (values), activities, stressors, and connections (including underpinning knowledge types) to include in the risk assessment, rather than the selection of the method itself.

Simple risk assessments generally focus on one activity (risk from what stressor) influencing one species or habitat (risk to what value). However, as decision makers and environmental managers transition towards ecosystem-based management, risk assessments must move beyond an evaluation of the direct impacts of a single activity on a species or habitat. Sustainable Seas ecosystem-based management principle 2 (Hewitt et al 2018) states '*Place and time-specific ecological complexities and connectedness, and present cumulative and multiple stressors, as well as those that might occur with new uses, are considered*'.

Many of the risk assessment methods currently in use in Aotearoa and internationally are not suitable for ecosystem-based management. To help practitioners and decision makers identify risk assessment methods that are fit for purpose, we have identified six questions that should be asked before selecting a risk assessment method to support ecosystem-based management (Clark et al, 2022). After explaining the factors to consider when choosing a risk assessment method we give case study examples.

## Six factors to help assess the suitability of risk assessment methods for ecosystem-based management

To help assess a risk assessment method, ask if the method can do the following.

1. **Integrate complexity**
   Desired outcomes (protection or enhancement of values) are frequently underpinned by other components which may be more directly affected by the stressor than the outcome. Ecological responses to stress are often non-linear, particularly those arising from the cumulative effects of

multiple stressors and involve indirect effects and feedbacks. Cultural and social (including economic) complexities and management actions also create indirect effects and feedbacks that should be considered when evaluating the risk generated by activities or decisions. Risk assessments need to be able to incorporate these types of complexities.

2. **Accommodate a range of components, outcomes, and stressors**
   Risk assessment methods must be able to assess how cumulative activities influence both the ecological response of multiple interacting ecosystem components (eg, biodiversity loss, contamination, changes to ecosystem function, alteration of food quantity/quality, and changes to trophic levels) as well as the social, cultural, and economic values that will be affected by, or drive, these changes. Examples of cultural outcomes include Cultural health indices and the Mauri Compass, are all of which are used widely by iwi and hapū.

3. **Accommodate a range of knowledge types**

   They must also be able to accommodate the use of multiple knowledge types (eg, expert opinion, mātauranga or local knowledge, as well as quantitative data). Including a wide range of knowledge types is essential to fill quantitative data gaps, widen our evidence-base and ensure that ecosystem-based management objectives align with the values of multiple sectors of society. Mauri is an example of mātauranga being taken into account in decision making - under Te Mana o Te Wai for example.

4. **Assess risk at a specific place and time**
   The relative importance of different ecosystem components, processes and their connections differ with location and time, as do the disturbance or stressor regimes that affect them. Risk assessment methods must be able to incorporate spatial and temporal variability and produce outputs that communicate the risk posed to the location of interest (eg, maps) and how this varies through time. Locational context is therefore important for informing risk, even when the 'risk to what' is the same. For example, a location dominated by suspension-feeding shellfish or sponges may be more susceptible to increased/decreased suspended sediment than one dominated by infaunal polychaetes or burrowing crabs.

5. **Evaluate recovery thresholds as well as degradation**
   Risk assessment methods must be able to explicitly and separately evaluate recovery, rather than combining it with impact. Ecological feedbacks can create hysteresis and recovery lags that hinder recovery, even when stressors are reduced and the object of the risk assessment may be recovery of the mauri rather than minimising future degradation.

6. **Evaluate and communicate uncertainty**

   Uncertainty is inherent in assessing the likelihood of an effect occurring, and whether a management action (including those focussed on recovery of degraded values) will be successful. The risk assessment method should be able to use scenarios to explore the relative success of different actions. Being able to give some level of confidence of the effect of different action scenarios on desired outcomes is particularly useful for a risk assessment operating under ecosystem-based management.

### Two other important considerations

Twelve considerations sit alongside these six questions. Most of these relate to the multiplicity of stressors and values but two are important for other reasons as well.

1. Many rules, regulations, plans, policies and laws refer to the use of 'best available information'. This information is frequently seen as being numeric (quantitative) and either collected using rigorous survey protocols, derived from numeric models or derived from controlled experiments. Step 2 in Diagnostic tool 2 refers to 'what is evidence?'. A good risk assessment method must be able to take multiple knowledge types (including expert opinion, local knowledge and Mātauranga) so that they can be accepted as 'evidence'.

   Step 4 points out that the applicable legislation under which decisions are made can constrain the evidence used. The RMA, EPA, and Environment Court all have rigid processes. However, decision-makers (and the courts on review) frequently take into account a range of considerations beyond just numerical data and models. The courts increasingly recognise tikanga and mātauranga as part of the law and sources of evidence, and there is now a Māori judge on the Environment Court.

2. Uncertainty can be difficult to separate from risk, particularly when thinking about how people respond to anything affecting something they value. Whakaaro Māori also does not separate uncertainty from risk. However, in a risk assessment that is being used for decision-making, uncertainty is highly important. Firstly, it can be used to make explicit the frequently voiced 'we don't know enough to make a decision' and test whether more information would actually be helpful or whether this is being used as a delaying tactic. Secondly, it can be used to assess how certain the management action taken is to achieve the desired response (whether it be environmental improvement or minimising degradation), aiding transparency in decision making.

## Assess a risk assessment method's fit for purpose

Use the figure below to guide whether a risk assessment method is fit for purpose for ecosystem-based management.

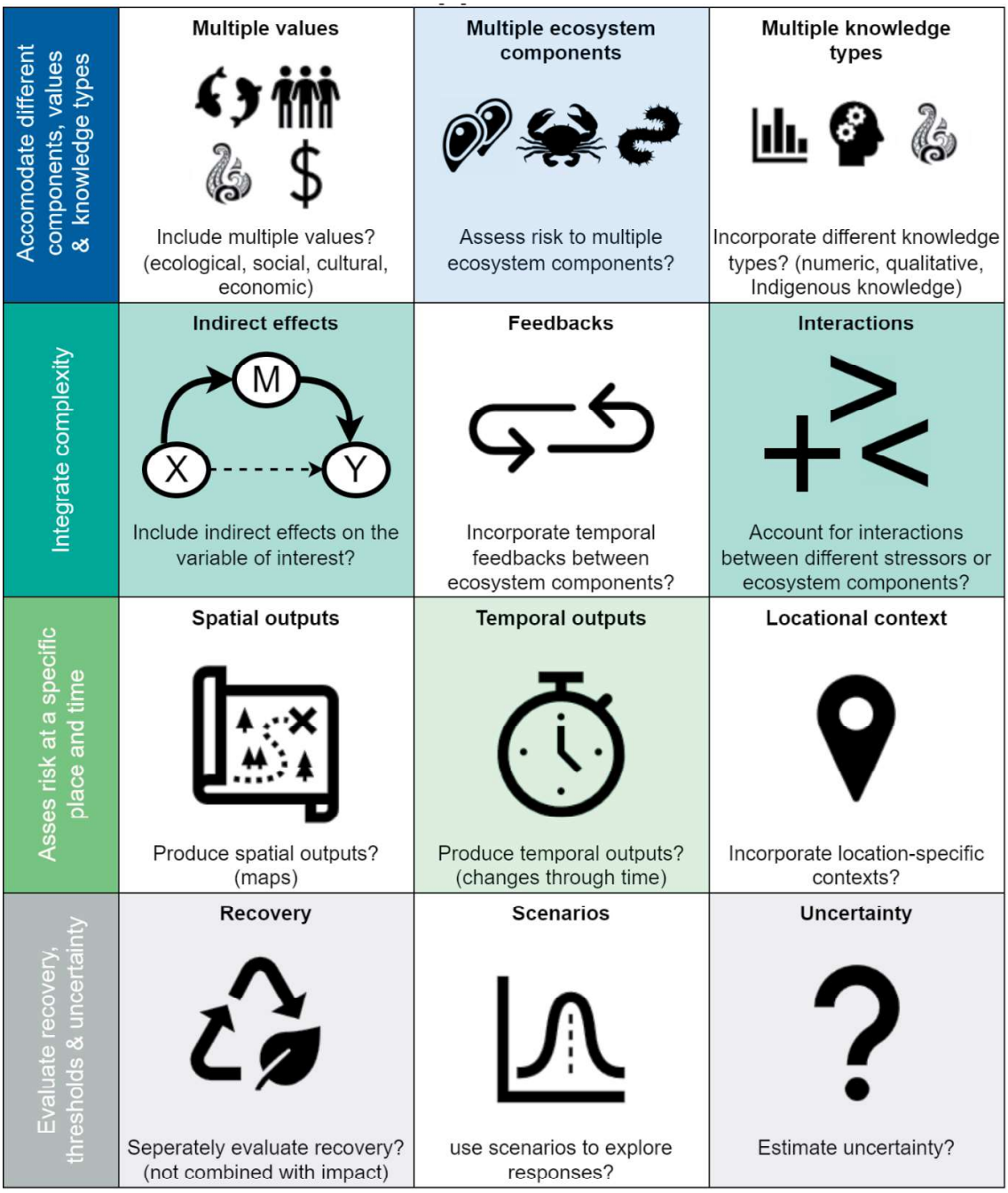



*Figure 11 Considerations for practitioners and decision makers when assessing the suitability of risk assessment methods to support ecosystem-based management. Considerations are broadly grouped by thematic areas (rows).*

A variety of risk assessment methods have been applied in an environmental risk and uncertainty context in Aotearoa New Zealand. The application, strength, and weaknesses of most of these risk assessment methods are covered in detail in Clark et al (2021). Others in use, and in development, internationally are discussed in Inglis et al (2018) and Clark et al (2021). Here we assess the fitness of

many of these methods for ecosystem-based management (Table 4). We include in the assessment two methods developed by Sustainable Seas research specifically for the purpose of assessing cumulative effects (CE models and CE principles). Our assessment is based on use of the method by itself and does not include linking one method to another which has been highlighted as one way of relating risks to multiple ecosystem components (eg, Australia and New Zealand, 2020).

*Table 4 Overview of a subset of risk assessment methods used to date in Aotearoa New Zealand (and subsequently considered in the decision tree Figure 15). For further details on many of these tools see Clark et al (2022)*

| Abbreviation/Name | Description |
|---|---|
| LC | Likelihood-Consequence |
| ERAEF | Ecological Risk Assessment for the Effects of Fishing |
| SICA | Scale-Intensity Consequence Analysis |
| PSA | Productivity Susceptibility Analysis |
| SAFE | Sustainability Assessment for Fishing Effects |
| MSE | Management Strategy Evaluation |
| SEFRA | Spatially Explicit Fisheries Risk Assessment |
| BN | Bayesian Network |
| CE models | Cumulative Effect models using generalised linear models (GLMs) |
| CE principles | Cumulative Effect principles |
| System mapping | Qualitative Network Models or 'Loop analysis' |
| Agent based models | Dynamic interacting rule-based models |
| ERFA | Ecological Response Footprint Analysis |
| Atlantis | Ecosystem model (biophysical, social and economic data) |
| MDP | Markov Decision Processes |

Risk assessment methods can range from 'simple' likelihood-Consequence analyses through to 'highly complex' Atlantis models. In the previous section we argue that a number of considerations make a tool fit for purpose for ecosystem-based management.

Our assessment below is based on the six questions listed in the preceding section, and also includes some practical operational considerations (Table 5). These include the amount of information required and the time/cost to implement the method. As recommendation 3 points out, the makeup of those involved in the risk assessment process will impact on the applicability of a method, so we have included information on how easily the method is to use and the outputs are to understand (Table 5).

In many cases, these practical considerations will have trade-offs. For example, most methods that can incorporate very high complexity will also be expensive or time consuming to implement and may require highly skilled people to use the tool and interpret the outputs. Therefore, the choice between the available methods, the context in which they can perform best (ie, their most likely applications), and other practical considerations will dictate which method/s may be most appropriate.

*Table 5 Definitions of considerations against which to assess risk assessment methods. Considerations denoted with * are used as endpoints in the decision tree (Figure 15). Some levels within factors denoted by ‡ are, by definition, not appropriate for an EBM risk assessment method – we include these levels here for completeness.*

| Considerations | Definitions |
|---|---|
| **Complexity** | **System complexity; number of stressors, response variables, etc.** |
| Low (‡) | Single stressor, single response |
| Medium | Multiple stressors or responses, no interactions or feedbacks |
| High | Multiple stressors or responses, interactions, indirect effects |
| Very high | Multiple stressors and components, feedbacks, interactions, indirect effects |
| **Outcomes** | **Number and types of components that are reported on (ecological, social, economic, cultural etc.)** |
| Low (‡) | Single component (1); one type of value |
| Medium | Multiple components (3-4); one type of value |
| High | Multiple components (3-4); multiple types of values |
| **Information requirements** | **Amount of available information** |
| Low | Not much information exists or is available, limited knowledge of system or case-study area |
| Medium | Some information or knowledge of the system/study area exists, including e.g., local knowledge, (limited) monitoring data or data from experimental studies, not location specific/for all components |
| High | There is an abundance of information to work with, including extensive spatial or temporal survey/monitoring data, spatial data layers at high resolution, local knowledge and/or mātauranga. |
| **Knowledge type** | **Type of knowledge that can be used** |
| Quantitative | Numerical values |
| Qualitative | Descriptive data, e.g., expert opinion, principles, social surveys |
| mātauranga Māori | Māori knowledge – the body of knowledge originating from Māori ancestors, including the Māori world view and perspectives, Māori creativity and cultural practices. |
| Multiple | A combination of knowledge types (mātauranga Māori and at least one of: quantitative and qualitative data; semi-quantitative) |
| **Time/cost to implement** | **Ease of implementation, cost or time, expertise required** |
| Low | Simple method, low cost and time (e.g., within a week), low expertise/skill required (can be done by almost anyone) |
| Medium | Moderate time/effort to implement the method (e.g., weeks-months), some expertise/skill required |
| High | Methods that are expensive or time consuming (e.g., within a year), high expertise/skill required (only selected few specialists can carry out the risk assessment) |
| *** Interpretability** | **Easy of interpretation of risk assessment outputs** |
| Easy | Understood by a lay person |
| Moderate | Understood by a lay person if there is some socialisation of the outputs |
| Hard | Expert/technical knowledge required to understand the outputs |
| ***Output type** | **Changing in time, spatial display, run scenario's/management decisions** |
| Spatial | Does it provide a map; spatial display of results? |
| Temporal | Do the outputs capture changes over time? |
| Scenario | Can scenarios or management decisions be simulated? |
| Uncertainty | Is uncertainty included in the method? |

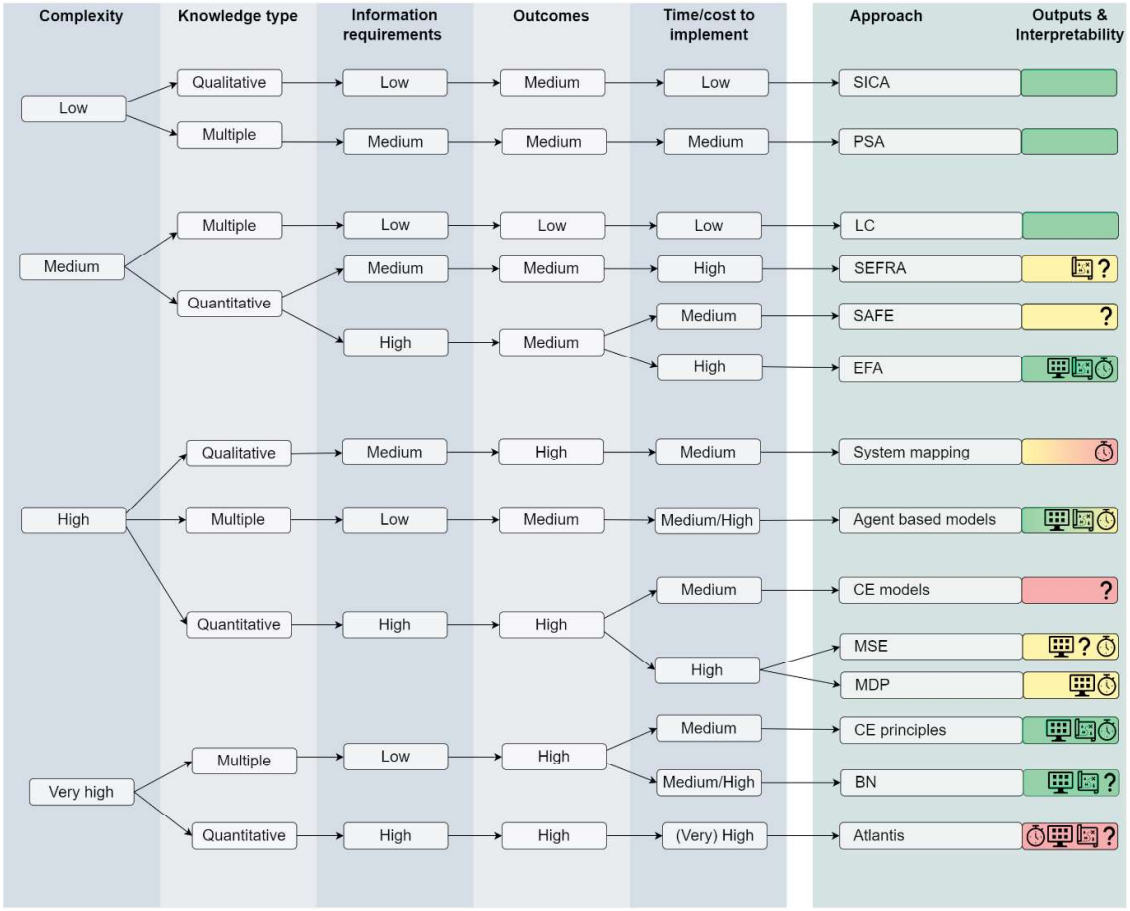



*Figure 12 Decision tree (Diagnostic Tool 3) to determine appropriate risk assessment method for a given application-based on complexity, outcomes, knowledge type, information availability and time/cost to implement method (see Table 2). Symbols are used to distinguish additional output types, including spatial, temporal, scenario, uncertainty ?. Colours are used to distinguish the interpretability of tool outputs as easy (green), moderate (orange), hard (red). Full names for risk assessment method abbreviations can be found in Table .*

An example of how these considerations can be used to help choose a method is provided in an example (case study 1 in next section). It's obvious that some tools are more flexible and can perform over a wider range of conditions. For example, Bayesian Networks or Likelihood-Consequence models can be used for risk assessments focusing on single stressor, single response and reporting on a single component (ie, denoted by ‡ in the Table ), and which would not be considered ecosystem-based management) but also for multiple stressor, multiple component, multiple discipline risk assessments. In contrast, other methods have more specific applications, for example, a *Spatially Explicit Fisheries Risk Assessment* analysis which to date has been used to assess the risk of fishing to endangered or vulnerable species (noting that there is work currently underway to look at multiple cumulative risks to some of these taxa).

In addition to the considerations outlined in the decision tree, a complex and difficult to quantify or summarise interplay exists between the precision, accuracy, and uncertainty in outputs from risk assessment methods. For example, the precision of an output (ie, whether the outputs are a single value) is high in deterministic numerical models (eg, Atlantis) despite the accuracy (ie, how close the outputs are to reality) often being unknown. In these cases, the incorporation, and accounting of, uncertainty in the underpinning models and then the outputs is important (assuming that the uncertainty is realistic). This problem is much rarer in methods that explicitly include uncertainty and

where scenario testing is undertaken to explore the sensitivity of model outputs to different assumptions.

Although complicated models are often perceived to reflect natural systems more accurately than simple models, how true that is depends on what components are modelled, whether the relationships between components represent important scales and how well the models are calibrated. Adding additional parameters to a model can lead to uncertainty and problems with the interpretation and validation of the model's predictions. Complicated models are also often limited by their considerable data requirements and the high effort and cost associated with their development. Simple models, conversely, are cost effective to construct and easy to communicate and quick to implement. But care must be taken not to reduce the system to a level that ignores important interactions as this generally leads to surprises – where decisions do not have the effect predicted by the model.

Methods that can use expert judgment to fill gaps and ensure that the intricacies of a system are not reduced beyond the level necessary to represent how the system operates ensure that robust decisions are still made even when there are unknowns. The ability of such methods to make generalisable predictions while accounting for non-linear dynamics, ecosystem interactions and feedbacks will be more useful for ecosystem-based management than numeric estimates from complex models (as is exemplified in case studies 1 and 3 of the next section).

# Case studies

## Case study 1: Ōhiwa mussel restoration — an example of selecting a risk assessment method

| | |
|---|---|
| **Method** | Ōhiwa mussel restoration tool: hybrid Species Distribution Model (SDM) & Bayesian Network (BN) |

| | | | |
|---|---|---|---|
| **Complexity** | Very high | **Knowledge type** | Multiple |
| **Information requirements** | Low - Mod | **Time/cost to implement** | Medium-High |
| **Interpretability** | Moderate | **Output type** | Uncertainty, Scenario, Spatial |
| **Outcomes** | High | | |

**Context:** Estuaries throughout Aotearoa New Zealand have experienced significant declines in ecological communities and function in recent years. The drivers of these declines are often complex and uncertain. Despite this complexity, management efforts to restore kaimoana and other biodiversity are occurring in many locations. In Ōhiwa harbour, mussels have experienced a rapid decline over the past 20+ years. In an iwi-led effort, mussels are now being actively restored to this harbour.

**Aim**: Working in collaboration with Sustainable Seas project T1 (Awhi Mai Awhi Atu) and project 3.2, we aimed to co-develop a tool to help inform the likelihood of mussel restoration efforts (while accounting for uncertainty in information and the impacts cumulative stressors).

**Key application-based considerations:** First, the method needed to be able to include multiple knowledge types – biophysical information on the environmental conditions and suitability of the environment for mussel settlement and growth (quantitative data) as well as knowledge of the locations of the traditional mussel beds and information on the interactions between seastars and mussels (mātauranga Māori). This narrowed down the suitable methods to five: Likelihood-Consequence, Productivity Susceptibility Analysis, Agent based models, Cumulative Effects

principles, and Bayesian Networks (Figure 12 - acknowledging the list of tools provided in Table 4 and Figure 15 is a subset of tools available for risk assessment).

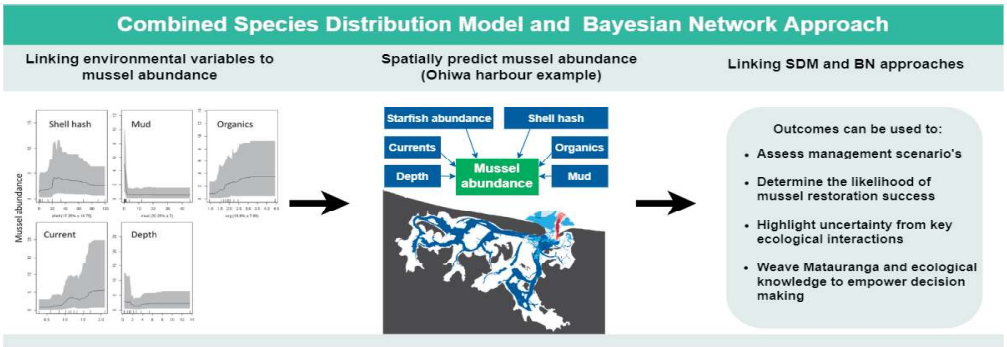
Secondly, the method must account for multiple stressors or responses to explore possible management strategies for improving restoration outcomes (Medium – very high complexity, column 1, Figure 12), in this case, the cumulative effects of changing habitat suitability (from increasing mudification of the estuary) and increasing predator abundance (starfish) and unknown distances they can travel to prey on mussels. This narrowed down the suitable method to three: Agent based models, Cumulative Effects principles, and Bayesian Networks.

Finally, the method must be able to provide spatial maps (ie, location of areas with high restoration potential), explore various scenarios (ie, multiple hypothetical management interventions, and multiple possible future impacts) and to a lesser extent account for the uncertainty in the data used as well as the outputs. Based on these final considerations, Bayesian Networks were decided as the best method to help inform mussel restoration efforts in Ōhiwa. This was further reinforced by the fact that outputs from Bayesian Networks are easily interpreted, reinforcing their utility during the co-development design with Māori and stakeholders (an important component of the process).

In this example, the prioritisation table was not interpreted in order of the columns but rather in the order of importance for achieving the goals of the study ie, column 2 was examined first. This also provides an opportunity for practitioners to decide, if there are no tools available that meet all their application-based considerations, whether compromising on these is possible. For example, here, exploring the uncertainty in the information wasn't a key component therefore Agent based models could be equally well suited to the task (especially if scenarios examining management interventions over time were warranted – see additional output types for Agent based models in Figure 15).

The tool combines a Species Distribution Model (SDM) with a Bayesian Network (BN) method to spatially model the implications of different management scenarios on the likelihood of mussel restoration. The tool was informed by quantitative empirical datasets and relationships as well as expert knowledge, weaving Mātauranga and ecological information to empower decision making (Bulmer et al, In review).

By melding an SDM with an expert driven BN method, it was possible to fill gaps in empirical datasets and relationships, as well as account for and display uncertainty in outputs using a probabilistic framework. The tool has highlighted uncertainty in key ecological interactions, including the impact of predatory starfish on mussel abundance. This has helped to inform ongoing field experiments and synthesize knowledge of the complex interactions driving mussel decline and recovery dynamics. Ultimately, this tool will support management decisions in the face of uncertainty and complexity. We believe this hybrid tool is well-suited for exploring the pūtahitanga (intersection) of Mātauranga Māori and western science to help support inclusive decision making as part of an ecosystem-based management method.



## Case study 2: Cumulative effect (CE) models

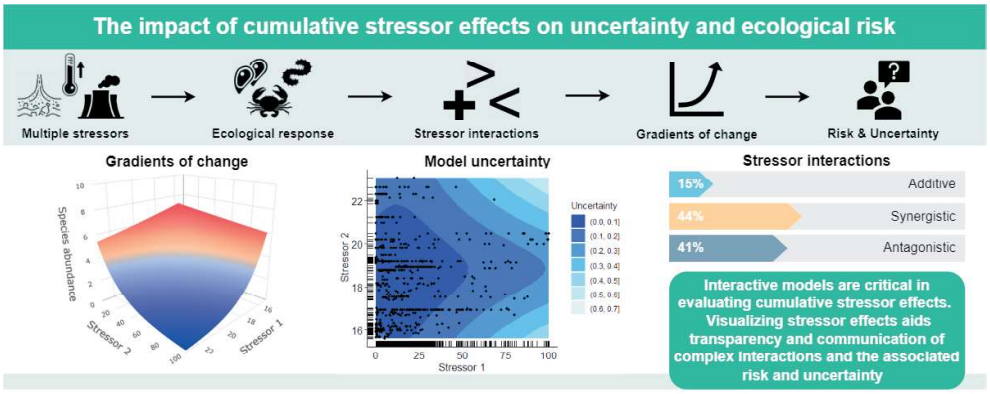
| **Method** | Cumulative effect (CE) models | | |
|---|---|---|---|
| **Complexity** | High | **Knowledge type** | Quantitative |
| **Information requirements** | High | **Time/cost to implement** | Medium |
| **Interpretability** | High | **Output type** | Uncertainty |
| **Outcomes** | Medium | | |

Our oceans and coasts are experiencing unprecedented stress from human activities putting systems at risk for degradation and collapses. A limited understanding of how a system will respond to multiple stressors increases uncertainty in how to best manage the environment. This case study modelled the response of indicator species in estuaries to a range of stressors to identify complex stressor interactions and how (un)certain we are of these effects (Rullens et al 2022).

For this case study we had access to a high amount of quantitative data collected as part of monitoring programs in estuaries across New Zealand. We based our CE method on Generalized Linear Model (GLM) which have high data requirements but are cheap and easy to run. The CE method extended the use of GLMs in cumulative effects assessments by developing new ways to visualise complex stressor interactions.

These visualisations aid the interpretation of a response to stress and reveal the direction, magnitude, and gradient of change as two stressors increase. A better understanding, together with a need for transparency and communication of complex stressor interactions, can reduce risk of unexpected declines or environmental collapses and can invoke precautionary management when uncertainty about the effects of two or more stressors is high. This risk assessment method:

- can identify priority stressor pairs
- guide future monitoring to target conditions where data is limited
- inform limit setting in management that takes risk and uncertainty into account.



## Case study 3: Development of a cumulative effect principles method

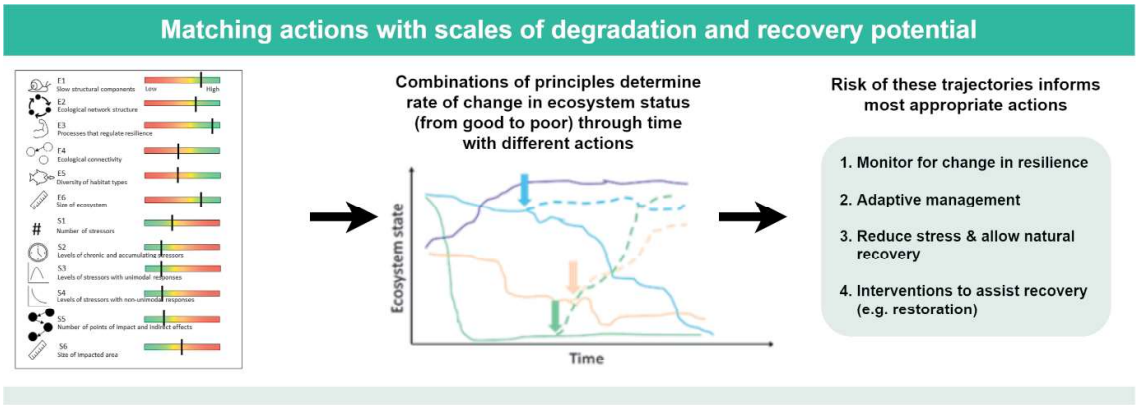
**Method** Cumulative effect (CE) principles

| | | | |
|---|---|---|---|
| **Complexity** | Very high | **Knowledge type** | Multiple |
| **Information requirements** | Low | **Time/cost to implement** | Low |
| **Interpretability** | Easy | **Output type** | Scenario, Temporal, Spatial |
| **Outcomes** | High | | |

Empirical coastal and marine research shows that these ecosystems are complex to manage because stressor impacts occur through a myriad of direct and indirect effects that occur at multiple spatial, temporal, and biological scales. Context dependencies in responses are common because different coastal systems have different levels of inbuilt resilience and recovery potential. These context dependencies are a challenge to deal with because it means that actions in one place or time may not work in another place or time. This method was developed to assess the risks associated with three types of management actions (adaptive management, stressor reduction with no active restoration, stressor reduction and active restoration) for a specific location.

The method is focussed on biophysical and stressor attributes summarised as a series of principles. While the principles are theoretical, the technique of ecological principles has been successfully used for predicting ecosystem services' potential, operating well even in areas of low information. Two categories of principles are used: ecological principles that define how healthy and resilient the ecosystem of a location is and how long it will take to recover; and stressor principles (ie, number and types of stressors). Where the ecosystem sits along a sliding scale for each principle and how these principles combine informs us about how fast the degradation will be or how fast or slow the natural recovery might be. Understanding or predicting rates of decline and improvement helps us to understand whether there are trigger points of when to act, and what the risks associated with delayed actions are.

The method does not need detailed locational data on the ecosystem and the stressors in play, being able to work with local knowledge and mātauranga, however it can also use any detailed information available. It does not explicitly output uncertainty.



## Case study 4: Exploring the usefulness of two risk assessment methods

**Background:** The usefulness of two risk assessment approaches for Māori commercial fisheries was explored during workshops in June and July 2022 by Sustainable Seas researchers and two co-development partners: Moana New Zealand and the Iwi Collective Partnership (ICP). Moana New Zealand is a Māori-owned fisheries company, and the Iwi Collective Partnership is a group representing Māori the commercial fishing interests of 19 iwi. These workshops and the views expressed within them only represent a preliminary assessment of risk within Māori fisheries and should not be interpreted as reflecting the views of all Māori, nor all fisheries companies. The two risk assessment approaches used (Likelihood Consequence Matrix (LCM) and Bayesian Network (BN)) were selected at an initial meeting.

**Workshop 1**: 13 June 2022, held at Moana New Zealand's Group Office. Attendance: Michelle Cherrington (Moana New Zealand), Nathan Reid (Moana New Zealand, ICP Director), Maru Samuels (CEO, ICP), Dana Clark (Sustainable Seas), Fabrice Stephenson (Sustainable Seas), Ani Kainamu (Sustainable Seas), and Joanne Ellis (Sustainable Seas).

**The aim of Workshop 1** was to understand the unique values and risks facing Māori fishing businesses and determine whether risk assessment approaches can help to better manage those risks.

**Key risks** were identified by Moana New Zealand and ICP representatives, including (in no particular order): land-derived stressors, climate change and carbon footprint, Marine Protected Areas/area closures, uncontrolled/unmonitored recreational fishing, negative perceptions of commercial fishing, 'not in my backyard' syndrome, impacts to the rights guaranteed within Treaty Fisheries Settlement, health of the moana, and price of fuel.

**Mitigation of risks** were identified by Moana New Zealand and ICP representatives, including (in no particular order): Mātauranga of fishers, contracts with fishers (to ensure core values are upheld, e.g., Moana New Zealand's sustainability strategy: https://moana.co.nz/content/our-sustainability-journey-strategy), innovations in fishing gear, data collection and analysis, use of improved technology such as cameras/smartphones, and growing the iwi knowledge base and expertise in commercial fisheries (the knowledge deficit is due to the relatively recent return into the commercial fisheries industry via the Treaty Fisheries Settlement; this needs to be addressed before risks can be fully understood).

Despite possible mitigation of risks, it was acknowledged that when making decisions in fisheries, some risks would be at odds with others (ie, there may be trade-offs). Where there may be trade-offs, Moana New Zealand and ICP described some key considerations:

- Health of fish stocks is always front of mind.
- Whakatipuranga: thinking about future generations, including the health of the environment.
- Social-economic considerations are integral — for example, the effect of a decision on the number of people employed, catch, profits, social and cultural benefits etc.
- Profits contribute to building and supporting the Māori economy (dividends go to Iwi entities rather than individuals, which support collective cultural and social facilities/outcomes).
- Considerations of generational equity issues — for example, climate change and the need to curb growth within a young and burgeoning Māori economy that is just getting off the ground versus established non-Māori industries.

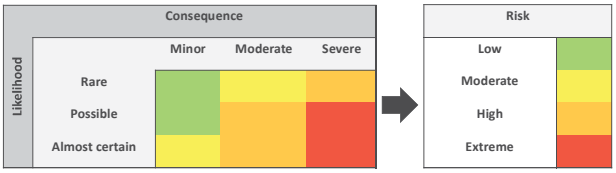
Formal risk assessment methods and frameworks are in the process of being developed for both Moana New Zealand and ICP. There was general agreement that **risk assessments could benefit by being more consistent/systemised and based on data/evidence** and could also help as **tools to communicate complex issues to stakeholders** to reach consensus on a decision. However, fisheries

are a complex industry and therefore risk assessments need to be able to capture this complexity whilst remaining simple to implement and communicate (eg, to stakeholders / shareholders). Two risk assessment methods were presented that meet the criteria of being flexible enough to accommodate the complexity of fishing whilst remaining simple to implement and communicate.

## Likelihood Consequence Matrix (LCM)

LCM uses non-numeric and/or quantitative data to produce a matrix of the likelihood and consequence associated with each activity. The output is a risk score for each ecological component, which is a product of the expected likelihood and consequence of an event.

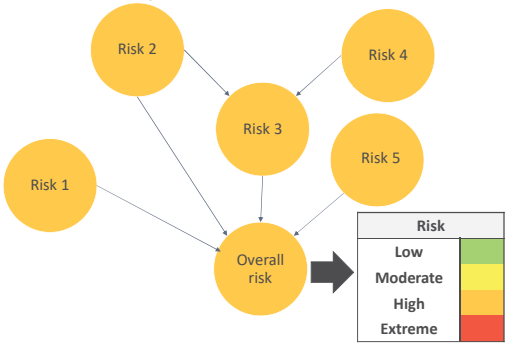
Schematic representation:




## Bayesian Network (BN)

BNs are probabilistic models that provide a graphical representation of a network of variables (called nodes) and their interactions. The relationships between variables are displayed as links (arrows), with the direction, strength, and shape of these dependencies quantified using conditional probabilities.

Schematic representation:




**Workshop 2**: 28 July 2022, held at Moana New Zealand's Group Office. Attendance: Michelle Cherrington (Moana New Zealand), Nathan Reid (Moana New Zealand, ICP Director), Maru Samuels (CEO, ICP), Mark Ngata (Moana New Zealand, Ngāti Porou Fisheries), Dana Clark (Sustainable Seas), Fabrice Stephenson (Sustainable Seas), Ani Kainamu (Sustainable Seas), Darcy Karaka (Sustainable Seas), and Joanne Ellis (Sustainable Seas).

Strawmen of the two risk assessment tools (LCM and BN) were developed based on the identification of risks by co-development partners in Workshop 1 and presented at Workshop 2. **The aim of Workshop 2** was to present these tools to elicit feedback from Moana New Zealand and the Iwi Collective Partnership (ICP), on the pros and cons of both methods for application within Māori fisheries.

**Summary of discussion at Workshop 2: Applying risk assessment tools in Māori fisheries**

The ICP and Moana New Zealand feel they are responsible for managing and understanding their own impact in terms of their values, but they have an overarching aspiration to see that applied nationally. As Māori-based businesses, they feel a responsibility to know and understand their own impact but also know and understand the full impact of fisheries because they want to play the role of kaitiaki across the entire fisheries EEZ marine space. Moana New Zealand and the ICP felt that Iwi fisheries are at a critical crossroads with many decisions requiring an understanding of risk and mitigation measures. Moana New Zealand and the ICP wanted to be able to make decisions that are transparent and that they can stand behind on a public platform and demonstrate to stakeholders and the public the process that they went through to come to a decision. In line with this desire, it was felt that there was a need to understand whether decisions are in line with their tikanga and values, while kaitiakitanga sometimes requires making hard decisions that could affect jobs, profit, and/or manaakitanga. Risk assessment tools can provide one approach (amongst others) to inform evidence-based decision making. Noting that risk assessments can also be used to demonstrate that

certain current fishing practices are already low risk or as a monitoring tool to evaluate environmental impact across the business.

| Likelihood Consequence Matrix (LCM) | Bayesian Network (BN) |
|---|---|
| *Pros* | *Pros* |
| • Easy to communicate<br>• Simple<br>• Sensible<br>• People are familiar with this type of approach because it is used in other settings<br>• Could be useful if it was applied in a specific area and the context, assumptions, and size of area were explicit | • Can accommodate and capture complexity (including knock on effects)<br>• Can accommodate the multifaceted (social-cultural-economic-environmental) nature that Māori fisheries operates in<br>• Easy to communicate complex information and step people through decisions (presentation in the iwi/Māori fisheries space was seen as crucial)<br>• Transparent - all facts and figures underpinning the decision are viewable (but could simplify and hide these if preferred)<br>• Outputs can be synthesised into a format that looks more like the likelihood consequence matrix - best of both worlds depending on who you are communicating the results to and the nature of the decision |
| *Cons* | *Cons* |
| • Oversimplifies – doesn't allow for the intricacies/challenges/externalities<br>• Can keep adding columns or matrices to account for more factors but it becomes harder to synthesize this information and communicate it<br>• Does not account for uncertainties very well (shows average)<br>• Looking at different components in isolation does not fit with a Māori point of view<br>• Difficult to make trade-offs<br>• Matrix did not account for likelihood (although it could be modified to account for this)<br>• Very linear method<br>• Could not see how this would fit with on-going research and risk projects | • Moana New Zealand and the ICP did not feel like they have had a chance to fully test the model capabilities using the strawman<br>• Need to develop expertise/skills in setting up and running BNs<br>• Takes a bit to understand and explain - maybe useful for managers rather than showing the full models to all stakeholders |

Risk assessments were seen as useful on multiple levels for decision making within Māori fisheries and particularly as a way of accounting for and acknowledging uncertainties. Both risk assessment approaches were seen to have utility, both for internal decision making but also to communicate to people outside the organisation. However, the BN was seen as better able to capture the complexities of Māori fisheries (noting that different people/iwi may have different opinions because they are from different rohe and may have different tikanga). BNs could be easily tailored to communicate risks and trade-offs to different users. In any case, risk assessments should be underpinned by robust information whether scientific data, mana whenua or expert opinion. These differences can be accounted for by tailoring the risk assessment to a specific location or doing scenario testing to see what effect differences of opinion have on overall risk.

It was felt that a collaborative effort is required to improve the health of the moana (which is impacted by multiple stressors, including land-based stressors). Addressing these complex and

difficult problems cannot be solved solely by the fishing industry. Risk assessment was one approach which could be developed and populated alongside other resource users (eg, recreational fishers, aquaculture, farmers, and other users of the land) for holistic decision making to improve ecosystem health. This multi-value collaborative approach would also help to build trust amongst different resource users and/or stakeholders.

Issues around the risk and uncertainty of the interplay between fishing footprint and intensity, and displacement and equity were identified as particular areas of interest for future applications of risk assessment tools by Moana New Zealand and the ICP (noting that these discussions were theoretical as Moana and ICP were unable to apply actual data to fully test the models).

**Acknowledgments**: We thank all workshop participants for their time and for freely sharing their ideas. We also acknowledge the generosity of Moana New Zealand for catering and hosting the workshops at their offices.

## Limitations and suggestions for future research areas

While the guidance and diagnostic tool developed here can help with the implementation of appropriate risk assessment methods, we acknowledge some gaps within this guidance and future research areas.

The risks associated with delayed management actions are linked with increasing likelihood of a tipping point to an altered undesirable state. Early interventions especially in light of increasing uncertainty can increase the likelihood of positive environmental outcomes. The sustainability of marine ecosystems demands a focus on ecological improvement, necessitating managers and conservationists to consider a range of actions from those that limit stressors to those that actively restore. Deciding the most appropriate action should be informed by environmental context, which includes assessing information on both degradation and recovery potential. To support decision makers and practitioners we have recently developed ecological and stressor principles that link to the risk of further degradation or successful recovery (Case study 3). We are presently developing a risk framework which combines these principles to define where an ecosystem is located along sliding scales of degradation and recovery and its likely response to protective and restorative interventions. This framework is designed to facilitate place-based conversations regarding the risks of different management actions (adaptive management, stressor reduction with natural recovery, stressor reduction and human assisted recovery). This framework should be well suited to evaluate when early interventions are needed particularly in areas where information is limited and decisions may be postponed.

Recent developments in the risk assessment field have included consideration of coupled natural human (CNH) systems that include feedbacks between ecological and social components. Many of the methods we have discussed here (eg Atlantis, BN, ABM) can include in a single model feedbacks between ecological and social components. However, this can become cumbersome to do within a single model, and it maybe that coupled models would be more effective. While there are presently very few examples of risk assessments that include dynamic feedback between social and ecological components of the system (Clark et al 2021), "tractable approaches to move CNH systems theory into practice for assessing risk in marine ecosystems are nascent but developing" (Holsman et al, 2017). Internationally, and within Aotearoa New Zealand there are some examples of CNH approaches (eg Bulmer et al, In review) however, in general, feedbacks and systems thinking are still underrepresented in practical applications. Further research to determine whether coupled approaches that can accommodate feedbacks between cultural and ecological knowledge would be valuable.

Ecological risk is still not well represented in the media. For example, a recent study found that ocean-related reporting is inadequate for the level of the crisis facing conservation and sustainability goals (Armoudian et al 2023). Whilst communicating science and concepts related to risk and uncertainty can be difficult it is essential that the scientific community improve communication and public dissemination. Suggested channels include press releases, guidance documents and optimised video science communication techniques. In New Zealand, the use of short policy guidance documents reached via scientific consensus has proven to be effective within more holistic Ecosystem Based Management frameworks that involve all parties in the decision-making process. Another platform, optimised video science communication, has been shown to be more effective than press releases and non-optimised communication tools in promoting better comprehension and a stronger manifest interest in learning more about the subject area by members of the public (Armoudian et al 2023). Positive outcomes from improved communication of marine media coverage are of importance due to the linkage with public support and awareness of conservation issues and subsequent policy decisions.

Finally, as multiple stressors and cumulative impacts continue to accelerate with new and emerging sectors and climate change, methods that address deep uncertainty will become increasingly important for management. Risk assessments generally address relatively well-known hazards in which the prospect of future events and their consequences can be predicted either by analysis of past occurrences or by experimentation. Now we are also in the realm of uncertainty of what threat the event poses (the known unknown Inglis et al (2018)) and the unknown unknown, that is, unknown (or presently unanticipated events) with unknown consequences. In deeply uncertain risk problems, the risk cannot be represented reliably by likelihood of occurrence or modelled relationships. However, there are some paths forward. Firstly, for the “known unknown”, allowing future (or increasing) stress will be more risky for maintenance of values (desired outcomes) - certainly more so than acting to reduce stressors. Secondly, also for the “known unknown”, scenarios can be run based on minimum to maximum effects. Thirdly, for the “unknown unknown”, scenarios related to effect of changes in values can be input and followed through to risks to other values in risk assessment methods that are network based (e.g., BN, ABM). It is possible that management actions (or policy options) that best reduce vulnerability may then be able to be identified.

# 5. Re-engage with diagnostic tools and assess 'success' of 'risky and uncertain' processes

This section discusses the need to reflect, evaluate, and assess decision-making processes where risk and uncertainty where encountered. This includes assessing how using the guidance, tools and methods developed in this document has or has not shaped decision-making towards ecosystem-based management and Te Ao Māori futures.

In Aotearoa New Zealand, governance and management dynamics are fluid. With this fluidity comes a bombardment of risk and uncertainty changing influences that are consciously or unconsciously assessed through the variously understood lens of positioning, disciplines, and worldviews. Entities can struggle to identify, let alone make sense, of the invisible or murky influences and key influencers.

New competencies and tools are being developed to cope with such pressures. Rubrics offer a way to regularly and robustly inspect the adequacy of new strategies. The rubric-based analytics in this section are a pioneering intervention that takes seriously the need to continually re-engage with diagnostic tools, and with iwi, hapū and communities involved in 'risky' decision-making processes. This coupling grounds rubric efforts in revealing lived experiences and the complexities and complications of making tricky decisions about the tricky realm of risk and riskiness.

## 1. Continually reengage with diagnostic tools

Throughout any decision-making or participatory process, people need to reengage with the diagnostic tools to promote on-going improvement in practice.

Figure 13 is an adapted diagram (from Sustainable Seas Phase 1 work) that illustrates the continual nature of engagement. The tools in this document are not designed as one-off tools. They are **meant to be referred to again and again** as processes progress.

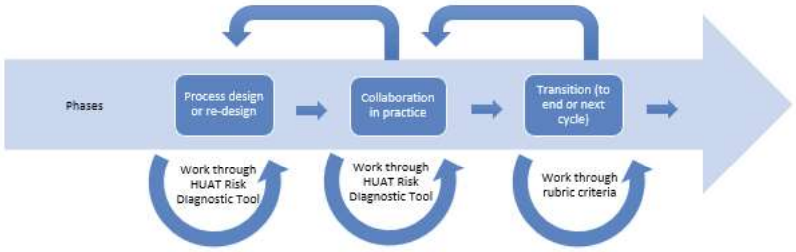



*Figure 13 Each phase requires re-engagement with the diagnostic tools. Adapted from (Le Heron and Allen et al 2021)*

## 2. Assess 'successful' performance against criteria (Evaluation rubric)

Sustainable Seas Phase 1 project 1.1.1[7] developed a performance assessment rubric to answer the perennial question 'what does success look like?' In other words, how do we know if we are doing a good job? Le Heron and Allen et al (2021) illustrate what it means to assess performance against meaningful criteria, and to evaluate 'success'. Rubrics can be helpful tools in re-engaging and evaluating the work achieved.

[7] https://www.sustainableseaschallenge.co.nz/our-research/testing-participatory-processes-for-marine-management/

Using this template, we have created a tailored assessment rubric for specific risk and uncertainty questions[8]. It provides assessment criteria for 'working with risk' in ecosystem-based management and Te Ao Māori positive ways. In short, the rubric asks you to assess how well you are doing at each criteria/question (developing, good, excellent), give evidence to support your conclusion, and identify future improvements. This exercise ensures a thorough examination of practice and outcome.

Once you've worked through *Diagnostic tool 2 Working with risk* and the *Working with risk rubric below,* you'll be more aware and agile in your thinking. However, as you upskill, you may hit barriers of institutions, existing practices, and pushback from others. The way you engage with others may shift. For more detail on working through these challenges, especially if you are engaging in risk assessment or 'risky' decision-making which involves participatory processes see Le Heron and Allen et al (2021). This paper discusses different phases of participatory processes (shared goals and visions; context history and connections; silences, absences, and presences; process (group process, meeting culture); diverse knowledges and values; politics and power; community support; planning, monitoring and evaluation) and the crucial components to consider in each phase.

[8] See Le Heron and Allen et al (2021) p. 7-10 for information on how to create and/or tailor a rubric

**Rubric: Ngā angitu me te arotakenga tūraru |what does success look like when 'working with risk and uncertainty'?**

Use this rubric to assess how well you've worked through *Diagnostic Tool 2 Working with Risk*.

| Steps to consider in risk and uncertainty decision-making | **Performance criteria for *Diagnostic Tool 2 Working with Risk***<br>*See also 'Guidance for each Step' as this has information and examples of good practice* | Assessment guide<br>1=Developing<br>2=Good<br>3=Excellent<br>**1 2 3** | Evidence of Performance | Future improvements |
|---|---|---|---|---|
| | **Unpacking perceptions of risk and uncertainty / Kia whakahura te tūraru me te haurokuroku (KWTH)**<br>Have worked through *Diagnostic Tool 1 Unpacking perceptions of risk and uncertainty*. The context and circumstance of self and others *is better understood.* Own worldview identified. Have identified other worldviews in use in this context. Have identified differences and similarities in what is 'risky and uncertain', including "risk to what, when and where" in this context between self and other parties. Have identified similarities and differences in approach and experience of the situation due to positionalities of self and others. Have identified differences and similarities in how own discipline sees risks compared with other disciplines. Process to be done by all parties. Worldviews, positionalities, and disciplines to be collectively discussed and documented. Clear points of engagement/difference identified. *Plan developed for making use of knowledge*. | | | |
| | **Enacting Treaty partnerships***<br>Goals, visions, and plans take account of Te Tiriti and support local iwi and hapū goals and visions. Appropriate hapū and iwi engaged with and empowered. It is recognised that engagement with hapū and iwi is an ongoing process not one-stop, this is worked into processes. Te Ao Māori worldview and multiplicity of other worldviews acknowledged and incorporated into decision-making. Processes anchored in te Tiriti principles, ethics, and co-governance. Different ways of knowing acknowledged and actively worked with – findings identified and documented. There has been a willingness to learn, reflect and evolve positions. There has been a focus on ethical decisions – equity, justice, power. Available tools and frameworks used as appropriate (e.g., Tikanga Process Model (Harmsworth et al, 2016), Te Mana o te Taiao Aotearoa NZ Biodiversity Strategy 2020, Mātauranga Māori Framework (EPA), National Policy Statement of Freshwater Management 2020).<br>Prompting questions discussed: What are considered (currently) suitable Tiriti partnership approaches? What does this mean in decision-making processes? | | | |
| | **Reconsidering what is evidence**<br>Recognition that evidence (e.g., numeric, models, stories) and the knowledge that support it (e.g., scientific data, mātauranga Māori, experiential, local) come in multiple forms. Have gone through a process to identify that different kinds of evidence are credible in different worldviews and for different purposes. Identified and documented findings. Dominant evidence biases in current process identified. Have identified what other kinds of knowledge would benefit current process, and created ways to allow these knowledges into decision-making.<br>• For example, EPA's Mātauranga Māori Framework to better include mātauranga as evidence, risk assessment methods that support EBM (*Guide to assessing risk assessment methods that support EBM* and *Diagnostic Tool 3 Decision tree to select risk assessment methods*).<br>• Other examples of tools to help: *Appendix 1: What is my worldview survey, Appendix 3: What kind of data is needed for a flourishing future?*<br>Prompting questions discussed: What is and is not considered evidence? Why might that be? To help with this, think positionality, worldview, discipline, i.e., are some disciplines given more weight than others? How are individual/company positionalities influencing their concerns and arguments? What do I think is evidence? How do I rank these? What does this mean in decision-making processes? Are we only getting answers that fit an artificially narrow context? What knowledge is being left out? What work do the different types of evidence do for the collective/society? | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Finding the right frameworks and methods**** considering that a diversity is preferred.<br>Reviewed what are available and to whom. Ensure that approaches are appropriate to the people involved, and that all have had access to those used. Reflection and identification done as a group process.<br>Prompting questions discussed: What are (currently) considered as suitable methods/frameworks? Are they considered appropriate to support EBM and Māori aspirations and needs? If not, why are methods that are appropriate to support these not being used? What types of knowledge inputs are involved? What the knowledge being collated? How is the knowledge being used/perceived/weighed? What is the impact of these factors on natural resource management decisions being made? Do the methods/frameworks allow for risks as seen by all world views to be represented?<br>Awareness of newly developed methods and frameworks developed, for example Waka Taurua/Hourua, EPA mātauranga Māori framework; Arotakenga Huringa Āhuarangi: National Climate Change Risk Assessment Framework; Mauri Compass; Māori Values and Perspectives to Inform Collaborative Processes and Planning for Freshwater Management Policy Brief for MWLR, Bayes Nets, Agent-based models, System Dynamic mapping and others. | | | | | |
| | **Process constrains content**<br>Constraints of legislation in this context identified – what is 'allowed' to be considered and what is not? e.g., natural resource management and policy is framed in a way that reflects worldview. Framings of issue identified. Multiple legislation/policies identified each with own constraints. What activities and what types of management actions are not being considered?<br>Findings documented.<br>Role of disciplines in framing content identified, e.g., what is seen as appropriate evidence (mātauranga, models, interviews etc)..<br>An appropriate content and framing for the current decision-making process has been identified and supported<br>Other knowledges included in the process; changing how issues are discussed as risky/uncertain/important. A range of views are included (stemming from worldviews, positionalities, and disciplines).<br>Prompting questions discussed: What influence does framing have? What does this mean in decision-making process? How can we improve this situation and expose other perspectives? For Māori, this might link to co-management/co-governance arrangements | | | | | |
| | **Balancing of rights**<br>Nature of tension between collective, individual and property rights identified in this context. Absent or marginalised people identified and included if possible.<br>Worldviews at play in the process identified. Relationship between risks (according to worldview) and rights identified. For example, whether the risk is seen as to future generations, to current environment, to property rights, to economic extraction rights.<br>Disciplinary influences in process identified: what each prioritises in this case identified. The effect on decision-making in this context discussed, and as broad as possible disciplines and actors included.<br>Positionality of actors involved identified and their relative support of which rights noted. The effect on decision-making in this context discussed, and actors with varied positionalities included.<br>Questions asked and answered: What is (currently) considered as an acceptable balance of rights? Where does this weighting come from? (history, dominant players, legislation, other…) Are the interests (that provide the weighting) being served by this or are others? What lobbying is occurring, from whom and for whom? Are you in a position to enable or advance a particular set of rights? How does this affect risk decisions? Whose "risks to what, when and where" are being left out and why? What does this mean in decision-making process? What is the right balance in any given situation? | | | | | |

*The rubric assigns Tiriti issues and partnerships top priority, and ideas of evidence and tools/frameworks/approaches are next, as once these have been worked through, it is easier to recognise how process constrains what is happening, and what is allowed 'in the room', and to think about balancing rights. ** Tools "perform or facilitate operations," aiding decision-making, while frameworks can be considered "a basic structure, plan or system, as of concepts, values, customs or rules". However, we do not hold these definitions rigidly, as frameworks are also tools of a sort, when they are used to facilitate decision-making.

*Figure 14 An evaluation rubric - Ngā angitu me te arotakenga tūraru: What does success look like when "working with risk and uncertainty"?*

# Ngā kupu whakakapi | Document conclusion

***Me tiro whakamuri, kia anga whakamua – Look to the past to inform the future***

This whakatauāki centres us in terms of our connection to our past and ensures that we also acknowledge that we are connected to those who have gone before us, with a responsibility to the generations to come (who will be looking to us for guidance and leadership on making decisions that account for their livelihoods). This is foundational to any holistic view.

In risk discussions, individual and institution wellbeing is often the focus. Our collective mahi in this document acknowledges past, present, and future connections, ensuring there is a balancing in our current activities with respect to how we engage with the environment.

It follows that if we take seriously that the research has identified three key paradigms (worldviews) active in Aotearoa New Zealand, then we acknowledge that some paradigms hinder ecosystem-based management progress and some advance it. Enacting ecosystem-based management and incorporating Te Ao Māori through the diagnostic tools represents ways forward to decision-making for longer term, wider-sense ecological aspirations.

Risk assessment methods to inform decision-making associated with ecosystem-based management must be able to cope with non-numeric data, particularly in Aotearoa New Zealand where Māori voices and knowledge must be heard and where resources for environmental monitoring are limited. Methods that can easily combine knowledge from different sources (ie, mātauranga Māori, expert opinion, non-numeric local knowledge, narratives and experimentally derived mechanistic relationships) such as Bayesian Networks are required.

Risk assessment methods used in applications may not always meet all the criteria, but the very act of considering these will allow gaps and weaknesses in the method to be explicitly acknowledged.

## Weaving together knowledges can inform future 'risky and uncertain' decision-making

This document has engages with and interweaves multiple sources of knowledge. The words of wisdom from Kukupa Tirikatene below illustrate the importance of an interwoven approach, and the need for reflection and evaluation as part of any process. This document gains strength from weaving together methodologies and approaches; the guidance contained within makes the most of multiple inputs, worldviews, knowledges, and resources.

**E kore e taea e te whenu kotahi ki te raranga i te whāriki kia mōhio tātou ki a tātou.**
**Ma te mahi tahi o ngā whenu, ma te mahi tahi o ngā kairaranga, ka oti tēnei whāriki.**
**I te otinga me titiro tātou ki ngā mea pai ka puta mai.**
**A tana wā, me titiro hoki ki ngā raranga i makere na te mea, he kōrero anō kei reira.**

**The tapestry of understanding cannot be woven by one strand alone.**
**Only by the working together of strands and the working together of weavers will such a tapestry be completed.**
**With its completion let us look at the good that comes from it.**
**In time we should also look at those stitches which have been dropped, because they also have a message.**

The work of project 3.1 and project 3.2 has brought together case study examples, assessed existing frameworks, worked through scenarios, asked diagnostic questions, and thoroughly interrogated the concepts of risk and uncertainty. We hope that the wealth of material will aid any practitioners and decision-makers in finding pathways for working with risk and uncertainty and will usefully inform any future 'risky' decision-making.

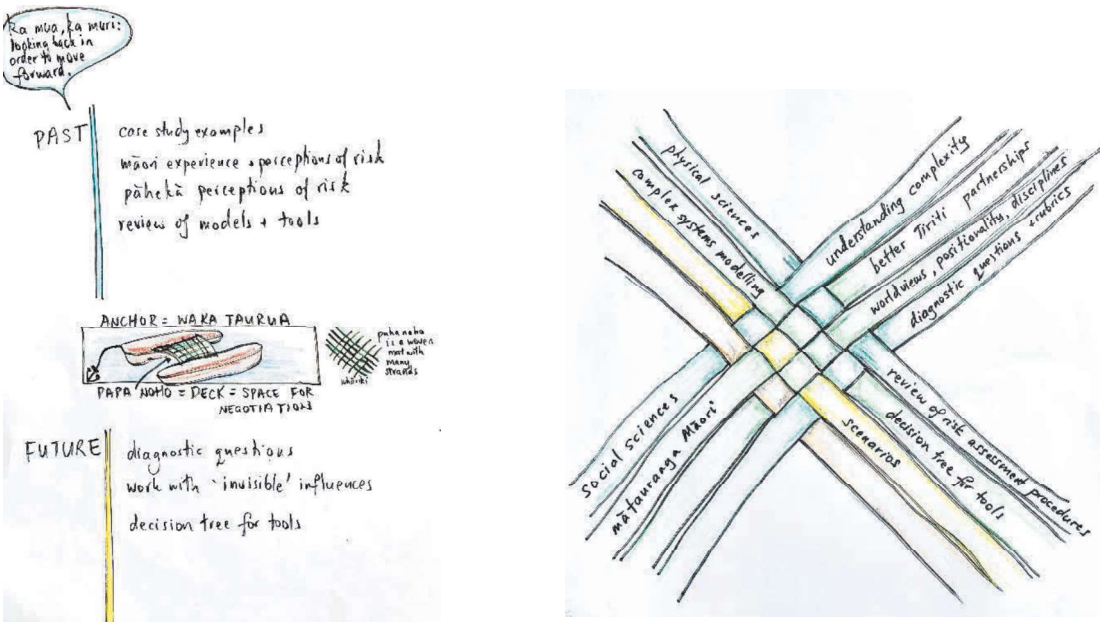



*Figure 15 This document weaves together many knowledges to inform future 'risky and uncertain' decision-making*

Risk and uncertainty are categories of particular conditions. The sociologists Ulrich Beck and Anthony Giddens heralded the appearance of new conditions in the 1990s with their theories on risk society (Beck, 1992; Giddens, 1991). The research has made unambiguously clear that today's enterprises are relatively free agents who have to interface with structural conditions. This diverges from the past era of tight state-economy relations. In Aotearoa New Zealand, signals about changes afoot need to be 'processed' to decide what investment decisions might be made. Our focus on developing knowledge of ecosystem-based management and addressing Māori futures is a pioneering intervention in guiding decision making.

Throughout this document we have made recommendations about how to engage with risk and uncertainty in the current context. We are increasingly convinced that understanding how Māori knowledge is reshaping risk is the decisive intervention that will create the space that counts most. We point to the Sustainable Seas Waka Taurua framing. This framing interweaves Te Ao Māori and Te Ao Pākehā in Aotearoa New Zealand, and could flow directly into future environmental legislation and decision-making. This encompassing and collectively directed approach has great potential to break short-termism and open up thinking, especially for intergenerational outcomes.

# References


Anderson, O.F., Stephenson, F., Behrens, E., and Rowden, A.A. (2022). Predicting the effects of climate change on deep-water coral distribution around New Zealand—Will there be suitable refuges for protection at the end of the 21st century? Global Change Biology 28, 6556– 6576.

Armoudian, M., Stevens, G., Stephenson, F. & Ellis, J. (2023). Media and Marine Science in New Zealand: Coverage of the crisis in the oceans before and after the IPCC report. Aquatic Conservation: Marine And Freshwater Ecosystems.

Australia and New Zealand (2020). Cumulative bottom fishery impact assessment for Australian and New Zealand bottom fisheries in the SPRFMO convention area, 2020. Report to 8th Meeting of the SPRFMO Scientific Committee.

Beck, U., 1992. Risk Society: Towards a New Modernity.

Blackett, P., Le Heron, R., Le Heron, E., Davies, K., Fisher, K., Greenaway, A., Sinner, J., Baines, J., Simmonds, N., Ford, J., Lundquist, C., 2017. Enacting participatory processes learnings: an experiment with interdisciplinary engagement. Presented at the New Zealand Marine Science Society conference, New Zealand Marine Science Society conference, Tauranga, November.

Bulmer, R., Paul-Burke, K., Ranapia, M., Ellis, J., Bluett, C., O'brien, T., Burke, J., Petersen, G., and Stephenson, F. (In review). Weaving indigenous and western ecological knowledge to enhance environmental sustainability. Ocean & Coastal Management.

Clark, D.E., Gladstone-Gallagher, R., Stephenson, F., and Ellis, J. (2021). "A review of risk assessment frameworks for use in marine ecosystem-based management (EBM) in Aotearoa New Zealand ", in: Report for Sustainable Seas National Science Challenge project Communicating Risk and Uncertainty (Project code 3.2). (Wellington).

Clark, D.E., Gladstone-Gallagher, R.V., Hewitt, J.E., Stephenson, F., and Ellis, J.I. (2022). Risk assessment for marine ecosystem-based management (EBM). Conservation Science and Practice 4, e12636.

Department of Conservation, 2020. Te Mana o Te Taiao - Aotearoa New Zealand Biodiversity Strategy.

Dunlap, R., 2008. The new environmental paradigm scale: from marginality to worldwide use. The Journal of Environmental Education 40, 1, 1–18.

Dunlap, R., van Liere, K., D., 1984. Commitment to the dominant social paradigm and concern for environmental quality. Social Science Quarterly 65, 1013–1028.

Environmental Protection Authority Te Mana Rauhi Taiao, 2020. Partnership in action: The EPA's mātauranga framework.

Giddens, A., 1991. Modernity and Self Identity: Self and Society in the Late Modern Age. Polity Press, Cambridge.

Gladstone-Gallagher, R.V., Hewitt, J.E., Stephenson, F., Low, J.M.L., Pilditch, C.A., Thrush, S.F., and Ellis, J.I. (in review). Matching marine ecosystem status with environmental management approaches: A risk-based approach.

Hanna, C., White, I., Glavovic, B., 2020. Uncertainty Contagion: Revealing the Interrelated, Cascading Uncertainties of Managed Retreat. Sustainability 12, 736. https://doi.org/10.3390/su12020736

Harmsworth, G., Awatere, S., Robb, M., 2016. Indigenous Māori values and perspectives to inform freshwater management in Aotearoa-New Zealand. Ecology & Society 21.

Hawcroft, L.J., Milfont, T.L., 2010. The use (and abuse) of the new environmental paradigm scale over the last 30 years: A meta-analysis. Journal of Environmental Psychology 30, 143–158. https://doi.org/10.1016/j.jenvp.2009.10.003

Holsman, K., Samhouri, J., Cook, G., Hazen, E., Olsen, E., Dillard, M., Kasperski, S., Gaichas, S., Kelble, C.R., Fogarty, M., and Andrews, K. (2017). An ecosystem-based approach to marine risk assessment. Ecosystem Health and Sustainability 3, e01256.

Hyslop, J., Harcourt, N., Awatere, S., Hikuroa, D., Blackett, P., Le Heron, R., 2022. Kia aiō ngā ngaru, kia hora te marino: Why values matter for mitigating risk and uncertainty in natural resource management. AlterNative.

Inglis, G., Soliman, T., and Djanibekov, U. (2018). Tools for risk assessment under uncertainty. NIWA client report number 2020259CH. National Institute of Water and Atmospheric Research, Christchurch, New Zealand.

Joseph, R., Rakena, M., Te Kuini Jones, M., Takuira, J., Te Tai, M., Rakena, C., 2020. Stemming the Colonial Environmental Tide - Shared Māori Governance Jurisdiction and Ecosystem-Based Management over the Marine and Coastal Seascape in Aotearoa New Zealand – Possible Ways Forward (Final report for the Whaia te Mana Māori Whakahaere Tōtika ki Tangaroa – in pursuit of Māori governance jurisdiction models over marine resources project). National Science Challenge Sustainable Seas Ko Ngā Moana Whakauka, Te Mata Hautū Taketake – the Māori and Indigenous Governance Centre, Te Piringa-Faculty of Law, University of Waikato.

Knibb, A., Awatere, S., Blackett, P., Le Heron, E., Le Heron, R., Logie, J., Hyslop, J., 2022. Rerehua Beach – what kind of data is needed for a flourishing future?

Le Heron, E., Allen, W., Le Heron, R., Logie, M.J., Glavovic, B., Greenaway, A., Hikuroa, D., Davies, K.K., Blackett, P., 2021. What does success look like? An indicative rubric to assess and guide the performance of marine participatory processes. Ecology and Society 26. https://doi.org/10.5751/ES-12211-260129

Le Heron, E., Le Heron, R., Awatere, S., Blackett, P., Logie, J., 2022a. He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa. Planning Quarterly submitted.

Le Heron, E., Le Heron, R., Awatere, S., Blackett, P., Logie, J., Hyslop, J., forthcoming. Kia ārahina i te tūraru me te haurokuroku: a pathway for enacting ecosystem-based management and incorporating te ao Māori in 'risky' decision-making. New Zealand Geographer.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2022b. Why do we argue about risk? The invisibility of worldviews in marine decision-making. Elementa.

Le Heron, R., Lundquist, C., Logie, J., Blackett, P., Le Heron, E., Awatere, S., Hyslop, J., 2022. A socio-ecological appraisal of perceived risks associated with mangrove (manawa) management. New Zealand Journal of Marine and Freshwater Research. https://doi.org/10.1080/00288330.2022.2097270

Lohrer, T., Hewitt, J., Lohrer, A., Parsons, D., Ellis, J., and Stephenson, F. (2023). Evidence of Rebound Effect in New Zealand MPAs: Unintended Consequences of Spatial Management Measures. Ocean & Coastal Management 239.

Maxwell, K.H., Ratana, K., Davies, K.K., Taiapa, C., Awatere, S., 2020. Navigating towards marine co-management with Indigenous communities on-board the Waka-Taurua. Marine Policy 111, 103722. https://doi.org/10.1016/j.marpol.2019.103722

Ministry for the Environment, 2020. National Policy Statement for Freshwater Management.

Ministry for the Environment, 2019. Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand. Ministry for the Environment, Wellington.

Mouton, T.L., Stephenson, F., Torres, L.G., Rayment, W., Brough, T., Mclean, M., Tonkin, J.D., Albouy, C., and Leprieur, F. (2022). Spatial mismatch in diversity facets reveals contrasting protection for New Zealand's cetacean biodiversity. Biological Conservation 267.

Reichelt-Brushett, A., Hewitt, J., Kaiser, S., Kim, R.E., and Wood, R. (2022). Deep seabed mining and communities: A transdisciplinary approach to ecological risk assessment in the South Pacific. Integrated Environmental Assessment and Management 18, 664-673.

Rout, M., Awatere, S., Mika, J.P., Reid, J., Roskruge, M., 2021. A Māori Approach to Environmental Economics: Te ao tūroa, te ao hurihuri, te ao mārama—The Old World, a Changing World, a World of Light. https://doi.org/10.1093/acrefore/9780199389414.013.715

Ruru, I., 2015. The mauri compass. A concept paper showing the mauri compass as an evaluation tool in a RMA Freshwater context, in: In. Te Rūnanga o Turanganui a Kiwa, Gisborne, New Zealand.

Rullens, V., Mangan, S., Stephenson, F., Clark, D.E., Bulmer, R.H., Berthelsen, A., Crawshaw, J., Gladstone-Gallagher, R.V., Thomas, S., Ellis, J.I., and Pilditch, C.A. (2022a). Understanding the consequences of sea level rise: the ecological implications of losing intertidal habitat. New Zealand Journal of Marine and Freshwater Research 56, 353-370.

Rullens, V., Stephenson, F., Hewitt, J.E., Clark, D.E., Pilditch, C.A., Thrush, S.F., and Ellis, J.I. (2022b). The impact of cumulative stressor effects on uncertainty and ecological risk. Science of The Total Environment 842, 156877.

Rullens, V., Stephenson, F., Townsend, M., Lohrer, A.M., Hewitt, J.E., Pilditch, C.A., and Ellis, J.I. (In Review). Accounting for uncertainty in marine ecosystem service predictions for spatial prioritisation. Diversity and Distributions.

Salmond, A., 2014. Tears of Rangi: Water, power, and people in New Zealand. HAU: Journal of Ethnographic Theory 4, 285–309. https://doi.org/10.14318/hau4.3.017

Stephenson, F., Hewitt, J.E., Torres, L.G., Mouton, T.L., Brough, T., Goetz, K.T., Lundquist, C.J., Macdiarmid, A.B., Ellis, J., and Constantine, R. (2021). Cetacean conservation planning in a global diversity hotspot: dealing with uncertainty and data deficiencies. Ecosphere 12, e03633.

Stephenson, F., Rowden, A.A., Anderson, O.F., Ellis, J.I., Geange, S.W., Brough, T., Behrens, E., Hewitt, J.E., Clark, M.R., Tracey, D.M., Goode, S.L., Petersen, G.L., and Lundquist, C.J. (in press). Implications for the conservation of deep-water corals in the face of multiple stressors: a case study from the New Zealand region.

Watson, S.L., Stephenson, F., Pilditch, C.A., and Lundquist, C.J. (2022). Improving predictions of coastal benthic invertebrate occurrence and density using a multi-scalar approach. Ocean & Coastal Management 230, 106355.

# Appendix 1: What is my worldview? A short self-reflective exercise

Understanding your own worldview can help you understand other people's. This table below invites you to reflect on your own worldview and what this means for how you interpret what's important and how the world works. There are no right or wrong answers — just differences among people.

Read the statement in the left column of the table and decide if you agree or disagree with the statement, and how strongly. Tick the appropriate column.

*Table 1 Questions to guide worldview self-reflection. Source (Thomson, 2013)*

| Statement | Strongly disagree | Disagree | Neither agree nor disagree | Agree | Strongly agree | Don't know |
|---|---|---|---|---|---|---|
| The balance of nature is very delicate and easily upset | 1 | 2 | 3 | 4 | 5 | 6 |
| Modifying the environment for human use seldom causes serious problems | 1 | 2 | 3 | 4 | 5 | 6 |
| Plants and animals exist primarily to be used by humans | 1 | 2 | 3 | 4 | 5 | 6 |
| The earth is like a spaceship with only limited room and resources | 1 | 2 | 3 | 4 | 5 | 6 |
| There are limits to economic growth even for developed countries like ours | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans were meant to rule over the rest of nature | 1 | 2 | 3 | 4 | 5 | 6 |
| Present generations of humans have NO moral duties and obligations to future generations | 1 | 2 | 3 | 4 | 5 | 6 |
| The so-called 'ecological crisis' facing humankind has been greatly exaggerated | 1 | 2 | 3 | 4 | 5 | 6 |
| We must take stronger measures to conserve our nation's resources | 1 | 2 | 3 | 4 | 5 | 6 |
| Plants and animals have as much right as humans to exist | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans have moral duties and obligations to other animal species | 1 | 2 | 3 | 4 | 5 | 6 |
| Environmental regulations have placed unfair burdens on industry | 1 | 2 | 3 | 4 | 5 | 6 |
| Natural resources should be used primarily to provide for basic needs rather than material wealth | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans have the right to alter nature to satisfy wants and desires | 1 | 2 | 3 | 4 | 5 | 6 |
| Nature is valuable for its own sake | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans live on a planet with limited room and resources | 1 | 2 | 3 | 4 | 5 | 6 |

### Interpreting worldview answers

The table below uses the detail in the preceding table to show which answers align to a dominant social paradigm worldview and which to a new environmental paradigm worldview. You may find you identify with a mixture, as many people do, but you will probably have a leaning one way or the other, even if small. Being aware of your stance on various statements is important in engaging with others.

**However**, Tables 1 and 2 ***only*** contain dominant social paradigm and new environmental paradigm worldviews. In the Aotearoa NZ context, we also have a Te Ao Māori worldview.

*Table 2 Questions to guide worldview self-reflection: **Answers***

| Statement | Strongly disagree | Disagree | Neither agree/disagree | Agree | Strongly agree | Don't know |
|---|---|---|---|---|---|---|
| The balance of nature is very delicate and easily upset | 1 | 2 | 3 | 4 | 5 | 6 |
| Modifying the environment for human use seldom causes serious problems | 1 | 2 | 3 | 4 | 5 | 6 |
| Plants and animals exist primarily to be used by humans | 1 | 2 | 3 | 4 | 5 | 6 |
| The earth is like a spaceship with only limited room and resources | 1 | 2 | 3 | 4 | 5 | 6 |
| There are limits to economic growth even for developed countries like ours | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans were meant to rule over the rest of nature | 1 | 2 | 3 | 4 | 5 | 6 |
| Present generations of humans have NO moral duties and obligations to future generations | 1 | 2 | 3 | 4 | 5 | 6 |
| The so-called 'ecological crisis' facing humankind has been greatly exaggerated | 1 | 2 | 3 | 4 | 5 | 6 |
| We must take stronger measures to conserve our nation's resources | 1 | 2 | 3 | 4 | 5 | 6 |
| Plants and animals have as much right as humans to exist (EXTRA) | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans have moral duties and obligations to other animal species | 1 | 2 | 3 | 4 | 5 | 6 |
| Environmental regulations have placed unfair burdens on industry | 1 | 2 | 3 | 4 | 5 | 6 |
| Natural resources should be used primarily to provide for basic needs rather than material wealth | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans have the right to alter nature to satisfy wants and desires | 1 | 2 | 3 | 4 | 5 | 6 |
| Nature is valuable for its own sake | 1 | 2 | 3 | 4 | 5 | 6 |
| Humans live on a planet with limited room and resources | 1 | 2 | 3 | 4 | 5 | 6 |

*New environmental paradigm (NEP) = light green; Dominant social paradigm (DSP) = light blue*

Table 3 shows the complexities and overlapping drivers of the common worldviews in Aotearoa New Zealand. It 'matches' key drivers from each worldview (blue = dominant social paradigm, green = new environmental paradigm, and yellow = Te Ao Māori) and shows that the comparisons are not a straightforward mapping.

*Table 3 The complexities and overlapping drivers of Aotearoa worldviews (E. Le Heron et al, 2022b)*

| | |
|---|---|
| **Dissimilar, and at times opposing, drivers** | |
| Economic growth | Harmony with nature, protect nature |
| Nature as use | Nature as awesome |
| Nature as use | Nature as awe inspiring (mana) |
| Abundant resource | Limited resource |
| Free market, limited government | Participatory processes |
| Science and technology value free | Science and technology value laden |
| Science and technology value free | Science and technology embedded within value systems e.g., manaakitanga – reciprocal relations between people and the environment |
| Science and technology value laden | Science and technology embedded within value systems e.g., manaakitanga – reciprocal relations between people and the environment |
| Humans separate from nature (hierarchy) | Humans genealogically connected with nature (whakapapa) |
| Humans separate from nature (awesome, best left alone) | Humans genealogically connected with nature (whakapapa) |
| Private property rights | Conservation estate and reserves |
| Private property rights | Communal property rights and use rights |
| Conservation estate and reserves | Communal property rights and use rights |
| **Similar, and at times aligning, drivers** | |
| Economic growth, nature as use | Intergenerational benefits for kin and ecosystems |
| Harmony with nature | Intergenerational benefits for kin and ecosystems |
| Abundant resource | Circular, interlinked (mana, tapu, mauri) and reciprocal (manaaki) resource use |
| Limited resource | Circular, interlinked (mana, tapu, mauri) and reciprocal (manaaki) resource use |
| Nature as awesome | Mana – nature is awe-inspiring |

# Appendix 2: Worldviews and legislation

Worldviews have implications for legislation. We asked, can worldview premises be detected in the country's natural resource management legislation? Table 1 summarises the Resource Management Act and Exclusive Economic Zone Acts according to their envisaged operation and functionalities, exposing critical differences that have implications for how *worldviews might be able and made to work* in consenting spaces, and for the outcomes that may be achieved.

> "The DSP is for the most part the guiding influence on development-oriented legislation. Legislation now in place for land and coast/marine resource governance and management has led to two separate pathways by which societal assessment of incremental use changes is carried out. The oversight framework for each pathway pivots on creating a competitive arena of argument where proposed developments are scrutinized. [Table 4] provides an in-depth summary of the development pathways enshrined in the RMA Act 1991 and the EEZ and Continental Shelf and Environmental Effects Act 2012. At stake with the legislation is the extent to which economy is privileged over environment by developers, or conversely whether environmental and Treaty obligations are successfully invoked to stop or greatly modify a proposal for different desired outcomes." (Le Heron, E. et al 2022a).

*Table 1 Legislation and worldviews. Source (E. Le Heron et al, 2022b)*

| **Specific elements** | **Resource Management Act 1991** | **Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012** |
|---|---|---|
| Preamble to legislation | Preceding fragmented legislation failed in best care of environment, and this has caused damage to forests, soil, air and waterways | Need an ocean equivalent to RMA<br>Controlled by UNCLOS, requires demonstration of governance in order for the EEZ to be administered by the country. |
| Purpose | Promote environmental management that meets the current and future needs of communities while also looking after the environment | Protect EEZ and continental shelf from pollution by regulating and controlling discharges, dumping, mining and removal of substances from the sea floor. |
| Goal | Effective, effects-based, and transparent management of environment and natural resources | Manage effects of particular marine activities in offshore waters |
| Delegation of governing powers | Regional councils and local councils must prepare plans showing how they will manage the environment in their area | EEZ Act requires the Environment Protection Authority (EPA) to make full use of powers to request information, obtain advice, and commission reviews when considering an application for consent |
| Decision-making criteria | Environment Court main judicial decision-making body, hearing appeals from people who disagree with decisions made by local bodies | EPA can be directed by the Minister to give effect to a government policy<br>If information is uncertain or inadequate the EPA must favour caution and the environment, and consider whether an adaptive management approach would allow an activity to be undertaken |
| Conditions of consenting | Various classes of activity are established through mandatory plans. Controlled or prohibited activities must get resource consent | Interested parties able to seek a marine consent, marine dumping consent or a marine discharge consent |
| Consenting channehls | Most consents are non-notified and do not need to go through a process involving public submissions. Notified consent is required when a Council considers environmental impact of a proposed work or activity to be more than minor. | Consent applications considered by an EPA Board appointed Decision-making Committee |
| Interface with Treaty obligations | **Take into account** the principles of the Treaty of Waitangi in urban development and ensure iwi/Māori are engaged in processes to prepare plans and strategies that shape urban environments. | **Recognize** Crown's responsibility to give effect to Treaty principles, recognition of Treaty and Māori interests in marine consent process, and an Independent Māori Advisory Board |

**Further information**


Hyslop, Jade, Nikki Harcourt, Shaun Awatere, Daniel Hikuroa, Paula Blackett, and Richard Le Heron. 2022. 'Kia Aiō Ngā Ngaru, Kia Hora Te Marino: Why Values Matter for Mitigating Risk and Uncertainty in Natural Resource Management'. *AlterNative*.

Rout, M., Awatere, S., Mika, J.P., Reid, J., Roskruge, M., 2021. A Māori Approach to Environmental Economics: Te ao tūroa, te ao hurihuri, te ao mārama—The Old World, a Changing World, a World of Light. https://doi.org/10.1093/acrefore/9780199389414.013.715

Thomson, J., 2013. New ecological paradigm survey 2008: Analysis of the NEP results. Waikato Regional Council, Hamilton.

# Perehua Beach

## WHAT KIND OF DATA IS NEEDED FOR A FLOURISHING FUTURE?

As we think about risky and contested futures the nature of evidence, and the data that constitutes evidence becomes important.

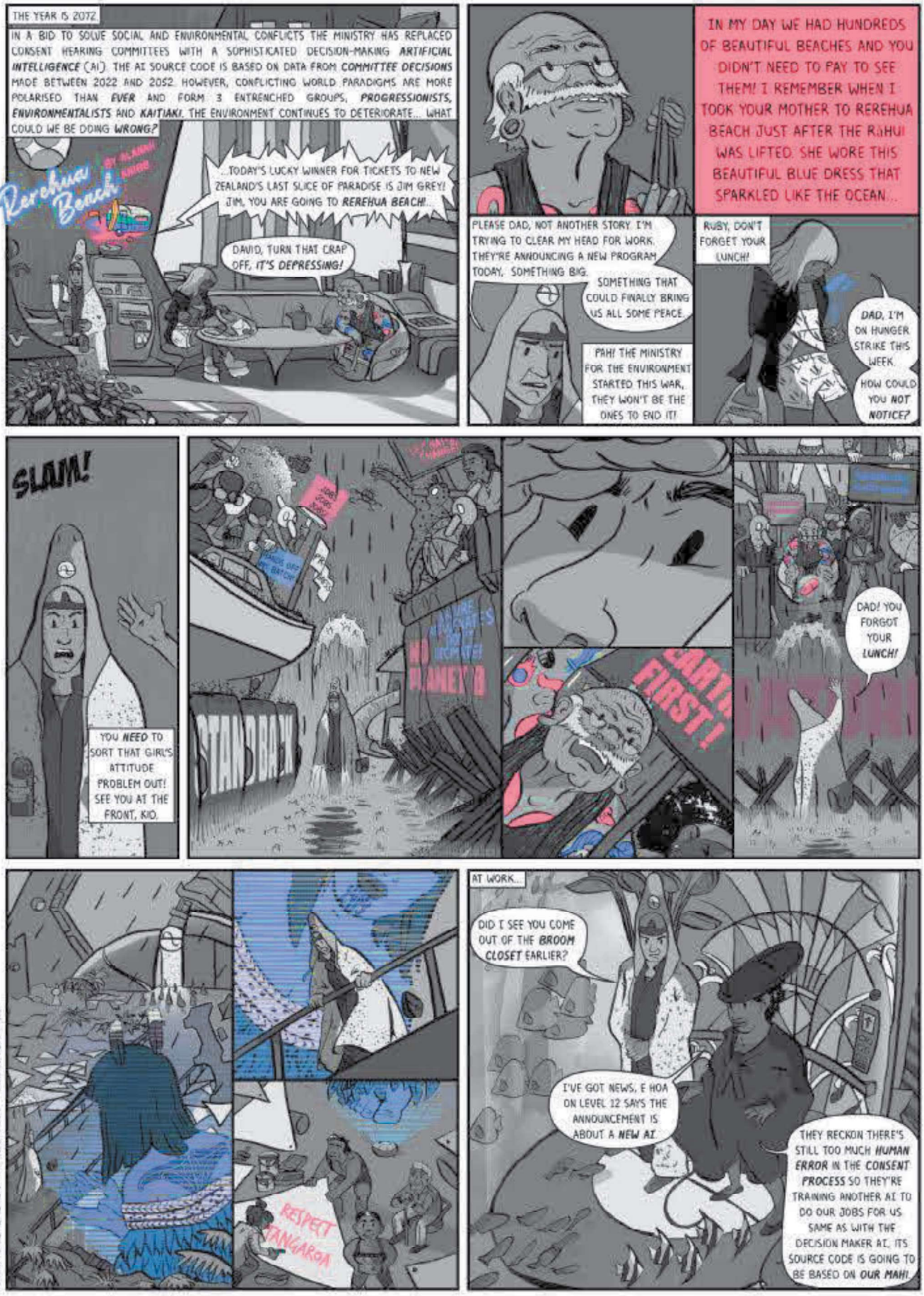
### BUT WHAT IS DATA AND EVIDENCE?

Evidence is information presented in a way that is seen as credible to base decisions on. If decisions are made based on evidence, then what we consider evidence is important because its shapes the decision. A single assessment (or view) of what is credible evidence could dominate, locking out other ways of knowing. This is extremely relevant when there are multiple versions of what is credible depending on worldview.

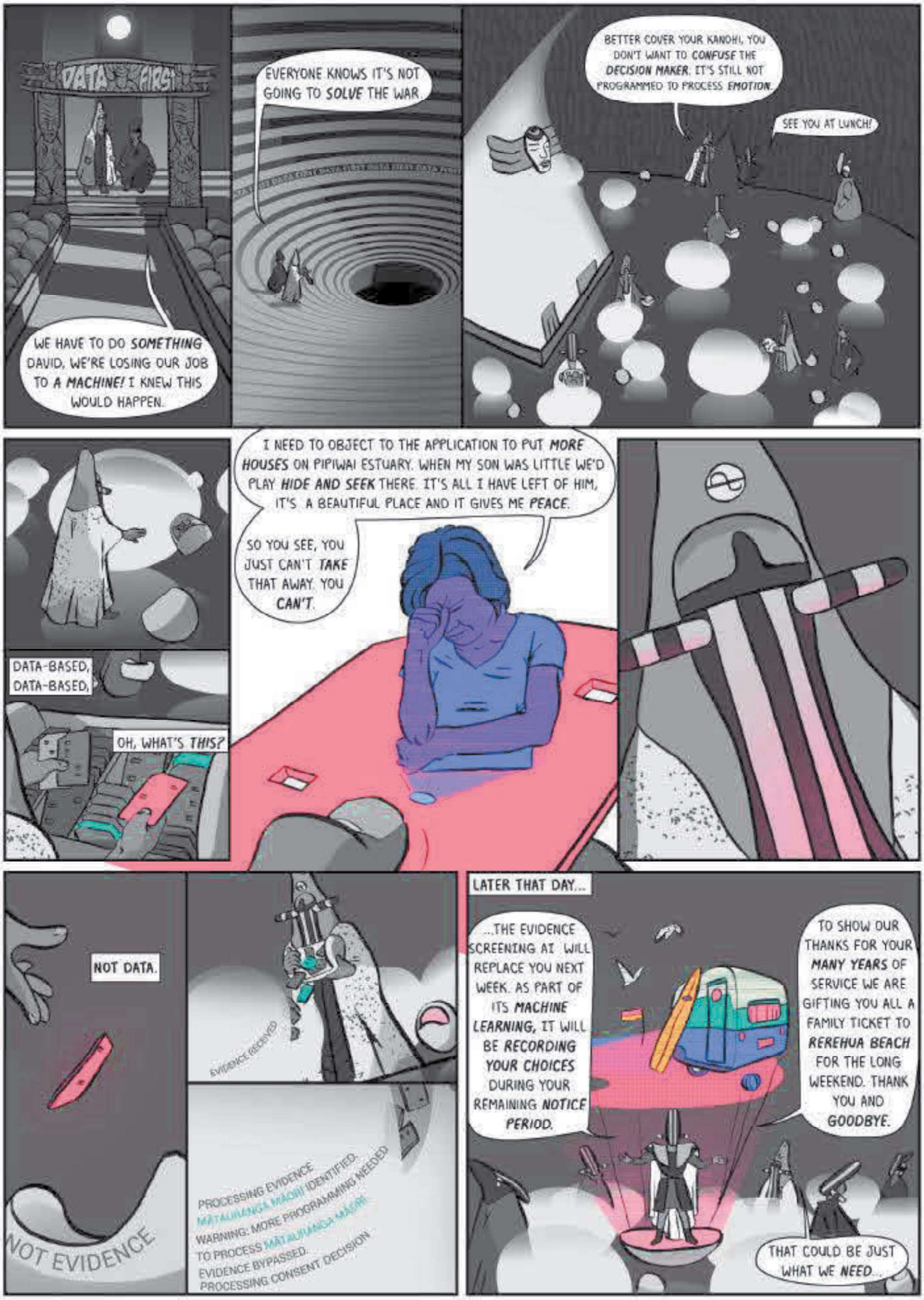
This cartoon exposes a future where one view on "what is evidence" determines the outcome of environmental decisions and actions: it asks if this is the future we want? And if not, what might we do?

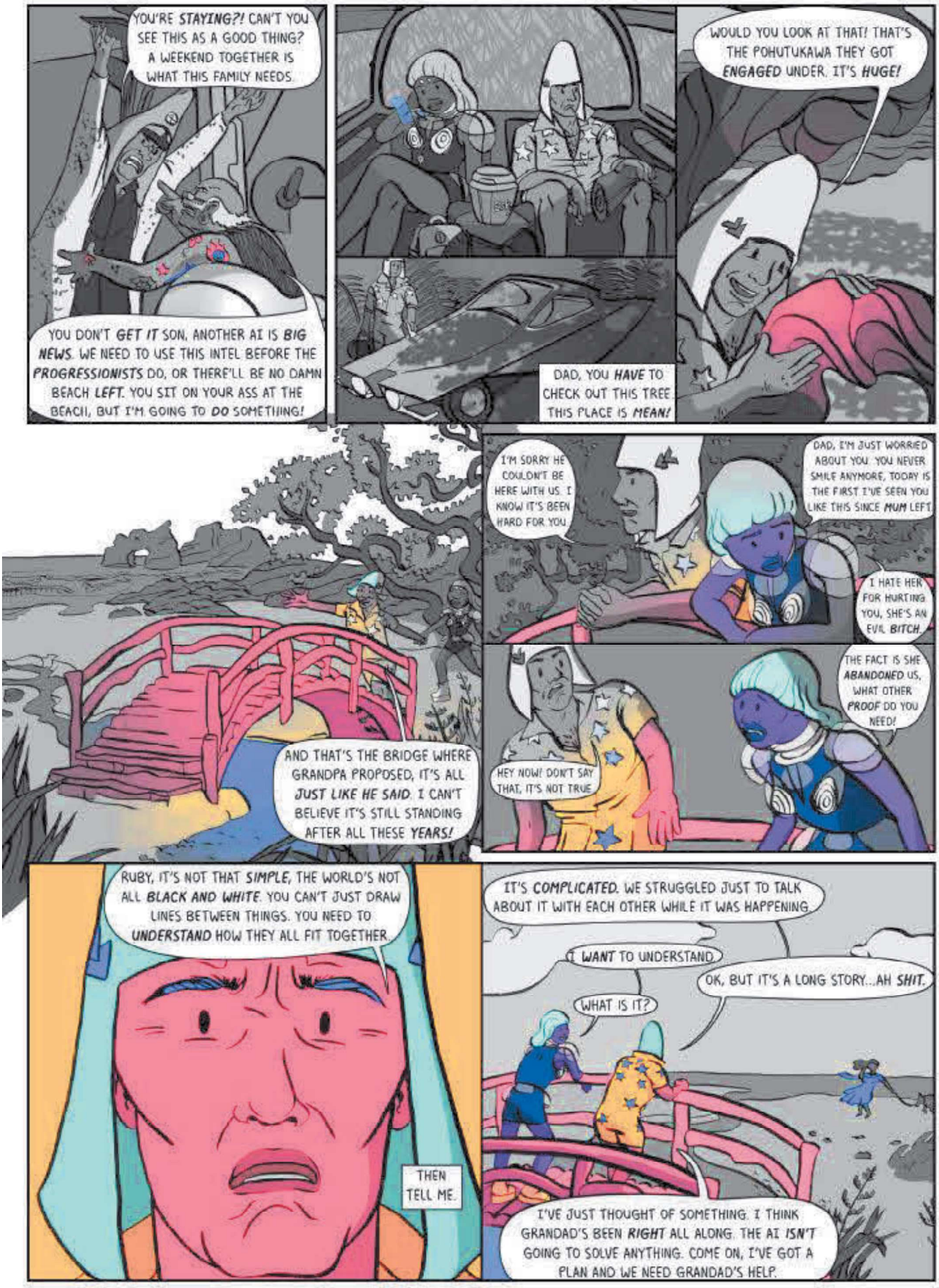
National SCIENCE Challenges SUSTAINABLE SEAS

Alanah Knibbs


THE YEAR IS 2072.
IN A BID TO SOLVE SOCIAL AND ENVIRONMENTAL CONFLICTS THE MINISTRY HAS REPLACED CONSENT HEARING COMMITTEES WITH A SOPHISTICATED DECISION-MAKING ARTIFICIAL INTELLIGENCE (AI). THE AI SOURCE CODE IS BASED ON DATA FROM COMMITTEE DECISIONS MADE BETWEEN 2022 AND 2052. HOWEVER, CONFLICTING WORLD PARADIGMS ARE MORE POLARISED THAN EVER AND FORM 3 ENTRENCHED GROUPS, PROGRESSIONISTS, ENVIRONMENTALISTS AND KAITIAKI. THE ENVIRONMENT CONTINUES TO DETERIORATE... WHAT COULD WE BE DOING WRONG?
Rerehua Beach
...TODAY'S LUCKY WINNER FOR TICKETS TO NEW ZEALAND'S LAST SLICE OF PARADISE IS JIM GREY! JIM, YOU ARE GOING TO REREHUA BEACH!...
DAVID, TURN THAT CRAP OFF, IT'S DEPRESSING!
IN MY DAY WE HAD HUNDREDS OF BEAUTIFUL BEACHES AND YOU DIDN'T NEED TO PAY TO SEE THEM! I REMEMBER WHEN I TOOK YOUR MOTHER TO REREHUA BEACH JUST AFTER THE RāHUI WAS LIFTED. SHE WORE THIS BEAUTIFUL BLUE DRESS THAT SPARKLED LIKE THE OCEAN...
PLEASE DAD, NOT ANOTHER STORY. I'M TRYING TO CLEAR MY HEAD FOR WORK. THEY'RE ANNOUNCING A NEW PROGRAM TODAY. SOMETHING BIG.
SOMETHING THAT COULD FINALLY BRING US ALL SOME PEACE.
PAH! THE MINISTRY FOR THE ENVIRONMENT STARTED THIS WAR, THEY WON'T BE THE ONES TO END IT!
RUBY, DON'T FORGET YOUR LUNCH!
DAD, I'M ON HUNGER STRIKE THIS WEEK.
HOW COULD YOU NOT NOTICE?
SLAM!
YOU NEED TO SORT THAT GIRL'S ATTITUDE PROBLEM OUT! SEE YOU AT THE FRONT, KIO.
STAND BACK
CARE FIRST!
DAD! YOU FORGOT YOUR LUNCH!
RESPECT TANGAROA
AT WORK...
DID I SEE YOU COME OUT OF THE BROOM CLOSET EARLIER?
I'VE GOT NEWS, E HOA ON LEVEL 12 SAYS THE ANNOUNCEMENT IS ABOUT A NEW AI.
THEY RECKON THERE'S STILL TOO MUCH HUMAN ERROR IN THE CONSENT PROCESS SO THEY'RE TRAINING ANOTHER AI TO DO OUR JOBS FOR US SAME AS WITH THE DECISION MAKER AI. ITS SOURCE CODE IS GOING TO BE BASED ON OUR MAHI.
MOKO DESIGNS BY PIP HARTLEY - KARANGA INK

WAHAROA DESIGN BY NGATI TOA CARVERS TANA AND HERMANN SALZMANN, TE PAPA




YOU'RE STAYING?! CAN'T YOU SEE THIS AS A GOOD THING? A WEEKEND TOGETHER IS WHAT THIS FAMILY NEEDS.
YOU DON'T GET IT SON. ANOTHER AI IS BIG NEWS. WE NEED TO USE THIS INTEL BEFORE THE PROGRESSIONISTS DO, OR THERE'LL BE NO DAMN BEACH LEFT. YOU SIT ON YOUR ASS AT THE BEACH, BUT I'M GOING TO DO SOMETHING!
DAD, YOU HAVE TO CHECK OUT THIS TREE. THIS PLACE IS MEAN!
WOULD YOU LOOK AT THAT! THAT'S THE POHUTUKAWA THEY GOT ENGAGED UNDER. IT'S HUGE!
AND THAT'S THE BRIDGE WHERE GRANDPA PROPOSED, IT'S ALL JUST LIKE HE SAID. I CAN'T BELIEVE IT'S STILL STANDING AFTER ALL THESE YEARS!
I'M SORRY HE COULDN'T BE HERE WITH US. I KNOW IT'S BEEN HARD FOR YOU.
DAD, I'M JUST WORRIED ABOUT YOU. YOU NEVER SMILE ANYMORE, TODAY IS THE FIRST I'VE SEEN YOU LIKE THIS SINCE MUM LEFT.
I HATE HER FOR HURTING YOU, SHE'S AN EVIL BITCH.
HEY NOW! DON'T SAY THAT, IT'S NOT TRUE.
THE FACT IS SHE ABANDONED US, WHAT OTHER PROOF DO YOU NEED!
RUBY, IT'S NOT THAT SIMPLE. THE WORLD'S NOT ALL BLACK AND WHITE. YOU CAN'T JUST DRAW LINES BETWEEN THINGS. YOU NEED TO UNDERSTAND HOW THEY ALL FIT TOGETHER.
THEN TELL ME.
IT'S COMPLICATED. WE STRUGGLED JUST TO TALK ABOUT IT WITH EACH OTHER WHILE IT WAS HAPPENING.
I WANT TO UNDERSTAND.
OK, BUT IT'S A LONG STORY...AH SHIT.
WHAT IS IT?
I'VE JUST THOUGHT OF SOMETHING. I THINK GRANDAD'S BEEN RIGHT ALL ALONG. THE AI ISN'T GOING TO SOLVE ANYTHING. COME ON, I'VE GOT A PLAN AND WE NEED GRANDAD'S HELP.


HO HO, I NEVER EXPECTED THIS FROM YOU M'BOY! I'M DAMNED PROUD OF YOU SON.
SSSH, KEEP IT DOWN DAD, THIS IS A STEALTH MISSION REMEMBER!
I ALWAYS LEAVE THE BROOM CLOSET WINDOW OPEN FOR INTEL FROM MY PAL ON LEVEL 12. HE TAKES ALL HIS IMPORTANT CALLS ON HIS BALCONY. HEAHEA DOESN'T KNOW I'VE BEEN LISTENING TO HIM FOR YEARS.
ALL RIGHT, LET'S MAKE THIS QUICK
NOT EVIDENCE
EVIDENCE RECEIVED
PROCESSING
WARNING: HIGH PERCENTAGE OF NON-DATA EVIDENCE RECEIVED
UPDATING PROGRAM TO PROCESS
NEW EVIDENCE
EVIDENCE ACCEPTED
CHOICE RECORDED FOR MACHINE LEARNING
PROCESSING CONSENT DECISION
TWO YEARS LATER...
E Pā, WE'VE REALLY TURNED THIS PLACE AROUND, BUT HOW DID YOU KNOW WHAT THE PROGRAM NEEDED?
MY WHĀNAU HELPED A LOT. I REALISED THAT PEOPLE ARE JUST COMPLICATED. WE HAVE COMPLEX LIVES AND CREATE COMPLEX ISSUES - AND WE DESERVE COMPLEX SOLUTIONS. WE'RE NEVER GOING TO FIND COMPLEX SOLUTIONS WITHOUT ADDING COMPLEXITY TO THE SYSTEM.
WE KEEP TRYING TO BREAK THINGS DOWN INTO NUMBERS, TO REMOVE THE HUMAN COMPONENT. WE DON'T NEED LESS OF IT, WE NEED MORE! TO IMAGINE A BETTER FUTURE WE NEED IMAGINATION. TO CHANGE OUR OWN STORY WE NEED TO START USING AND VALUING STORIES FOR THE COMPLEX, MULTI-LAYERED NEGOTIATIONS THAT THEY ARE
AND WE CAN START BY SHARING THEM.
AND YOU READER, HOW DO YOU INCLUDE MULTIPLE KINDS OF DATA IN YOUR DECISION-MAKING?

## A NOTE FROM THE ARTIST:

This comic features reproductions of original artwork by Pip Hartley, Hermann and Tana Salzmann. I would like to acknowledge these artists as creators of the ta moko on page one and the waharoa on page two, respectively. Images for the waharoa were sourced through the Museum of New Zealand Te Papa YouTube channel, the ta moko designs were comissioned specifically for this comic. I would also like to aknowledge the artists who inspired some of the futuristic designs in the comic, including Syd Mead, Jean Giraud and Dániel Taylor.

## QUESTIONS TO CONSIDER:

1) What do you think the impact is of using (mostly) quantifiable evidence-based information on the decisions you or others make?

2) Have you though about how Hapū and Iwi are involved in environmental decisions?

3) What do you think is missing from decisions where risk is portrayed as knowable and measurable?

4) How could Ecosystem Based Management (EBM), TAM framing, and a wider conception of data take us to a different future?

5) What steps can be taken right now?

# Appendix 4: Summary of project 3.1 contributions

| Contribution | How | Where |
|---|---|---|
| **Making visible three 'invisible' factors that influence decision-making:**<br>- **Worldviews**<br>- **Disciplines**<br>- **Positionalities**<br>**to unpack understandings of risk and uncertainty** | ***Diagnostic Tool 1.* Kia whakahura te tūraru me te haurokuroku (KWTH) Unpacking perceptions of risk and uncertainty**<br>A diagnostic tool that<br>Outlines dominant worldviews in Aotearoa NZ (Te Ao Māori, dominant social paradigm, new environmental paradigm) and their influence on views of risk<br>Outlines impact of disciplinary training on views of risk<br>Outlines effect of positionality on views of risk | *Risk and Uncertainty Framework and Guidance document (this document).*<br>*Quick guide 2: Worldviews influence people's perceptions of risk and uncertainty*<br>*Quick guide 4: Tools to help navigate perceptions of risk and uncertainty*<br>*Articles:*<br>He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa, *Planning Quarterly*<br>Why do we argue about risk? The invisibility of worldviews in decision-making, *Elementa*<br>Kia aiō ngā ngaru, kia hora te marino: Why values matter for mitigating risk and uncertainty in natural resource management, *AlterNative* |
| **Reconceptualising risk and uncertainty for EBM and TAM futures** | Acknowledgement of multiple understandings of risk and uncertainty<br>Creating new practices around including risk and uncertainty that better support EBM and Te Ao Māori | *Risk and Uncertainty Framework and Guidance document (this document).*<br>*Quick guide 3:* Te Ao Māori understanding of tūraru me te haurokuroko (risk and uncertainty)<br>*Quick guide 1:Perceptions of risk and uncertainty influence marine management decisions*<br>*Articles:*<br>He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa, *Planning Quarterly*<br>Kia aiō ngā ngaru, kia hora te marino: Why values matter for mitigating risk and uncertainty in natural resource management, *AlterNative* |
| **Steps to manage 'risky' decision-making** | ***Diagnostic Tool 2*. He Uiui Aromatawai Tūraru (HUAT) Working with risk**<br>A diagnostic tool to think through the implications of worldviews disciplinary perspectives, and positionality – using five themes<br>Expanded explanation of the 5 themes and how to improve practices<br>***Appendix 3: What kind of data is needed for a flourishing future?***<br>A dystopian future explores the impacts of narrowly defining what counts as evidence. | *Risk and Uncertainty Framework and Guidance document (this document).*<br>*Quick guide 4: Tools to help navigate perceptions of risk and uncertainty*<br>*Appendix 3: What kind of data is needed for a flourishing future?*<br>*Articles:*<br>He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa, Planning Quarterly<br>Kia ārahina i te tūraru me te haurokuroku: a pathway for enacting ecosystem-based management and incorporating Te Ao Māori in 'risky' decision-making, New Zealand Geographer |
| **Case studies of worldviews, disciplines, and positionalities in action.** | Illustrates how risk is understood in actual decision-making contexts.<br>Highlights the influences that worldviews have on 'risky' decision-making<br>Highlights the influences that disciplinary training and positionality have on 'risky' decision-making or processes in which decision-makers are currently involved. | *Risk and Uncertainty Framework and Guidance document (this document).*<br>*Articles:*<br>A socio-ecological appraisal of perceived risks associated with mangrove (Mānawa) management in Aotearoa New Zealand, NZJFMR<br>Why do we argue about risk? The invisibility of worldviews in decision-making, Elementa |

| | | |
|---|---|---|
| | | Kia ārahina i te tūraru me te haurokuroku: a pathway for enacting ecosystem-based management and incorporating Te Ao Māori in 'risky' decision-making, New Zealand Geographer |
| **Process to reflect, re-engage and assess 'risky' decision-making** | ***Rubric:* What does success look like when 'working with risk and uncertainty'? Performance criteria for HUAT Working with risk (Diagnostic Tool 2)**<br><br>A rubric to assess performance against criteria to reflect and evaluate 'risky' decision-making processes<br><br>Importance of continually reengaging with diagnostic tools<br><br>Guides assessment of processes through rubrics<br><br>Discusses the need to reflect, evaluate and assess decision-making processes that have occurred. | *Risk and Uncertainty Framework and Guidance document (this document).*<br><br>*Quick guide 4: Tools to help navigate perceptions of risk and uncertainty*<br><br>*Quick guide 1: Perceptions of risk and uncertainty influence marine management decisions* |

# Appendix 5: For more information

**Recommendation 1: reconceptualise risk and uncertainty for ecosystem-based management and Te Ao Māori in Aoteraoa New Zealand**


Hanna, C., White, I., Glavovic, B., 2020. Uncertainty Contagion: Revealing the Interrelated, Cascading Uncertainties of Managed Retreat. Sustainability 12, 736. https://doi.org/10.3390/su12020736

Hyslop, J., Harcourt, N., Awatere, S., Hikuroa, D., Blackett, P., Le Heron, R., 2023. Kia aiō ngā ngaru, kia hora te marino: Why values matter for mitigating risk and uncertainty in natural resource management. AlterNative.

Le Heron, E., Le Heron, R., Awatere, S., Blackett, P., Logie, J., 2023a. He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa. Planning Quarterly submitted.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023c. Quick guide 3: Te Ao Māori understanding of tūraru me te haurokuroku (risk and uncertainty), Sustainable Seas National Science Challenge.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023d. Quick guide 1: Perceptions of risk and uncertainty influence marine management decisions, Sustainable Seas National Science Challenge.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023e. Fact sheet 8. Perceptions of risk and uncertainty are entangled: examples, 3.1 Perceptions of Risk and Uncertainty, Sustainable Seas National Science Challenge.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023j. Why do we argue about risk? The invisibility of worldviews in marine decision-making. Elementa.

Le Heron, R., Lundquist, C., Logie, J., Blackett, P., Le Heron, E., Awatere, S., Hyslop, J., 2022. A socio-ecological appraisal of perceived risks associated with mangrove (manawa) management. New Zealand Journal of Marine and Freshwater Research. https://doi.org/10.1080/00288330.2022.2097270

Rout, M., Awatere, S., Mika, J.P., Reid, J., Roskruge, M., 2021. A Māori Approach to Environmental Economics: Te ao tūroa, te ao hurihuri, te ao mārama—The Old World, a Changing World, a World of Light. https://doi.org/10.1093/acrefore/9780199389414.013.715


**Recommendation 2: expose worldviews, discipline, and positionality to unpack understandings of risk and uncertainty**


Hyslop, J., Harcourt, N., Awatere, S., Hikuroa, D., Blackett, P., Le Heron, R., 2023. Kia aiō ngā ngaru, kia hora te marino: Why values matter for mitigating risk and uncertainty in natural resource management. AlterNative.

Le Heron, E., Le Heron, R., Awatere, S., Blackett, P., Logie, J., 2023a. He Uiui Aromatawai Tūraru: Guidance for 'risky' resource use decision-making in Aotearoa. Planning Quarterly submitted.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023f. Quick guide 4: Tools to help navigate perceptions of risk and uncertainty, Sustainable Seas National Science Challenge.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023h. Quick guide 2: Worldviews influence people's perceptions of risk and uncertainty, Sustainable Seas National Science Challenge.

Le Heron, E., Le Heron, R., Blackett, P., Awatere, S., Logie, J., Hyslop, J., 2023j. Why do we argue about risk? The invisibility of worldviews in marine decision-making. Elementa.

Le Heron, R., Lundquist, C., Logie, J., Blackett, P., Le Heron, E., Awatere, S., Hyslop, J., 2022. A socio-ecological appraisal of perceived risks associated with mangrove (manawa) management. New Zealand Journal of Marine and Freshwater Research. https://doi.org/10.1080/00288330.2022.2097270


**Recommendation 3: think about implications of worldviews, positionalities, and disciplines and negotiate a pathway for enacting ecosystem-based management and incorporating Te Ao Māori decision-making**

**Arotakenga Huringa Āhuarangi: National Climate Change Risk Assessment Framework**

Ministry for the Environment, 2019. Arotakenga Huringa Āhuarangi: A Framework for the National Climate Change Risk Assessment for Aotearoa New Zealand. Ministry for the Environment, Wellington. https://environment.govt.nz/publications/arotakenga-huringa-ahuarangi-a-framework-for-the-national-climate-change-risk-assessment-for-aotearoa-new-zealand/

**Mātauranga Māori Framework (EPA)**

Environmental Protection Authority Te Mana Rauhi Taiao, 2020. Partnership in action: The EPA's mātauranga framework. https://www.epa.govt.nz/assets/Uploads/Documents/Te-Hautu/Matauranga-Maori-Report_Framework-Report.pdf

**Mauri Compass**

Ruru, I., 2015. The mauri compass. A concept paper showing the mauri compass as an evaluation tool in a RMA Freshwater context, in: In. Te Rūnanga o Turanganui a Kiwa, Gisborne, New Zealand.

**National Policy Statement of Freshwater Management**

Ministry for the Environment, 2020. National Policy Statement for Freshwater Management. https://environment.govt.nz/assets/Publications/Files/national-policy-statement-for-freshwater-management-2020.pdf

**Tikanga Process Model**

Harmsworth, G., Awatere, S., Robb, M., 2016. Indigenous Māori values and perspectives to inform freshwater management in Aotearoa-New Zealand. Ecology & Society 21.

**Te Mana o te Taiao – Aotearoa NZ Biodiversity Strategy**

Department of Conservation, 2020. Te Mana o Te Taiao - Aotearoa New Zealand Biodiversity Strategy. https://www.doc.govt.nz/globalassets/documents/conservation/biodiversity/anzbs-2020.pdf

**Waka taurua**

Maxwell, K.H., Ratana, K., Davies, K.K., Taiapa, C., Awatere, S., 2020. Navigating towards marine co-management with Indigenous communities on-board the Waka-Taurua. Marine Policy 111, 103722. https://doi.org/10.1016/j.marpol.2019.103722

Le Heron, Erena, Richard Le Heron, Shaun Awatere, Paula Blackett, June Logie, and Jade Hyslop. forthcoming. 'Kia Ārahina i Te Tūraru Me Te Haurokuroku: A Pathway for Enacting Ecosystem-Based Management and Incorporating Te Ao Māori in "Risky" Decision-Making.' New Zealand Geographer.

**Recommendation 4: select a risk assessment method that is capable of meeting ecosystem-based management requirements and Māori needs and aspirations**

Anderson, O.F., Stephenson, F., Behrens, E., and Rowden, A.A. (2022). Predicting the effects of climate change on deep-water coral distribution around New Zealand—Will there be suitable refuges for protection at the end of the 21st century? *Global Change Biology* 28**,** 6556– 6576.

Armoudian, M., Stevens, G., Stephenson, F. & Ellis, J. (2023). Media and Marine Science in New Zealand: Coverage of the crisis in the oceans before and after the IPCC report. *Aquatic Conservation: Marine And Freshwater Ecosystems*.

Australia and New Zealand (2020). Cumulative bottom fishery impact assessment for Australian and New Zealand bottom fisheries in the SPRFMO convention area, 2020. *Report to 8th Meeting of the SPRFMO Scientific Committee*.

Bulmer, R., Paul-Burke, K., Ranapia, M., Ellis, J., Bluett, C., O'brien, T., Burke, J., Petersen, G., and Stephenson, F. (In review). Weaving indigenous and western ecological knowledge to enhance environmental sustainability. *Ocean & Coastal Management*.

Clark, D.E., Gladstone-Gallagher, R., Stephenson, F., and Ellis, J. (2021). "A review of risk assessment frameworks for use in marine ecosystem-based management (EBM) in Aotearoa New Zealand ", in: *Report for Sustainable Seas National Science Challenge project Communicating Risk and Uncertainty (Project code 3.2).* (Wellington).

Clark, D.E., Gladstone-Gallagher, R.V., Hewitt, J.E., Stephenson, F., and Ellis, J.I. (2022). Risk assessment for marine ecosystem-based management (EBM). *Conservation Science and Practice* 4**,** e12636.

Gladstone-Gallagher, R.V., Hewitt, J.E., Stephenson, F., Low, J.M.L., Pilditch, C.A., Thrush, S.F., and Ellis, J.I. (in review). Matching marine ecosystem status with environmental management approaches: A risk-based approach.

Holsman, K., Samhouri, J., Cook, G., Hazen, E., Olsen, E., Dillard, M., Kasperski, S., Gaichas, S., Kelble, C.R., Fogarty, M., and Andrews, K. (2017). An ecosystem-based approach to marine risk assessment. *Ecosystem Health and Sustainability* 3**,** e01256.

Inglis, G., Soliman, T., and Djanibekov, U. (2018). Tools for risk assessment under uncertainty. *NIWA client report number 2020259CH. National Institute of Water and Atmospheric Research, Christchurch, New Zealand*.

Lohrer, T., Hewitt, J., Lohrer, A., Parsons, D., Ellis, J., and Stephenson, F. (2023). Evidence of Rebound Effect in New Zealand MPAs: Unintended Consequences of Spatial Management Measures. *Ocean & Coastal Management* 239.

Mouton, T.L., Stephenson, F., Torres, L.G., Rayment, W., Brough, T., Mclean, M., Tonkin, J.D., Albouy, C., and Leprieur, F. (2022). Spatial mismatch in diversity facets reveals contrasting protection for New Zealand's cetacean biodiversity. *Biological Conservation* 267.

Reichelt-Brushett, A., Hewitt, J., Kaiser, S., Kim, R.E., and Wood, R. (2022). Deep seabed mining and communities: A transdisciplinary approach to ecological risk assessment in the South Pacific. *Integrated Environmental Assessment and Management* 18**,** 664-673.

Rullens, V., Mangan, S., Stephenson, F., Clark, D.E., Bulmer, R.H., Berthelsen, A., Crawshaw, J., Gladstone-Gallagher, R.V., Thomas, S., Ellis, J.I., and Pilditch, C.A. (2022a). Understanding the consequences of sea level rise: the ecological implications of losing intertidal habitat. *New Zealand Journal of Marine and Freshwater Research* 56**,** 353-370.

Rullens, V., Stephenson, F., Hewitt, J.E., Clark, D.E., Pilditch, C.A., Thrush, S.F., and Ellis, J.I. (2022b). The impact of cumulative stressor effects on uncertainty and ecological risk. *Science of The Total Environment* 842**,** 156877.

Rullens, V., Stephenson, F., Townsend, M., Lohrer, A.M., Hewitt, J.E., Pilditch, C.A., and Ellis, J.I. (In Review). Accounting for uncertainty in marine ecosystem service predictions for spatial prioritisation. *Diversity and Distributions*.

Stephenson, F., Hewitt, J.E., Torres, L.G., Mouton, T.L., Brough, T., Goetz, K.T., Lundquist, C.J., Macdiarmid, A.B., Ellis, J., and Constantine, R. (2021). Cetacean conservation planning in a global diversity hotspot: dealing with uncertainty and data deficiencies. *Ecosphere* 12**,** e03633.

Stephenson, F., Rowden, A.A., Anderson, O.F., Ellis, J.I., Geange, S.W., Brough, T., Behrens, E., Hewitt, J.E., Clark, M.R., Tracey, D.M., Goode, S.L., Petersen, G.L., and Lundquist, C.J. (in press). Implications for the conservation of deep-water corals in the face of multiple stressors: a case study from the New Zealand region.

Watson, S.L., Stephenson, F., Pilditch, C.A., and Lundquist, C.J. (2022). Improving predictions of coastal benthic invertebrate occurrence and density using a multi-scalar approach. *Ocean & Coastal Management* 230**,** 106355.

**Rec 5 Further information**

Le Heron, E., Allen, W., Le Heron, R., Logie, M.J., Glavovic, B., Greenaway, A., Hikuroa, D., Davies, K.K., Blackett, P., 2021. What does success look like? An indicative rubric to assess and guide the performance of marine participatory processes. Ecology and Society 26. https://doi.org/10.5751/ES-12211-260129