SUSTAINABLE SEAS | Ko ngā moana whakauka | National SCIENCE Challenges

# Innovation Fund Research Proposal Template

## A. PROJECT TITLE

Estimating historic effects from sedimentation and fishing, Nelson Bays

## B. PROJECT TEAM


| Project Leader: | Investigators: |
|---|---|
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## C. ABSTRACT


The *Sustainable Seas Challenge* is very forward looking seeking *enhanced utilisation of marine resources within environmental and biological constraints*, but current funded projects fail to account and estimate historic conditions that supported them. This knowledge gap is especially poignant in Nelson Bays, which used to support: a ca.$70M/annum scallop fishery that collapsed in the last decade; an oyster fishery the decade before that; and a green-lipped mussel fishery 5 decades before that. A NIWA initiated review of the decline of Nelson Bays shellfish fisheries highlighted a range of potential negative drivers including sedimentation and bottom contact fishing.

Our highly innovative project aims to quantify the losses attributed to historic and contemporary sediments derived from land, quantify which land-use cover they were derived from (using a NIWA sediment 'finger-printing' method), and test for the additive effects of bottom contact fishing methods to sediment structure and the mollusc species (e.g. scallops) response. In an ocean where nearly everywhere is fished – where trawling and dredging homogenise soft sediment habitats – finding control sites to test for the effects of fishing are very rare. Fortuitously, between Golden and Tasman Bays there is a 146 km$^2$ toanga of seabed that has been protected from the use of synthetic nets and shellfish dredges for over 30 years: the Separation Pt. Power Fishing **Exclusion Zone (EZ)**. This site offers a unique laboratory to study the effects of fishing disturbance[6] and sedimentation.

To achieve our ambitious aims (below), we will use a range of specialised scientific techniques. Sediment cores collected offshore inside the EZ will test for effects from the expected rapid increase in sediment coming from land and being deposited on the seafloor. Our cores will drill back in time and quantify sediment accumulation rates (SAR) before humans, during colonisation, and during important shellfish production periods up to the present day. The SAR's derived from the layers in the cores will be dated using a combination of radiocarbon dating of mollusc shells and analysis of

bomb radioistopes[9] that have been deposited in the sediments since atmospheric nuclear testing began. Outside the EZ, where we believe the sediments have been homogenised by contact fishing methods like bottom-trawling and shellfish-dredging, we will also collect cores to test if discontinuities in the radioisotope layering, x-rays of the cores, and analysis of fine particles in the sediment, differ to the layering in cores that have not been disturbed by contact-fishing inside the EZ. The unique part of our study, will be to compare the mollusc death assemblage (dead shells preserved in the sediments: DA) to validate our findings. This peleoecological method has been used overseas to detect effects of pollution, but has never before been used to investigate historic and contemporary effects of fishing and sedimentation concurrently at the same site.

## D. RELEVANCE TO CHALLENGE OBJECTIVE

*"Enhance utilisation of our marine resources within environmental and biological constraints"*

The primary hypothesis this research will test (Hø1): is that historic land-based disturbance during human colonisation has changed molluscan assemblages [eg. 16] relative to benchmark pre-human conditions. A subsequent hypothesis (Hø2) then predicts that the stressors: i) sedimentation and ii) ploughing effect from contact fishing methods have impinged on *utilisation of our marine resources* thus acting as *biological constraints*. These hypotheses have direct relevance to the Objective of the Challenge as Hø1 will estimate baseline benthic *marine resources* that were historically available to be sustainably utilised, and the second Hø2 will investigate the *environmental and biological constraints* of the benthos in relation to the two stressors: i) sedimentation and ii) fishing disturbance. The methods outlined herein, will allow for comparative (from pre-human baseline) estimates of "effect size" of these stressors, and provide data to populate the Atlantis, Ecosystem Model.

## E. INTRODUCTION

Historical reviews demonstrate significant decadal to century scale changes have occurred to soft-sediment habitats in the Nelson/Marlborough Region[1,2,3,4]. Soft-sediments that dominate coastal habitats once supported shellfish beds including the SCA7 scallop fishery that had an annual value of \$70 M[1], which has subsequently collapsed. Two long-term stressors – i) contact fishing methods (trawl doors, bobbins, shellfish dredges) and ii) increased sediment accumulation – have been hypothesised as primary drivers in the lack of innate recovery and decline of biogenic habitats including shellfish beds in Nelson-Marlborough [1,2,3,4,8].

Determining the relative magnitude of fishing versus sedimentation effects is problematic. This is because **i)** quantifying the effects of historic and contemporary sedimentation on the benthos in Sustainable Seas Challenge areas like Nelson Bays is confounded because most areas have been fished by contact fishing methods[13] that can modify sediment structure through the "ploughing effect"[6]. That is, the disturbance from contact fishing introduces confounding as it disrupts and modifies the sediment structure deposited in layers over time preventing accurate aging of disturbed layers. **ii)** Similarly, trying to assess the effects of fishing could be masked by the additive effects of widespread and accelerated sedimentation[14]. Our novel approach to these problems is to use sites within and adjacent to the Separation Point Power Fishing Exclusion Zone (EZ)[6]. This exclusion zone is a rare 30+ year old marine protected area where we can examine historical and contemporary effects of sedimentation (inside the EZ = no contact fishing) versus effects from fishing plus sedimentation (outside the EZ). To achieve our aims we will use sediment cores, radioisotopes, stable isotopes and a paleo-ecological technique. The results of which will have wide-ranging relevance to soft sediment habitats throughout New Zealand and overseas that have been similarly modified[9-11].

## F. AIMS

The Separation Point Power Fishing **E**xclusion **Z**one (**EZ**), a 146 $km^2$ area protected from bottom contact fishing methods for over 30 years[6], offers a rare site to examine historical and contemporary effects of sedimentation (inside the EZ) versus fishing plus sedimentation (outside the EZ) using sediment cores, stable isotopes, radioisotopes and a paleo-ecological technique.

Project aims are to:

1. Quantify contemporary and historic (benchmark) sedimentation rates (inside the EZ);
2. Quantify the relative proportion of soils derived from different land-use practices contributing sediment to the seabed using a NIWA compound specific isotopes (CSSI) 'finger-printing' and tracing method developed by Max Gibbs[7];
3. Test whether discontinuities in sediment grain size characteristics and radioisotopes ($^{210}Pb$ and $^{137}Cs$) can be used to detect the "ploughing effect" from contact fishing methods. This will be achieved by comparing sediment grain size changes; x-ray imaging, radioisotope profiles, and mollusc death assemblages in cores between inside and outside the EZ.
4. Quantify the mollusc macrofaunal response to sedimentation (inside the EZ) versus sedimentation plus fishing (outside the EZ) by analysing the mollusc death assemblage[15, 16]. By processing whole sections of cores back through time, we will estimate and compare contemporary macrofaunal with pre-fished, and pre-human benchmark conditions.

## G. PROPOSED RESEARCH

**Sample collections**: To achieve the project aims (above), replicate sediment cores (12 inside: 12 outside the Separation Point Power Fishing Exclusion Zone, EZ) will be collected at paired stations across 3 depth strata (25, 30, 35m) on the south side of the EZ similar to Handley et al. (2014)[6]. The 3 depth strata were chosen to cover the depth distribution covered by estimated trawl paths [e.g.24] along the south side of the EZ. Within the 10m depth range studied herein, estimates of near-bed orbital velocities[25] increase by nearly a factor of 2, which will affect sediment resuspension and accumulation rates. Understanding how sediment deposition varies with depth will be important for interpretation of our results. In conjunction, contaminant soils (40 samples) from different land-uses (e.g. forestry, farming, horticulture, urban, native forest), river deltas, and marine sources will be collected.

**Sediment accumulation rate estimates (SAR), and mixing [Andrew Swales]:** Six of the sediment cores (3 inside vs 3 outside) will be processed in 2 phases. The cores will be first split longitudinally, and x-rayed (below). Articulated filter feeding bivalve shells located near the base of the cores will be sampled, identified and sent to the University of Waikato's Radiocarbon dating facility (2 shells/core). These radiocarbon dates will be used to estimate the maximum age of the base of each core, to constrain pre-human sediment accumulation rates. The 1$^{st}$ phase samples of sediment are then sampled (9 samples) from 1 cm slices at increasing intervals down-core. During this sampling, a smear of fine sediment is retained for later laser size analysis (below). These samples are shipped to ESR for Gamma spectrometric detection of bomb radioisotopes $^{137}Cs$, $^{7}Be$ and $^{210}Pb$ estimation. The results of the 1$^{st}$ phase sampling are then used to inform a 2$^{nd}$ phase sampling to achieve a total of 15 samples per core. Sediment accumulation rates (SAR) are then estimated based on the radioisotope activities of lead-210 ($^{210}Pb$: ½ life 22.3 years), caesium-137 ($^{137}Cs$: ½ life 30 years) and beryllium-7 ($^{7}Be$: ½ life 53 days) in the sediments, as well as radiocarbon dating ($^{14}C$) of shell material preserved in the cores.

Discontinuities in $^{7}Be$, $^{137}Cs$ and $^{210}Pb$ radioisotopes stratigraphy in the cores between inside and outside the EZ will be interpreted as resulting from disturbance from contact fishing. The effects of this mixing will be validated using comparisons of paleo-ecological mollusc death assemblage (below).

**NIWA sediment source tracking method (Compound Specific Stable Isotopes, CSSI) [Dr Max Gibbs/Dr Ben Woodward]:** The CSSI method uses compound-specific isotopic analysis of naturally occurring biomarkers (fatty acids) derived from plants to link source soils to land use within a single catchment[7]. Where possible, to better inform the analysis of core sediments using CSSI, 3 replicate samples of each contaminant soil/sediment are collected across a range of sites to provide some spatial resolution and information on the natural variation of the resulting contaminant source CSSI signatures.

Once the geochronology of the cores is known, 15 x 1 cm slices of additional 2 cores (1 inside and 1 outside the EZ) will be sampled for CSSI analyses. Catchment-soil samples and core-sediment samples are subsampled, freeze dried and (depending upon sample) sieved prior to CSSI processing. Subsamples are weighed and the fatty acids (FA) extracted with the solvent dichloromethane. FAs extracted are converted to methyl esters, then shipped to University of California, UC Davis for CSSI analysis. A subsample of the source soils/sediments are also treated with 1N HCl to remove carbonates, and rinsed with reverse osmosis water and shipped to NIWA Wellington's isotope lab for bulk C ($\delta^{13}C/^{12}C$) isotope analysis.

A recently developed Bayesian isotopic mixing model, which incorporates advances in mixing model theory "MixSIAR"[19,20] will be used to calculate probability distributions of soil source proportions from the UC Davis results that can be summarised by various descriptive statistics, including the 95% credible interval. A continuous effects model is employed to estimate the posterior distributions of sources for each individual sediment mixture sampled from the dated cores. An array of polygon biplots are used to test conformity of the sediment mixtures along with test modelling used to validate the soil sources chosen[e.g 16].

A study comparing SARs, relative sea level rise and tsunami signatures in estuaries east and west of the EZ (Wainui, Totaranui and Awaroa Inlets) reported pre-European sedimentation rates were 0.5-1.7 mm/a, Polynesian sedimentation rates were 0.98-1.19 mm/a compared with post-European settlement rates of 1.6-2.7 mm/a increasing to modern rates of 2.3-3.3 mm/a[21]. The biggest contributor to the average annual suspended sediment load to Tasman and Golden bays is the Motueka River (41% of the total load delivered to the bays), with significant contributions from the Waimea (13%), Aorere (12%), the Wainui catchments (9%), and the Takaka (8%)[22]. SARs estimated from a single, un-replicated core taken at ca.25 m depth offshore from Whariwharangi Bay, west of Separation Point (Handley, unpub. data), were comparable to those previously measured. We will sample source signatures from surface-sediment deltas from each of these rivers to include in our CSSI soil library to apportion their relative contribution at our coring sites.

**Mollusc Death Assemblage (DA) [Dr Sean Handley]:** The unmodified sediments within the Separation Pt. exclusion zone contain a high proportion of shell-gravels[6] which we expect to yield a high sampling rate to quantify mollusc death assemblage in this study. To analyse the DA present in 12 cores (6 inside: 6 outside EZ), once the age stratigraphy of the sediment profiles is known, the cores will be partitioned into arbitrary historic time periods of interest (see VM section below). To maximise the quantity of shells available for analyses, whole sections of the cores will be processed [e.g. 16]. Each core section will be analysed by percentage of volume between predicted sediment depth/age ranges. During sectioning, a small ca.5 g fraction of sediment will be retained for laser grain-size analysis (below) by compositing 3 subsample smears of sediment haphazardly sampled from the top, middle and bottom of each section of core. To extract shell and gravels, the remainder of each core section is gently washed through a 1 mm sieve. The shells and gravel are weighed after air drying to constant weight at 60°C. All shells (eg. scallops, oysters, mussels) are identified to lowest practical taxonomic level, weighed, including weights of all unknown shell fragments. Percent weight of shell and terrigenous gravels are calculated from the volume of the core analysed per time period, after conversion to equivalent volume. Mollusc shells weights will be converted to volume based on regression of oyster shell weights to volumes calculated from a study of Pacific oyster *Crassostrea gigas* condition indices[23,16]. As pre- and post-human sediment accumulation rates will likely differ among cores, the DA shell volume estimates will be standardised to percent material accumulating per year, by back calculating the number of years each core section represented, and dividing the percent volume of material deposited in each core section by the estimated years that deposited them.

**X-ray imaging:** An x-ray image or x-radiograph provides information on the fine-scale sedimentary fabric of sediment deposits. Density differences (due to particle size and composition, porosity) between layers of silt and sand or animal burrows that are infilled with mud make these often subtle features easily recognisable in the x-ray image even though they may not be visible to the naked eye.

**Fine particle analyses:** Particle size distributions (0.5–300 µm) based on particle volume is determined using a 'Galai CIS-100 time-of-transition stream-scanning-laser' following ultra-sonic dispersion.

**Statistical analyses:** Multivariate analyses (e.g. PERMANOVA, Primer) will be used in a 3-way design to test for: treatment (sedimentation [inside EZ) vs fishing + sedimentation [outside EZ]); depth (25m, 30m, 35m); and historic period (e.g. modern sediments, late European, early European, Maori, pre-human) on both the sediment characteristics (granulometry, isotopes, chemical markers etc.) and the mollusc DA data-sets. As the mollusc fauna alter the sediment characteristics by contributing dead shell thereby armouring sediments from erosion, and bioturbation by molluscs can mix the sediments, these two datasets are interrelated, and co-dependant. Thus, multivariate approaches (e.g. MDS, CAP) will explore changes to sediment characteristics and the DA, searching for unique indicators of the effects of sedimentation by comparing before and after human colonisation, and subsequent indicators of fishing (outside EZ) and sedimentation and fishing (inside the EZ) in modern sediments after bottom fishing commenced (outside the EZ). Disentangling the effects of fishing versus sedimentation will also incorporate  a functional feeding and bioturbation trait analysis[6] used in a novel way to investigate functional changes to mollusc species composition back between treatments and time periods. Our DA responses will be validated against published studies of the effects of fishing as compared with responses to sedimentation. It will be important when interpreting changes in sediment mixing (from radioisotope signature profiles, X-ray images, and sediment grain size) to attempt to control for confounding from bioturbation from macrofauna as estimated by trait scores that will be assigned to species present in the mollusc DA. Observed historic changes will be compared with published results from surface sediments previously sampled using Van-Veen grabs inside and outside the EZ[6].

Outputs:
1. A manuscript will be submitted to a high-profile journal, including:
    - quantification of SAR's from: pre-human, Maori, and European periods;
    - quantification of land-use practices contributing soil to the benthos;

- test whether sediment mixing attributed to contact fishing can be detected using a combination of: radioisotope signature profiles, X-ray images, sediment grain size and changes in DA consistent with published responses;
- descriptions of the historic macrofaunal (DA) response to sedimentation (inside EZ) and contact fishing + sedimentation (outside EZ);
- estimates of the effects of fishing and sedimentation disturbance from historic pre-human benchmark levels;

2. 0Results will be reported to the Nelson Biodiversity forum, the Te Tau Ihu Fisheries Forum, and the NZ Marine Science Conference.

If we are successful in finding concurrent physical and biological anomalies in our cores consistent with disturbance derived from contact fishing, then the next logical step (not funded herein) would be to test the utility of these methods in other areas affected by fishing. We would recommend evaluating whether the suite of methods herein can be used to quantify gradients of fishing disturbance to test against gradients of scallop productivity.

## H. RESEARCH ROLES

| Researcher | Organisation | Contribution |
|---|---|---|
| Dr Sean Handley | NIWA Nelson | Mollusc death assemblage and multivariate analyses |
| Andrew Swales | NIWA Hamilton | Sediment core dating, sediment source tracking |
| Dr Max Gibbs* | NIWA Hamilton | Stable isotopes, radioisotopes, sediment source tracking |
| Ben Woodward | NIWA Hamilton | Stable isotopes, radioisotopes, sediment source tracking |

Add more rows as required.

## I. LINKAGES AND DEPENDENCIES

- Complements existing *funded projects* by:

i) providing historic habitat data (e.g. sediment grain size, sediment carbon, carbonate, mollusc macrofaunal death assemblage) to validate historic habitat change, with the potential to develop a tool to parameterize the Atlantis ecosystem model [5.1.1, CP1.1, CP2.1];

ii) gathering knowledge to underpin mitigation of stressors to underpin restoration of historically important components of the blue economy [2.2.1] and improving understanding the barriers to innate habitat recovery;

iii) estimating historic and contemporary importance of stressors (contact fishing methods, sediment), and estimating their influence [4.2.2, 5.1.1];

iv) quantifying role of anthropogenic stressors relevant to ‘social license to operate’ from land (sedimentation) and in the sea (contact fishing methods) [1.2.1, 5.1.1];

v) a successful disentanglement of effects of fishing and sedimentation, will provide results that can inform spatially-explicit decision support tools [5.1.2].

* Note: Dr Max Gibbs retired in late March, but will be staying on at NIWA with Emeritus Status and has confirmed he will contribute to and mentor Ben Woodward in this project.

- Disentangles and quantifies historic changes associated with sedimentation and bottom contact fishing hypothesised to reduce the availability of resources in the *marine economy.*

This project directly addresses the primary objective of the *Sustainable Seas Challenge* by assessing contemporary versus historic role of sedimentation and fishing (ploughing effect) – stressors hypothesised to be strongly associated with lost "*utilisation of our marine resources*" implicated in habitat change[1-4]. There has been significant decadal to century scale losses of natural capital and fisheries production in Nelson Bays, and other inshore regions around New Zealand[2,3,4,8]. Sediment-surface living shellfish (scallops, oysters, mussels, horse mussels), once provided ecosystem services that facilitate biogenic habitat formation, enhancing sediment stability and integrity[6]. We hypothesise that habitat modifications have diminished seabed natural capital and ecosystem services leading to lost economic and social returns: including commercial, traditional, and recreational.

- Informs mitigation and restoration

This knowledge will *inform mitigation measures underpinning restoration* of soft-sediment habitat integrity, restoring value and resilience to the marine economy (*not funded herein*). For example, if sediment contamination inhibits habitat integrity, then mitigation could involve restoring sediment-binding shellfish in areas prone to instability, and/or mitigating terrestrial erosion. Similarly, if fishing disturbance is negatively associated with lost productivity, then 'habitat friendly' harvest methods should be developed and employed.

- Targets *biological constraints*

This project targets the sustainable utilisation of marine resources within the *biological constraints* of fine sediment and physical disturbance, by asking:

i) has - contact fishing gear - through the "ploughing-effect" homogenised surface sediments such that the fine sediments dominating the seabed surface modifying the benthos? i.e. what were benchmark sediment conditions and what macrofauna did that support?;
ii) what were historic and contemporary sediment accumulation rates, and from which land-use source were/are soils discharged, back through time;
iii) what were the relative effects of sedimentation and cumulative effects of contact fishing methods on mollusc macrofauna (via analysis of death assemblage)?

The *Sustainable Seas Challenge* is very forward looking, and current funded projects do not investigate drivers and mechanisms of historic changes of soft sediment habitats, potentially missing out on unmeasured lost natural capital with economic potential that could be restored. This study, and a concurrent sediment coring project completed in Pelorus Sound, seek to fill some of these regionally and nationally important knowledge gaps.

## J. RISK AND MITIGATION

1. Sediment core collections

We propose to use a 'gravity corer' to collect our sediment cores. There is the remote possibility that the coarse nature of the sediments (high shell content[6]) may reduce the effectiveness of this sampling tool. This risk is however small, as we know from a previous core collected near the proposed sampling sites that pre-human sediment conditions are approximately 750mm below the sediment surface, meaning the gravity corer, to be effective for this project, needs to penetrate ca.1.2m into the sediment. This is a realistic expectation given what we know about these sediments[6] and how our corer works in such sediments. A back-up contingency, which will be more expensive is to sub-contract the core collections to a commercial dive company that has an electric vibra-corer[eg. 16].

2. Compound Specific Stable Isotope (CSSI) analyses

NIWA currently sub-contract CSSI analyses out to the UC Davis Stable Isotope Facility in California, where they routinely carry out these analyses, have a proven track record, and deliver timely results. There is the remote potential that international political events or US cutbacks on science funding may impact on the price or capability of this facility to process our samples. If this unlikely scenario eventuated, we would have to investigate the use of the NIWA isotope facility to undertake these analyses. This will likely result in potential delays to delivery of results, as the NIWA facility would have to be modified to undertake CSSI analyses which are not routinely carried out.

3. Sediment mixing from "bioturbation" versus contact fishing methods

To test for mixing of sediment or homogenisation resulting from contact fishing methods, we will compare: radioisotope signature profiles, x-ray images, and sediment grain size between core sections collected in fished and unfished (outside the EZ) locations. There is the risk that bioturbation or vertical and horizontal movement of macrofauna (e.g. shellfish, echinoderms) within the sediment may also mix the sediments, masking the effects of contact fishing. To control for this risk, we will also compare the response of mollusc death assemblage including estimates of species functional traits (e.g. indices of feeding mode, and bioturbation potentials)[6], corroborative evidence from published macrofaunal responses, and quantification of carbonate contribution to validate our results and conclusions.

## K. ALIGNED FUNDING AND CO-FUNDING

This project is aligned and complimentary to two contaminant sediment source tracking projects being led by Max Gibbs and Andrew Swales, funded by i) Tasman District Council (TDC) for the Waimea and Moutere Estuaries (Trevor James, TDC pers. comm.), and ii) Nelson City Council (NCC) – associated with identification of sources of sediment contaminating the Maitai River and the Nelson Haven (Jo Martin, NCC pers. comm.). Both projects are developing a soil source library that could be partially used herein (not essential). Note: these two studies will not be investigating historic sources of sediment deposition using sediment cores. Rather, they are focussing on contemporary sources of surficial sediments in those estuaries.

This project is also complimentary to a sediment coring and paleoecological study recently led by Sean Handley and completed in Pelorus Sound, jointly funded by Marlborough District Council, MPI Aquaculture and the NZ Marine Farming Association Inc[16]. That coring project has documented the historic changes in sedimentation rates and contributory land-use sources of sediment back through time (CSSI sediment source tracking) at sites within Kenepuru Sound and Beatrix Bay, Pelorus Sound. That study differs to the proposal herein because everywhere in Pelorus Sound has been commercially fished by trawling and dredging in the past, so the effects of fishing and sedimentation cannot be differentiated in the absence of unfished reference sites. The Pelorus Sound is an estuarine system, differing hydrologically to the coastal setting of Nelson Bays, and historically supported smaller, less-productive scallop beds. Although the main focus of the Pelorus study was to investigate sources of soil contamination and quantify sediment accumulation rates (SAR), it also investigated factors implicated in the lack of innate recovery of greenshell mussel beds fished beyond recovery from Kenepuru Sound by the early 1970s using death assemblage analyses (DA)[2].

## L. VISION MĀTAURANGA (VM)

This research benefits Tangata whenua iwi of Te Tau Ihu o Te Waka a Maui, for three significant reasons: Manawhenua, land-ownership and fisheries quota interests.

At previous stakeholder meetings, significant concerns regarding decline of kaimoana resources were expressed by local tangata whenua[1]. A joint outcome of a resulting shellfish review was a "desire from iwi and stakeholders for ecosystem approaches to management and for research to better understand ecosystem function"[1]. This research addresses two significant ecosystem stressors affecting these kaimoana: i) sediment, ii) contact-fishing.

The mana whenua of Te Tau Ihu are significant innovators in agriculture, horticulture, fisheries and aquaculture, and well recognised before the recent Te Tau Ihu Te Tiriti o Waitangi claim settlement (eg. Wakatu Inc.). More recently, Ngāti Apa ki te Rā Tō, Ngāti Kuia, Rangitāne o Wairau, Ngāti Kōata, Ngāti Rārua, Ngāti Tama ki Te Tau Ihu, Te Ātiawa o Te Waka-a-Māui and Ngāti Toa Rangatira have increased their regional importance through the claims settlement process. As some of these land-based ventures may contribute sediment to Nelson Bays, the results of this research will inform: i) future land-use policy and management, and ii) restoration potential of scallops allowing for sustainable *utilisation of* Maori owned scallop quota.

Feedback on this proposed research from Ngāti Kuia and Ngāti Tama[†] requested greater understanding the drivers of scallop decline including habitat change. The vision of Te Tau Ihu Fisheries Forum: 'To achieve a sustainable fishery in a healthy aquatic environment' based on Tino Rangitiratanga and Kaitiakitanga[17], is consistent with our project objectives. Prior to analysing our cores, we will seek inclusion of iwi through the Fisheries Forum and/or Nelson Biodiversity Forum to help delineate historic time-periods important to Tangata whenua that could be used as the basis for sectioning the cores analysed for the mollusc death assemblage.

## M. CONSENTS AND APPROVAL

No consents or ethics approval is required for this research.

[†] Raymond Smith, Ngāti Kuia; Frans van Boekhout, Ngāti Tama

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