Project proposal

A. PROJECT TITLE	Ecosystem-based management of shellfish in the Marlborough Sounds – Stage 2
"SHORT" TITLE	Marlborough Sounds regional study
B. THEME / PROGRAMME	EBM and blue economy in action (Synthesis)

C. PROJECT KEY RESEARCHERS

Role	Name	Institution / company	Email
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Project Leader(s)	Oliver Wade	Marlborough District Council	oliver.wade@marlborough.govt.nz
Project Leader(s)	Eric Jorgensen	Marlborough Sounds Integrated Management Trust	
Project Leader(s)	Larne Wichman	Marlborough Sounds Integrated Management Trust	
Key Researcher	Sean Handley	NIWA	
Key Researcher	James Williams	NIWA	
Key Researcher	Vera Rullens	Independent contractor	
Key Researcher	Emma Toy	Marlborough District Council	
Key Researcher	Jane Halliday	NIWA	

D. CO-DEVELOPED WITH*

Name	Role	Organisation / company / agency	Level of partnership
Eric Jorgensen	Co-development participant	Marlborough Sounds Integrated Management Trust	Workshop, proposal review, community connector
Larne Wichman	Co-development participant	Marlborough Sounds Integrated Management Trust	Workshop, proposal review, community connector
Vera Rullens	Modelling advice	Independent contractor	Modelling advice
Chris Cornelisen	Synthesis lead	Cawthron	Workshops, proposal review, Sustainable Seas CLT links
Judi Hewitt	R&U lead	Auckland University	Sustainable Seas CLT
Conrad Pilditch	Degradation & Recovery lead	University of Waikato	Sustainable Seas CLT

*we gratefully acknowledge the contributions from many community and tangata whenua members who attended the two workshops and online meetings over the past years. These discussions have helped shape this proposal. Due to time constraints, it was not possible to determine from each person whether they were happy to be named.

E. ABSTRACT

The Marlborough Sounds has been selected as one of the Challenge's Phase 2 case study areas for research on implementing ecosystem-based management in a real-world context. This case study will focus on planning for the management and restoration of shellfish populations in the sounds.

F. RELEVANCE TO CHALLENGE OBJECTIVE

This case study will bring together knowledge for guiding management and restoration of shellfish populations, which are critical to the health of the Marlborough Sounds ecosystem. The Sounds ecosystem underpins a high value marine economy that includes more than half of NZ's aquaculture resources. The project is therefore of direct relevance to the Challenge objective: "To enhance utilization of marine resources within environmental and biological limits". This case study will inform options available to future proof and improve negative trends in shellfish populations.

G. OUTPUTS	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:

	• A visual knowledge summary of spatial distributions of seabed habitats and shellfish populations in the Marlborough Sounds.	(a) Biophysical and social-ecological knowledge that supports the development of understanding and tools that underpin EBM	Iwi and stakeholders will be actively engaged as they are the organisations and groups who hold the information that will inform this output. They will be regularly updated on progress by email and/or newsletter. The findings of this step will be clearly explained and demonstrated to the participants involved in developing the project during a face to face workshop at the completion of the output.
	• *An evaluation method/tool for identifying and prioritising locations, focal species and habitats for future restoration activities; Participatory process to share local ecological knowledge and matauranga maori to understand where remedial action is needed and desired.*	(d). Decision-making processes that recognise risk and uncertainty evaluated, developed, and demonstrated. (b). Traditional, local and other cultural knowledge that supports EBM is captured/understood/recognised.	The participants will attend a face to face workshop to use the knowledge summary to evaluate where future activities should occur.
	• *Final report detailing priorities for work (where, what, when, how) in the following decade. Includes assessments of risks and benefits of activities/ management options. this needs to be multi-use and multi-sector, and integrated with existing systems where possible.*	(c). Effective partnership models for an EBM approach to decision-making and management developed, evaluated, and demonstrated.	The information within the report will be co-developed. Spatial information outputs will be shared and integrated with existing data sharing platforms such as MDC's smartmaps. The case study outputs will inform ongoing projects within the region such as the Te Hoiere Restoration project and the Kotahitanga mo te Taiao strategy that will ensure the longevity of this work.

H. OUTCOMES	This project will contribute to the following Theory of Change Outcomes:
	• (2) Decision-making practices that are more inclusive, multi-sectorial and account for the effects from cumulative and multiple activities are adopted (FO2, FO4)
	• (3) Knowledge from the Challenge (science and mātauranga) is used in decision making to improve ecological health and influences Aotearoa New Zealand's marine management practice and policy (FO3)
	• (6) EBM practices are understood and accepted as a viable approach by decision makers, stakeholders and iwi (FO2)

I. INTRODUCTION

The Sustainable Seas NSC (Phase II) wishes to trial ecosystem-based management (EBM) through a series of case studies ('EBM in action'). In marine environments that are experiencing multiple stressors these case studies provide an opportunity to assess and trial management options that may ultimately benefit and improve ecosystem health. To succeed, EBM requires involvement of multiple groups with a diversity of uses and interests in the marine environment. Their engagement is essential to the evolution and ongoing improvement of management processes.

A regional case study must satisfy the following criteria:

- Address a real-world EBM issue
- Co-designed with willing partners
- On-the-ground champion(s) committed to driving progress
- Access to existing data and knowledge
- Opportunity to trial tools
- Ability to demonstrate EBM in action
- Supported through opportunities fund with form(s) of co-investment

The Marlborough Sounds is a large and ecologically diverse area with multiple values, that is also facing a range of environmental stresses. Most notable are those associated with land use changes, including forestry activities, which have degraded marine habitats over time (e.g. Fahey & Croker 1992; Handley 2015, 2016; Handley et al. 2017; Urlich 2015; Coutts & Urlich 2020; Urlich & Handley 2020a, b). This region has been identified, along with Hawke's Bay and the Hauraki Gulf, as an area where the Challenge can work collaboratively with the community to address an EBM issue. The idea of a shellfish focus for this case study was co-developed at earlier workshops attended by representatives of Marlborough iwi and stakeholders, central, and regional government, and researchers. Shellfish represent a functional group of organisms that are critical to sustaining healthy seabed habitats and the wider Marlborough Sounds ecosystem. This focus reflects the values associated with shellfish in the region, including to ecosystem services, tangata whenua and the shellfish industry, and the widespread recognition that shellfish health must be improved.

In the first official year of this project (Stage 1; December 2020–September 2021), case study partners were tasked with identifying the specific focus and pathway for trialling EBM of shellfish within the Marlborough Sounds. Information for several areas (Te Hoiere/Pelorus Sound, Tōtaranui/Queen Charlotte Sound, East Bay, Waikawa Bay, Waitohi Harbour) and shellfish (scallops, cockles, shellfish beds) that had been identified in an earlier workshop (July 2020; Sustainable Seas 2020) was reviewed. The aim was to narrow the case study focus to one most useful and acceptable to multiple interested groups. Information was collated (spreadsheet; metadata) and summarised in an easily readable form. At an end-of-stage in-person workshop (Sustainable Seas 2021a), 12 participants agreed this information form the basis of habitat suitability and shellfish species distribution maps for the Marlborough Sounds. These maps could then be used in multiple ways to inform management decisions and restoration efforts to advance EBM in the region. Workshop participants prioritised the need for the case study to have longevity beyond the period of Sustainable Sea Phase 2 and be linked to other/ongoing work. This premise, and the previous work and korero by the development partners underpin this Stage 2 proposal.

J. AIMS

This Marlborough Sounds case study will develop a method for shellfish-ecosystem evaluation and management in a region of stakeholders with diverse interests and values. It will produce a decision support tool in the form of an interactive (and updatable) mapping product to visualise the current state – and state of knowledge - of shellfish and their habitats and prioritise EBM activities and future restoration efforts. Our specific aims are, to

1. Integrate existing information to map distributions of shellfish and their habitats;
2. Carry out predictive distribution modelling to generate information on expected distributions of shellfish and their habitat;
3. Develop a longer term ecosystem based management plan for shellfish in the Marlborough Sounds.

This project will inform, enhance and improve EBM practises, providing a pathway and plan for improving shellfish populations and habitats that can guide future management actions and priorities. Identifying local aspirations for shellfish recovery, and the information and activities required to achieve these, will form part

of Aim 3.

K. PROPOSED RESEARCH

The Marlborough Sounds is a large, diverse and complex area, for which a great amount of information relevant to the project and the aims of the Challenge and EBM already exists. The information is wide ranging - spanning local knowledge and history, ecology, habitats and oceanography (e.g. Giles 2021). Combined, it can provide a framework for prioritisation and evaluation of ecosystem-based management strategies and interventions, within which future targeted on-the-ground activities can be embedded.

The shellfish focus for the Marlborough Sounds case study was co-developed at previous workshops attended by representatives of iwi and stakeholders from the Marlborough community, central, regional, and local government, as well as researchers. Stage 1 of the case study included the scoping and collation of metadata on shellfish-relevant information in the Marlborough Sounds, and has identified data and information to form the basis of maps of current shellfish habitat and distributions. These maps, which will be produced as part of this project, will allow us to highlight areas of interest, including shellfish hotspots, areas with important shellfish habitat now, where shellfish were thought to be previously (and may have degraded). Also important will be identification of information-poor areas for further exploration. Species distribution modelling - a tool which is increasingly being used to predict distributions and abundances in spite of a lack of comprehensive baseline data (e.g. Townsend et al. 2018) – will then be implemented to predict the occurrence and abundance of shellfish of interest in the study area (Rullens et al. 2021).

Together, the models produced for various areas of Marlborough Sounds will provide a framework to enable prioritisation of management strategies and interventions aimed at reducing the gaps between current and desired shellfish ecosystem states. This may include recommendation of areas for marine protection, where ecosystem stressors need to be reduced or alleviated, and for implementing activities for restoration of the habitat, species or catchment. Many shellfish are suspension feeders which prefer sandier bottoms (low mud content) and low suspended sediment concentrations (e.g. Ellis et al. 2002). A key outcome will be identification of habitat that *could* support shellfish but currently does not due to historical activities (e.g. overfishing); these areas could benefit from active restoration. In choosing locations for targeted activities we will also consider their connectivity (through hydrodynamics) to other areas; for example it may be advantageous to restore reproductive populations in areas that are important sources of potential larval colonists to already 'healthy' areas (e.g. Broekhuizen et al. 2011; Lundquist et al. 2009, 2012; Norrie et al. 2020). As well, this could result in identification of areas where stressor management alone should lead to improvements without the need for active restoration or enhancement (e.g. a focus on reducing elevated suspended sediment concentrations from coastal runoff). Plans for, and prioritisations of strategies and interventions may include understanding current and future stressors and risks, and evaluation of likely outcomes (success) of the various potential management and policy options.

Our approach to this Marlborough Sounds case study is to provide a pathway and plan for improving shellfish ecosystems (species and habitat) that could guide management actions and priorities. We will develop a framework for shellfish-ecosystem focussed management practises, in a region of stakeholders with diverse interests, backgrounds and values. It is important to consider the different drivers, desires and needs across this broad spectrum of stakeholders to ensure our 'product' has maximum usefulness. We note that despite the differences, these groups generally share a common goal of a healthy sustainable ecosystem for future generations. We recognise the need for strong community and tangata whenua engagement, and the ability to align to local needs and at multiple scales. We envisage that our learnings and experience will inform and enhance EBM elsewhere.

Aim 1. Integrate existing information to map current knowledge of shellfish and their habitats in Marlborough Sounds.

Sourcing data and generating maps. Data and information on Marlborough Sounds exists from a many studies conducted over a number of decades (Giles 2021). In this first step of the case study, metadata relevant to shellfish will be amalgamated, including that identified in an earlier review (Sustainable Seas 2021b) and additional information identified by partners. All of the shellfish species for which there is quality data and that are present in reasonable abundances will be considered in the initial data analysis and mapping. The distribution and level of detail for this information will then be visualised in map form for the two main Sounds, Pelorus Sound/Te Hoiere and Queen Charlotte Sound/Tōtaranui. Data availability will likely be a limiting factor that will drive the robustness of our models and uncertainty in their predictions. This high-level mapping exercise will help identify areas within each Sound where useful species distribution maps could be generated and enable identification of particular areas to focus more detailed mapping/modelling (e.g. a region or an arm within each Sound) and areas that need more research effort. The metadata maps will be examined by the research team, and decisions made on focal areas for further modelling. The geographical location and species for study will be well focused after this initial data analysis. Local ecological knowledge for areas of interest, informed by tangata whenua and community values and priorities, will be included in this decision making. Once the focus areas have been identified, links with local iwi/hapū/whanau will be able to be made/expanded and their potential involvement in the project will be further explored (e.g. engagement via hui, student/intern(s) involvement).

Data on bivalve presence/absence, abundances and trends for the focal areas will then be sourced (from councils, government agencies, report/research paper authors) where available. Our data compilation will include collection details (e.g. when collected, where, replication, methods) so that maps can be generated at multi-spatial and temporal resolution, and the bounds of the data appropriately specified. This data will be used to generate maps of species' current distributions, which will be reviewed by project partners and finalised.

Aim 2. Predictive distribution modelling of shellfish and shellfish habitat.

Using the map(s) to predict distributions and identify suitable shellfish habitat, and to highlight data gaps.

Predictive modelling will generate species and habitat distribution models of shellfish, expanding the models of current distributions developed in Aim 1. Models will incorporate environmental information (e.g. seafloor sediments, currents) including hydrodynamic models and coastal bathymetry (e.g. Hadfield et al. 2014; Broekhuizen et al. 2015; Broekhuizen & Plew 2018; LINZ HS66 Hydrographic Survey, 2019; Watson et al. 2020). The maps will be reviewed to identify locations where new/more data need to be generated or existing data needs to be validated (the data is considered outdated, contrasting anecdotal evidence exists). Different partners will carry out these activities, and this information, including mātauranga knowledge (as in Aim 1) will be incorporated into updated maps and models.

Models will be used to predict the probability of occurrence of a shellfish species, and, importantly, their expected densities (Rullens et al. 2021) and/or the distribution of habitats where conditions are potentially suitable for filter feeding shellfish to thrive (e.g. Ribó et al. 2020). Species distribution models relate species occurrence or abundance data at known locations with information on the environmental and/or characteristics of those locations (Elith & Leathwick 2009). Decision trees (e.g. Random Forest, Boosted Regression Trees or BRTs; Elith et al. 2008) will be the preferred method, having been successfully applied for shellfish presence and abundance in Tauranga Harbour (Rullens et al. 2021). Models will be built as a Hurdle model, in which the probability of occurrence (based on presence/absence of a species) is predicted first, followed by a model in which abundance is modelled conditional on the species presence (e.g. Dedman et al. 2015, Rullens et al. 2021). Areas of limited data availability within our focal areas will be highlighted and compared against model confidence estimates to identify areas of interest for future monitoring programmes. Furthermore, areas predicted to have environmental conditions suitable for shellfish that currently don't support populations, will be assessed to determine the cause (e.g. known areas of high stress)

and potential for restoration projects.

Species distribution models will be generated in R statistical software (R core team, 2020) and distribution map(s) will be generated in ArcGIS, by researchers experienced in spatial ecological modelling. The final maps and models will be agreed with co-development partners including community and tangata whenua. Distribution map(s) will be hosted on the Marlborough District Council smartmaps service, which is accessible and usable by all (https://www.marlborough.govt.nz/services/maps).

Aim 3. Develop an ecosystem based management plan for shellfish in the Marlborough Sounds.

Results of Aims 1 and 2 will be used to generate **shellfish-centric management priorities** for our Marlborough Sounds focal areas. We will incorporate the needs and concerns of the multiple stakeholders that make up our co-development group, by (i) developing this plan with the group, (ii) integrating it with other work completed, underway in/planned for the region, and (iii) building on knowledge from other Sustainable Seas SS projects.

Distribution maps from Aims 1 and 2 will provide a framework against which to assess the current state of shellfish ecosystems. With our co-development partners, and working towards the shared goal of a healthy, sustainable Marlborough Sounds ecosystem for future generations, we will ***evaluate the disconnects between the current and desired shellfish ecosystem states***, through a combination of virtual and in person meetings, and survey(s). If tangata whenua capacity limits the ability to for involvement through in-person means, there will be documented information available to draw from (e.g. tangata whenua aquaculture plans). The reasons for any disconnects will be examined, and sources of knowledge and data not specific to shellfish may also be considered, and/or added to this map to expand its usefulness. These may include environmental variables experienced by the shellfish that could affect their successful establishment and maintenance of their populations longer term (e.g. knowledge of anthropogenic influences and environmental stressors, such as those available from other Sustainable Seas National Science Challenge projects). The maps will contribute to prioritising research and/or restoration of shellfish around the Sounds. By understanding these disconnects in our focal area(s), we can identify the activities required within the ecosystem to mitigate impacts and restore suitable habitat, maximising the potential for sustainable shellfish populations in future. In this way the project is supporting an EBM approach to managing shellfish in the Marlborough Sounds.

The team will ***identify and prioritise intervention activities,*** considering (i) areas/species of concern, (ii) what can realistically be achieved (thereby managing expectations), (iii) the impact of our activities. When time allows, we will evaluate the associated risks and benefits of each option, their feasibility and effectiveness if successful implementation was possible (e.g. risk assessment matrix; Morrison et al. 2015, Hare et al. 2016).

Priority activities will be multi-level, including those that can be undertaken by a range of groups (councils, central agencies, schools, community groups, tangata whenua). Thus, smaller scale activities that align to local needs can contribute meaningfully to a larger coordinated plan, methods successful elsewhere can be used (e.g. Handley et al. Envirolink) and success can be compared across locations. Care will be taken to tailor any mapping, modelling and management plan outputs to meet the needs of tangata whenua specifically, by seeking their involvement or feedback on approaches, design, development and testing. Due to the limited duration (2 year) of this project, we will generate a management plan and activities that continues beyond this project's lifetime (e.g. 10 years).

Identify and prioritise species and/or areas for remedial action and longer-term shellfish ecosystem management needs. We will leverage and where possible incorporate research initiatives that are already underway - both in the region and elsewhere. We will be guided by the objectives of the Kotahitanga Alliance (2019), which have carefully laid out the process for considering and planning future activities (e.g. Interagency Management Group's shellfish plan; Jorgensen 2020). We will align with programmes that bring together the representation and interests of multiple parties (e.g. Te Hoiere Catchment Restoration Project,

Southern Scallop Strategy), and biophysical research underway in Tōtaranui (Project 1.1 *Ecological responses to cumulative effects*). We will also learn from initiatives that are underway elsewhere in NZ; for example, by linking with research teams working on shellfish restoration in the Hauraki Gulf. Linking with the Te Hoiere Catchment Restoration Project will be key to work in that area, with benefits likely in both directions as that project's 'marine stage' is initiated in 2022.

L. LINKS TO PHASE I RESEARCH

Project 4.2.1 (Simon Thrush) Tipping points in ecosystem structure, function and services;
Project 4.1.1 (Steve Wing) Ecosystem connectivity: tracking biochemical fluxes to inform EBM;
Project 2.1.3 (Drew Lohrer) Measuring ecosystem services and assessing impacts;
Project 2.1.1 (Jim Sinner) Development of valuation frameworks and principles;
IF4.3.2 (Malcolm Clark) Sediment tolerance and mortality thresholds of benthic habitats on the Taranaki Shelf.

M. LINKS TO & INTERDEPENDENCIES WITH PHASE II RESEARCH PROJECTS

Project 1.1 (Simon Thrush, Kura Paul-Burke): Ecological responses to cumulative effects. Particularly with research related to tohu and recovery of key shellfish and kelp species.
Continuation of project CP2.1 (Judi Hewitt): What could EBM look like in Tasman and Golden Bays? Trial use of system dynamic mapping with iwi and management stakeholders and causal loop mapping with Ngati Tama around scallop management.
Project T1 (Kura Paul-Burke): Awhi Mai Awhi Atu: Enacting a kaitiakitanga-based approach to EBM – using matauranga and western science (eg hydrodynamic models and SDM, iwi organisations and local government interactions stakeholders.
Project 1.3 (Ewa Siwika): Community restoration.
Innovation Fund project 2.15 (Phil Ross): Thinking outside the can: Engineering toheroa aquaculture
Project S1 (Carolyn Lundquist): Enabling EBM in the Hawke's Bay - Stage 2. Co-development of potential management interventions to reduce the gaps between current and desired states.

N. VISION MĀTAURANGA (VM)

Tangata whenua capacity limitations, and the lack of specificity of the areas for research focus early in this project, have limited their availability to be named as active members of the research team. However representatives have attended all of the workshops held previously that have helped to direct this proposal, and their ongoing involvement will be sought to refine aspects of the project and at key activity milestones (e.g. identifying tangata whenua values and priorities, design and development of outputs). Progress updates will continue to be sent to the entire community. We will seek input to tailor our mapping, modelling and management plan design and development activities to meet tangata whenua needs, thus ensuring their utility in informing tangata whenua management and decision making.

Vision Mātauranga Deliverables

Partnerships:

VM P1 none

VM P2 none

Distinctive Contribution:

VM D1. In person workshops to review proposed outputs will be held associated with Tasks c, f and g, and will include tangata whenua representatives

Meaningful Outcomes:

VM M1. Management plans developed will be empowering in terms of encouraging and enabling the provision of space and resource for tangata whenua to be active in decision making and implementation.

O. ENGAGEMENT REQUIRED WITH IWI AND STAKEHOLDERS

We will continue to engage across all interested stakeholder groups, through regular electronic updates (e.g. newsletter), along with virtual and in person workshops (at least 3) at specific stages of the project. Once our focal area(s) have been identified, we will engage specifically with the local iwi/hapū/whanau and encourage involvement in the project (should their capacity allow).

P. PROJECT COMMUNICATIONS

This project will engage with a wide range of iwi, stakeholders and decision-makers through its already established distribution list of 19 people (excluding Sustainable Seas researchers). We will work with this network, using newsletters, websites and other venues for communications. At the conclusion of the project, summaries will be prepared and designed with the Sustainable Seas communications team, to ensure their understanding by a general audience.

Q. RISK & MITIGATION

Primary risks are working with a stakeholder group built of diverse partners, potentially with conflicting objectives, and/or an unfocussed case study, which make it challenging for some groups to commit time and resources. Two-way communication is key to mitigating these risks. The pathway that we have outlined involves workshops at key stages of the project to ensure that all voices are heard regarding input to the project outcomes and utility of those outcomes. We have included resources within the budget to enable attendance of key groups at the workshop, should this be required.

R. CONSENTS & APPROVAL required to undertake research	• None. • Consents may be required for on the ground activities, but these will be applied for if and when they are required.

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