Enabling effective marine spatial planning for ecological and economic wellbeing

Our current marine management system focuses on single sectors and single consent decision-making and does not consider multiple users, activities, and values. Continuing this focus will lead to further degradation of the marine ecosystem and missed opportunities for a thriving blue economy. Marine Spatial Planning (MSP) enables multiple uses and values to be considered to achieve ecological, cultural, economic, and social objectives.

About this document

This document introduces marine spatial planning and recommends how to use it effectively to manage the different uses and values we have for the ocean – from commercial and recreational uses to the customary and spiritual benefits of having a healthy ocean. It includes two examples to show marine spatial planning in action.

MSP is not a specific tool, but a broad term to describe a way to inform the use of marine spaces and resources and how those uses interact. MSP uses maps to help understand where there are complementary or conflicting uses and values.

The advice in this document is based on Sustainable Seas National Science Challenge research.

Recommendations

Marine spatial planning uses data and knowledge to assess the diversity of overlapping uses of the marine environment, and how these uses in combination affect social, cultural, economic and environmental values and can be used to support more effective decision making.

While MSP has been used both nationally and globally, historically MSP has been applied in a siloed fashion, considering spatial management of only one or few sectors. At regional scales, resource consent decisions are often approved with limited consideration of cumulative effects occurring from multiple uses and stressors.

The current sectoral framework is at high risk of causing habitat degradation or collapse of marine environments due to lack of consideration of multiple overlapping and interacting stressors and uses.

We recommend that marine spatial planning in Aotearoa New Zealand is:

- applied at small (eg rohe moana scale) and regional (eg Hauraki Gulf, Kaikōura) scales to inform decisions about spatial management
- underpinned by participatory processes that are accessible to all relevant parties, with clear and effective communication of MSP objectives and management goals
- evidence-based, but not stalled by lack of 'perfect' data – decisions can still be informed and made with imperfect data, acknowledging gaps and uncertainties with precautionary decision-making
- used to enable decision-makers to consider and integrate multiple and cumulative stressors into spatial planning
- informed by ecosystem-based management principles and integrated across multiple activities and stressors to holistically assess and achieve environmental, economic, social, and cultural well-being
- used to consider ecological scales that may cross management or legislative area-based boundaries
- used to inform the allocation of marine space to support economic development opportunities that uphold blue economy principles, ie generating economic value for Aotearoa while contributing positively to ecological, social, and cultural well-being.

Encourage participation from the beginning

Marine spatial planning (MSP) can be applied at small (eg rohe moana) and regional (eg Hauraki Gulf or Kaikōura) scales to inform decisions about spatial management.

Many of the current human uses of the marine area are allocated spatially. However, fragmented legislative regimes and single-sector management and legislation have resulted in these uses being managed independently by individual sectors, uses, or consents. Historically, this wasn't a big issue as there were few uses of marine space, but the increase in number of existing and potential activities has increased demand for use of marine space.

Marine management is also based largely on management boundaries that often do not align with ecological footprints. These constraints result in a high risk of overuse or habitat degradation due to lack of consideration of multiple overlapping activities and stressors. It also means that there is limited integration of how land-based activities impact on marine activities and values, and limited connections between ocean-based spatial planning and the management of upstream impacts. Conflicting values and rights, power imbalances, and a lack of guidance on how to resolve these conflicts also serve as a barrier to the implementation of MSP.

A major barrier to the use of MSP is the perception that MSP requires substantial data and technical capacity to be implemented. However, MSP does not necessarily require extensive quantitative data and complex tools. Simple maps informed by local knowledge can be used to inform allocation of resource use, with recognition of locations and uncertainty. Local-scale MSP processes often rely on local, expert knowledge, and can use simple visualisation tools to illustrate overlaps between uses and values. When available, high resolution quantitative data reflecting stressors, uses, and biodiversity can be used. Complex data compilation is more common for large scale processes involving one or more commercial uses, particularly when there are likely to be impacts on seafloor habitats and biodiversity. Data accessibility can be a challenge; while sufficient data may exist, it is often not easily shared across different institutions and users.

Underpin marine spatial planning with participatory processes

Marine spatial planning must be underpinned by participatory processes that are accessible to all relevant parties, with clear and effective communication of objectives and management goals.

How do you do MSP?

An MSP project should begin with a process that enables participation of all relevant parties (iwi, hapū, central and local government agencies, environmental non-governmental organisations, local communities, and industry representatives) (figure 1). Iwi and hapū partnership and participation in the MSP process, and the recognition of Māori rights and interests, underpin effective MSP in Aotearoa New Zealand and are essential to upholding the principles of Te Tiriti o Waitangi.

Empowering mana moana and supporting kaitiakitanga by enhancing and integrating mātauranga Māori within MSP should be enabled at tangata whenua- and rohe-specific scales (Hayden et al 2023a). Ongoing communication and collaboration are important to ensure the process is transparent (Le Heron et al 2018, Le Heron et al 2019, Sustainable Seas 2020).

Key steps in a participatory MSP process

MSP processes should involve all relevant partners in defining objectives that are achievable, clear, and measurable, and in bringing together data and knowledge to inform the MSP. Example objectives could include 'enhancing yield of fish stocks' 'improving ecosystem health' and 'improving access to customary resources'. Ecological goals should incorporate historical and cumulative impacts and biological uncertainty and complexity (*Addressing risk and uncertainty in decision-making*[1]). Understanding how MSP fits within relevant legislation and policy is necessary to ensure it can be implemented and enforced (*Enabling EBM in Aotearoa New Zealand's marine law and policy*[2]).

Many 'best-practice frameworks' exist for MSP. Here is a selection of guiding principles from one such framework developed for Aotearoa New Zealand (Environment Foundation 2015).

- Include tangata whenua (iwi, hapū), user groups, and conservationists at the beginning and identify a common goal and appropriate process.
- Plan for the future rather than the past by anticipating future pressures and uses, while being informed by the past.
- Focus on identifying opportunities which serve to both protect the environment and support economic, social, and cultural wellbeing.
- Use multiple sources of knowledge (including science and mātauranga Māori) to inform but not drive the process.
- Include a historical perspective to address the 'sliding baseline' problem, where the extent of degradation is under-estimated due to it spanning more the one human lifetime.
- Ensure all those needed to implement the plan are fully engaged from its inception.

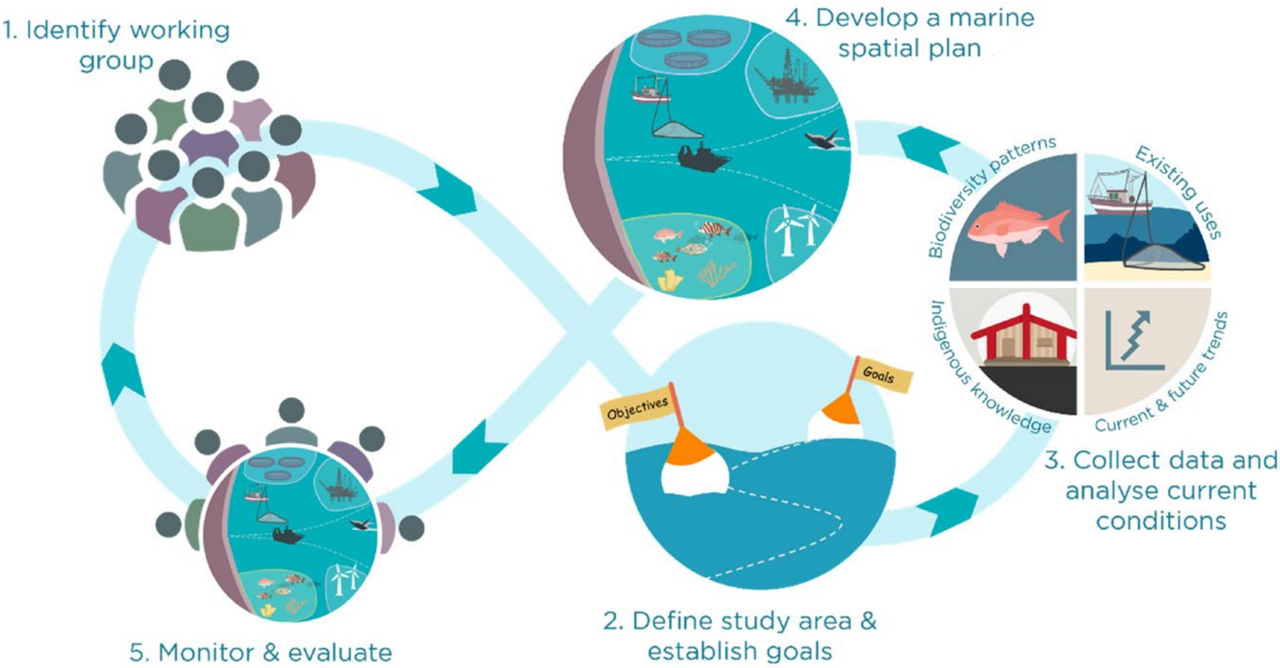


Figure 1 Key steps in a participatory MSP process

Note: the process is continuous and does not necessarily end at 'monitor and evaluate'

Use evidence-based processes that aren't stalled by imperfect data

MSP processes must be evidence-based, but not stalled by lack of 'perfect' data. Decisions can still be informed and made with imperfect data, acknowledging gaps and uncertainties with precautionary decision-making. Many decision-support tools are available to inform MSP, and a lot of data and knowledge is available to inform MSP at local, regional, and national scales.

Evidence to support MSP can take many forms

Supporting evidence can include mātauranga Māori, local and multi-disciplinary knowledge, and quantitative data on biodiversity and habitats, resources, uses and values (*Enabling a broad knowledge base for marine management decisions*[3]).

Accessibility of data and knowledge to enable MSP has been supported through the development of **Te Ukaipo o Hinemoana**: a MSP tool for Aotearoa New Zealand (figure 2). This decision-support tool is designed to help visualise the spatial extent and patterns of multiple stressors from land and sea and how they overlap with each other and with marine biodiversity and habitats.

Better data is becoming more available

Technological advancements such as underwater photography, sensors, and molecular methods have contributed to the increased availability of high-quality datasets that can be used within MSP processes. For example, remotely sensed information from boats (multi-beam echosounder derived data) and satellites (ocean colour and hyperspectral imagery) have given rise to finer resolution maps of physical habitats and stressors (activities that cause harm) over much larger scales than previously possible.

The widespread accessibility of open-source datasets and software packages, in combination with high-performance computers, has led to a wide range of 'new' modelling approaches and the ability to apply existing models at larger and finer scales. Available information on species presences, abundances and functions can be complemented by fine-scale environmental information to map the spatial-temporal distributions of species or habitats. The advent of powerful open-source artificial intelligence tools and quantum computing will likely have a much larger role in the future.

Decision-support tools are typically software developed to help inform analysts, decision-makers and the public to make better decisions. For MSP, they can vary from simpler visualisation tools and maps to complex spatial prioritisation tools. These tools use diverse datasets on marine values and uses to inform an optimal multi-objective spatial solution. The tools can incorporate qualitative and quantitative types of information to assess options.

The Sustainable Seas National Science Challenge has progressed spatial modelling, including approaches using the open-source spatial prioritisation software Zonation, which can inform decision-making across multiple objectives (Lundquist et al 2021). The complexity of analyses depends on data availability, and analyses can identify uncertainty in both datasets and model results (Brough et al 2024, Stephenson et al 2023, 2024, and Watson et al 2022, *Addressing risk and uncertainty in decision-making*[1]).

Figure 2 Te Ukaipo o Hinemoana. Online decision-support tools for informing the management of cumulative effects in the coastal and marine environment

Consider multiple stressors and cumulative effects in marine spatial planning

Approaches to MSP should enable decision-makers to consider and integrate multiple and cumulative stressors into spatial planning.

With information on stressors and cumulative effects available through work carried out as part of our research, it's now possible to incorporate cumulative effects into MSP (Brough et al 2024, *Addressing cumulative effects in marine management decisions*[4]). You can incorporate cumulative effects into MSP by prioritising management interventions for different areas depending on the degree to which they have been impacted by stressors. See Bennion et al (2023) for examples of spatial management of seafloor impacts and Cook et al (2024) for quantification of land-based impacts on coastal ecosystems.

Conversely, assessment of impacts can lead to identification of areas that require management intervention to reduce degradation, ie areas that could recover if stressors were reduced.

Marine spatial planning can include considering the impacts of interacting stressors when there are high levels of available data (Brough et al 2024), (figure 3). These complex models can explore overlaps between species and habitats, and the distribution of stressors and their interactions with other stressors and with the environment. Concepts such as ecosystem response footprints, and ecological and stressor principles have been explored within Sustainable Seas (Low et al 2023, Gladstone-Gallagher et al 2024). Zonation software allows you to explore different planning scenarios including uses, stressors, and the underpinning environment and biodiversity layers (Lundquist et al 2021, Stephenson et al 2023, 2024). When used effectively within a MSP process, tools such as these can directly support ecosystem-based management by allowing you to consider cumulative stressors.

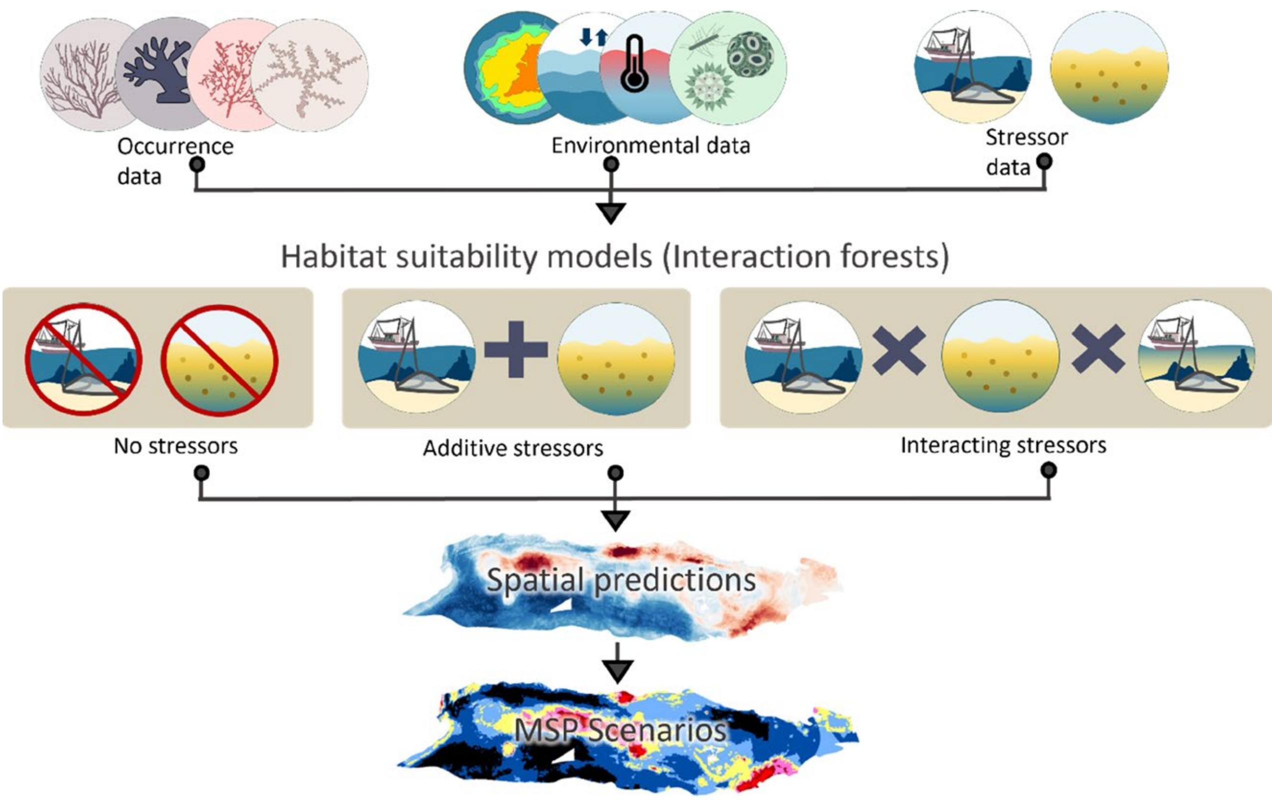


Figure 3 Incorporating cumulative stressors in models and spatially-explicit decision-support tools (Brough et al 2024)[4]

Use ecosystem-based management principles to inform marine spatial planning

Ecosystem-based management (EBM) principles should inform MSP processes and be integrated across multiple activities and stressors. Using EBM principles will help with holistic assessments and achieve environmental, economic, social and cultural wellbeing.

Incorporating EBM principles (Hewitt et al 2018) into an MSP process increases the chance of a successful outcome.

The seven principles of EBM should be applied to MSP processes. Examples of how each EBM principle applies to MSP processes include the following:

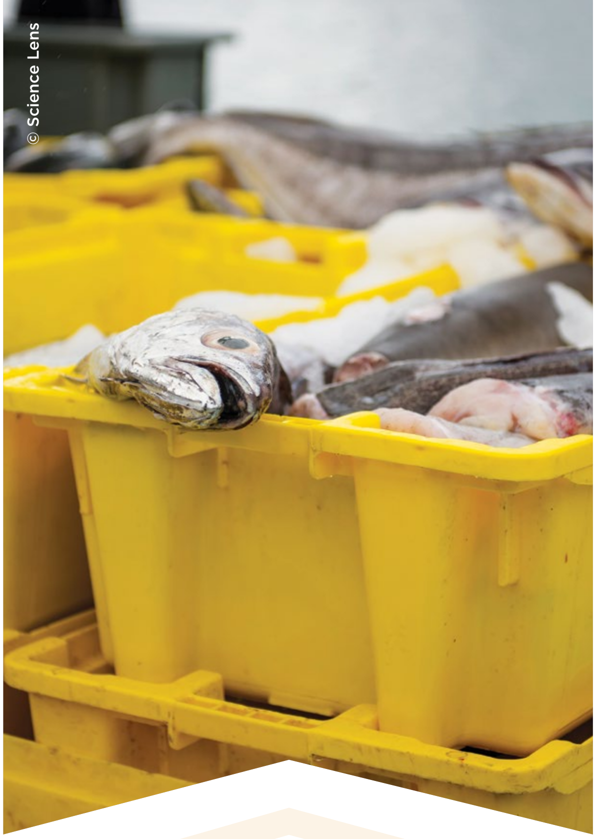
- **Co-governance** – Governance structures for MSP must observe Te Tititi o Waitangi, supporting partnership, tikanga, and mātauranga Māori (*Marine governance – sustaining ocean outcomes for future generations*[5]).
- **Collaborative decision making** – MSP should be underpinned by collaborative, co-designed and participatory decision-making processes involving all interested parties. In settings such as working groups and advisory groups, participants should be given the opportunity to communicate values and visions for MSP.
- **Knowledge-based** – MSP should be informed by science and mātauranga Māori and by community values and priorities. Various tools, datasets and approaches now exist that can help incorporate multiple knowledge systems into MSP processes and enable a te ao Māori lens and approach to marine management (Hayden et al 2023a and 2023b, *Enabling a broad knowledge base for marine management decisions*[3]).
- **Human activities** – Humans, and the variety of uses and values they have for the marine environment should be included within MSP. Social (individual, cultural, spiritual) and economic (resource extraction, jobs for the community) values should be considered within the decision-making process, and impacts to values should be mitigated, where possible.
- **Tailored** – Processes should be place and time specific, allowing specific inclusion of ecological interconnectedness, spatial and temporal dynamics and addressing ecological responses to cumulative and multiple stressors.
- **Sustainability** – An underpinning aspect of MSP is that marine environments, and their values and uses, are safeguarded for future generations.
- **Adapts** – MSP processes should be flexible, promote appropriate monitoring and adaptive management, and acknowledge uncertainty.

Ecosystem-based management is, at its core, about connectivity between:

- biodiversity and functions
- stressors and ecosystem health
- ecosystem health and human health
- biological, socioeconomic, and governance perspectives.

In Aotearoa New Zealand, MSP processes could support EBM through:

- increased links between ecosystems, for example land-use effects on marine ecosystems (Cook et al 2024)
- increased accounting of economic and societal value, and inclusion in assessments
- adaptive participatory place-based frameworks
- assessments that strive to consider ecosystem functions, as well as the constituents and the present (and future) stressors acting in a system.



Consider appropriate ecological scales

MSP processes must consider ecological scales that may cross management or legislative area-based boundaries.

Legislation and policy can result in artificial boundaries for decision making, whether these are boundaries between land and sea, between regions, or between inshore and offshore areas. The Exclusive Economic Zone (EEZ) Act provides for a joint application process for cross-boundary activities for which both the Resource Management Act and the EEZ Act apply. However, other management boundaries can influence the scale of decision-making, such as broad-scale fishery management areas, which typically include both the territorial seas and EEZ and multiple regional council boundaries.

MSP processes need to understand the broader scale of decision-making for various activities within an area. Similarly, a disconnect exists between science and management of terrestrial and marine areas. The National Policy Statement for Freshwater Management recognises connections between land and sea and envisions limit-setting that will mitigate impacts on downstream environments, such as coasts and estuaries. MSP processes must consider values, uses, and stressors from both land and sea (Cook et al 2024) when assessing ecological health, along with the number and location of activities to minimise the chance of exceeding tipping points in ecological, economic, societal or cultural health (Low et al 2023, Gladstone-Gallagher et al 2024).

Use MSP when allocating marine space to support economic development

Marine spatial planning processes should inform the allocation of marine space to support economic development opportunities that uphold blue economy principles. The blue economy is about generating economic value for Aotearoa while contributing positively to ecological, social, and cultural well-being.

Compared to single sector or consent-based approaches, MSP can inform the proactive management of overlapping resource uses and activities and improve environmental and economic outcomes. See Appendices 2 and 3 for examples.

Diverse opportunities are available for economic development, including:

- offshore wind or tidal energy
- offshore aquaculture for finfish or shellfish
- opportunities that involve recreation, culture, or tourism such as zones for mooring and anchoring of vessels
- areas for development of customary fisheries or aquaculture.

Marine spatial planning can:

- improve understanding of overlapping distributions of proposed developments and existing activities and values
- consider the additional stressors that might result from new activities
- show how these activities or stressors add to the cumulative stressors within the existing system to minimise the potential of passing tipping points or thresholds in the system (Low et al 2023, Gladstone-Gallagher et al 2024)
- simplify management tools – there is a proliferation of spatial management tools of similar names but with different rules, which adds confusion and makes enforcement difficult (high protected areas, seafloor/benthic protected areas, marine reserves, marine parks, trawl corridors, cable protection zones, etc).

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Appendix 1
Challenges remain for effective marine spatial planning in Aotearoa New Zealand

Historically, qualitative information has not been used to inform MSP, and most of the tools that support MSP are better equipped for incorporating quantitative information. But as management approaches become more inclusive, tools and strategies to bring these data types and knowledge systems together have been developed, for example in the Sustainable Seas project *Awhi Mai Awhi Atu* (Enacting a kaitiakitanga-based approach to EBM) (Paul-Burke et al 2018).

More needs to be done to increase the acceptability of incorporating multiple knowledge systems including mātauranga Māori and values, concepts, traditions, and philosophies into MSP decision-support tools (Hayden et al 2023a and 2023b, *Enabling a broad knowledge base for marine management decisions*[3]).

Effective MSP depends on sufficient information on environment and resources. While avoiding waiting for perfect data to enact MSP is important, data limitations can diminish the chances of effective spatial management. For example, high-resolution data on seafloor characteristics and stressors is often not available. These data gaps reduce the ability of scientists to develop accurate assessments of habitat condition and composition, and so reduce the information available to decision-makers.

Sustainable Seas has published guidance on making assessments in places with limited data. Rather than wait until the perfect information is available, MSP should be viewed as a 'living process' – dynamic approaches are needed to ensure that management can adapt to new information and a rapidly changing marine environment.

Ensuring that participatory processes include all relevant parties remains a significant challenge. In Aotearoa, key participants include tangata whenua (iwi/hapū), user-groups (local communities and industry), regional and central government agencies, and environmental interest groups, but power dynamics and capacity often limit who has a seat at the table (Le Heron et al 2018, Peart et al 2019). This limitation is not unique to Aotearoa but does limit effectiveness and social license for spatial management measures.

Uncertainties and risk remain a challenge (*Addressing risk and uncertainty in decision-making*[1]). For example, we often lack information on the spatial and temporal impacts of new economic activities. Marine spatial planning efforts can be stalled due to information gaps. Alternatively, decisions can be made before key information is acquired due to rapid decision-making timelines. Adaptive management that embraces uncertainties by introducing flexibility into MSP would reduce risk and uncertainty (Gladstone-Gallaher et al 2024).

Recognising and adapting legislation, mindset, tools, and processes to the challenges of the present day will help prepare for the MSP challenges of the future. A focus on several key areas could bolster our preparedness for a variety of future scenarios. These areas include:

- climate smart MSP – an approach that acknowledges change and uncertainty associated with a changing climate and provides 'wriggle room' to respond to extreme weather events and complex issues driven by range extensions and contractions
- blue economy smart MSP – a dynamic form of adaptive MSP that incorporates pathways for change and flexible responses to new industries and their associated impacts – a static approach won't work to support a growing blue economy
- removal of legislative barriers that limit the implementation of EBM, and the development of legislation that supports integrated and holistic MSP (*Enabling ecosystem-based management in Aotearoa New Zealand's marine law and policy*[2]).

Appendix 2
MSP example: Informing allocation of space for renewable energy

Objective: Zone areas for an offshore windfarm that balance the benefits of renewable energy with the protection of habitats and threatened species, and minimises impact to other uses and values.

Interested parties: Windfarm companies, recreational fishers, commercial fishing industry, regional and central government, mana whenua and mana moana, public, environmental NGOs.

Issues: Impact of long-term operation of windfarm not fully understood, overlap with threatened species distributions and with other commercial uses.

Process: All interested parties take part in workshops to identify concerns which are incorporated into the design. Spatial information on biodiversity value, current stressors (eg sedimentation), commercial interests, mana whenua interests, local community interests, and administrative boundaries are compiled. Decision-support tools are used to identify areas that balance conservation, mana whenua values, stakeholder values, and economic enterprise. Targeted surveys ground truth models and pinpoint areas of critical importance for threatened species. Risk assessments are used to identify uncertainties and presented to managers and stakeholders.

Outcome: Windfarms are classified as permitted activities in a plan change. Consent is given for the windfarm, but boundaries are altered after considering mana whenua values and stakeholder input, decision-support tool outputs, uncertainties and risks (figure 4). Mana whenua and stakeholders can see how their input was integrated, which contributes to broad support of management decisions.

Alignment with EBM: Ecosystem-based management comes through via the collaborative participation in decision making, the tailored place-based process, the evidenced-based design and incorporation of local knowledge, and the consideration of humans as part of the system through inclusion of human activities (recreational and customary value), commercial enterprise (and displaced value), and other stressors on ecosystem services.

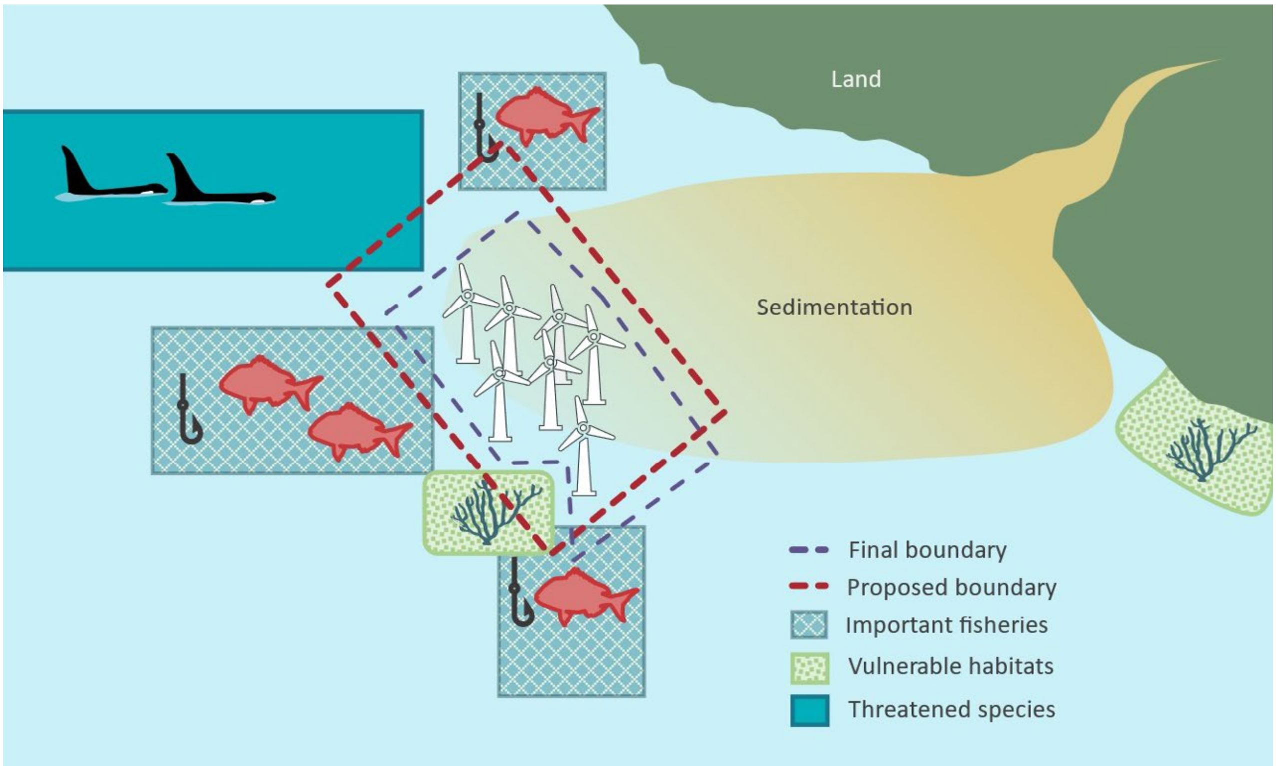

Figure 4 MSP example for informing allocation of space for renewable energy production. This conceptual figure shows the various uses, activities, and stressors in the space and their overlap with the 'proposed boundary' for renewable energy production. The 'final boundary' shown is a hypothetical output of MSP that shows an altered boundary to reduce potential impact for threatened species, vulnerable habitats, and important fisheries

Appendix 3
MSP example: Cross-boundary infrastructure zones

Aim: Create zones around cables to protect them from damage, with minimum impact to habitats and resource extraction.

Interested parties: Cable laying companies, recreational fishers, commercial fishing, regional and central government, mana whenua, public, and environmental NGOs.

Issues: Cable options are limited due to cable laying and telecommunication needs. Cables are protected under the Submarine Cables and Pipelines Protection Act 1996, and the public understands that the cable zones support critical infrastructure. However, the cable zone will displace some recreational and commercial fishing. Stakeholders disagree on the width of the zone required for cable protection, and whether this zone provides biodiversity benefits. The cable extends past the 12 nautical mile territorial sea boundary into the exclusive economic zone (EEZ), involving regional and central government agencies.

Process: The placement of the cable is decided. Interested parties agree that the cable must be protected from human activity, though there is concern for access to customary and recreational harvesting of coastal seafood. Areas are allocated to ensure that iwi, hapū, and local communities can continue to collect kaimoana, with gear restrictions (eg anchoring and bottom-impact gear) to protect the cable (figure 5). Facilitated discussions lead to an agreement between stakeholder groups on the impacts and benefits of the cable protection zone for habitats.

Outcome: Protection zones are designated to protect cables from impact but allow some access for users (within 200 metres of the coast). A communications campaign ensures that protection zones are enforced and respected. Fish abundance is monitored inside and outside of the cable protection zone.

Ecosystem-based management comes through in the:

- collaboration in decision making
- use of local knowledge
- flexibility of the protection zones (allowing for some continued resource extraction)
- consideration of humans as part of the system
- tailored place-based decisions
- continued assessment of impacts and benefits of the protection zones for the ecosystem.

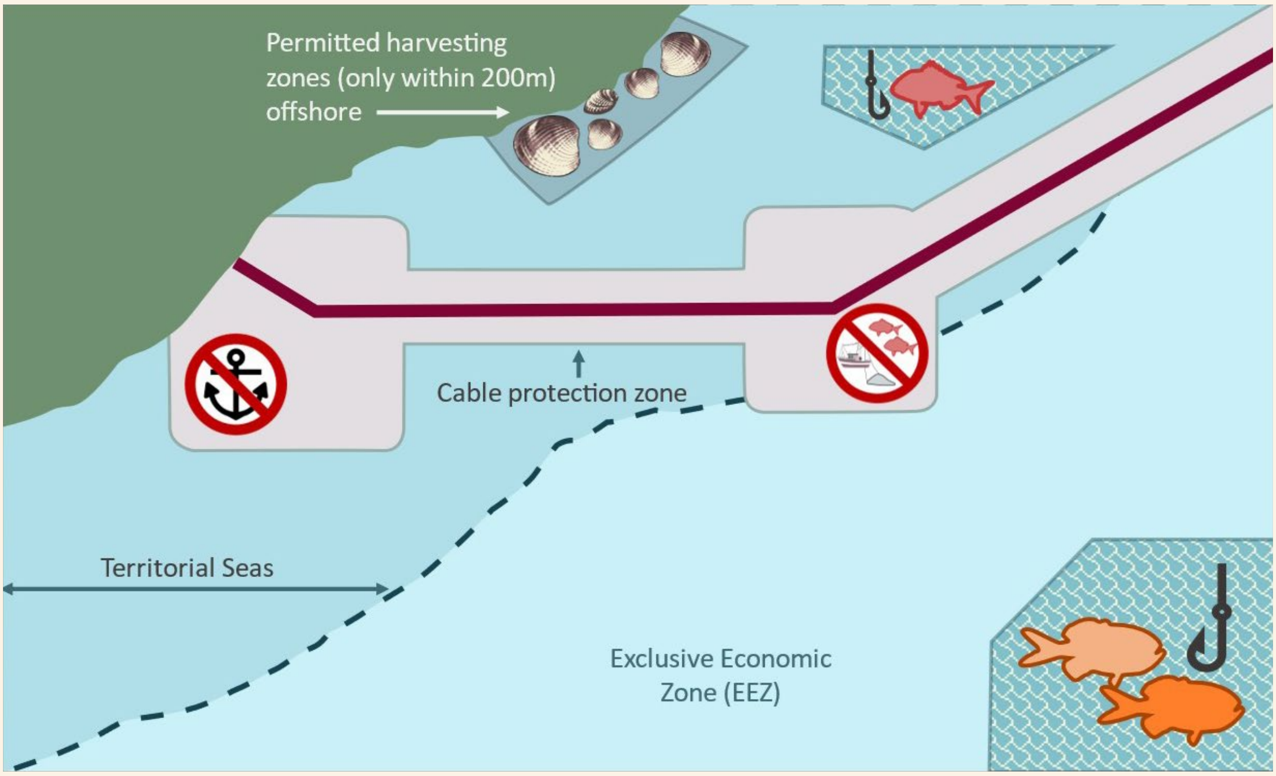

Figure 5 MSP example for informing allocation of space in an MSP process that crosses legislative boundaries. This conceptual figure shows the various uses, activities, and stressors in the space and their overlap with different management boundaries. The 'final boundary' shown is a hypothetical output of MSP, where different uses are allocated spatially to balance recreational, commercial and customary fisheries, and space required for infrastructure

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