National SCIENCE Challenges

SUSTAINABLE SEAS

Ko ngā moana whakauka

Guidance and tools to help navigate marine restoration projects as part of ecosystem-based management in the top of the South Island

Image: Nelson, New Zealand - Douglas Bagg/Unsplash

Summary

This summary has been prepared for the Kotahitanga mō te Taiao Alliance by the Sustainable Seas National Science Challenge. The recommendations in this document apply solely to opportunities for use of guidance, frameworks and tools that have been produced by Sustainable Seas.

For our seas to thrive, people need to make decisions about managing marine ecosystems in a holistic, inclusive way – this is ecosystem-based management (EBM). EBM is a way to manage marine environments and the competing uses for, demands on, and ways New Zealanders value them.

EBM sets the overarching attributes of how we will interact with the marine environment based on a principles approach. Between 2019 and 2023 Sustainable Seas National Science Challenge (hereafter referred to as the Challenge) researchers and partners have co-developed guidance, frameworks and tools (GFTs) to support EBM in Aotearoa New Zealand.

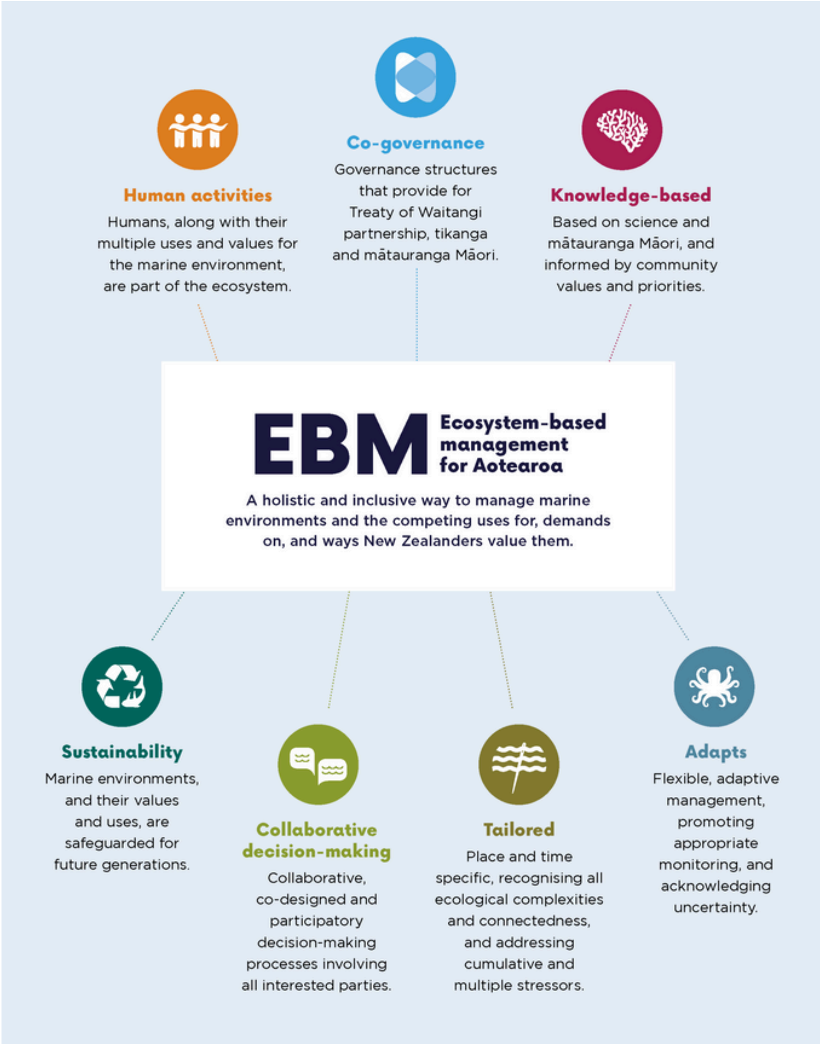
During 2023, in the Synthesis phase of the Challenge, activities have been undertaken to test with end-users how these GFTs can contribute to EBM and decisions that support the improved health and utilisation of our seas.

One of these activities was for Challenge researchers to collaborate with the marine workstream of the TNC NZ facilitated 'Restoration by Design' planning process with the Kotahitanga mō te Taiao Alliance (the KMTT Alliance); an activity that was part of the KMTT Alliance's new strategic planning and implementation phase.

The opportunity over the course of 2023, was to align with a series of TNC NZ facilitated workshops which identified priority issues, locations and opportunities for impact in the top of the South Island.

This process culminated in a series of strategies to be unpacked into results chains (diagrams that map out a series of causal statements that link short-, medium-, and long-term results in an "if… then" fashion) that make up the marine workstream's theory of change.

Activities include restoration projects to be worked up by the KMTT Alliance into proposals for funding and/or workplans for implementation. The value add from the Challenge has been to provide information on where Challenge GFTs have the potential to support the design and implementation of identified restoration projects.



Challenge researchers attended some of the marine workstream workshops at moments in the process that were judged to be relevant by the TNC NZ facilitators. As resource persons, the researchers initially presented a broad summary of GFTs that the Challenge had produced that could be relevant to the priority issues identified at an early stage of the 'Restoration by Design' process. These ranged from simple likelihood-consequences methods that can be used for risk assessments that focus on a single stressor, through to end to end models (such as Atlantis) that can explore the full cycle of processes that affect the ecosystem. Gradually the suite of GFTs was narrowed down to those that seemed likely to be most relevant based on key considerations identified by the marine workstream. These included the need for GFTs to be:

- Able to assess risk from different points of view and acknowledge obligations under a Te Tiriti o Waitangi partnership
- Able to link and account for different indicators / measures
- Multi-disciplinary
- Account for uncertainty
- Able to account for different types of data (incl. science and mātauranga Māori)
- Ability to be used in situations with low data / information
- Be able to explore different scenarios and sensitivities
- Account for and generate outputs that were temporal and spatial

When the workshops were complete a Results Chain that focused on a restoration project for an as yet unidentified marine location and taxa was provided to Challenge researchers (Figure 1).

Challenge GFTs that could support the design of activities in the restoration project such as the selection of a site and assessing the likelihood of success of restoration of a particular taxa/habitat at that site, have been mapped to the Results Chain.

A strategy to restore and/or rehabilitate to support cultural harvest and support ecosystem health and resilience with the expected outcome that: abundance, harvest, and restoration of native kai increases cultural, economic and ecological health across Te Tauihu.

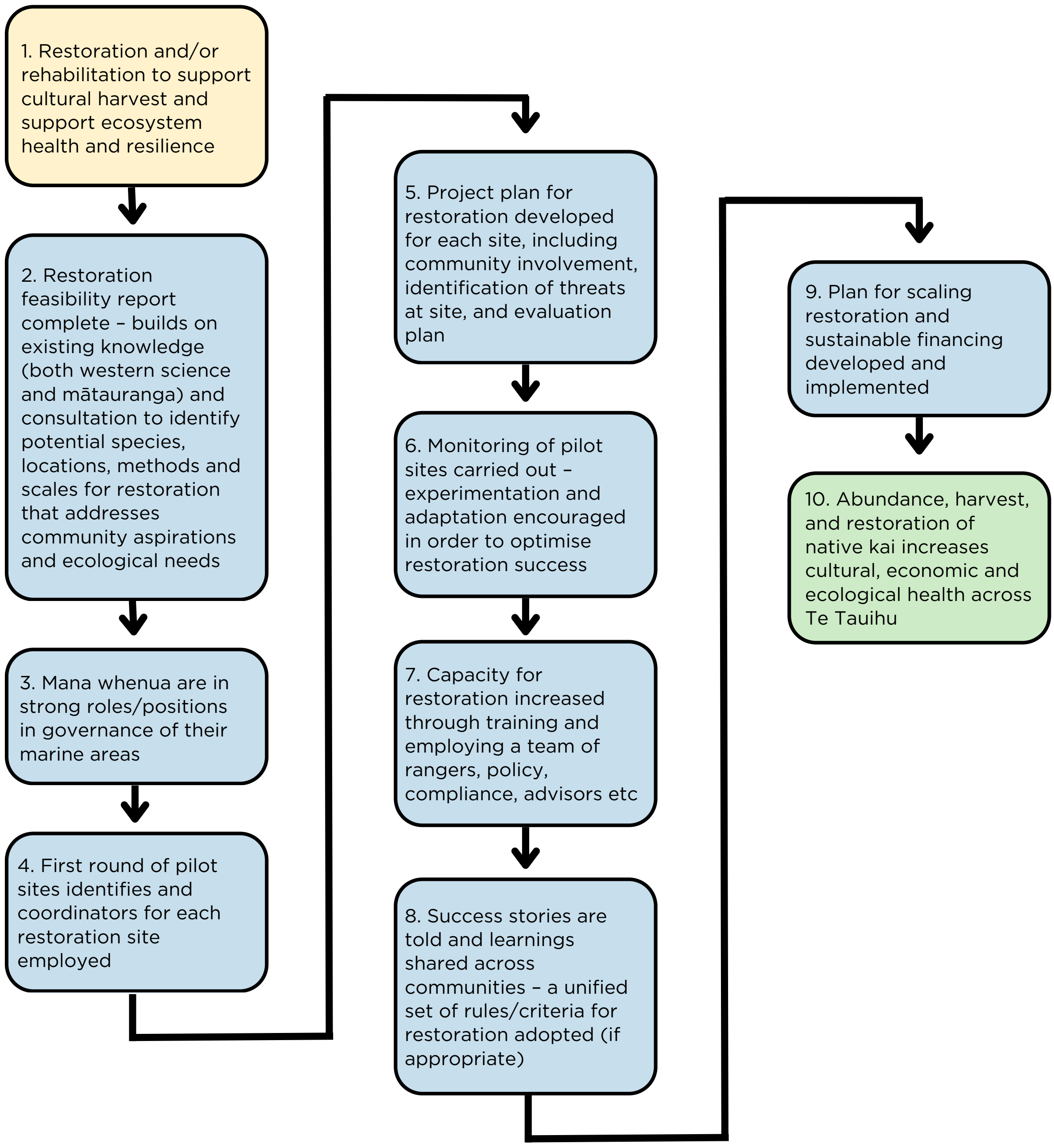


Figure 1: Results chain for achieving the strategy: *Restoration and/or rehabilitation to support cultural harvest and support ecosystem health and resilience* (yellow box). Expected outcomes (or objectives) are shown in the blue boxes, the direct links between outcomes are shown by the arrows, and the desired impact (or goal) is shown in the green.

Guidance, frameworks and tools (GFTs) to support coastal marine restoration initiatives

Six types of Challenge GFTs (Table 1) have been identified that can be readily mapped to the actions identified in boxes 2,4,5,6,8 and 9 (Figure 1). These include guidance on participatory processes for stakeholder consultation, relatively high- level guidance on the decision to restore based on the status of the ecology, the stressor(s) and the scale of the issue at hand, guidance on selecting decision support tools and three tools and frameworks to support restoration initiatives. Each of the types is summarised below, followed by a reflection on the relative utility of each for the results chain outcomes/objectives.

Guidance on stakeholder consultation

Stakeholder consultation and participatory approaches to support restoration initiatives within an EBM approach in an Aotearoa New Zealand context and that aim to include a strong role from Mana whenua in governance (Box 3, Figure 1), community involvement (Box 5, Figure 1) and a co-developed approach (Box 7, Figure 1) may be informed by a series of quick guides on navigating risk and uncertainty in marine management.

The quick guides step through: 1. Perceptions of risk and uncertainty influence marine management decisions; 2. Worldviews influence people's perceptions of risk and uncertainty; 3. Te Ao Māori understanding of tūraru me te haurokuroku (risk and uncertainty); 4. Tools to help navigate perceptions of risk and uncertainty; and 5. How to incorporate risk and uncertainty in EBM.

To support EBM, decision-makers need to understand how people perceive risk and uncertainty. Perceptions are shaped by worldview, discipline, and positionality and have a profound effect on how individuals and groups respond (Quick guide 1 and Risk and Uncertainty Guidance).

People bring different perspectives into a decision-making, or collaborative policy process based on their worldview. No worldview is 'right' or 'wrong' and worldviews may co-exist, overlap, or collide with each other. Understanding different worldviews can help identify why people disagree. By making differences in world views more visible, potential sticking points can be identified as well as possible solutions (Quick guide 2) including through the use of tools which can help highlight these differences (e.g., see systems models).

A Te Ao Māori-centred approach enhances the mana and intrinsic value of marine resources and gives an alternative to standard risk assessments in natural resource management decision-making (Quick guide 3). To complement EBM of the moana, we need to transition to decision-making frameworks that support the mana of the environment. Te Ao Māori perspectives can help with this transition. Essential steps to ensuring Māori worldviews are included in decision-making include:

- framing environmental issues from a Te Ao Māori perspective
- avoiding gratuitous co-opting of Te Ao Māori in natural resource management
- providing adequate resources for Māori participation in natural resource management.

A framework to help navigate perceptions of risk and uncertainty within a consultative / participatory approach is provided in Quick Guide 4. This consists of three tools which aim to help all participants in the planned initiative (in this case restoration of native kai and ecological health across Te Tauihu) make decisions that carefully consider risk and uncertainty to aid decision making.

- Tool 1. individual reflection: This tool gives questions to ask to uncover the worldviews, education, context, and experiences influencing those within the planned initiative.
- Tool 2. plan your process: This tool can be used individually or with the group (of the planned initiative) and steps everyone through thinking about partnership, evidence, tools, processes, and balancing rights.
- Tool 3. reflection on progress: The third tool shows those within the planned initiative how to measure success against different criteria. This tool is most helpful as a prompt for discussion in a group as progress during the decision-making process is assessed.

Guidance on likelihood of recovery/restoration

Considerations for effective ecological restoration can be drawn from the major findings of several studies based on the concept of "ecological response footprints" (to stressors).

When selecting a location for restoration or prioritising different locations it is important to think of

- How stressed these locations are. That is, are the locations situated within an ecological response to one or more stressors.
- Whether stressors can be removed.
- Whether recovery can be achieved naturally once stressors are removed – including consideration of time scales.
- Whether enhancement is needed and whether it can be maintained – including consideration of time scales.

Guidance on selecting a location for restoration and to help prioritize when and where decision makers should act to reverse ecological degradation and support recovery is drawn from research (Hewitt et al., 2022 (summarised here), Low et al. 2023) that assessed the likely effective recovery and / or restoration of an area given historical and current stressors (including the considerations of multiple and cumulative impacts) using ecological theory that is generalisable to all marine habitats. Approaches are based on the stressors' characteristics and seabed ecosystem characteristics to determine the relationship between stressor footprints and the ecological (or species) response footprint; i.e. is it the same size, larger, smaller, patchy or divorced from the stressors' footprints?

Guidance on selection of decision support tools

EBM requires people to make decisions about managing marine ecosystems in a holistic, inclusive way. Various decision support tools enable evidence based planning to foster EBM. Decisions involve assessing risk from different points of view and dealing with uncertainty and must acknowledge obligations under a Te Tiriti o Waitangi partnership.

Risk assessment tools are a subset of decision support tools. A set of risk assessment tools that address criteria for EBM in Aotearoa are summarised in Quick Guide 5 Navigating risk and uncertainty in marine management. The most appropriate methods included tools that used a "systems approach", e.g., Bayesian networks, agent-based models, system mapping, and tools that can account for spatial, temporal, and scenario testing, e.g., Species and biodiversity modelling.

This decision tree (Figure 2) can help you choose a risk assessment method for use in Aotearoa New Zealand. 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 that focus on a single stressor, a single response and for reporting on a single component (not EBM). But they can also be used for multiple stressors, multiple component, and multiple discipline risk assessments (EBM). Other methods have more specific applications, for example, SEFRA, which to date has only been used to assess the risk of fishing to endangered or vulnerable species.

Those of most relevance to the KMTT Alliance marine strand for a restoration project are shown in the right hand column as results chain boxes mapped to the tools.

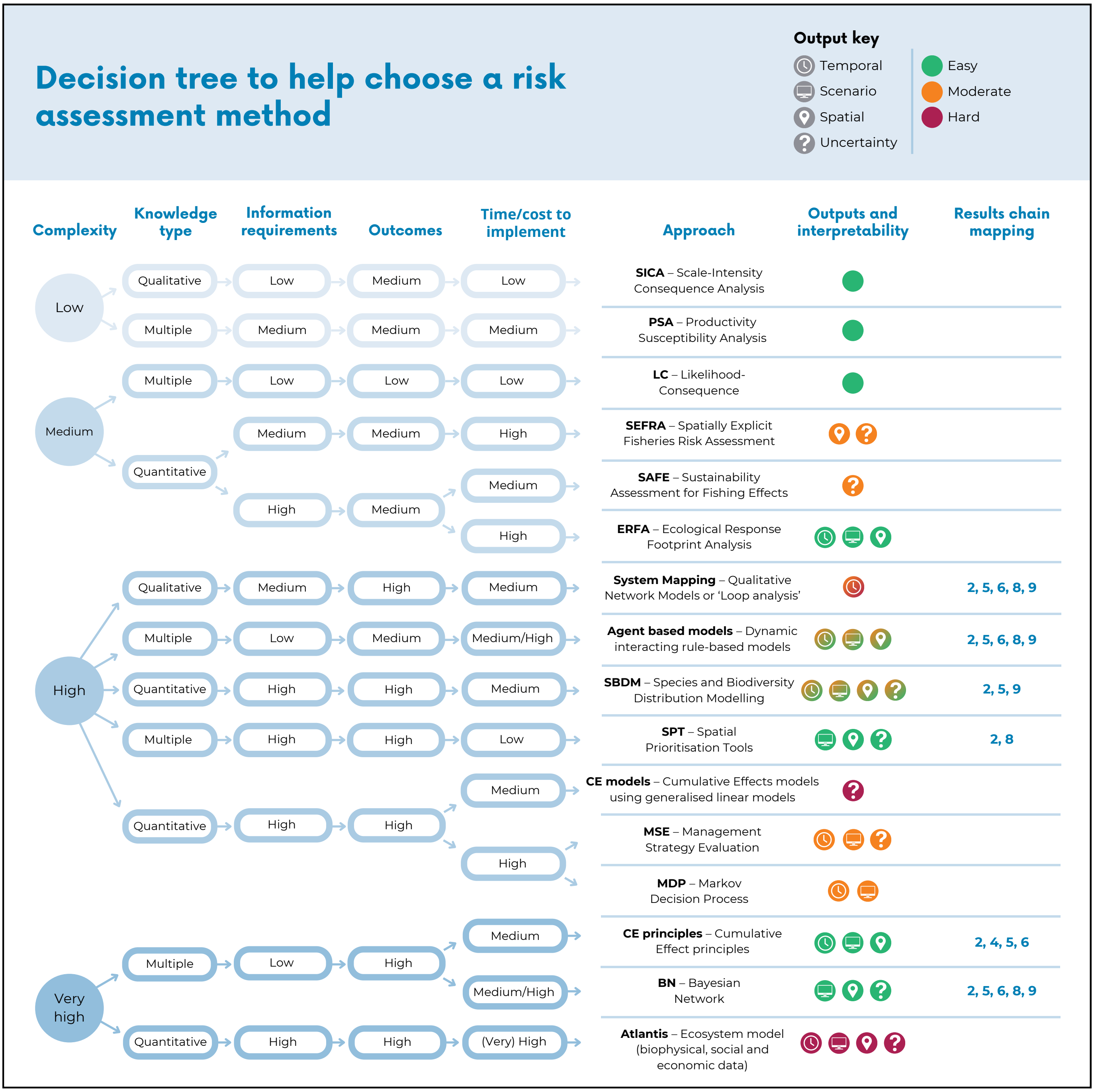


Figure 2: Decision tree to help choose decision support tools for use in Aotearoa New Zealand with Results chain boxes from the strategy: Restoration and/or rehabilitation to support cultural harvest and support ecosystem health and resilience mapped to the different tools. Decision tree is expanded on that presented in Quick Guide 5 Navigating risk and uncertainty in marine management. The symbols distinguish whether the outputs account for Spatial or Temporal variation, allow Scenario Testing and/ or account for Uncertainty. Each tool is also assessed as being relatively as easy, moderate, or difficult to use.

Tools and frameworks to support restoration initiatives

The processes and tools that may be most suitable to support restoration initiatives within the example Results Chain, are described below, acknowledging that multiple tools are likely to be needed given the multi-disciplinary nature of strategy. This overview is by no means comprehensive and, as with all tools / methods, there will be complex, and difficult to quantify considerations to account for around the interplay between the precision, accuracy and uncertainty in outputs as well as the cost and time it takes to develop and use these tools for specific contexts.

These considerations are not detailed below, but are broadly available in Rojas-Nazar et al. (2023) and in Section 4 of a framework and guidance document (2023) Understanding and communicating risk and uncertainty | te tūraru me te haurokuroku in marine management, allowing users to judge whether the tools are suitable for their specific applications.

In addition, appropriate resources and time for socialising tools should be planned for as part of the work plan to ensure uptake and buy-in by users and stakeholders. Socialising a tool is a process where end-users and stakeholders are provided with information on management objectives, the data that may be used, the tool to be used, including information on how the tool works, what kind of questions the tool can answer and the type information / outputs the tool can generate as well as any limitations associated with the data, the tool / approach and the outputs. This context is useful to manage expectations, including around the availability of relevant data (and limitations to these), and for buy-in when exploring management objectives (e.g., see Rowden et al., 2019 for an example of socialising a spatial decision support tool).

Socialising a tool should be considered as separate to (prior to) the exploration of specific management questions, i.e., where decisions are being made. That is, the socialisation should be about firstly understanding the tool and its limitations. Socialisation of tools is an important component to ensure successful uptake and buy-in by stakeholders and feeds into achieving the objective of box 8, Figure 1, that ‘Success stories are told and learnings shared across communities’.

Species distribution models (and other similar spatial biodiversity models)

Species distribution models (SDMs) are correlative models that predict the occurrence or abundance of species in relation to environmental variables. They can be used to provide estimates of habitat suitability or species probability of occurrence / abundance across broad spatial scales, including where data are sparse. Spatial predictions of species distributions from SDMs have become an important part of resource management.

In New Zealand, SDMs have been used to predict the distribution of 579 taxa across four taxonomic groups: demersal fish, reef fish, subtidal invertebrates and macroalgae (Stephenson et al., 2023b) which are available to view and download from the DOC online geoportal. These distributions can be used as a broad starting point to identify species and locations that may support restoration initiatives (i.e., explore whether the current environmental conditions would support the occurrence and abundance of species identified for restoration). From a practical standpoint, spatial estimates of species abundance using SDMs have been made for kaimoana species in Tauranga (tuangi and pipi) and in Ōhiwa harbour (tuangi and kuku) providing information on areas of importance for sustainable harvest (Rullens et al., 2021 and 2022) and for exploring the likely effectiveness of restoration initiatives (see example below).

Spatial prioritisation models

Spatial prioritisation models like Zonation (Moilanen et al., 2022) use spatial data, including biological, physical, economic, or socio-cultural information (e.g., habitat type, species distributions, or economic data such as costs associated with fishing or shipping) to identify sets of priority areas which meet preset management objectives.

For example, spatial prioritisation models can be used to identify areas that maximise the representativity of biodiversity and richness if the goal is to maximise conservation value. They can also be used to identify areas that match multiple criteria, e.g., identify areas which maximise biodiversity and are suitable for restoration whilst minimising the impact to existing users such as commercial and recreational fishing (e.g., see Lundquist et al., 2021 for guidance on using spatial prioritisation models). Importantly the impacts of stressors can be accounted for in these models which means that areas which are currently not suitable can be identified or, in contrast, could be suitable with restoration initiatives including under future climatic conditions (e.g., Stephenson et al., 2023a). Spatial prioritisation tools are familiar to central and regional government and stakeholders in New Zealand.

Systems models

System dynamics seeks to understand the network of cause-and-effect relationships (causal relationships) which present as some kind of behaviour over time (or trend) in an area of interest. The network, or the 'system' can be made up of both tangible (e.g., sediment loads in rivers) and intangible (e.g., community desire for clean rivers) influences.

Three tools / approaches can be broadly identified which may be of use for informing restoration initiatives:

- System mapping (also sometimes called qualitative loop analysis)
- Agent-based modelling
- Bayesian networks (also sometimes called Bayesian belief networks).

The advantage with all these tools is that they can easily incorporate multiple knowledge types (e.g., mātauranga Māori, quantitative, semi-quantitative and qualitative data), can be used in low data situations and can have high complexity (e.g., can account for multiple influences and components, feedbacks, interactions and indirect effects) and therefore are well suited for supporting multi-disciplinary process such as that proposed for the KMTT Alliance restoration initiative.

The concepts summarised in these tools are easy to communicate to stakeholders because scientific and technical complexity is translated into an easily understandable graphical representation. They can therefore lend themselves to participatory modelling, allowing stakeholders to be involved in the process of model building and scenario testing. Participatory modelling increases stakeholder understanding of the model structure and assumptions, promotes open discussion and acceptance of model results and helps to ensure the model meets the diverse needs of end-users, who often have differing values and knowledge sets.

The tools can be used to investigate the utility of a wide range of management scenarios (i.e., explore "what if" questions) (Gladstone-Gallagher et al., 2019). However, it is important to decide which ones are the most realistic, practical, and useful in the process, because this will determine the management actions to take forward. Agent-based modelling and Bayesian Networks can be both spatially and temporally explicit (i.e., produce maps and results can be viewed over time).

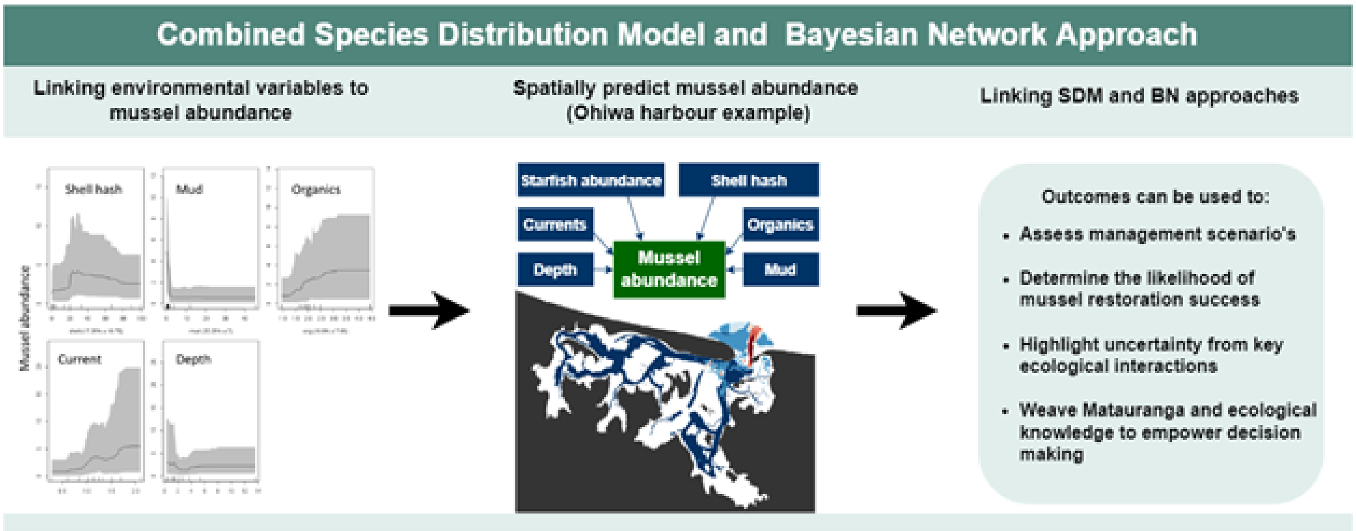
There have been some key applications in New Zealand that are relevant to draw on for supporting restoration efforts in Te Tauihu include:

- A Bayesian Network to compare outcomes on seabed health and scallop abundance from different management scenarios for fisheries, sediment and nutrient inputs, and restoration of seabed habitat.
- A hybrid SDM-BN tool which spatially modelled the implications of different management scenarios on the likelihood of mussel restoration in Ōhiwa Harbour (see example below).
- Participatory approach where a system model was used to explore restoration of the scallop fishery and seabed health in Tasman and Golden Bay, helping participants gain insights into the factors influencing habitat quality and scallop populations, and increasing awareness of participant shared understanding around the multiple management interventions that likely need to occur (Connolly, 2019).
- Conceptual system map used to describe three marine economy activities in Aotearoa New Zealand – wild fisheries, farmed fisheries, and ecotourism. The system maps provided a basis for visualising the complexity of the inter-relationships within the economic activities, potential management interventions and opportunities for transitioning to a blue economy (Connolly and Lewis, 2019).
- Systems mapping and Agent-based model to explore fisheries management of multi-species complexes and highlight problems with specific types of actions in Tasman and Golden Bay SNA7 (Hewitt and Jorgensen, 2022; Allison, 2022).

Example: Ōhiwa mussel restoration tool – hybrid species distribution model (SDM) and Bayesian network (BN)

For complex, multi-disciplinary problems such as restoration initiatives, single tools are unlikely to be appropriate. Integration of multiple tools can be a powerful way to combine the advantages of each tool into a holistic framework. To facilitate mussel restoration efforts in Ōhiwa harbour, a tool was developed that combined a species distribution model (SDM) with a Bayesian network (BN) 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.

By melding an SDM with an expert driven BN method, it was possible to fill gaps in empirical datasets / 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. The authors 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 EBM method.



This work is described further in a publication from Challenge research (Bulmer et al. (in review)).

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