SUSTAINABLE SEAS | Ko ngā moana whakauka | National Science Challenges

Project Proposal Template

A. TITLE OF PROJECT

2.1.3: Measuring ecosystem services and assessing impacts

B. IDENTIFICATION

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C. ABSTRACT

The Sustainable Seas mission is to enhance use of marine resources within environmental constraints. It is acknowledged that the species and habitats in our natural marine ecosystems provide many 'Ecosystem Services' (such as the provision of wild seafood and the remediation of wastes), but we lack specifics on: how marine biodiversity supports the delivery of multiple ecosystem services; where hotspots of ecosystem service delivery may be; discrepancies between where services are produced and where associated societal benefits are realised; and how human impacts on the marine environment affect service delivery. In this project, with improved measures of ecosystem service delivery and understanding of how human activities impact these, we can better articulate the links between ecosystem services and stakeholder perceptions of value and benefit in case study areas, which will facilitate cutting-edge ecosystem-based management. Our work will tie in with many other Sustainable Seas Science Challenge Projects and will feed into major international initiatives including the Intergovernmental Platform on Biodiversity and Ecosystem Services and the new TEEB (The Economics of Ecosystems & Biodiversity) 4 Oceans and Coasts programme that was recently launched in New Zealand.

D. INTRODUCTION

The importance of the natural environment for sustaining human life has been implicitly or explicitly recognised by civilisations for millennia. In the face of growing pressure to improve environmental stewardship and manage resources sustainably, frameworks based on 'Ecosystem Services' (hereafter ES) have been used to identify, link and communicate the benefits of nature to humans [1-3]. The ES concept forms the bridge between underpinning ecosystem functions generated by species and habitats, the benefits we receive from the marine environment, and the values we place on it [4-5]. Integrating environmental, social and economic perspectives [6], the ES concept increases the 'visibility' and traceability of the ecosystem components in support of long-term sustainability [7-8]

ES have been adopted worldwide and are now supported by international organisations and initiatives including the United Nations Environment Programme (UNEP), the Inter-governmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO), the Convention of Biological Diversity (CBD), Europe's Marine Strategy Framework Directive (2008/56/EC), and the global TEEB initiative (The Economics of Ecosystems & Biodiversity). This is driving the need for innovative research to move ES beyond 'compelling concept' and into the realm of 'practical tool' [9].

This project will use ES to provide the connection between nature and human values and to understand the scale of threats to ES and values, while considering the potential for services to be valued at different space and time scales. In order to achieve this we will confront three major challenges. Firstly, for many marine ES, data and methods to measure individual services are lacking; we will validate recently developed proxies [10-11], and devise new measures where appropriate. Secondly, impacts of human activities on service delivery are not well understood, even when impacts on processes underlying the services may be. Using a variety of experiments, surveys and modelling we will determine impacts of selected human activities on delivery of selected services. Thirdly, ES are only just beginning to be linked directly to social values, but this is critical to understanding impacts of activities on perceived values and using ES within an EBM framework. We will develop processes to: link values to the specific ES that underpin them and communicate this information to the communities holding those values; and to understand whether, and how, decreases in service delivery affect perceptions of values.

This project interacts with many other key challenge projects and will support the Sustainable Seas Science Challenge mission by providing a more holistic accounting of the potential social and economic trade-offs or non-negotiables in the both direct and indirect use of marine resources. These interactions will allow us to provide internationally cutting edge research in an area that is often lacking in current EBM utilisation.

E. AIM OF THE RESEARCH AND RELEVANCE TO OBJECTIVE

This project will facilitate marine environmental decision-making, stewardship and sustainability by elucidating the multiple values and uses of marine systems. It will also provide information on the broader implications and consequences of degradation stemming from multiple uses. First, we will develop appropriate and cost-effective methods and indicators for (a) measuring and predicting individual marine ecosystem services and (b) linking them to the values held by Māori and stakeholders. Perceptions of value associated with marine ecosystems will be canvassed from Māori and a diverse range of stakeholders[1] early in the project to ensure that measurement methodologies for the most relevant set of ES are developed. This will provide for a seamless integration of ES into ecosystem-based management. Secondly, we will assess the impact of selected human activities to specific ES and follow this by research on how this may change social values. Where possible, we will evaluate impacts stemming from individual activities as well as cumulative effects, acknowledging the potential for crossing of tipping points in service delivery.

F. PROPOSED RESEARCH

This is a primarily biophysical research project composed of 4 interactive work streams that match the aims above: (1) understanding values and how they are underpinned by ES; (2) developing and validating measures (or proxy measures) of ES; (3) understanding the impact of human activities on

[1] As per the definition in the Sustainable Seas National Science Challenge Science Plan, this includes industry, government agencies, NGOs and communities.

ES delivery; (4) understanding how changes in service delivery affect human perceptions of values. Given the number of potential values, services and human activities, the project will initially focus on a subset of values, supporting services, and human activities.

1- **Values and underpinning ES**. This stream will link strongly to work undertaken in project 2.1.2, where non-monetary values including Māori values will be identified. We will use the collaborations developed with project partners and local communities in Project 2.1.2 to co-produce a **subset** of both **values** of specific interest to Māori and local communities, **and human activities** that may impact on them. The potential for generalisation from these locally situated values to the broader New Zealand context will be determined by reference to the review also being conducted in Project 2.1.2 and may lead to broadening of the values incorporated in this study. A workshop with industry and management agencies operating in each of the project 2.1.2 case study areas using semi-structured focus group questions will determine a set of activities, and consequent positive and negative influences on different ES, to be studied in the project.

Co-development methods identified as most useful in the initial phases of Project 2.1.2 will then be used to co-produce community understandings about the specific ES that underpin values and **select specific ES** for use in streams 2 and 3. During this co-development phase, discussions will illustrate how ecosystem functions support ecosystem services and provide benefits to society. While ES offers a common language to link human values to underpinning ecosystems functions, ES has become very jargon rich. Thus although we will use current terminology (the European Environment Agency's Common International Classification of Ecosystem Services [CICES Version 4.3] and the UK's National Ecosystem Assessment), we will adapt and enhance this to ensure all participants' values are respected and represented. Strategies for communicating results to the general public will also be co-developed here for use by all work streams in the project.

2- **Measuring ES**. In the true spirit of EBM, we do not have a predetermined list of ES that will be studied, making it difficult to provide exact methods. However, the procedures followed are likely to involve: validation of a method for estimating ES in data scarce areas; determining relationships between key species and habitats with ES delivery; and development of robust methods or surrogates for measuring ES delivery.

(A) Estimation of potential ES delivery based on the Ecosystem Principles Approach [10-11]. This method acknowledges the difficulty in assessing ES delivery from complex mixtures of ecosystem functions and processes, particularly when the distributions of habitats and species contributing to ES delivery are unknown, but it needs further development and proof-of-concept testing. The method is built upon broad and general ecological concepts or theorems. The simple ecological 'principles' that form the basis of the method (e.g., that sunlight is needed to drive primary production; that clear water supports more productivity than turbid water; that deeper water attenuates more light than shallow water [10]) can be linked to basic biophysical data that varies in space and time. In this way, areas of relatively high and low service delivery can be mapped [11], but note that this is a "potential" ES delivery unaffected by human activity. This method will be validated for the selected ES in at least two areas, one of which will be the Tasman/Golden Bay case study area. If any of the selected ES were mapped previously in Tasman/Golden Bay during MBIE programme MAUX1208, this information will form a key part of the empirical validation procedures. It will allow us to compare maps produced by alternative methodologies, and to judge each map type relative to empirical measurements. The best available ES maps will be provided to the cross programme project CP2.1.

(B) Determination of the relationship between density and health/condition of key species and habitats in the delivery of ES. Previous work in New Zealand funded by DOC has examined the use of an approach developed in the UK by Potts et al. [12], which related particular ecosystem components (specific habitats and species) to provisioning, regulating, supporting and cultural ES.

However, in this approach, the relationship between ecosystem components and ES is usually defined by 'expert opinion', and components are usually judged to contribute to particular services in an all-or-nothing manner. We will conduct surveys and experiments to determine actual relationships between selected key species or habitats and ES delivery, including the potential for environmental factors to affect results. The surveys and experiments will be conducted across known environmental gradients to elucidate how relationships change with environment context. The locations for this work will be driven by data availability on benthic habitats (e.g., Tasman/Golden Bay; Bay of Islands and up to Spirits Bay; Kawau Bay; Taranaki Coastal Region; Bay of Plenty; Chatham Rise) and the need to cover a range of environmental (including hydrodynamic and oceanographic) conditions.

(C) Both of these methods require the ability to objectively assess levels of ES delivery, in 2A to allow validation of the method to occur and in 2B to allow assessment of relationships. Objective, preferably quantitative, measures of ES delivery will also be needed for work stream 3 (described below). Because robust measures for most ES do not exist, method development or identification of surrogates will need to be undertaken. This is likely to involve field measurement of the functions underlying the ES, in relation to environmental or ecological variation (e.g., density of key species) followed by modelling to scale-up functions to 'systems-scales' and develop linkages to service delivery. We will apply and adapt new statistical approaches (e.g., Structural Equation Modelling, Species Distribution Modelling) as well as seek to develop power law scaling relationships. For example, if the goal was to quantify the capacity of the sediment (and its biota) to remove inorganic nitrogen and remineralise organic carbon, we would make empirical measurements of denitrification and organic matter degradation in soft-sediment habitats at numerous sites in at least two locations. We would then upscale these small-scale estimates using models to determine removal efficiencies per time at scales associated with management, or at the scale required for use in work streams 2A and 2B. Dependent on how time consuming and expensive the data collection of the functions were, potential surrogate variables would be collected and assessed for utility using multiple regression or multivariate canonical ordination techniques. The proxies and surrogate variables that we develop may or may not respond to environmental variation in the same manner as quantitative measures do; an important aim of this project is to understand the sensitivity of surrogate variables in different environmental contexts.

3- **Impacts on ES delivery.** The actual impact of human activities on ES delivery is mediated through impacts on ecosystem functioning (species, communities and ecosystem processes). While the impacts of some activities on ecosystem functioning are understood, the resultant effect on ES delivery is rarely known. In this work stream we will use three methods to move from impacts on ecosystem functioning to ES delivery. (A) Statistical analysis of the relationships between intensity of human activities and differences in ES potential from measured ES observed in surveys. This will initially focus on the Tasman/Golden Bay area where aquaculture, fisheries, recreation, tourism and conservation activities occur, as well as land-based activities that deliver sediments, nutrients and contaminants to the system through riverine inputs. The intensity of many of these activities has been assessed and is available for this project. (B) Experimental manipulation of the major stressors associated with the selected human activities and measurement of resultant changes in the proxies or direct measures of ES identified by work stream 2 (we anticipate links to project 4.2.1 _tipping points). These manipulations will take place at a subset of locations that are used by work stream 2 and Project 4.2.1 and are likely to involve combinations of stressors. (C) Modelling of the impacts on ecosystem functioning, including interactions between functions that supply specific ES, to determine how probabilities of changes may transfer, accumulate or dissipate. Initially this is likely to be done using Bayesian Belief Network Modelling [13], although this may change over time as the project develops, to the more sophisticated methods being developed in Dynamic Seas (4.2.1, Tipping points).

4- **Impacts on values**. The role of values in present management and how changes in values by human activities (e.g., decreased desire to snorkel along reefs due to lack of water clarity, or acceptance of increased turbidity over time) will be assessed from participation in a review and workshops being conducted in project 2.1.1 in 2016-2017. Here we will seek to incorporate local, national and international assessment of values and how they are likely to impact on the importance of different ES. This will form the starting point for a series of discussions (using the same co-development methods as work stream 1 and conducted in conjunction with Tangaroa Project 3.1.2 [Kaitiakitanga in practice in our marine environment]) with local communities on how changes to ES delivery may result in changes to what they value and how this type of information could be dealt with in EBM. As perceptions of benefit and value associated with the sea shift from place to place, and as risks to benefits and values will also vary from place to place in accordance with the types and levels of environmental stressors and the specific composition of communities, this research will need to be conducted in a range of locations. These will be chosen with regard to locational differences in values highlighted by the review conducted by Project 2.1.2 in 2016-2017, and also to the locations selected for study in streams 2 and 3, which are likely to cover a range of differing hydrodynamic conditions and human activities. However, efforts will be made to avoid stakeholder fatigue by choosing alternative but acceptable sites as needed and linking to other Challenge projects.

Phase 2

Within the short time period of the first phase of the Challenge only a few priority services and stressors will be able to be investigated. Similarly, perceptions of related degradation to values will be limited. In phase 2, new supporting services and activities will be selected for analysis, driven both by Māori and stakeholder input, but also by information derived from projects 2.1.2, 2.2.1, 3.1.2 and CP2.1. Depending on the findings of projects 2.1.1 and 2.1.2, marginal valuation research may be undertaken during Phase 2. Perceptions of degradation will also be expanded to new communities and locations to increase generality of results. Interpretation of results will be fine-tuned to allow maximum use in the models in the blue economy modelling of project 2.2.1.

G. ROLES, RESOURCES

We have assembled the best team in New Zealand in terms of track record of research on ecosystem services, and boast oceanographers, ecologists, social scientists, economists, modellers, and Maori researchers, representing multiple institutions and a range of career stages. Members of the team regularly publish in high impact international journals, and have published seminal articles on ES, ecosystem principles, ecosystem functions, and 'wicked' problems (see CV section). We will use the diverse skillset and experience of the investigators to meet the programme objectives. The project leader, Lohrer, has spent more than a decade building knowledge on the role of key benthic species in driving ecosystem function, in conjunction with Hewitt, Pilditch, Thrush, Townsend, and others. Lohrer currently manages a large NIWA core-funded project where initial explorations of the links between function and service were undertaken; this core research is aligned to the Challenge and Project 2.1.3 specifically. Thrush and Townsend were co-developers of the Ecosystem Principles Approach. Cornelisen and Knight (Cawthron) have developed expertise in ecosystem services, having characterised seventeen ES in the Tasman Bay – Golden Bay area (MBIE contract MAUX1208). This involved multiple stakeholder workshops and interactions with environmental economists, experiences that will benefit this project. Law and Pilditch will provide water column and offshore oceanographic perspectives that are needed, given the primarily coastal benthic emphasis of many of the other researchers in the team. Awatere and Davies will oversee and guide the social science and Maori engagement that is critically important for project success. Davies, a NIWA post-doc (formerly supervised by Thrush and Fisher, who are also leading Challenge projects), is making her

mark in New Zealand marine science, and internationally, using innovative participatory processes. Awatere, who will provide vital economics perspectives, is also the Project Leader of Valuable Seas project 2.1.2 (Mauri Moana, Mauri Tangata, Maura Ora – Documenting Social Values), which will facilitate the incorporation of Matauranga Maori in our project and encourage co-learning.

H. LINKAGES AND DEPENDENCIES

This project is not dependent in the first phase on results from projects in Dynamic Seas, but will benefit as time progresses from the results of those projects. In particular the potential exists for tipping points identified by project 4.2.1 to be exacerbated by lags in value perceptions, or by supporting services that integrate across key species or ecosystem components. The project also links strongly with projects 2.1.2 and 3.1.2 utilising collaborations and results on values derived from these projects. It will provide outputs that can be used in:

- Project 2.1.1 on human activities and their likely impact on specific values to assist with setting parameters for choice modelling or other scenario testing
- Project 2.2.1 on likely effects of particular combinations of human activities and results of trade-offs
- Project 5.1.2 on layers of service and value impact to be incorporated in spatial planning
- Project 5.1.3 to add to estimations of risk and incorporate in expert elicitations
- and project 5.1.4 to add to participatory models that the general public can use to visualise effects of specific activities and management actions.

I. COLLABORATIONS

The research team engage in a range of research but this project is not dependent on any.

J. INTERNATIONAL LINKAGES

Dr Carolyn Lundquist of NIWA and University of Auckland (and leader of Our Seas) is currently a coordinating lead author and contributor to IPBES, the Intergovernmental Platform on Biodiversity and Ecosystem Services (http://www.ipbes.net/), which will provide avenues for international information transfer and impactful uptake of project results. We will also be closely involved with the new TEEB (The Economics of Ecosystems & Biodiversity) 4 Oceans initiative that is being kicked off in New Zealand; a TEEB 4 Oceans workshop was hosted by University of Auckland, the Department of Conservation and the Challenge itself in July 2015, and several key international connections (e.g., Yannick Beaudoin) were strengthened through team members Thrush, Lohrer, and Townsend. The researchers involved in this project have close connections to many of the top ES researchers working today. For example, Prof Nicholas Hanley, University of St Andrews, UK, is an internationally renowned environmental economist and has collaborated with Townsend on a number ecosystem service projects and continues to support the development of our ideas in this space. Prof Melanie Austen, is Head of Science at Plymouth Marine Laboratory, UK, leading the 'Seas and Society' area of science. She was a lead author on the marine chapter of the UK NEA (2011). Dr Nicola Beaumont, Plymouth Marine Laboratory, UK is an interdisciplinary scientist who combines marine science with environmental economics. Dr Stefanie Broszeit, Plymouth Marine Laboratory, UK is a marine ecologist now working in the ecosystem services field. Relationships to a team from the Univ. of British Columbia (Dr Sarah Klain), who has worked on value mapping and ES using participatory mapping techniques, have been fostered by Chris Cornelisen and others at Cawthron. Also, although Dr Joanne Ellis (Cawthron) is moving to a University position in Saudi Arabia, she is keen to continue involvement in this project and support ES work in New Zealand. Finally, Prof Alf Norkko, Professor of Baltic Sea research, Finland and Prof Ronnie Glud, University of Southern Denmark are presently researching techniques for assessing and scaling up benthic metabolism.

K. ALIGNED FUNDING AND CO-FUNDING

This project is dependent on aligned core funding from Coasts and Oceans Programme 5. Within this programme, there are projects related to measuring ecosystem functions and ecosystem services. Not only will past results from these core funded projects be used in this project, but the core funded projects will provide support in terms of human resources, equipment and field-related expenses for components of this project related to (1) linking values to services and (2) field validation and measurement of ecosystem services. The latter is most likely to take place outside Tasman and Golden Bays to extend the generality of any findings.

L. VISION MĀTAURANGA (VM)

Throughout our project we will seek to capture and translate unique iwi perspectives on values and benefits associated with the sea, initially building on relationships developed during the MBIE Smart Ideas project 'Integrated Valuation of Marine and Ecosystem Services' (Cawthron). Strong links to project 2.1.2 led by Shaun Awatere (Mauri Moana, Mauri Tangata, Maura Ora – Documenting Social Values) will be used to ensure that mātauranga Māori is utilised appropriately and to maximum effect. Links to Tangaroa Project 3.1.2 (Kaitiakitanga in practice in our marine environment) will be used to engage with Māori as partners in management of marine resources. It is our hope that the co-development strategies used in our project will both allow Māori traditional knowledge and values to be incorporated and enhance their role as as tangata whenua and kaitiaki.

M. COMMUNICATION AND OUTREACH

We will use the outreach and communications facilities of the Challenge to the fullest extent to effectively engage with communities. The involvement of social scientists in our project and the communications teams at NIWA and other participating organisations will ensure wide coverage of the project in the local and national media. The stakeholder workshops (with representation from the general public, Māori, Department of Conservation, fishing and aquaculture industry, etc.) will provide excellent opportunities for direct information sharing and knowledge transfer. The articulation of the benefits of marine systems in simple non-technical language is a key component of the ES concept, which by its very nature lends itself to communications and outreach. This will be a key strength of our project.

N. CAPACITY BUILDING

During this project, we will oversee the development of a NIWA post-doctoral scholar (Kate Davies), and two PhD students will be trained at the interface of environmental science, social science and economics. This project will be linked to the Tangaroa theme of the Challenge and to other areas of the Valuable Seas programme, and will give the students the opportunity to be supervised by New Zealand's foremost authorities on marine ecosystem services and to join an internationally recognised team.

O. ETHICS APPROVAL

Ethics approval for this research will be sought using NIWA's Human Research Ethics Approval Process, as this is the host organisation for this project. Investigators based at other institutions will comply with their own ethics policies as required.