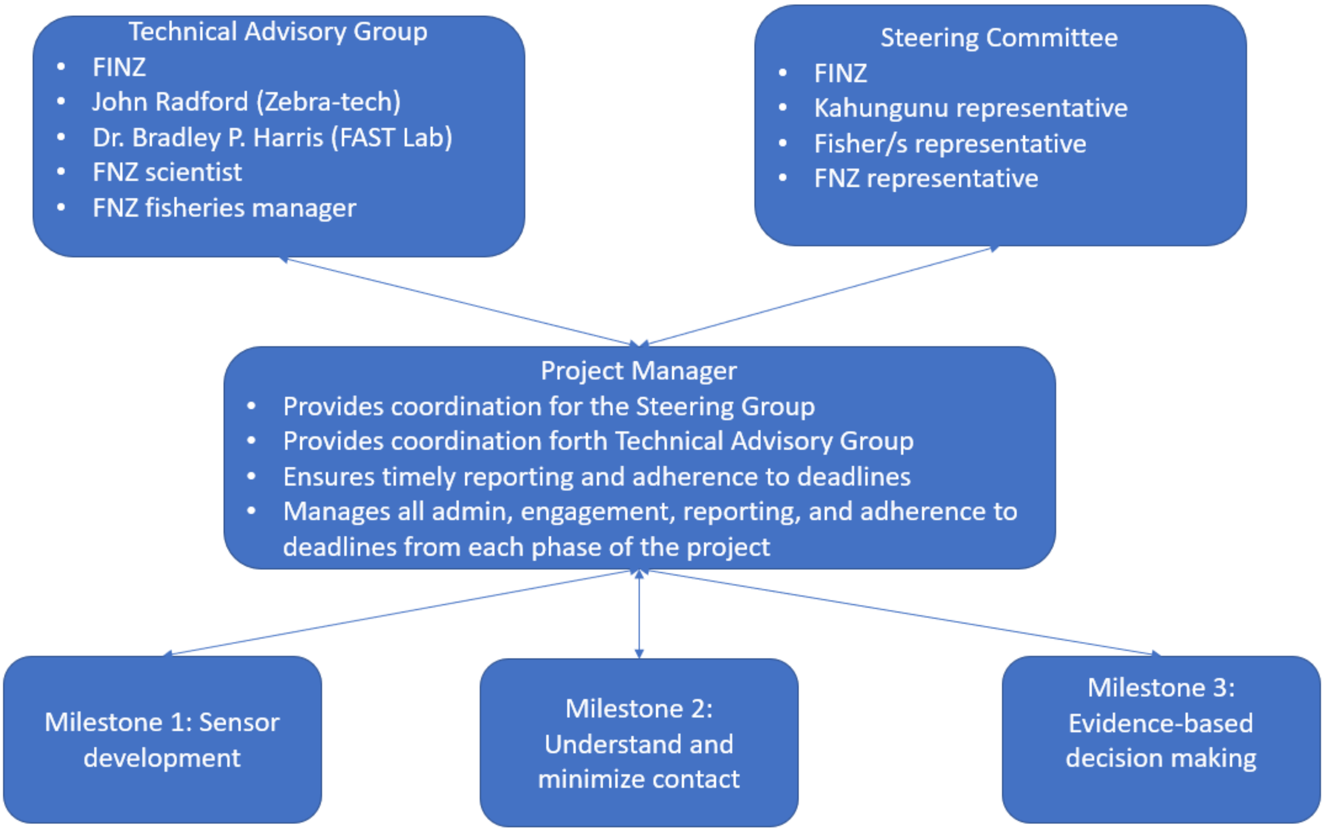
Research Proposal

A. PROJECT TITLE	**Quantifying and reducing interactions between commercial fishing gear and the seafloor in New Zealand**
"SHORT" TITLE	Quantifying seafloor contact
B. THEME / PROGRAMME	Blue Economy Innovation Fund

C. PROJECT KEY RESEARCHERS

Role	Name	Institution / company	Email
Project Leader/Manager	Oliver Wilson	Fisheries Inshore New Zealand (FINZ)	oliver@inshore.co.nz
At-sea technician	Shade Smith	Ngati Kahungunu	
Sensor developer	John Radford	Zebra-tech	
Principle researcher	Brianna King	Wild Pacific Fisheries Research	
Technical scientific advisory role	Dr Ian Tuck	Fisheries New Zealand (FNZ)	
Technical scientific advisory role	Dr Emma Jones	NIWA	



D. PROJECT PARTNERS

Name	Organisation / company / agency / Iwi / Māori	Role in project
Oliver Wilson	Fisheries Inshore New Zealand (FINZ)	Project Manager and commercial inshore steering group representative
Brianna King	Wild Pacific Fisheries Research	Scientific advisor, data analysis, and compilation of reports, presentations, and peer-reviewed manuscripts
John Radford	Zebra-tech	Provision of bespoke contact measuring device
Shade Smith	Kahungungu	At-sea technician, data collection and review of reports
Alicia McKinnon	Fisheries New Zealand (FNZ)	Steering committee
Dr. Ian Tuck	FNZ	New Zealand based experts in spatial statistical analysis and conservation engineering in commercial fishing gear
Dr Emma Jones	NIWA	
Dr. Bradley P. Harris	FAST Lab – Alaska Pacific University	International expert in gear contact quantification, spatial statistical analyses, and conservation engineering in commercial fishing gear

E. ABSTRACT/SUMMARY

Increasingly interactions with the seafloor are a focus of international and national debate. This debate is reliant on models that have not been ground-truthed against empirical information about how gear interacts with the environment in-situ. Quantifying interactions between fishing gear and the seafloor is necessary to ensure that management decisions and/or gear adaptations reflect the environmental impact of decisions related to benthic biotic and abiotic structures, susceptibility rates, and recovery rates of those structures.

Gear modification is cited as an effective tool for minimising bottom contact while still maintaining productivity in a fishery. Informed appropriate, effective gear modification will meet the goals of the Blue Economy (finding marine activities that create economic value and contribute positively to social, cultural and ecological well-being in Aotearoa New Zealand) by minimising contact whilst maximising productivity.

We propose to design low-cost, easy-to-use sensors to measure contact to establish nominal swept area for status-quo inshore fishing gear, focusing on a trawl vessel(s) in the Hawke's Bay region. The data collected will be presented as a 'tow profile' and demonstrate when and where the various components of gear make contact. This data collected from status quo gear will then inform modifications to be made to the gear to minimise bottom contact whilst maximising catches. The nominal swept area calculations of the status-quo and modified gear will then be overlaid with BOMEC habitat class data to compare the amount of habitat disturbance occurring with status-quo verses modified gear, using the data collected.

F. PROBLEM DEFINITION/OPPORTUNITY

It is recognised that bottom fishing interacts with the seafloor, causing disturbance and changes to the benthic environment, including superficial contact as well as penetration into sediment. Fisheries managers are required to balance economic activity with sustainable practices that ensure the long-term health of fisheries[1]. Gear modification is recognized as an effective way to minimising contact with the seafloor, while maximising catches[2]. If modifications are to be made, we first need to empirically measure contact in typical fishing gear during a normal fishing event.

Our understanding of baseline benthic contact is based on model assumptions of door spreads and 100% contact between doors spatially and temporally during a fishing event. These assumptions are applied to inshore trawl vessels, whose footprint makes up 7% of the area available to trawling but have a much wider variety of gear used in the fleet[3].

The consequences of oversimplistic assumptions being used to understand our inshore trawl footprint is that management decisions and promotion of innovation is undermined. It results in inaccurate statements and predetermined assumptions to be made on the extent and scale of benthic interactions[4]. AEBR 2019-20 recognises the need for ongoing research to refine 'methods to estimate the extent and effect of bottom fishing'[5].

To understand the effects of mobile bottom fishing on benthic habitats, it is necessary to have knowledge of the amount of interaction by gear and component (e.g. trawl doors) and the extent to which mobile bottom fishing methods are used in each habitat (the overlap). Towed fishing gears and their components affect benthic habitats and organisms but the level of effect will depend on the type of trawl doors and ground gear used, the way the gear is rigged, and the physical and the biological characteristics of the seabed habitats in the fishing grounds. The extent and nature of any effect will also vary dependent on the resilience of the benthos to disturbance, and the frequency and intensity of bottom fishing[6].

[1] Ray Hilborn et al., "The Trade-off between Biodiversity and Sustainable Fish Harvest with Area-Based Management," *ICES Journal of Marine Science*, 2020, https://doi.org/10.1093/icesjms/fsaa139.
[2] Hilborn et al.
[3] Fisheries New Zealand, "Aquatic Environment and Biodiversity Annual Review 2019-20," 2020.
[4] Stephen Eayrs, Tony Craig, and Katherine Short Partner, "Mitigation Techniques to Reduce Benthic Impacts of Trawling," 2020.
[5] Fisheries New Zealand, "Aquatic Environment and Biodiversity Annual Review 2019-20."
[6] Fisheries New Zealand.

Collecting this type of information has not been pursued due technology, time, and resource constraints. The inshore trawl fleet, made up of smaller vessels with smaller gear, are not as well-equipped with net mensuration technology as larger commercial fishing vessels. Data that has been collected has been done in one-off experimental designs rather than observing contact in normal fishing events over a season or across multiple vessels. The lack of quantitative information on benthic interactions means that when fishers make proactive gear modifications there is no empirial data to determine the success of these changes.

G. OUTPUT/SOLUTION

End user focussed solution that will align outputs to support the outcomes sought by stakeholders of reduced bottomcontact whilst maintaining productive. Given this broader context this solution has been developed to support long term sustainable fisheries. The management objectives in FNZ's draft inshore finfish fisheries plan look to support innovation of fishing technology to avoid, remedy or mitigate impacts of fishing on habitats of significance for fisheries management and the benthic environment. This aligns with FNZ's Fisheries Change Programme promotion of improved monitoring and verification of fisheries.

Our solution is a multi-phased project to improve data collection on gear and benthic interactions, use data collection to make vessel specific gear modifications and develop more informed evidence-based decision-making.

1) Demonstrate the utility of empirically derived contact data to establish current inshore footprint based on real world observations
    a. *Manufacture 15 prototypes of low-cost, easy-to-use bottom contact sensors appropriate to the New Zealand inshore fleet that can be used during normal fishing events and record gear-seabed interactions over many fishing events.*
2) Use Hawkes Bay pilot study to demonstrate how data from sensors can assist decision making when fishers make gear modifications to minimise bottom contact: Deliverables include:
    a. *Empirically derived contact data during normal fishing operations.*
    b. *Analysis of contact-adjusted swept area of status-quo gear, and calculation of contact-adjusted swept area using gear modification.*
    c. *Maps overlaying swept area maps for the fisher involved in the project with BOMEC habitat classes to demonstrate changes in benthic interactions.*
    d. *Peer reviewed reports*

H. PROPOSED RESEARCH/APPROACH

This research addresses emerging issues highlighted by AEBR 2019-20 that highlight the opportunities presented by better spatial information from finer scale reporting and will benefit from finer scale spatial information on bottom interactions. Furthermore it recognises and looks to build on the knowledge of existing research:

1) ZBD2019-01 Quantifying benthic biodiversity Part 2;
2) BEN2019-01 Monitoring the extent and intensity of bottom contact by trawl and dredge fishing in the Territorial Sea and Exclusive Economic Zone;
3) BEN2019- 04 A spatially explicit benthic impact assessment for inshore and deepwater fisheries in New Zealand;
4) BEN2019-05 Towards the development of a spatial decision support tool for managing the impacts of bottom fishing on in-zone, particularly vulnerable or sensitive habitat

This work directly aligns with the Hawke's Bay Marine Advisory Council's involvement with Sustainable Seas project "Enhancing implementation of Ecosystem-Based Management in Hawke's Bay", in which benthic interactions due to commercial fishing activities was identified as a stressor in the Hawke's Bay region. This work is aligned with the management objectives stated in FNZ's draft inshore finfish fisheries plan which will look to support innovation of fishing technology to avoid, remedy or mitigate impacts of fishing on habitats of significance for fisheries management and the benthic environment. Furthermore this work aligns with FNZ's Fisheries Change Programme which promotes improved monitoring and verification of fisheries.

This project builds on work that has been done in the North Pacific by King et al (2020 – *in review*).

A three-phased approach is proposed:

Phase 1: Development & deployment of low-cost, user-friendly bottom contact sensors

Commercially available bottom contact sensors are not designed to be used on small inshore vessels that have limited communication capacity, and are generally prohibitively expensive for small operations as well, especially if intending to use more than one (one commercially available unit is quoted at $40-$50k NZD). Some custom designs have been used in research contexts; however these use sensors that need a significant amount of involvement from the operator in terms of pre-programming and downloading. Additionally, some have used acoustics to monitor net performance and contact; however, the resolution of this information is not enough to determine direct contact between components and the seafloor.

A tilt-sensor uses an accelerometer which can measure angles based on the offset from gravitational force. The angle measured by the sensor is translated into an estimate of height above the seabed based on the length of the sensor, either by a quadratic equation [7] or trigonometric equation. Tilt sensors will provide a cost-effective for measuring bottom contact.

With the expertise of Zebratech, a New Zealand-based company that specializes in underwater and fisheries-related instrumentation development , we will build custom-designed housing with an incorporated tilt-sensor (collectively referred to as a 'sensor') appropriate for New Zealand inshore trawl components (footrope, sweeps, and doors).

Several features will be incorporated into the design of the sensor housing:

- Ability to attach to multiple trawl components (doors, sweeps, footrope)
- Attachment point needs to allow some freedom of movement, but not have data that is too noisy
- Ability to attach and detach quickly so it can be used during normal fishing operations and not need to remain on the net (e.g. snap shackles)
- Use material that can protect the instrumentation but allow for wireless transmission of data (e.g. a protective stainless-steel frame)
- Be hydrodynamically designed so that it is possible to differentiate between 'off' the bottom (in an upright position) and 'on' the bottom (in a vertical position) with at least 95% confidence
- The sensors will need to transmit data wirelessly, such as through a Bluetooth connection. This will allow the sensors to be deployed during normal fishing operations, and not require additional personnel to collect data
- A pressure-switch will be incorporated so that the sensors will also turn on and off on their own. This will also alleviate any duties off the user.

To begin with, the logging rate will be set at 1 second. Through developments of algorithms, we will determine if a 1 second logging rate is necessary, or if we are able to use a less frequent logging rate to maximize data storage and shorten download periods. In conversations with Zebratech, there is the possibility to incorporate the tilt sensor into existing Moana sensors[8]. It is anticipated that the tilt sensor data may take several minutes per sensor to download, depending on the length of the tow. If so, we would then look to install a Moana deckbox to transmit the tilt sensor data, again alleviating the fisher from these tasks.

We will develop prototypes of custom-housing to be attached at the doors, the sweeps, and the footrope, for a total of 3 prototypes. To design the housings, we will rely on the experience of John Radford in developing sensors that have been attached to fishing gear to inform the sensor design, as well as Brianna King's and Dr. Brad Harris' experience of attaching custom-designed bottom contact sensors on North Pacific trawl vessels for previous experimental studies. Validation of prototypes will be done through simulation (such as a flume tank) and through video observation during fishing operations. Once the prototypes have been validated, we will manufacture the total number of sensors (4x door sensors, 4x sweeps sensors, 6x footrope sensors, plus 1 for contingency) and move to the next stage of the project.

[7] Kenneth L. Weinberg and Stan Kotwicki, "Reducing Variability in Bottom Contact and Net Width of a Survey Trawl by Restraining Door Movement and Applying a Constant Ratio of Warp Length to Depth," *Fishery Bulletin* 113, no. 2 (2015): 180–90, https://doi.org/10.7755/FB.113.2.6.

[8] https://www.moanaproject.org/

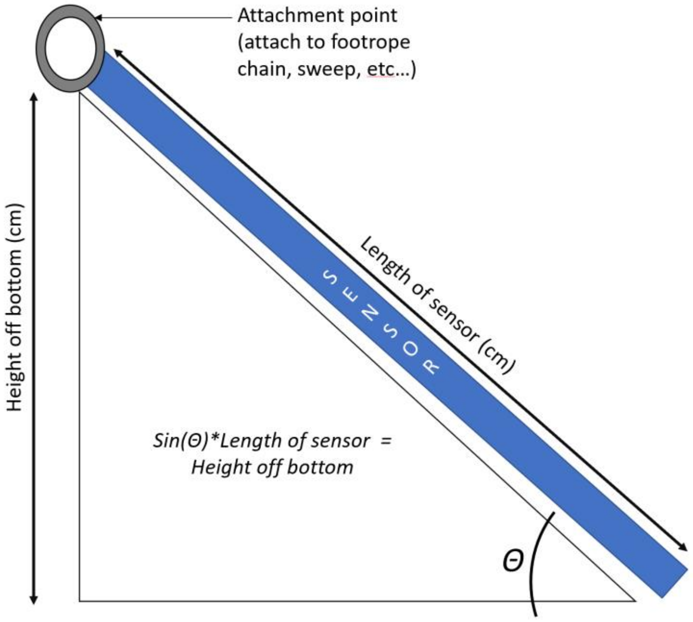


Figure 1 Generic sensor design, and explanation of how the sensor works.

Phase 2: Understand and minimise contact

Status quo gear

Once sensors have been manufactured, they will be deployed on the footrope, sweeps, and doors to collect data on contact points of 'normal' trawl gear during multiple fishing events. This will be performed on inshore trawl vessels in the Hawke's Bay region (one has confirmed interest in their participation in the project, others yet to be determined). This will involve at-sea technician/s such as Shade Smith working onboard the participating vessel to ensure the sensors are operating correctly under phase 1 and provide field work support and technical oversight under phase 2.

We will also take measurements of gear dimensions at the time of data-collection. This will include the 'fixed' measurements of the gear itself and 'dynamic' (i.e. during fishing) measurements deemed relevant to seafloor contact (e.g. door-to-door width, headline height). Location and length of tow events will be acquired from ER/GPR data. Vessel-related variables (e.g. overall length, beam width, horsepower) and fishing-event level data (e.g. date, time, sea-state, current bearing, current speed, fish density, target species, etc.) will also be recorded. This may require leasing additional sensors to deploy with the vessel while bottom contact data is collected.

Any data post-processing will be determined and done to create the tow profiles following methods outlined in King et al 2020 (e.g. determining signal-to-noise ratios and conducting appropriate filtering or smoothing). These will essentially be polygon data files that will display a heat map of contact and no contact per sensor (Figure 1). The proportional area that a particular sensor accounts for will be calculated, and the amount of contact that took place weighted according to this proportion. For example, a sensor in the middle of the footrope may account for 25% of the total swept area of the tow, so the amount of contact measured by this sensor will be weighted by 25%.

Total contact per tow will be summed and presented as the *contact-adjusted swept area* for that tow, and will be compared to the nominal swept area (100% contact from beginning to end of the tow). The sensors that had the highest amount of contact proportionately will be noted. We will analyse which sensors (i.e. locations) measured the most contact and focus on these areas to make gear modifications to help reduce this contact.

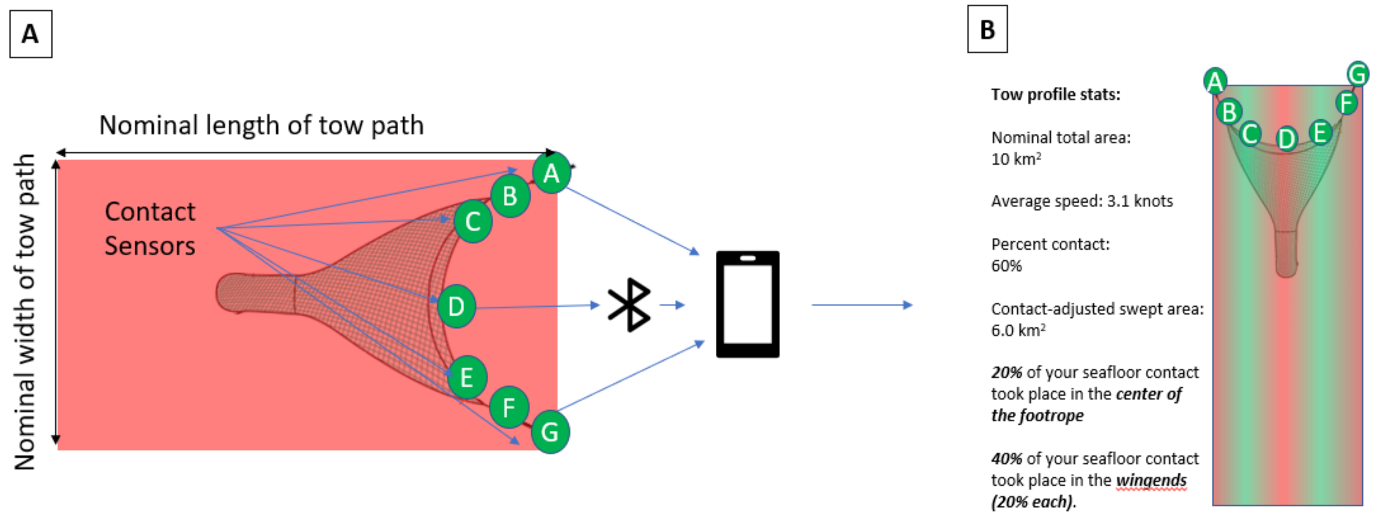


Figure 2 Demonstration of how the sensors are used to develop more high-resolution fishing footprints. Rather than a swept area just using the nominal width of the tow path and the nominal length of the tow path (Panel A), the sensors will inform what portions of the net are making direct contact during a tow (Panel B).

Modified gear

After collecting data on contact-adjusted swept areas using the status-quo gear (what will now be our baseline), these data would inform where it would be best to specifically focus effort to reduce contact in the gear. This analysis alone would demonstrate how this type of data collection can better inform gear operation and design, by using real-world observations and data collection. For example, we may find that in targeting red gurnard, the contact-adjusted swept area is on average 80% of the nominal swept area, but a majority of this contact takes place in the sweeps. For the second stage of this project, we would then focus our efforts on how to reduce contact in the sweeps, such as elevating sweeps using rubber discs. We would then collect data from the same contact points as in Phase 1, and compare the tow profiles of the 'typical' gear with the elevated-sweeps gear, and compare the contact-adjusted swept area with the modified gear to the status-quo gear. The same analysis, in terms of developing polygon data files, will be produced, and the area and percent area swept will be calculated.

There are several approaches to lightening fishing gear. Lighter materials include the use of Dynex line, using pelagic doors to minimize contact of doors and sweeps with the seafloor, or raising sweeps using rubber discs. Some vessels already employ some of these methods. Our goal is to demonstrate how much of a decrease in gear-seabed interaction these modifications can make.

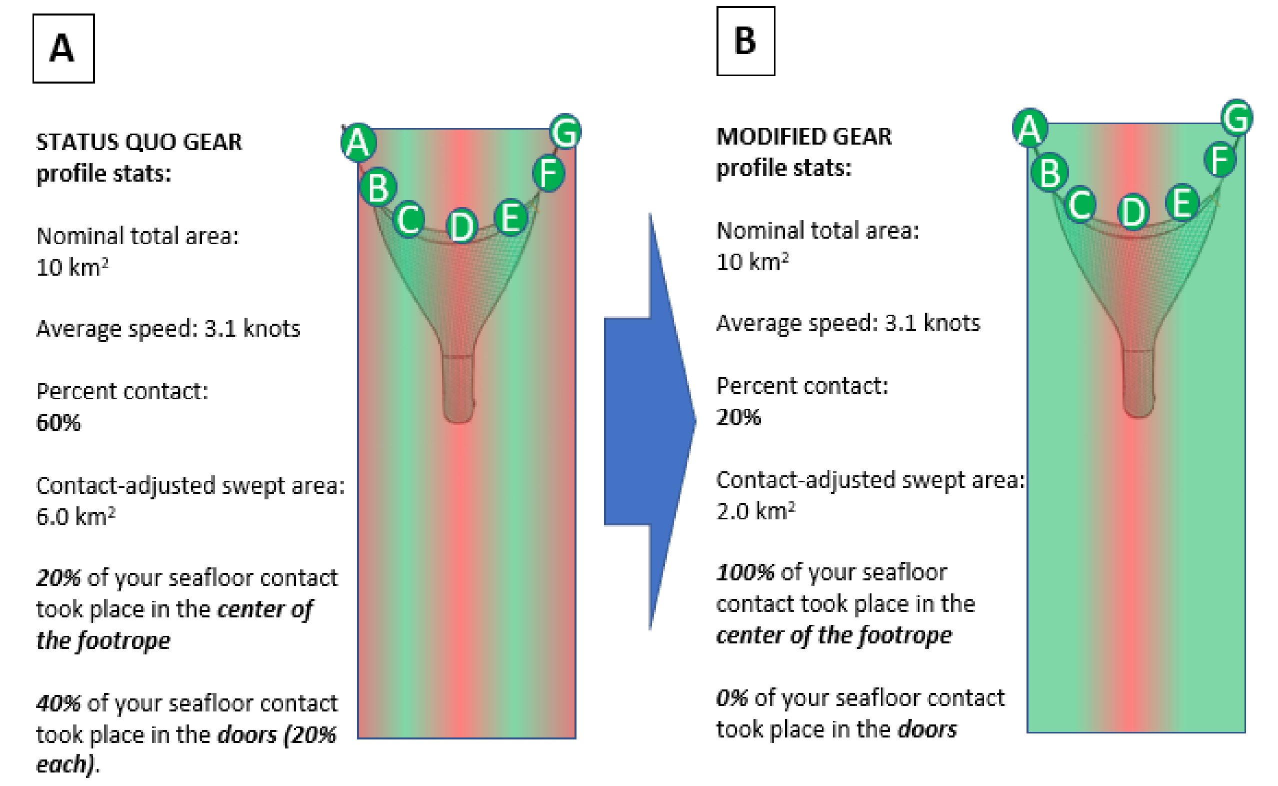


Figure 3 How modifications to status-quo gear (Panel A) can result in improvements in contact (Panel B) with modified gear, using the results of measuring the status quo gear to inform the modifications.

This phase emphasises that what we are proposing is a new datastream for decision making not only for fisheries managers, but for operators and net-makers as well. We will demonstrate the process of how collecting data on the status quo gear can directly better inform modifications and improvements to reduce contact. Net-makers and technologists can better understand how their fishing gear operates in an oceanic environment and make modifications accordingly to suit the needs of their customers. This has ancillary benefits to the operator in minimizing fuel consumption (consequently reducing the CO_2 footprint) and reducing the risk of damaged or lost fishing gear, further amplifying the environmental benefits.

For the Hawke's Bay region, with our participating vessels, we will calculate the spatial footprint of those vessels for the time period of the study; i.e. all tows for which we collected contact data. We will produce 2 spatial footprint calculations:

1) Status-quo map
    a. This will use empirically derived calculations of contact adjustments per tow event. This will be an aggregated contact-adjustment coefficient that is applied to all tows, or the individual tows will have their real-world contact adjustment applied. We anticipate this will show a decrease in contact, both with Maps 1 and 2.
2) Modified gear map
    a. This will demonstrate how the use of alternative gear (such as raised sweeps) reduce contact further, compared to Maps 1, 2, and 3.

Phase 3: Evidence-based decision making

We will demonstrate using the pilot vessel data how this aggregated data could be used to better inform estimates of fishing footprints, and calculating improvements made by using gear modifications as a way of managing benthic interactions.

Identification of benthic environments in the Hawke's Bay region well-suited to gear modification

The amount of long-term disturbance to benthic habitats is dependent on several factors. Disturbance affects biological and geological structures differently, and the long-term effects are different high energy environments vs low energy environments. High energy environments are generally more resilient to anthropogenic disturbance, as they are adapted to more frequent and/or intense natural disturbance events (severe tides and/or currents, frequent storms, etc). These types of environments have quicker recovery and lower susceptibility to fishing disturbance. Gear modification has been cited in the literature as an effective tool for mitigating disturbance in these types of environments [9]. Low recovery and high susceptibility environments may also benefit from modifications made to gear.

Pre-existing habitat data, such as BOMEC classes, will be overlaid with the status-quo map and the modified gear map to demonstrate changes in benthic disturbance and estimates of total disturbed habitat. We can demonstrate where gear modifications could be effective tools to mitigate benthic disturbance without decreasing fishing effort, based on the type of benthic habitats present. We have been in discussion with FNZ, and there is the opportunity to present the methodology and results of this work through one of the science working groups (either Aquatic Environment Working Group or the Benthic Environment Working Group). This will assure that our methods and results are assessed through the peer-review process.

The results of this process – empirical measurement of status quo gear, using data to inform gear modifications, quantification of reduction in benthic impacts as a result of gear modifications, and an estimation of reduced benthic impacts as a result of the data feedback loop – will be compiled in to a manuscript and submitted to a peer-reviewed journal. Included in the final report will be a discussion of to what kind of results would be anticipated should a broader rollout of these sensors and methods be used in the future, and what that could mean for management measures and decisions.

I. CONTRIBUTION TO BLUE ECONOMY IN AOTEAROA NEW ZEALAND

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"Blue Economy" is a term increasingly used internationally to describe people's interconnectedness and dependence on marine resources. These activities in New Zealand utilise marine resources that generate economic value and contribute positively to social, cultural, and ecological well-being. This implies transitions and new approaches, including ecosystem-based management, addressing the main question of the Sustainable Seas challenge: how can we best develop our marine economy, while protecting the taonga of our marine environment?

Our proposal's approach to answering this question is to improve real-world data streams so that we can better understand our interactions with the oceanic environment, and so manage our interactions more precisely and accurately. This will ensure responsible and well-informed management of our fishery resources, allowing for continued and sustainable utilisation. Understanding our interactions with the seafloor will help feed into objectives of ecosystem-based management, using a more holistic approach to understanding commercial fisheries' interactions with the environment. Better understanding of benthic interactions will benefit New Zealanders by supporting long term food security in a manner that reflects the need to minimise environmental impacts and support New Zealand's social, cultural and economic objectives.

This project is focussed on end-user outcomes both in terms of both direct and indirect economic benefits. Direct benefits realised by reducing gear interaction with the seafloor, include reduced fuel usage which reduces operational costs, whilst minimising interaction with the seafloor also reduces the risk of damage to gear, which in turn also reduces costs for replacing or repairing gear. Indirect benefits from reducing interactions with the seafloor include maintaining the health of the benthic environment, ensuring the environmental and economic sustainability of fisheries that are reliant on this habitat.

These same benefits have other direct environmental outcomes as well. Reduced fuel usage reduces the overall carbon footprint of the fleet. Reducing the risk of lost or damaged gear reduces the risk of derelict gear remaining in the oceanic environment. Measuring benthic interactions supports the sustainable use of fishery resources for economic growth, improved livelihoods, and jobs while preserving the health of New Zealand's marine ecosystem. Ensuring the economic sustainability of fisheries is important for providing work for New Zealanders, for which the social and cultural ramifications are significant.

While this project is a pilot study to demonstrate the implications of this innovative approach in the Hawke's Bay region, the development of this project will provide the basis for broader adoption of vessel specific benthic interactions in inshore New Zealand vessels. It provides a transformational steppingstone to use empirical data to support evidence-based decision making and support broad scale uptake of sensors and subsequent gear modifications as appropriate.

[9] McConnaughey et al., "Choosing Best Practices for Managing Impacts of Trawl Fishing on Seabed Habitats and Biota"; Jonathan H. Grabowski et al., "Assessing the Vulnerability of Marine Benthos to Fishing Gear Impacts," *Reviews in Fisheries Science & Aquaculture* 22, no. 2 (2014): 142–55, https://doi.org/10.1080/10641262.2013.846292; Jake Rice, "C s a S" 3848 (2006).

J. BENEFITS AND CONNECTIONS TO IWI, HAPŪ AND MĀORI ORGANISATIONS

Benefits and connections to New Zealand as a whole

The improved understanding of the interactions of fishing gear with the seafloor can better inform the impacts of fishing on the local environment, which will better inform management of the fishery resources for customary use as well as recreational or commercial use. Improved data collection will improve stewardship and kaitiakitanga of marine resources such as fish stocks, and also improve protection of taonga by ensuring the quality of the benthic environment. Managing benthic impacts with gear modification can allow for utilisation of the resource for customary purposes as well. Te Ohu Kai Moana have expressed their interest in this work and in providing their input and expertise on how this project could benefit Māori.

Benefits and connections to the Hawke's Bay region

Ngāti Kahungungu (Kahungungu) is the local iwi of the Hawke's Bay and Wairarapa region. FINZ has worked collaboratively with Kahungunu on other fisheries sustainability research, including selectivity trials conducted in 2020, and have both served on the Hawke's Bay Marine Advisory Council. In the collaborative spirit of this project, fish collected during this project may be used for pātaka. FINZ and Kahungunu believe this could be a direct, immediate, and tangible positive contribution to the local Hawke's Bay community as a result of this research. Kahungunu's involvement, by way of its membership on the steering committee will contribute māutaranga Māori, data collection, and coordinate the use of pātaka, will be a significant and important contribution to this project.

K. COMMUNICATION OF PROJECT RESULTS

Project results will be communicated through the recognised Fisheries New Zealand peer-review process via the Aquatic Environment Working Group (AEWG). AEWG will provide the scrutiny and oversight needed to ensure that we are collecting the appropriate data, and that the data products have been analysed appropriately and sufficiently.

We foresee the potential for two peer-reviewed pieces of work to result from this work. One would be a quantitative comparison of the standard fishing footprint, an empirically derived fishing footprint, and a fishing footprint of modified gear. Statistical spatial analyses would be conducted to demonstrate the changes in benthic interactions. The other would be a demonstration of using these data as a way for fisheries managers to make decisions on ways to mitigate impacts to benthic interactions. This would be a case study using the data collected in Hawke's Bay as a demonstration of what could be done for the wider New Zealand marine space.

Communications for the project results will also be achieved through FINZ's industry networks to promote this work, including via the Seafood New Zealand magazine and via nationwide industry forums such as at the Seafood New Zealand conference, the Maori Fisheries Conference and the Federated Fisheries Conference,

Additionally, results will be communicated via the HBMAC to locally promote the project results in order to support this group in the context of aligning the engagement approach of Sustainable Seas project looking at Systems Mapping of benthic disturbance in the Hawkes Bay.

L. CO-FUNDING (Source and amount)

Fisheries Inshore New Zealand will be contributing their time and expertise to project management and also through their personal experience on similar projects. This will be contributed through their core-funding. Other contributions will be made through technical expertise by collaborative partners. Chartering vessels can range from $3000-$7000 per day, and so a commercial vessels' time to collect several days' worth of data will be a significant contribution to this project. In-kind contribution include time on vessels, particularly Rick Burch's vessel the Nancy Glen will be circa $15,000. FNZ staff time to support the project as part of the technical advisory committee will provide approximately $5000 of in-kind staff time.

M. RISK & MITIGATION

Risk: Restrictions or delays directly related to COVID-19.

Mitigation: Trade and delivery risks have been mitigated primarily by using New Zealand based companies for the development of the sensors themselves, and also for the data collection and technical roles. This will reduce reliance on international suppliers. International contribution can be easily done with Zoom and other platforms. The risk of impacts on fishing have been mitigated

Risk: Lack of vessel availability

Mitigation: The vessel is being chartered to mitigate this. Once fishing the equipment will automatically log data so delays in operations will not impact project outcomes.

Risk: Equipment delivery / failure
Mitigation: Contractual arrangements will ensure warranties are in place and delivery milestones.

Health and safety in the implementation of this project will be of primary importance. Risk is minimised by the level of expertise and experience of all involved on the project to ensure its success.

N. CONSENTS & APPROVAL required to undertake research	• It is not anticipated that the modifications made to fishing gear will be outside of regulations and require a Special Fishing Permit. However, if necessary, we will apply for a Special Fishing Permit for the purpose of testing alternative gear. • For this research, we may use fish as pātaka for the Hawke’s Bay region. The appropriate kaitiaki, rohe moana, and other processes will be supplied as a proposal to FNZ prior to fishing and data collection. • We will need the consent from the quota owners to access their ER/GPR data relevant to the study. FINZ has been through this process for other projects.