

A. PROJECT TITLE

Near real-time forecasting using operational oceanographic forecasting of contamination risk to reduce commercial shellfish harvest and beach closures.

B. PROJECT TEAM

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C. ABSTRACT

As a result of being at the ‘end of the pipe’, the productivity (and revenue) of expansive shellfish growing areas in Tasman and Golden Bays is compromised by extended closures due to land-derived contamination and conservative closure criteria¹. Users of nearby beaches, among the most popular in New Zealand, are also placed at risk due to the inability to provide timely information on contamination risk: beaches are closed after the containments have arrived, and remain closed for some time after they have cleared. Our proposal will reduce the extent of commercial shellfish harvest and beach closures by addressing two priority needs identified by the aquaculture industry and Tasman District Council (TDC), including **refined closure criteria** and **operational catchment and oceanographic forecasting** that supports resource management in response to changes in coastal conditions and contamination risk.

These outcomes will be achieved by:

- delineating river plumes using state-of-the-art modelling, extensive hindcast datasets, and monitoring technologies
- forecasting contamination risk in time and space using leading coastal and catchment modelling tools and microbial risk assessment methods
- validating revised criteria through council and industry-led water/shellfish quality surveys combined with rapid bacteriological-testing technologies
- providing coastal models in an open-source format to enable operational forecasting capability to be picked up by a range of providers that can supply ongoing services.

The deliverables include a first-in-class dynamic management tool that will underpin closure criteria by providing a visual spatial forecast of physical conditions (e.g. surface salinities from river plumes) and predictions of contaminant risk. This will allow risk assessment of contamination to shellfish growing areas and neighbouring highly-valued bathing beaches in the region.

D. RELEVANCE TO CHALLENGE OBJECTIVE

- The research will lead to added value and increased economic returns using existing aquaculture space in Tasman-Golden Bays (estimated at \$1M/yr additional revenue, increasing to \$5M/yr as expansion proceeds), thereby *enhancing utilisation of our marine resources within environmental and biological constraints*.
- Forecasting tools that link rivers and the sea will provide visualisations of river plume behaviour, will complement currently funded projects and contribute toward ecosystem-based management of marine resources.
- Daily ‘nowcasts’ and forecasts combined with innovations in rapid bacteria testing will better inform beach closure decisions in the region, increasing recreational bathing days at some of New Zealand’s most popular beaches.
- Links to Dynamic Seas goals to describe connectivity in the region and Managed Seas objectives to provide tools useful for the development of sustainable industries in the region of interest.

E. INTRODUCTION

The vision of Aquaculture NZ is to increase annual revenues from a current ~ \$400M to \$1B by 2025. Arming shellfish growers with the tools required to more efficiently manage harvests and ensure safe and high quality products for export will directly contribute to achieving this target. An immediate problem facing shellfish aquaculture is a lack of evidence on the implications of river plumes on bacteriological quality of growing waters. Presently, simple indicators such as rainfall in a catchment, flow levels from adjacent large rivers or salinity at a shellfish aquaculture site are used as proxies for faecal bacteria contamination and to make harvest closure decisions.

In Tasman-Golden Bays (Figure 1), closure criteria for aquaculture harvests are largely based on river flows, which likely to lead to unnecessary closures. This is particularly detrimental in spring when shellfish are in peak condition, but bacterial risk may be low due to cleansing of catchments by higher rainfall over winter.

Councils have similar problems in managing bathing beaches, and currently make closure decisions based on limited or delayed information. For example, standard culture-based bacterial water quality testing requires 48 hrs to obtain a result, by which time people may have already been exposed to contamination.

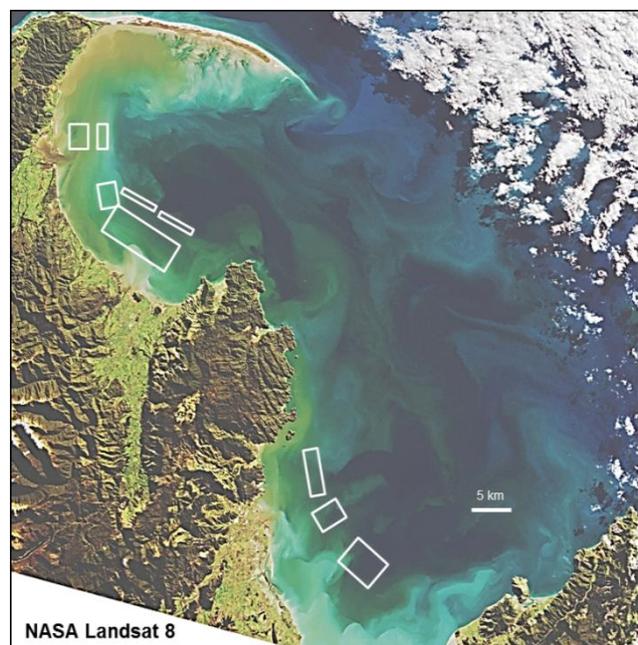


Figure 1. Tasman-Golden Bays following flooding with existing and proposed aquaculture areas in white.

Immediate gains can be made by improving data and tools that support new criteria for harvest closures and managing bathing beaches. For example, there are times when out-welling river plumes do not encompass farm areas, but farms are closed due to criteria based on river flows. In addition, existing data on river plumes indicate it can take more than a day for contaminated freshwater to reach aquaculture areas, which is time that could be used for harvest. Even one day can equate to hundreds of labour hours and revenue lost across farmers, harvesters, processors and exporters that depend on the flow of product. We estimate that improved harvest criteria and an ability to respond adaptively to changing conditions will generate an additional 10% harvest volume per annum (\$1M in export value) by shortening grow-out time, and improving mussel condition at harvest. This value would increase with growth in export revenue with planned and consented expansions in the Bays.

Currently there are insufficient data and tools to confidently change criteria and manage closures. Filling these gaps requires substantial coordination of resources and the right mix of expertise. This project pulls together modelling expertise in the domains of meteorology, catchment, rivers, coasts and ocean from three New Zealand research organisations (NIWA, Cawthron Institute and MetOcean Solutions Limited). In addition, specialist biologists and health sanitation experts are included to capitalise on the linkages between modelling and 'real-world' contamination risks.

Our project represents an opportunity to use a 'best teams' approach to combine existing datasets and models with new data and innovations to produce practical outcomes for managing contamination risk and maximising access to marine resources. Both marine farmers and Council are especially interested in obtaining faster estimates of faecal indicator bacteria (FIB) concentrations.

F. AIMS

Our project will achieve the following:

- A marked reduction in the economic and social impact of harvest closures in Tasman and Golden Bays by developing new closure criteria that narrow the gap between rain events and harvest access
- Development of operational catchment and coastal hydrodynamic modelling tools that support on-going application of criteria and dynamic on-farm management in response to changing coastal conditions and contamination risk
- Publication of forecasts for wider use, including an improved ability for Tasman District Council to manage closures of the region's internationally recognised bathing beaches
- Newly formed linkages in capability and disciplines of coastal oceanography, numerical modelling, remote monitoring technologies, and bacteria modelling and testing that will contribute toward meeting the Challenge mission and be highly transferable
- Provision of datasets and tools that can be used within the Challenge and beyond to visualise and communicate the importance of land-sea connections, stressor footprints associated with river plumes, and the economic and social benefits of taking an ecosystem-based approach to managing our marine resources
- A practical outcome from science innovation that will directly contribute to growing New Zealand's marine economy

G. RESEARCH APPROACH

The research reflects the spirit of the National Science Challenge by demonstrating the benefits of a cross-institutional collaborative science approach which combines expertise from a range of disciplines to contribute toward achieving the Sustainable Seas mission. The project will focus on

Tasman and Golden Bays, which fall within the Challenge's case study region and supports some of the country's largest existing (and future) aquaculture areas for shellfish farming and most popular bathing beaches. The overall approach and methods will be transferable beyond the study area. An innovative, dynamic management tool that enables and underpins refined harvest criteria will be a critical point of difference from the existing conservative management of aquaculture closures based on rainfall or river flows, which provides no spatial information on land runoff and associated contaminants.

Before undertaking the research, a Partners Group will be established for assisting in harvest criteria revisions and tool development. The group will include marine farmers, Trevor James (TDC), an MPI food safety representative, and Al Campbell (shellfish sanitation expert). This group will identify gaps to guide subsequent modelling and data collection for developing and validating criteria.

Years one and two of the research will initially focus on development and linkages of underlying river and coastal models and collection of data for developing models and shellfish quality criteria. Year two will involve the continued development of the models, operational tools, and the collection of additional data for validation at key locations within Tasman and Golden Bays.

Together with the Partners Group, the proposal brings together a best team composed of numerical modelling specialists from NIWA, Cawthron and MetOcean Solutions Ltd (MSL). NIWA will lead the operational catchment loading components of this work, and the collection of physical data to study the dynamics of the plume system and validate the hydrodynamic model. The outputs from the catchment and bacterial loading models will be inputs into a hydrodynamic model co-developed by NIWA and MSL staff. MSL will be responsible for operationalising the model within the project term and providing a web portal to make the data accessible. Cawthron scientists will focus primarily on the targeted collection of bacterial data for calibrating and validating criteria and models, and the construction of a management model to assist with the application of data and model results for assessing shellfish harvest and bathing risks.

The proposed research is organised according to the components presented in Figure 2.

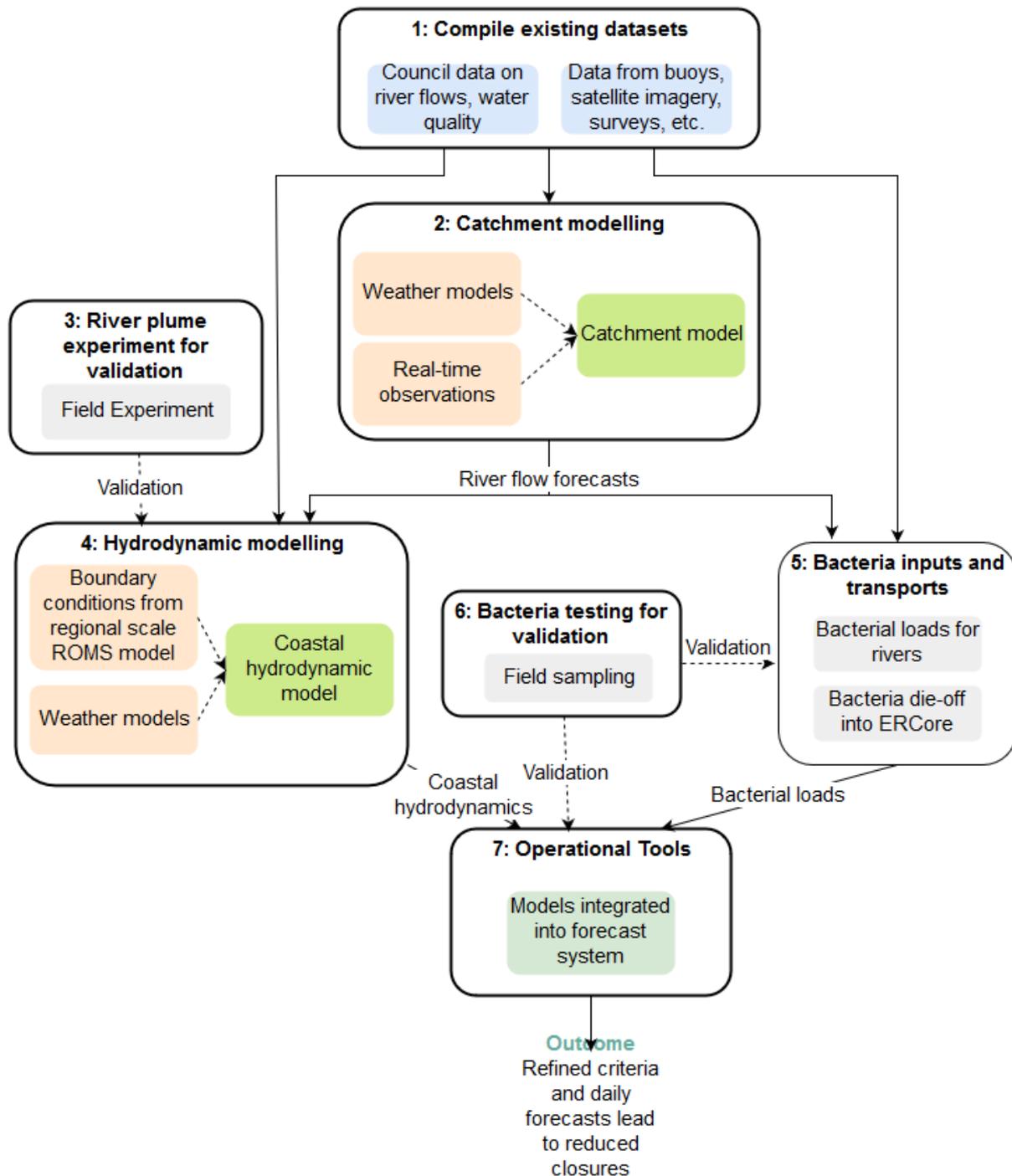


Figure 2. Major components of the proposed research. Note that the numbers correspond with milestones presented in Section O.

Catchment and river flow modelling

Coastal water quality issues in the study area are largely driven by riverine inputs. To successfully forecast coastal water quality requires knowledge of what the river flows are and will be. Within this project we will test the use of catchment models to improve estimates of freshwater inputs from ungauged catchments, and also to forecast river flows to extend the period over which water quality predictions can be made. NIWA will develop catchment models for Tasman and Golden Bays to provide the best possible predictions of river discharges to the coast. River flows, including from ungauged rivers and streams, will be predicted using the NIWA hydrological model TOPNET [1], driven by a high-resolution meteorological model and assimilating streamflow observations. The hydrological

model will be calibrated against measured river flows using NIWA's NZ Convective Scale Model (NZCSM) as input. The NZCSM meteorological model produces 36 hour forecasts at 1.5 km resolution. New forecasts are produced every 6 hours. At this scale, NZCSM can capture fine-scale variations in orographic and convective rainfall distribution that permits a high degree of accuracy in predicting river flows. For catchments for which there are no flow data, the model will be generalised based on weather patterns, soil type, land use and geology.

The coupled meteorological-hydrodynamic models will be used both to recreate river flows over the past ~2.5 years to enable validation of the coastal hydrodynamic model, and also used to forecast hourly river flow ensembles ~36 hrs in advance. The river flow forecasts will be shared via ftp for inclusion in the operational coastal hydrodynamic model. Validation of all gauged subcatchments within Tasman and Golden Bays is outside of the scope of this project. Subcatchment validation will be prioritised to the major sub-catchments of the Aorere, Motueka and Takaka catchments.

Hydrodynamic modelling

A down-scaled (high resolution) hydrodynamic model will be developed for the Tasman and Golden Bay regions using the SCHISM modelling platform [2]. SCHISM (Semi-implicit Cross-scale Hydrodynamic Integrated System Model) is an open-source 3D baroclinic modelling system based on unstructured grids enabling seamless spanning between high spatial resolutions in the near-shore environments and coarser resolution further offshore.

The developed model will be used as a cross-scale connector between a nationally validated shelf - scale ROMS dataset (~5 km resolution) and the coast, providing a high-level of spatial detail (e.g. about 20-50 m resolution) in the nearshore environment. This 3D model will use hindcast and operational ROMS data to provide the hydrodynamic flow fields in which the particle and microbial modelling aspects of the project will be built on. To ensure the outputs from these models are accurate, existing NIWA, Cawthron, Council, MSL and other data sources (e.g., Industry, Marlborough Shellfish Quality Programme-MSQP) will be used to calibrate and validate the physical aspects of the model. In addition, targeted funding for field research allocated for the Dynamic Seas work programme will be used to provide contemporary data to fill in any knowledge gaps in the existing data sets. This may include the use of nearshore released 'smart-drogues' to track plume movements and stratification properties or targeted boat-based sampling.

Key assets available for use in calibrating and validating the hydrodynamic model, and later driving the operational models, include the coastal observing platform TASCAM, which is permanently located near the aquaculture areas within the Motueka River plume (Figure 3), and the Golden Bay Marine Monitoring Buoy in the centre of Golden Bay. These systems provide near real-time data on a number of parameters that will be used in this project, including weather and currents, as well as salinity and temperature. The MSQP buoy in Golden Bay provide similar data, and if required, we will use sensor data from other locations (see attached support letter from MSQP).

A shared approach to hydrodynamic model development will be undertaken between MSL and NIWA. MSL will lead the development of the hydrodynamic model and focus on the operational (forecasting) aspects. NIWA will support MSL's work by focusing on model validation, and testing and comparing the influence of boundary condition data sources (wind fields, ocean boundary conditions, measured vs modelled river flows) and model parameterisations (mixing and turbulence schemes).

The first year of the project will focus on the model development. This will begin with the construction and validation of the coastal hydrodynamic model against available current and water level elevation data. Oceanic boundary conditions will be supplied from the fully validated New Zealand wide Regional Ocean Modelling System (ROMS) hindcast model at 5 km resolution. The coastal hydrodynamic model will implement such that it is able to operate using atmospheric boundary conditions from a range of sources. Two such sources will be compared during the validation period. These are the 4 km resolution Weather Research and Forecasting model (WRF) model of New Zealand, and the 1.5 km New Zealand Convective Scale Model (NZCSM) used for driving the catchment model. The WRF model has been specifically optimised for use for modelling the marine environment, while the higher resolution NZCSM model may better resolve near-shore topographic influences on wind fields. The inter-comparison will help address long-standing questions about what resolution of atmospheric forcing is required for resolving hydrodynamics in coastal waters, and whether this is significant relative to other issues such as uncertainties in fresh-water inputs.

In order to ensure models are representative of *in situ* conditions, nudging of model nowcasts towards measured data will be achieved using available daily satellite and near-realtime buoy data.

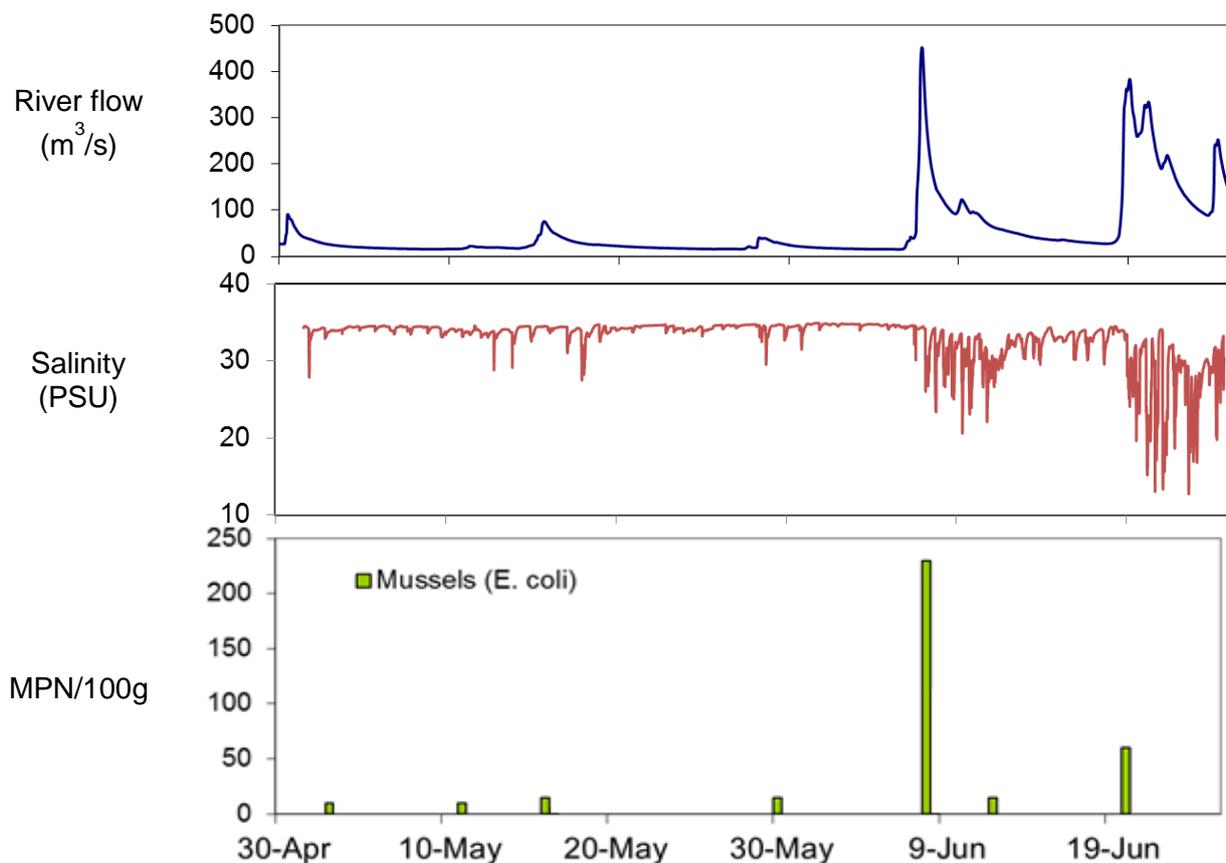
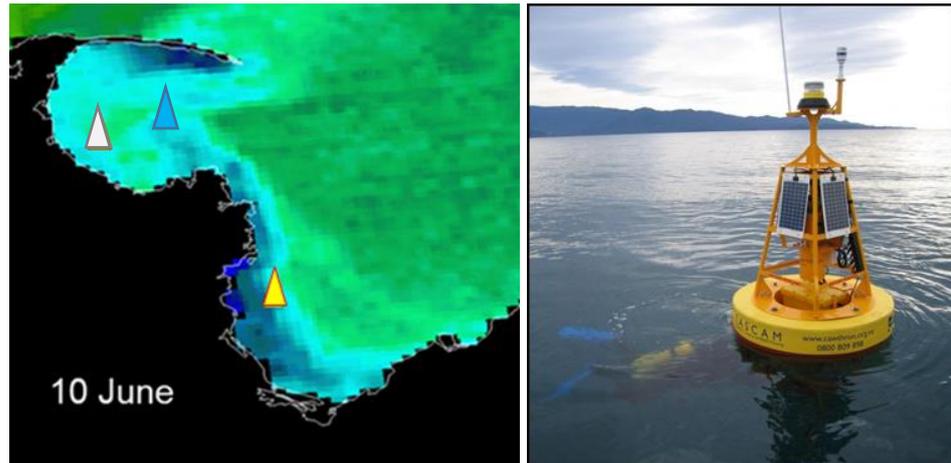


Figure 3. Technologies and data to be applied in this project include satellite imagery (upper left), and real-time data on water quality, weather and currents e.g. TASCAM (yellow triangle and photograph upper right), Golden Bay Marine Buoy (blue triangle) and MSQP buoy (grey triangle); and data on river flows, salinity and faecal bacteria measurements from mussels (lower three panels). Figures and data sourced from [3].

Water quality modelling

Riverine bacterial inputs will be predicted using adaptations of operational bacterial modelling techniques developed for the Motueka River. These techniques are based on simplified ‘virtual river’ models that account for settling, resuspension and die-off of bacteria instream in order to more accurately predict how discharge of bacterial loads to the sea vary over time. While the model has been validated for the Motueka River, it is beyond the scope of the current project to fully calibrate such models for other catchments. Instead, we will use a combination of CLUES (the GIS Catchment

Land Use and Environmental Sustainability model [4]) and Council monitoring data to scale between catchments while accounting for different land use, and also use other indicators as described below to estimate contaminant risk in the coastal model.

Within the coastal hydrodynamic model, physical proxies (salinity and temperature), along with water aging (using tracers to determine how recently riverine-sourced water was delivered to the coast) will be used to provide initial estimates of contamination risk to key aquaculture areas and beaches within Tasman and Golden Bay. A bacterial tracking model will also be implemented to simulate bacterial survival and movement to enhance estimates of FIB concentrations.

In order to ensure that propagation and survival within the bacterial model are realistic, a review of relevant literature and survival characteristics of river-sourced bacteria under changing conditions (i.e. temperature, salinity, light) will be undertaken. Knowledge from this review will be encapsulated in a new bacterial module which will be integrated with the modelling of other environmental drivers (e.g. waves, light, temperature and salinity). This model will be open-source and may be decoupled from the hydrodynamic platform. Both the catchment and bacterial modelling developments will provide additional tools for a wide range of applications around NZ.

Bacteria testing for validation

In addition to compiling all existing data on water and shellfish quality, we will undertake targeted sampling to validate models described above. Standard culture-based tests for faecal indicator bacteria (FIB) will be applied to water and shellfish samples.

Operationalising the modelling tools

The initial physical outputs from the models will be made available near the start of year two of the project, and for the rest of year two the programme will focus on tuning the bacteria model to make it relevant for operational use. This will involve integrating the bacterial now/forecast model with other available datasets, such as on water measurements of wave or clarity conditions. The forecast system would run up to four times daily to quantify the effects of river discharges on the microbial risk to key aquaculture and recreational beaches within Tasman and Golden Bay.

Initial visualisation tools will ensure public and industry can access FIB short-term forecasts at key locations in the study region, longer-term forecasts will be provided on completion of catchment modelling. An accessible prototype portal will be set up and shared to display this data for the period of the project. An application programme interface (API) will also be made available to Council and relevant parties to allow data to be seamlessly incorporated into other website platforms (e.g. the Sustainable Seas website).

The management model

We recognise that the modelling of any biological system is inherently complex and that perfect accuracy of the final model for estimating FIB concentrations (and therefore risk of exceeding criteria) is unlikely. Hence we propose that a final management model is implemented to draw on tools developed through the project. Development of this model will occur in the second year of the project and Cawthron will lead this component. It is envisaged that it will combine available information from the bacteria transport model, as well as a wide range of available data on environmental variables such as river flows, salinity, turbidity and temperature. In addition, both MSL and NIWA run several operational models (wind, wave, tide), the outputs of which industry have indicated are important for managing harvest times according to conditions. The information from which decisions would be based will utilise a weight-of-evidence approach, incorporating both model predictions and

measurements of water quality parameters to estimate contamination risk. Field validations of FIB concentrations will further minimise this risk by progressively improving model outputs and providing uncertainty information for decision-makers.

The effectiveness, usefulness and potential economic benefits of the management tool will be evaluated by applying the tool to compare historic actual mussel farm closures with those predicted by the tool using model output generated during validation of the hydrodynamic and water quality models. This will utilise at least 2 years of hind casted data from the models in year two of the programme.

After ensuring that developed coastal models are fit for purpose, the partner group will refine and implement improvements to harvesting and beach closure criteria. This approach will ensure that knowledge gains captured in this project will result in coastal aquaculture and communities that remain open for business.

H. RESEARCH ROLES

Researcher	Organisation	Contribution
Ben Knight	Cawthron	Project leader, bacterial model development and management modelling lead.
Jonathan Banks	Cawthron	Bacterial expert, bacterial sampling and testing coordinator
Ross Vennell	Cawthron	Numerical model review, validation and oversight
Brett Beamsley	MSL	Project co-lead, Operational hydrodynamic modeller
David Johnson	MSL	Operational implementation of bacterial modelling
Peter McComb	MSL	Oceanographic and project support
David Plew	NIWA	Project co-lead, plume dynamics experiment/validation
Christian Zammit	NIWA	Catchment forecasting and operationalisation
Mark Hadfield	NIWA	Ocean and coastal hydrodynamic modelling
Graham Rickard	NIWA	Ocean and coastal hydrodynamic modelling
Al Campbell	Aquaculture Compliance	Shellfish sanitation, criteria development

I. LINKAGES AND DEPENDENCIES

The proposed research will link closely with research planned under project 4.2.2 to define stressor footprints (including the spatial dynamics of river plumes and their influence on coastal waters) and will provide a quantifiable economic benefit from research investment. The project engages scientists from project 4.2.2, thereby providing a bridge between physical datasets and models being developed in the region and the proposed research. The proposal leverages off existing datasets and models, and does not replicate efforts already underway. Rather it will complement and provide additionality to projects within, and outside of, the Challenge. It will also produce model domains and datasets that can be used further within project 4.2.2 and beyond. Key validation data will be obtained under a near-field experiment funded under project 4.2.2.

The project heavily depends on the involvement of a shellfish sanitation expert and Industry throughout all stages of the project. In order to be successful and ensure revised criteria and forecasting tools are implemented, we need to establish a significant level of confidence that any

changes in operation will not result in a negative outcome (false negative results, resulting in illness or product recalls). For this reason, Al Campbell, an expert in shellfish sanitation, will be contracted on the project to work closely with the team in developing criteria and ensuring credible and robust deliverables. The Partners Group will also be heavily involved with criteria and tool development; proposed members that have agreed to participate include Dr Colin Johnson (MSQP coordinator and AQNZ technical director), Trevor James (TDC), and marine aquaculture representatives (to be determined).

The project will link with others that involve sampling and modelling in the region. We will coordinate with fortnightly water sampling conducted in Tasman and Golden Bay that is carried out at key locations by Cawthron and MSQP for the MBIE funded project Coastal Acidification: Rate, Impacts & Management (CARIM). The research will also benefit from alignment with Industry-led projects, such as a Sustainable Farming Fund project on forecasting spat fall in the Top of the South, and we will also form linkages with a Seafood Innovations Ltd project led by Sanford to forecast trends in shellfish condition in growing regions.

The project will link with the Cawthron-led Safe New Zealand Seafood programme by applying microbial modelling techniques being developed for Pacific oysters, *Crassostrea gigas*, in the Hauraki Gulf and clams, *Autrovenus stutchburyi*, Otago Peninsula to greenshell mussels in Golden and Tasman Bays. The top of the south project will benefit from the extensive, existing microbiological, and oceanographic datasets available. We believe the two projects will complement each other producing a positive feedback loop to improve tool development, data visualisation, and ensure that shellfish are safe to eat and bathing beaches are safe for swimming.

This project will make use of existing NIWA data-sets for validation of models also link with NIWA Strategic Science Investment Funding research projects in the areas of Climate, Atmosphere and Hazards (meteorological forecasting); Water Resources (catchment modelling; Coasts and Oceans (observational data); and Aquaculture (observational data).

J. RISK AND MITIGATION

The primary risk to achieving the research aims is that the new methods, models and ultimately closure criteria will not be robust enough to convince regulators to change from a current conservative approach to harvest management. This risk will be mitigated by active involvement of Al Campbell, manager of Aquaculture Reporting and Compliance, and Trevor James, bathing water quality monitor for the Tasman District Council within the project. Their involvement along with others in the Partners Group described above will ensure that the project remains solutions based and meets the long-term needs of the Industry and Council for managing and protecting their increasingly valuable shellfish growing waters and bathing beaches.

The risk of non-uptake of deliverables will be further mitigated by the use and integration of models that have been proven previously to be accurate, and by gathering together an experienced team from a range of institutions. The novelty and innovation of this project is not within the individual models, but rather the combination of these models into a single, powerful forecasting tool that aids in the development and ongoing validation of harvest criteria. The project puts a large weighting on the calibration and validation component, which in turn will enable the tool to provide much better predictions of contamination likelihood than anything currently available.

K. CO-FUNDING AND INDUSTRY SUPPORT

Industry, TDC, and regulators (MPI) have expressed support for this project (see attached letters). The support is primarily in-kind, and includes data provision, assistance with field sampling, and time

associated with participation on the Partners Group. If deliverables are proven successful and of value to their industry, marine farmers have expressed that they will support the ongoing maintenance of the models and refinement of criteria into the future. This is expected to be a nominal cost and similar to resourcing on-going website management (in the order of \$20,000 per annum) that would be shared across companies in the region for ongoing maintenance and improvements.

Sources of co-funding and support include the following:

- NIWA's Coasts and Oceans CORE Flows and Productivity Programme
- NIWA's Climate CORE
- NIWA's CORE funded Environmental Effects of Aquaculture Programme (ACEE) will deploy ADCP current meters in Tasman/Golden Bay. The data will be available for model calibration.
- Data from the Golden Bay Marine Monitoring Buoy, which is funded jointly by NIWA and TDC.
- Sustainable Seas Project 4.2.2 Stressors Footprints and Dynamics will provide validation data from mooring and glider deployments, as well as fund a targeted near-field experiment to the value of \$35K
- Hardware and maintenance of a coastal observing platform - TASCAM (\$25k per annum maintenance covered by Cawthron, and \$5k from TDC). The data from TASCAM will be used to validate models, and also provide near real-time data for operational modelling and production of nowcasts.
- Provision of river flow data, weather data, and water quality sampling data from Council, including the Motueka River bacterial forecaster developed by Cawthron.
- MSQP assistance with sampling, and use of industry monitoring buoy data for Golden Bay (see support letter attached)
- Industry assistance with field sampling (we have commitment from individual farmers)
- Aligned Cawthron internal capability funding for development of remote sensing and monitoring capability (approx. value \$20k).
- TDC assistance with collection of bacterial field samples.

The project will also benefit from access to extensive datasets for the region. Cawthron has conducted many years of research in Tasman and Golden Bays, including developing Integrated Catchment Management for the Motueka and Aorere Rivers. Existing datasets on the Motueka River plume (CTD surveys, FIB surveys, molecular data on source-specific bacteria, etc) will assist in validating models.

L. VISION MĀTAURANGA (VM)

The proposal is highly relevant to the marine management interests of Māori, who own major companies (e.g. Sealord, Wakatū (Kono), Ngāi Tahu Seafood) that actively manage numerous marine farms across the Tasman-Nelson-Marlborough-Canterbury regions. The Māori Commercial Aquaculture Claims Settlement Act 2004 provides settlement assets representative of 20% of existing (since 1992) and new marine farming space. There is potential for future expansion in Aquaculture Management Areas in Tasman and Golden Bays. As kaitiaki of the environment, the Ki Uta Ki Tai (mountains-to-sea) approach proposed is well aligned with Māori whole-of-ecosystem views and addresses concerns around contamination of kaimoana.

Māori will be an integral part of the proposed research through active engagement with Maori-owned companies throughout all stages of the project, and marine farmer representation on the

Partners Group. The proposal also aligns with a new collaboration, “Tuia te here tangata, tuia te here mātauranga: Connecting people and weaving western science and Mātauranga Maori to protect our freshwater,” supported by the Te Pūnaha Hihiko Vision Mātauranga Capability Fund. This new project will develop a resource that enables water quality monitoring by iwi, for iwi and NZ.

In the proposed research, we will complete the Ki Uta - Ki Tai connection. Jonathan Banks in collaboration with Tiakina, will be working on extending freshwater techniques to the marine space. There is therefore an opportunity to merge learnings and results from the two projects. This will ensure Māori are involved in the laboratory component of the research, and will also strengthen capability in drawing land-sea connections between freshwater quality and downstream marine resources.

M. CONSENTS AND APPROVAL

Ethics approvals are not required. Monitoring buoys are already in place and consented.

N. DATA MANAGEMENT

Our approach to data management will be open public access, with any new data collected as part of the project archived by Cawthron and available to interested parties at the end of the project. Data and associated metadata (e.g. site and date of collection, method applied) will all be packaged with the data. Similarly, any virtual data products created through the use of models will also be available on request to interested parties at the end of the project.

Both NIWA and MSL have extensive expertise in running and hosting data from models; they will use their existing in-house data management tools and infrastructure to host and serve the data to the public for the period of the project. At the end of the project period any model generated, or collected data, will be made publicly available to interested parties. Ongoing running and access to model nowcasts for industry and council will be supported through a subscription service. It is envisaged that by the end of the project the capability to run and provide management outputs will be available for all the organisations involved.

Public-facing web tools are already developed and will ensure public and industry can access bacterial hindcasts and nowcasts at key locations in the study region. Initially this will occur through a prototype portal. An API will also be provided that will allow model data to be available on a range of other platforms.

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