Project Proposal

A. PROJECT TITLE	1.2 Incorporating ecological responses to cumulative effects into spatially explicit decision support tools
"SHORT" TITLE	Spatially explicit cumulative effects tools (SPEXCET)
B. THEME / PROGRAMME	Theme 1: Understanding degradation and recovery in social-ecological systems

C. PROJECT KEY RESEARCHERS			
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D. CO-DEVELOPED WITH			
Name	Role	Organisation / company / agency	Level of partnership
Conrad Pilditch	Co-development researcher	University of Waikato	Cross-project/Cross-theme coordination meetings; Attended co-development workshop
Anna Madarasz-Smith	Co-development partner	Hawkes Bay Regional Council	Attended co-development workshop; ongoing email/in person meetings re: Hawkes Bay case study
Simon Thrush	Co-development researcher	University of Auckland	Cross-project/Cross-theme coordination meetings
Joanne Ellis	Co-development researcher	University of Waikato	Cross-project/Cross-theme coordination meetings
Fabrice Stephenson	Co-development researcher	NIWA	Cross-project/Cross-theme coordination meetings
Lesley Bolton-Ritchie	Co-development partner	Canterbury Regional Council	Attended co-development workshop
Mike Townsend	Co-development partner	Waikato Regional Council	Attended co-development workshop
Blake Abernethy	Co-development partner	MPI	Attended co-development workshop; Provided feedback and MPI input
Richard Saunders	Co-development partner	MPI*	Attended co-development workshop
Jade Maggs	Co-development partner	MPI*	Attended co-development workshop
Kristopher Ramm	Co-development partner	DoC	Attended co-development workshop
Gemma Couzens	Co-development partner	EPA*	Attended co-development workshop
Abbie Bull	Watching brief	MfE	Email communication
Stuart Brodie	Watching brief	MfE	Watching brief only
Ray Wood	Co-development partner	Chatham Rock Phosphate	Email communication
Amanda Leathers	Co-development partner	WWF	Email communication
Lucy Jacob	Co-development partner	WWF	Attended co-development workshop
*This person has shifted organisations and is no longer involved in this project			

E. ABSTRACT

A lack of relevant tools to assess the cumulative effects of multiple stressors in marine ecosystems is hampering effective stressor management to maintain and/or recover ecological functioning and associated ecosystem services in degraded systems. It is also a source of uncertainty in management decisions around a system's capacity for new activities. This project will expand the capacity of decision support tools that enable ecosystem-based marine spatial planning to incorporate the assessment of cumulative effects from multiple stressors on ecosystem health and functioning.

The project will build on prior research from Sustainable Seas Phase I and aligned funding to develop spatially explicit cumulative effects tools (SPEXCET).

The project will first develop approaches to incorporate the complexity of multiple stressors and their ecological responses which interact in both linear and non-linear ways into spatial tools, informed by empirical stressor-response relationships developed in Project 1.1.

These spatially explicit multiple stressor tools will be further developed to evaluate system capacity, and how this varies with different combinations of stressors, and their associated ecological impacts that may vary in space and time. Time lags in stressor response, as well as recovery dynamics and trajectories from restoration or mitigation activities will then be built into the decision-support tools.

The spatial tools will be further informed by findings from a combination of Phase 1 and 2 Sustainable Seas projects, which will be integrated into the further development and parameterisation of the decision-support tool. These include identifying and progressing findings on ecological stressor-responses, linking ecological indicators with cultural and mātauranga Māori indicators of degradation and recovery, and developing approaches that integrate uncertainty in our understanding of cumulative effects into spatial tools.

Case studies will provide a platform for testing of the decision support tools at local, regional and national scales. National scale testing will occur in coordination with the Marine Science Advisory Group (MSAG), building on existing approaches to spatial optimisation for biodiversity to incorporate multiple stressors. For regional and local rohe moana scale case studies, discussions have been initiated to identify suitable locations for these collaborations that are planned for the later stages of the project. We have tentatively identified the Hawke's Bay for a regional scale case study based on planned collaboration with partners in the Challenge S1 Hawke's Bay project. For the rohe moana scale case study we are investigating possibilities based on either direct alignment with other Challenge projects or via other interested iwi/hapu/whanau where there are existing discussions and relationships, and capacity to participate and engage.

F. RELEVANCE TO CHALLENGE OBJECTIVE

This project directly contributes to the Challenge objective: To enhance utilisation of our marine resources within environmental and biological constraints, through the development of spatially explicit decision-support tools to assist in quantification of existing and potential impacts of different policy and management options on ecosystem health.

Ecosystem based management is challenging due to the co-occurrence of multiple human activities including extractive and non-extractive activities, along with impacts from land-based and non-point source stressors such as sediments, nutrients and chemical pollutants.

This project will contribute to filling gaps in our ability to assess the cumulative effects of multiple stressors in marine ecosystems within a spatial planning context. Tool based assessment of management scenarios will inform the need for restoration or mitigation to reverse ecological degradation, the capacity of the system to cope with new activities, and where activities could be located to minimise the likelihood of exceeding of ecological thresholds.

G. OUTPUTS			
	We deliver specific types of outputs for different purposes. For brevity, we define the purpose and nature of different forms of outputs as: **Papers** and **Popular Articles** – independent peer reviewed scientific and indigenous publications are essential to build trust in science and Māori worldviews and ensure international credibility. They are critical if we are to use our research findings to inform EBM practices, support high-level reports and evidence in Environment Court – scientific papers are internationally recognised as having tremendous value. **Frameworks** – guidelines and tools to support decision making within EBM contexts. These products will be used to synthesise ecological/environmental/cultural knowledge to help EBM practitioners and project partners. They will demonstrate connections and interactions that have important consequences on ecosystem structure, function, resilience and ecosystem services. We will build these models/tools and trial them with project partners and other parties as the project develops. We expect these to evolve within the project and with partner projects. **Education support tools** – These will aim to work with iwi/ hapū and public media to encourage understanding and valuing marine ecosystems.		
	This project will produce the following Outputs:	Linked to which Theory of Change Outputs:	Explain briefly your plan to ensure uptake by iwi and stakeholders:
	• Three scientific papers that explore case study testing of tools to incorporate interactions of multiple stressors, recovery dynamics, time lags and trajectories in ecological systems into spatial decision-support tools (Outputs 4.1, 4.4, 4.6) • Three tool frameworks that facilitate quantitative assessment of interactions between multiple stressors in marine ecosystems to work hand in hand with empirical studies of stressor interactions (Outputs 1.2, 2.1, 3.1)	(a) Biophysical and social-ecological knowledge that supports the development of understanding and tools that underpin EBM	Ongoing co-development with iwi and stakeholders through targeted engagement, and with co-development partners and the Theme 1 Advisory Group, will ensure tools are developed that are fit for purpose and transferable and are able to assess the typical challenges of cumulative effects management, and the key stressors identified by iwi and stakeholders across scales (local rohe moana, regional planning initiatives, and national spatial planning).
	• Integration of Māori perceptions and indicators of cumulative effects into decision-support tool frameworks that assess cumulative effects on ecological, cultural and society values (Outputs 1.3, 4.2, 4.5) • One popular article prepared for a Māori audience to provide accessible tools that facilitate translation and communication of concepts of cumulative effects on marine ecosystems (Output 1.5) • Three SeaSketch education resource support tools providing easily accessible data on cumulative effects for local kaitiaki, community and	(b) Traditional, local and other cultural knowledge that supports EBM is captured/ understood/ recognised	Through data gathering (incl reviewing iwi/hapū management plans) an initial baseline of information (mātauranga and Māori values/perspectives) will be prepared. This baseline will be integrated in the first instance to gauge appropriateness and capability, whilst also provide a platform to initiate the "why and what" engagement with partnering rohe moana groups/kaitiaki. This will be presented and discussed at workshops with iwi/tangata whenua/kaitiaki, with the intent to outline our "why, what, where" and to discuss the "how" and guidance on access and use of mātauranga. Additionally, workshops with stakeholders will be undertaken to identify and incorporate societal indicators of degradation and recovery into the decision support tools and frameworks to allow assessment of thresholds in ecological, cultural, and societal values.

	educational facilities from local to national scales (Outputs 5.1, 5.2, 5.3) • One scientific paper on mātauranga Māori perceptions and indicators of cumulative effects (Output 1.4)		
	• Frameworks for integrating cumulative effects into decision-support tools at local, regional and national scales (Outputs 1.3, 4.2, 4.3, 4.5) • Three presentations at annual co-development partner workshops and Challenge conferences (Outputs 1.2, 2.1, 3.1)	(f) Tools for predicting and managing cumulative and multiple stressors developed, assessed and demonstrated	We will hold workshops and hui with partnering rohe moana groups and stakeholders to develop and test suitable management scenarios at different scales (local rohe moana, regional planning initiatives, and national spatial planning activities). Information sharing with broader Challenge iwi and stakeholders will occur through presentations of modelling approaches at Challenge annual conferences.

H. OUTCOMES	This project will contribute to the following Theory of Change Outcomes:
	• (1) The value of blue economy business models is recognised and adapted by Aotearoa New Zealand businesses.
	• (2) Decision making practices that are more inclusive, multi-sectorial and account for the effects from cumulative and multiple activities are adopted.
	• (3) Knowledge from the Challenge (science and mātauranga) is used in decision making to improve ecological health and influences marine management and policy.
	• (8) Researchers and iwi and stakeholders involved during the life of the Challenge continue to actively promote, research in, and use knowledge from the Challenge.

I. INTRODUCTION

Ecosystem based management (EBM) is challenged globally by the difficulty of incorporating the effects of multiple stressors (from human activities both on land and sea) into decision making. Effects of multiple stressors on ecological health vary between habitats and ecosystems and can be additive, synergistic, or exhibit other non-linear interactions that are often poorly understood (Davies et al. 2018; Thrush et al. 2016). Further development of existing spatial management tools to enable them to incorporate cumulative effects can improve EBM decision making, and inform setting of robust and appropriate targets for marine resource use that facilitate maintenance and/or recovery of ecological function and the ecosystem services provided by marine habitats and species (Tulloch et al. 2015).

Current practice typically manages for single stressors, or single sectors, or evaluates impacts on single habitats, locales or taxa (Holon et al. 2018; Kroodsma et al. 2018; Maxwell et al. 2013). However, interactions amongst stressors are likely to generate adverse impacts at thresholds well before those anticipated for single stressors. For example, Project 1.1 will explore ecological responses to cumulative effects such as sediments and seafloor disturbance from fishing, both of which have been identified as key stressors to coastal ecosystems (Korpinen et al. 2013; Thrush et al. 2004). Project 1.2 will bring these new understandings of interactions between stressors, and how these stressors act both singularly and in combination, into decision support tools, providing a framework for decision makers to evaluate consequences of different management decisions and likely implications on ecosystem health. These tools can assist in the understanding of cumulative effects and development of robust criteria for assessing whether new activities can be accommodated (and if so, at what intensity, and in what spatial configuration) before a tipping point is passed. Further, in addition to identifying thresholds in ecological functioning, these tools can be used to improve understanding of cultural and societal tipping points which may be reached at different states of degradation (or recovery) than for ecological tipping points (Lundquist et al. 2016).

Globally, new approaches to cumulative effects assessments have focussed on mapping the spatial distribution, intensity, frequency and seasonality of potential stressors of different anthropogenic activities (i.e., the stressor footprint), and assessing the vulnerability of different biodiversity features to individual stressors to calculate cumulative impact scores (Ban et al. 2010; Halpern et al. 2008; MacDiarmid et al. 2012). Marine spatial planning (MSP) has been informed by ongoing developments in systematic conservation planning and trade-off models, typically balancing extractive activities with conservation of biodiversity features; the addition of cumulative effects represents a natural progression for MSP tools. In Phase I, our team developed approaches using 'discounting' to incorporate single stressor impacts as a proxy for degraded habitat condition (Klein et al. 2013; Rowden et al. 2019) within a multiple use MSP decision support tool. Reflecting on input from the formal stakeholder workshop for the Degradation and Recovery theme as well two 'in person' and virtual workshops hosted by Project 1.2 leaders with interested co-development stakeholders (see section D), we have identified research priorities, developing a project work plan reaching across local to regional to national scales to represent the diversity of scales at which cumulative effects are applicable. In Phase II, this project will further develop decision support tool approaches to incorporate multiple stressors and their impacts on ecological, societal and cultural values. These tools will be tested in case study areas (to be confirmed in later stages) to inform decision-making processes on whether or not systems can accommodate additional uses, and where to place new activities to minimise risks of tipping points due to cumulative impacts. These tools will be designed in dialogue with regional and central government and iwi/ hapū to maximise their applicability to decision making needs at multiple scales of management.

J. AIMS

Research questions, as identified from a series of co-development hui and workshops in 2018 and 2019, where cumulative effects and marine spatial planning were consistently highlighted by iwi and stakeholders:

1. **How do we integrate ecological responses to cumulative effects into spatial management tools?**
2. **How do we calculate ecological-physical system capacity to stressor loading and how does this vary between systems and drivers?**
3. **How do we integrate recovery dynamics/potential in ecological systems into spatial management tools?**
4. **How can we communicate/translate information generated by spatial management tools into indicators (ecological, cultural and societal) of degradation and recovery?**

K. PROPOSED RESEARCH

This project has been developed as a sequence of research aims that will result in the development and testing of new approaches to integrate cumulative effects and ecological recovery into spatially explicit decision support tools. This approach will inform the determination of system capacity for new activities, and the extent required and optimal location for these activities, and for restoration activities and mitigation zones (Rowden et al. 2014; Rowden et al. 2015) to reverse degradation and facilitate recovery of ecological functioning and services provided by marine ecosystems.

RA1: Integrating ecological responses to cumulative effects into SPEXCET tools
This RA will contribute to the delivery of Outputs 1.1, 1.2, 1.3, 1.4, and 1.5.

In our first Research Aim, we will build on prior use of systematic conservation planning tools in Phase 1 within the 'Spatially Explicit Decision Support Tools (SEDS)' project to inform ecosystem-based management. The Phase 1 project developed methods to facilitate creation of robust, modelled data layers when faced with the limited data typical to describe biodiversity and ecosystem services within New Zealand's marine ecosystems. Resulting data layers now available for use through Phase 1 and through co-funding by central government partners as part of the Marine Science Advisory Group (MSAG) include a suite of national data layers representing best available information to describe key ecological criteria to determine priority areas for supporting ecological function (Stephenson et al. 2018, Lundquist et al. 2020a). Within the Phase 1 project, we also contributed methodology that was used in a stakeholder spatial planning process, resulting in revised spatial management measures for the South Pacific High Seas to jointly enhance protection of Vulnerable Marine Ecosystem (VME) taxa, and support a sustainable fishery (Rowden et al. 2019). Approaches developed included: guidance on how to incorporate uncertainty in modelled predictions of biodiversity features (e.g., habitat suitability models based on limited empirical observations), and incorporation of a 'naturalness' layer that allowed for inclusion of the response of biodiversity features to a single stressor through a proxy relationship modeled by the discounting of habitat condition. These preliminary explorations of stressor impacts are building blocks for integrating multiple stressor impacts within these tools.

In this Phase II project, we will develop new methods that allow for multiple overlapping stressors with differing impacts on biodiversity and ecosystem features. We envision using Zonation software (Moilanen et al. 2009; Moilanen et al. 2014) due to the versatility of different mechanisms within the software to allow for discounting of biodiversity features, inclusion of multiple stressor layers through negative weighting algorithms, and through its multiple connectivity algorithms that can facilitate modelling of stressor dispersal. The software tool Marxan will also be considered, as well as other tools, as new developments within the Marxan with Zones toolbox may better facilitate incorporation of multiple stressors (Klein et al. 2010; Mazor et al. 2014). The model will be parameterised using conceptual stressor-response relationships based on Phase 1 outputs, for example a set of empirically derived layers for eight conceptual macrofaunal functional groups (Lundquist et al. 2018) that quantify the degradation following cumulative impacts of both seafloor disturbance from fishing and from sediment deposition (Bulmer et al. draft manuscript). Additional stressor-response relationships will be driven by data from other Phase 1 projects, and from Project 1.1, which in particular within their *RA1: Mahere tapuwae: Develop methods to determine the spatial-temporal ecological response footprints of overlapping diffuse broad and local-scale stressors*, will provide conceptual information to define stressor interactions (e.g., additive, multiplicative, or other non-linear stressor interactions). While our primary project aim is in developing decision support tools to manage for cumulative effects, we will bring in societal and cultural indicators of stressor impacts as much as possible within our tools, noting that these tools already have the capacity to incorporate economic, social and cultural factors. Some further insight of tohu/indicators of societal/cultural perceptions of degradation and recovery will be provided by Project 1.1, as well as from the systems mapping exercise as part of the S1 Hawke's Bay case study project, and through interactions with this project's VM liaison (see data gathering described in Section G) and case study areas that will be confirmed by early 2021. Collaboration with Project 3.2 through shared supervision of PhD student Stephanie Watson will result in new approaches for integrating uncertainty in stressor interactions with spatial tools. In particular, this project will directly integrate approaches developed in Project 3.2's *RA2: Analysis of cumulative effects and scaling on uncertainty*, where methods using a spatial Bayes net framework including conditional probabilities and other novel approaches will be used to investigate how uncertainty changes moving from single to multiple stressor interactions. We will also interact directly with a proposed Challenge cross-project social-ecological postdoctoral researcher and the Challenge cross-project synthesis postdoctoral researcher to further populate linkages between ecological indicators of stressor impacts with societal and cultural perceptions, but specifically note that further translation to economic and societal values is beyond the scope of this particular project.

RA2: Incorporating ecological-physical system capacity to stressor loading into SPEXCET tools
This RA will contribute to the delivery of Outputs 2.1.

A key conceptual shift from using trade-off models to balance conflicting (and/or co-benefiting) marine uses is to flip these tools on their end to evaluate system capacity in a multi-use marine ecosystem. Here we define system capacity as the level of additional resource use and stressor impacts which does not result in the system exceeding a threshold or tipping point resulting in ecological degradation. While spatial tools are often used to prioritise optimal locations for different, often competing uses, they have not to date been used to determine the maximum amount of cumulative effects that a system can cope with. Determination of this system capacity is further complicated by the multitude of marine uses and stressor impacts which have different spatial and temporal footprints, and different impacts on biodiversity and ecosystem features. Sequentially building from our Phase I research on single stressor footprints, to multiple stressor footprints and their interactions based on empirical data from Project 1.1's RA1, here we will explore an optimisation approach within a multi-use marine spatial planning framework to assess multiple uses (White et al. 2012a; White et al. 2012b) to determine whether this approach could be used to evaluate a system capacity in the management of multiple stressors. Our team initiated a collaboration with Crow White, a leader in the development of this approach from California Polytechnic Institute, San Luis Obispo in 2019, and will directly collaborate with him while he is on sabbatical hosted by the University of California, Santa Barbara (with the SeaSketch team led by Dr Will McClintock) and by CSIRO and the University of Tasmania in Hobart, Australia. This nature of this collaboration will likely change slightly due to COVID19 travel restrictions.

RA3: Integrating recovery dynamics/potential in ecological systems into SPEXCET tools
This RA will contribute to the delivery of Output 3.1.

Our third research aim is envisioned to occur sequentially following RA1 and RA2, and be initiated in year 2 of the project. In Phase 1, we explored spatial modelling of VME taxa, and stakeholder workshops highlighted the need to understand recovery of taxa following disturbance (for example, from seafloor trawling, dredging or mining activities), and determine ways of incorporating recovery trajectories, and the time lags of recovery responses following mitigation or conservation management measures being put in place. Building on these prior models for offshore VME taxa (Clark et al. 2016; Georgian et al. 2019), we will use empirical research from MBIE and aligned NIWA SSIF funded research to explore stressor-response relationships as well as recovery-response relationships of seafloor communities to develop spatially explicit models that include a temporal component of recovery to explore how location and extent of restoration or mitigation activities influences longer term ecological function. Information on recovery potential and time lags following the cessation of disturbance or stressors will be available from Project 1.1, in particular from their *RA3 Haumanu moana: Assessing the recovery potential of degraded systems (both rate and likelihood) and the causes of hysteresis in the recovery of key habitat forming species*, which will provide conceptual information including organism habitat requirements, species-species interactions, meta-community dynamics, and present/future stressor regimes.

RA4: Testing of SPEXCET tools with iwi and stakeholder groups
This RA will contribute to the delivery of Outputs 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6.

Over the course of the first 12 months, we will actively engage with iwi and stakeholders to confirm case study areas for parameterising and testing the decision support tools developed within this project. These case studies will be selected based on multiple criteria: 1) the availability of datasets on biodiversity and stressors in a suitable format for modelling, recognising that significant effort is often required to translate raw data into model appropriate data layers for marine spatial planning; 2) the ability to parameterise and test the model at three scales (local, regional, national); and 3) the existence of a coordinated iwi and/or stakeholder group for each case study with which we have a direct relationship either through other Challenge projects, or via project team members, to facilitate co-development and testing of the decision support tool.

National scale: At a national scale, we will explore how best to incorporate cumulative effects into marine spatial planning with respect to marine reserve planning. Substantial co-funding by the Marine Science Advisory Group (MSAG) has led to the compilation and development of national scales layers of biodiversity and ecosystem features, including representation of key ecological criteria for identifying significant areas, a process that is also part of regional council responsibilities with respect to revisions of regional coastal plans. A number of 'naturalness' datasets that provide spatial maps of stressors have been compiled in these national layers (Stephenson et al. 2018, Lundquist et al. 2020), and we will explore how to extrapolate our case study approach to national scales, guided by project team member Dr Shane Geange (DOC) who is a member of MSAG as well as a contributor to other NZ spatial planning projects at national and international scales. Dr Geange will provide direct interactions with central government decision making and policy, particularly with reference to revisions to the Marine Reserves Act that will guide how marine reserve planning is applied at national and regional scales. DOC has also been directly funding and utilising the tool SeaSketch (see RA5) to support MSAG and other spatial management and marine protected area processes.

Regional scale: Following involvement of the team in the Hawke's Bay case study, and upcoming Tangaroa research in the region (T5 project proposal in development), we envision direct applicability of the model conceptual framework to a regional case study of cumulative effects on seafloor ecosystems in the Hawke's Bay. The short-term objective of the Challenge-funded Hawke's Bay case study project is to develop a conceptual social-ecological systems map of stressors and their impacts and importance to reversing environmental degradation in the Hawke's Bay marine environment, which can be directly translated into the framework for this regional case study. Here, sediment transport has modified coastal habitats through both deposition and increased muddiness of local estuaries as well as increased water column turbidity. Nitrogen inputs from point source (municipal outfalls) and non-point source pollution from rivers and streams have been associated with eutrophication on the coast and extensive phytoplankton blooms and water column hypoxia. Co-funding by HBRC has resulted in a compilation of spatial layers of biodiversity and habitat features, and some stressor layers (Lundquist et al. 2020c, Haggitt and Wade 2016). Further spatial quantification of stressor footprint layers is expected to occur as part of the case study project and through collaboration with Project 1.1, whereby a PhD student (supervised by Karin Bryan) will model contaminant dispersal and provide spatially explicit stressor footprints. We are also collaborating with Manaaki Whenua Landcare Research (via team member Anne-Gaelle Ausseil) within a Land and Water NSC project to model land-based stressor inputs into Hawke's Bay. Interest has been confirmed with Hawke's Bay Regional Council to host the regional case study, and further discussions are planned with the S1 Hawke's Bay case study partners. Conversations will continue with the T5 project to investigate potential alignment of the two projects as T5 is further developed and research is initiated.

Local/rohe moana scale: Following proof of concept of use of the tool at national and regional scales, and interactions with this project's VM liaison and potential case study project areas of other Challenge research projects, we will identify co-development partners for the final local rohe moana scale case study that will be initiated in the second half of the project. Initial data gathering of mātauranga and Māori values/perspectives relevant to the tool will be used to gauge appropriateness and capability for potential rohe moana case study locations, whilst also provide a platform to initiate the "why and what" engagement with iwi/tangata whenua/kaitiaki. Potential case study locations and partners could be, but are not limited to, the following locations: 1) a local rohe moana case study within the Hawke's Bay region, facilitated through involvement in the regional scale case study, and with the S1 Hawke's Bay case study project with HBMaC whose membership includes environmental kaitiaki from hapū/iwi (Ngāti Kahungunu, Ngāti Pāhauwera, Te Taiwhenua o Tamatea, Ngāti Kere); 2) a rohe moana case study that directly aligns with the T5 project proposal, which is currently in development; or 3) a rohe moana case study that aligns with the T1 project in Ohiwa where there are extensive long-term datasets of mātauranga Māori knowledge collected since 2007, and further exploration and identification of contemporary tohu or environmental signs, signals and indicators of the natural world are also planned in Ohiwa through project 1.1.

RA5: Communication tool to translate information generated by SPEXCET tools
This RA will contribute to the delivery of Outputs 5.1, 5.2, and 5.3.

The team has substantial experience in socialising spatial management tools for central and regional government, and industry-led processes, from informing the Ross Sea Marine Protected Area and the South Pacific Regional Fisheries Management Organisation stakeholder process to providing support to regional planning processes such as Sea Change in the Hauraki Gulf (Lundquist et al. 2020b, Rowden et al. 2019). Recognising that the complexity of spatial management tools such as Zonation may be unsuitable for translation of cumulative effects information, here we plan to collaborate with the University of California, Santa Barbara-based SeaSketch (http://www.seasketch.org/) developers to investigate new methods of reporting on cumulative impact assessments and evaluating different management scenarios within this web-based tool. SeaSketch has been populated for the Phase I Tasman and Golden Bays case study as well as a new release anticipated by DOC of its key ecological area layers to inform the MSAG decision making, and it has also been used to support stakeholder-led processes such as Sea Change in the Hauraki Gulf and the Southeast Marine Protected Area Forum. While the primary use to date in New Zealand for SeaSketch and its predecessor MarineMap

(Merrifield et al. 2013) has been as a static approach to visualising layers, SeaSketch can also be used as more of a game playing 'App'. For example, SeaSketch could report the potential benefits and costs of different management strategies (as developed for use in the Hauraki Gulf in Sea Change to report on benefits to biodiversity of different protected area designs as well as costs to existing or future resource uses). Here, we will explore the use of a SeaSketch new application, building on products developed by SeaSketch with Symphony https://www.openchannels.org/blog/seasketch/seasketch-platform-mobilizes-sweden%E2%80%99s-cumulative-impacts-models-planning and with ECOMAR (see Figure 1) to allow visualisation and quantification of cumulative effects. We envision this as a plug and play application to evaluate ecosystem responses to different user-selected management options that would reduce stressors to coastal and estuarine ecosystems. For example, different restoration options and associated costs to each option could be parameterised to determine extent and optimal locations to reduce sediment loads to reverse habitat degradation. SeaSketch is also in process of collaborating with developers of systematic conservation planning tools (e.g., Zonation, Marxan) to integrate spatial biodiversity prioritisations directly into the web-based tool. We will continue to collaborate with the UCSB SeasSketch team to inform this development, and if available within the timeframes of project 1.2, utilise it within Sustainable Seas.

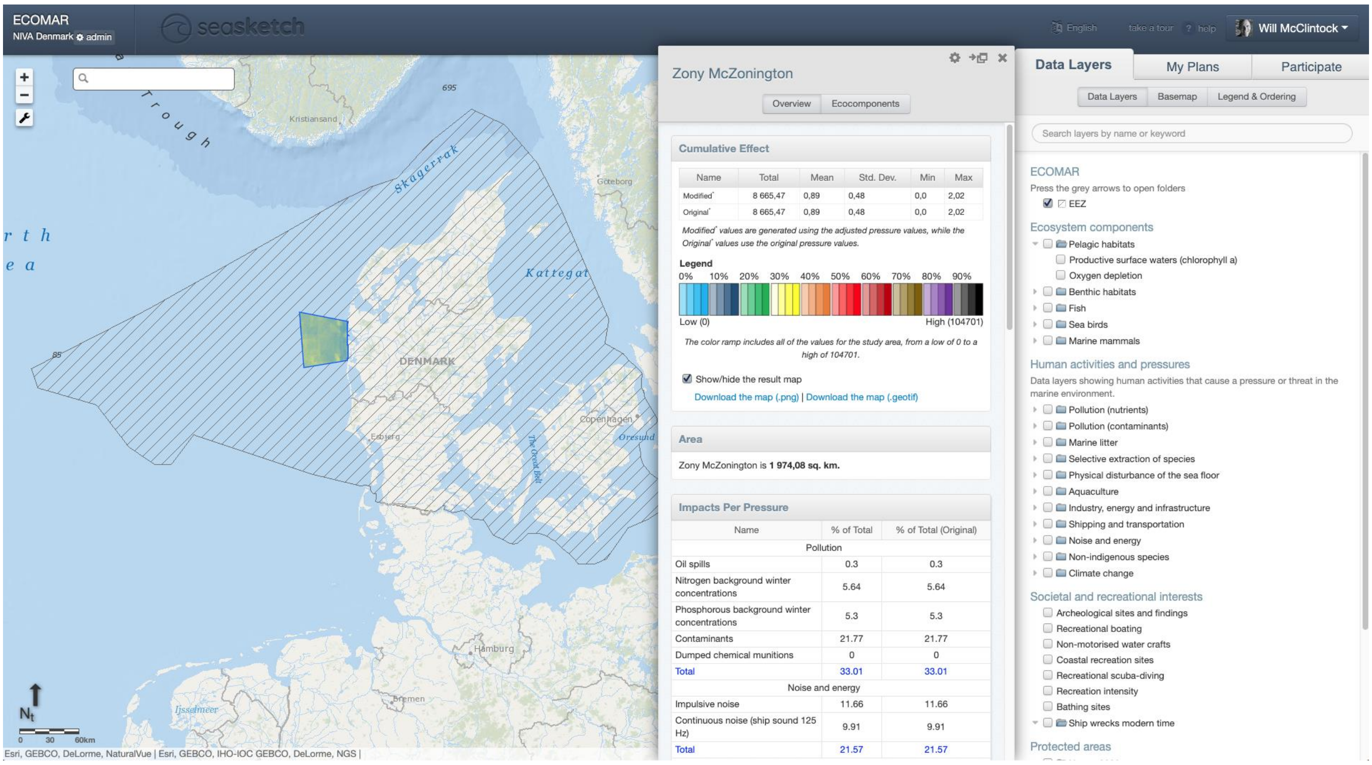

Figure 1. Draft visualisation of ECOMAR cumulative effects software collaboration with SeaSketch (reproduced with permission from ECOMAR team to include in proposal).

L. LINKS TO PHASE I RESEARCH

This project builds substantially on ***5.1.2*** *(Spatially explicit decision support tools)* which developed approaches to incorporate responses to single stressor footprints within spatial biodiversity prioritisation tools (e.g. Zonation). 5.1.2 also used novel methods to model ecosystem and biodiversity features with limited data, and to incorporate uncertainty in modelled biodiversity layers into decision support tools. The project will also utilise ecological datasets and responses to multiple stressors in soft sediment coastal ecosystems from ***4.2.1*** *(Tipping points in ecosystem structure, function & services)* and ***4.3.2*** *(Sediment tolerance and mortality thresholds of benthic habitats),* stressor footprints and/or approaches for their development based on ***4.2.2*** *(Stressor footprints and dynamics)* and ***2.2.2.3*** *(Near real-time forecasting using operational oceanographic forecasting of contamination risk to reduce commercial shellfish harvest and beach closures*), and approaches for modelling ecosystem service layers from ***2.1.3*** *(Measuring ecosystem services and assessing impacts).*

M. LINKS TO & INTERDEPENDENCIES WITH PHASE II RESEARCH PROJECTS

The suite of projects with direct interdependencies to this project, and for which PLs have agreed to informal MOUs and quid pro quo delivery of team hours to support linked deliverables include:

1.1 Understanding ecological responses to cumulative effects (including sediment stressor footprint mapping using hydrodynamic models provided by a PhD student supervised by Dr Karin Bryan)

3.2 Communicating risk and uncertainty to aid decision-making (including shared supervision of PhD student Stephanie Watson)

S1 Hawke's Bay case study project

Relationships with other projects will be further developed as appropriate during the course of the project:
T1 Awhi Mai Awhi Atu: Enacting a kaitiakitanga-based approach to EBM
T4 Te Tāhuhu Matatau: Empowering kaitiaki of Tangaroa (parallel project which is developing a marine spatial planning digital tool developed by Māori for Māori)
T5 He Kāinga Taurikura ō Tangitū: Treasured Coastal Environment) (project proposal in development)
3.1 Perceptions of risk and uncertainty
4.2/4.5 Options for policy and legislative change to enable EBM, and Enabling EBM at different scales
Synthesis: Ecosystem-based management and blue economy in action; regional case studies

Other interdependencies include collaboration with a Land and Water NSC project in the Hawke's Bay (team member Anne-Gaelle Ausseil) that is developing models of riverine sediment and nutrient loads under future land-use and climate scenarios.

N. VISION MĀTAURANGA (VM)

Vision Mātauranga is seeking to unlock the innovative potential of Māori knowledge, resources and people to assist New Zealander's to create a better future. There are four themes in the Vision Mātauranga (VM) policy framework (Indigenous Innovation, Taiao, Hauora/Oranga, and Mātauranga). This project will develop innovative products, and support processes, systems and services through the development of new tools that enhance understanding and participation in ecosystem-based management.

Māori continue to express concerns regarding the condition of coastal marine environment in their local rohe. Initial conversations were held during the development of this project with kaupapa Māori researchers leading Tangaroa projects and with other iwi/hapū groups associated with regional case studies, as potential collaborators where mutual benefit might exist. These conversations will continue and case study opportunities will be explored as our respective projects and connections establish themselves and gain momentum and structure.

We envision engagement initially at the project leader or kaitiaki level, allowing for shared learnings and information about cultural indicators of degradation and recovery to be integrated into our project, while minimising impacts on capacity of iwi engagement. As the co-development process continues, we envision more direct engagement with these partnering rohe moana groups through workshops during the testing phase of the decision support tool, which will be led by Mr Whetu. Initially, we will review existing information around mātauranga Māori perspectives regarding cumulative effects and degradation and these approaches may be incorporated into the SPEXCET tool design and development. We will socialise model concepts with our partnering project leaders or kaitiaki to ascertain their potential uses for whanau in these areas, and then, within RA4 (testing phase) we will utilise these concept tools to communicate and translate information generated into indicators (ecological, cultural, and societal) of degradation and recovery. This approach will identify how these tools could be used to assist decision making of Māori and enable their expression of kaitiakitanga. As part of this VM component of the project, we will also identify and report on commonalities in the cultural/Māori values for development and/or use in tool(s), whilst also identifying distinct/spatial differences in values.

The Taiao VM theme looks to achieve environmental sustainability through iwi and hapū relationships with land, and in this Challenge, the seas. Māori are active participants in resource management, as well as having world views with strong environmental ethics as evidenced in recent EPA hearings on potential minerals, petroleum and sand mining exploration on the seafloor; many of these consent processes have used spatial prioritisation tools and species distribution models to inform placement of potential mitigation sites to protect biodiversity. Spatially explicit decision support tools also have the potential to support the role of kaitiaki by providing management tools spatially specific to their local rohe, while at the same time, providing tools to support Māori investors in investment decisions.

The decision-support tools will be developed such that they can integrate mātauranga Māori in accordance with tikanga Māori practices, and strengthening localised mātauranga Māori understandings and kaitiakitanga practices to inform contemporary management approaches (e.g., 'customary management tools'), and translate best science practice operationally in a way that recognises Māori cultural values, uses and opportunities.

Vision Mātauranga Deliverables

Partnerships:

VM P1. Desktop exploration on Māori perceptions of cumulative effects (Output 1.3)
VM P2. Host workshop to discuss and finalise regional case study model scenarios (MS4.3)
VM P3. Host co-development workshop to finalise rohe moana model scenarios (MS4.7)

Distinctive Contribution:

VM DC1. Submit scientific publication based on mātauranga Māori perceptions of cumulative effects to support kaitiakitanga (Output 1.4)
VM DC2. Prepare popular article on mātauranga Māori perceptions of cumulative effects to support kaitiakitanga (Output 1.5,)

VM DC3. Populate SeaSketch tool populated with datasets for stakeholder testing of regional case study, including specific content designed for Māori (MS5.2)
VM DC4. Workshop to disseminate and build trust and confidence in SeaSketch tool for regional case study (Output 5.1)
VM DC5. Populate SeaSketch tool with datasets for stakeholder testing of rohe moana case study, including specific content designed for Māori (MS5.4)
VM DC6. Workshop to disseminate and build trust and confidence in SeaSketch tool for rohe moana case study (Output 5.1)

Meaningful Outcomes:
VM M1. Workshop to disseminate and build trust and confidence in the regional case study outputs (Output 4.2)
VM M2. Workshop to disseminate and build trust and confidence in the outputs of the rohe moana case study (Output 4.5)

O. ENGAGEMENT REQUIRED WITH IWI AND STAKEHOLDERS

Ongoing co-development will occur with iwi and stakeholders through targeted engagement, and with collaboration in mind, with appropriate personnel and representatives in potential/likely case study areas.
As part of the project co-development process we have communicated extensively with the Hawke's Bay Marine and Coastal Group (an existing multi-stakeholder and iwi entity), and participated in a system dynamics workshop process to assist in identifying research priorities for tool development. Two project-specific co-development workshops were held with a diversity of stakeholders, suggesting that this project would benefit from having both case study specific advisory groups, directly coordinated with other Challenge projects, in addition to the Impact Advisory Group that advises at the scale of the thematic Degradation and Recovery projects. We have engaged Mr James Whetu to serve as our VM liaison and coordinate with project leaders of other Phase II Sustainable Seas projects and iwi/hapū groups and their representatives. Learning from Phase I, we recognise that the Challenge does not have the capacity to be fully embedded in only one project in a case study area; rather we will utilise Mr Whetu's expertise to identify and progress information that ensures the integrity of mātauranga Māori is maintained in the incorporation of societal and cultural values and indicators into our decision support tools. As part of joint co-development of these case studies, we will work with other project leaders, attending joint workshops as appropriate to jointly inform Challenge progress in these areas, while recognising limited capacity and avoidance of having workshops that are specific to only one decision support tool. We have also engaged Dr Hilke Giles as an advisor to assist in engaging across regional councils to inform implementation of cumulative effects in marine spatial planning at a regional scale. Dr Shane Geange (DOC) will perform a similar role at a national scale with central government, facilitating our project's integration with MSAG, a national level expert group in marine science that will bring learnings of how to incorporate stressor impacts into evaluation of suitable areas for marine conservation.

P. PROJECT COMMUNICATIONS

Project 1.2 will engage with a wide range of iwi, stakeholders and decision-makers through its collaborations with other Cross-programme projects, particularly the Hawke's Bay case study and Tangaroa projects when the timing and approach is right for all parties, and we will work with their networks (e.g., the Hawke's Bay Marine and Coastal Group, directly supported by HBRC) and newsletters, websites and other venues for communications. In RA5, in collaboration with SeaSketch, we will develop a tool for translating and communicating information generated by spatially explicit decision-support tools into ecological, cultural and societal indicators. WWF have volunteered support from their communications team in assisting with broader outreach at national scales. We will communicate findings with national and international cumulative effects researchers through conference presentations (both in NZ and overseas). Through our collaboration with SeaSketch, we have been invited to participate in international fora to maximise sharing of tool development.

Q. RISK & MITIGATION

We are dependent on other projects to inform stressor-response relationships to parameterise our cumulative effects models and interactions between stressors. While final analyses from Project 1.1 will not yet be complete in our required timeframe, we have confirmed that the conceptual information will be available (and from prior and aligned projects) to inform model development. We have also directly linked with aligned projects: a Land and Water NSC project that will deliver land-based stressor inputs, and a HBRC funded PhD project to UoW that will deliver hydrodynamic models of stressor dispersion in collaboration with Project 1.1. Further, to co-develop management scenarios to test within the decision-support tools, we have indicated our intention to align with iwi and stakeholder groups for which relationships have already been developed (including through other Challenge projects), thus maximising opportunities within limited funding. Further conversations are planned with relevant Challenge Project Leaders and other iwi and stakeholder groups to gauge appropriateness and capability of potential case study locations. We also identify some risk of collaboration with overseas partners with respect to SeaSketch (UCSB) and any COVID19 implications for their cofunding, and travel restrictions that may prevent in person collaboration with Will McClintock or Crow White (who had planned a sabbatical in Australia).

R. CONSENTS & APPROVAL required to undertake research	• Depending on the scope of the project once the full co-development process has occurred, if human ethics approval is required for this research, appropriate procedures will be followed and approval will be sought from NIWA's Human Research Ethics Committee.

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