FORM 2

Fisheries New Zealand
Tini a Tangaroa

Voyage Programme TAN1908: Sub-Antarctic Ecosystems

Date:	**30 September 2019**
Research Provider:	**National Institute of Water and Atmospheric Research (NIWA)**
Project Code:	**ZBD2018-05**
Project Title:	**Ecosystem function and regime shifts in the Sub-Antarctic**
Principal Investigator:	**Ian Tuck**
Vessel:	**R.V. *Tangaroa***
Area:	**Southland and Sub-Antarctic**
Voyage Start Date:	**11 November 2019**
Voyage End Date:	**8 December 2019**
Voyage Leader:	**Pablo Escobar-Flores**
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OBJECTIVE

This *Tangaroa* survey will address information gaps for understanding and modelling the effects of climate variability on ecosystem function in the Sub-Antarctic region, including effects on protected species and on ecologically and economically important fisheries.

VOYAGE OBJECTIVES

1. Carry out a stratified random acoustic survey of the Western Campbell Plateau and adjacent regions of the Subtropical Front to estimate the relative abundance of micronekton
2. Undertake mark identification sampling to ground-truth acoustic data and to collect biological information on micronekton
3. Carry out a bottom trawl survey, using the same randomised spatial design as Objective 1, to provide information for assessing the spatial coupling of focal fishery species with their mesopelagic prey
4. Carry out acoustic transects in selected regions of the Subtropical Front and the western Auckland Islands shelf break for determining the relative spatial density of mesopelagic taxa in megafauna foraging hotspots and high productivity regions adjacent to the survey strata
5. Collect environmental data for developing ocean climate predictors of mesopelagic and focal fish density in space and time
6. Recover acoustic mooring previously deployed on the Campbell Plateau to monitor the abundance and vertical distribution of pelagic organisms.

BACKGROUND

Fisheries New Zealand has commissioned NIWA to assess ecosystem function and regime shifts in the Sub-Antarctic region (project code ZBD2018-05). A voyage to the region is required to collect data currently unavailable from existing data sets that are needed to inform the modelling component of the overall project (Objective 4 below).

PROJECT OBJECTIVES

The overall objective of this project is to understand and model the effects of climate variability on ecosystem function in the Sub-Antarctic region, including effects on protected species and on ecologically and economically important fisheries.

The Specific Objectives for this project are:

1. Explore information providing environmental/biological signals about environmental change in the Sub-Antarctic marine environment;
2. Explore evidence for synchronous changes and identify environmental mechanisms of ecosystem change;
3. Construct ecosystem models incorporating mechanisms identified in Objective 2;
4. Design and conduct a RV *Tangaroa* survey to test structural assumptions and inform parameterisation of ecosystem models produced under Objective 3; and
5. Identify indicators of environmental change, e.g., regime shifts, tipping points or persistent trends affecting the distribution and productivity of marine living resources, to inform the design of environmental monitoring.

This *Tangaroa* survey will address information gaps for developing ecosystem models, focussing on spatial distributions and inter-relationships of ecosystem components. The survey aims to:

1. Characterise the taxonomic composition and relative spatial density of micronekton taxa, including mesopelagic fish and crustaceans;
2. Assess the spatial density and relative biomass of their fish/squid species predators, including hoki, southern blue whiting, and southern arrow squid—all key fish stocks of the New Zealand Sub-Antarctic;
3. Characterise the diet composition of focal fish and squid species;
4. Collect environmental information that can be used to develop climate predictors of micronekton/focal fish and squid species distribution and
5. Explore the relative density of micronekton/focal fish and squid in areas of high productivity and megafauna species foraging.

Research benefits

The project science is crown-funded through Fishery New Zealand's Marine Biodiversity Research Programme and will contribute to improved understanding of marine biodiversity in the Sub-Antarctic region.

The data collected during the voyage will be used to improve current knowledge about micronekton diversity in an unsampled area of New Zealand waters. The data will be used to develop multispecies models for assessing climate effects on the NZ Sub-Antarctic marine ecosystem, including endemic fauna (e.g. New Zealand sea lions, albatross species) and economically important fish stocks (e.g. hoki, southern blue whiting, arrow squid). The survey will also build on a New Zealand sea lion prey species survey of the Auckland Islands and Stewart-Snares Shelf in Feb/March of 2016, by assessing prey species distributions in areas for which spatial information is currently lacking.

The New Zealand Government is committed to meeting its international obligations under UNCLOS, CBD, and FAO, as well as its own legislative responsibilities and strategies, to maintain ecosystem services and biodiversity that underpin the functionality and productivity of our seas (see references). The survey proposed here meets the objectives of the New Zealand Biodiversity Strategy and the New Zealand Biodiversity Action Plan Targets 1, 5 and 6 (DOC 2016 www.doc.govt.nz/nature/biodiversity/nz-biodiversity-strategy-and-action-plan/new-zealand-biodiversity-action-plan/).

EXPERIMENTAL DESIGN AND METHODS

The survey area is shown in Figure 1 and Table 1. The 12 survey strata range from Puysegur in the north to the southern Campbell Plateau shelf break in the south, and from 300–1000 m depth, and are a subset of strata which have been surveyed in previous summer and autumn surveys (e.g., Bagley et al. 2017). These strata include regions of the Subtropical Front, where younger hoki will typically be more abundant, and colder regions at the southern end of the Campbell Plateau, which are normally dominated by older aged hoki. This design was chosen to provide the contrast in conditions (i.e. ranging from sub-optimal to optimal) required for fitting habitat preference functions for hoki and other focal fish stocks (a primary objective of project ZBD2018-05). Survey strata in the northwest of the survey region (e.g. around Pukaki Rise and the eastern Campbell Plateau) will not be covered by this survey, due to insufficient time. Strata 3 and 5 were recombined (i.e. from 3a and 3b, or 5a and 5b, respectively) in order to reduce the number of survey strata.

The survey design and methods for each of the five voyage objectives are detailed below. The survey station locations are listed in Appendix 1.

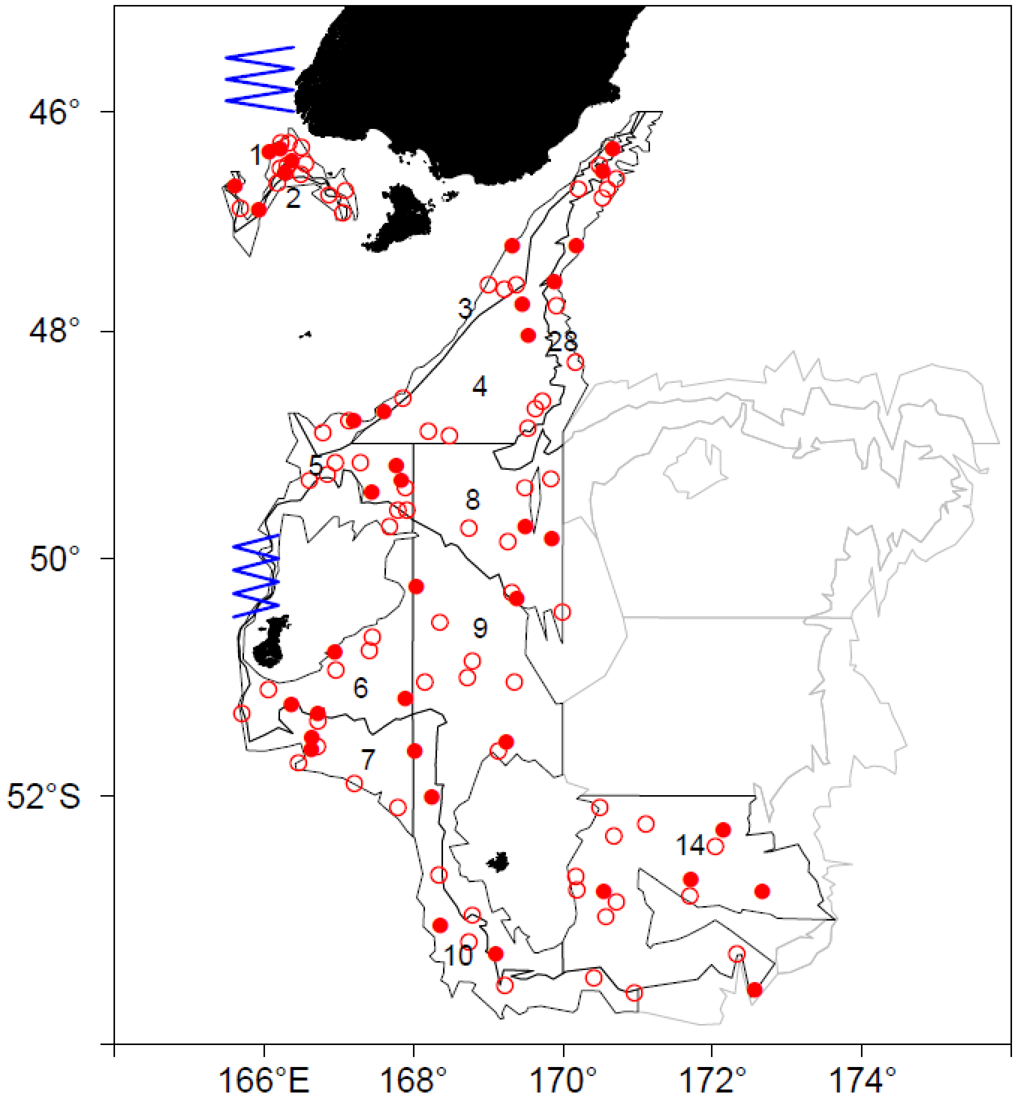

Figure 1: TAN1908 survey area. The random acoustic and bottom/midwater trawl survey stations for estimating the relative spatial density of mesopelagic taxa and their predators, are displayed as red points (filled = first phase, open = spares). Trawl survey strata are represented by black polygons (based on the Southland and Sub-Antarctic trawl survey design). Approximate tracks of acoustic transects are represented by blue lines, including one transect west of Fiordland region (high primary production) and another north-west of the Auckland Islands (New Zealand sea lion foraging hotspot). Targeted midwater trawls may also be deployed along acoustic transects.

Table 1: Proposed stratum areas, depths, and random bottom/midwater trawl station allocation for TAN1908. Survey strata numbering is consistent with the Sub-Antarctic and Southland bottom trawl survey design (with modifications to strata 3 and 5) (see Figure 1).

Stratum	Region	Depth (m)	Area (km^2)	Number of stations (first phase only)
1	Puysegur Bank	300–600	2 150	3
2	Puysegur Bank	600–800	1 318	3
3	Stewart-Snares	300–600	6 104	3
4	Stewart-Snares	600–800	21 018	3
5	Snares-Auckland Islands	600–800	6 262	3
6	Auckland Islands	300–600	16 682	3
7	South Auckland Islands	600–800	8 497	3
8	N. E. Auckland Islands	600–800	17 294	3
9	North Campbell Island	300–600	27 398	3
10	South Campbell Island	600–800	11 288	3
14	East Campbell Plateau	300–600	27 659	5
28	East Stewart Island	800–1 000	8 336	3
Total		300–1 000	154 008	38

Objective 1: Carry out a stratified random acoustic survey of the Western Campbell Plateau and adjacent regions of the Subtropical Front to estimate the relative abundance of micronekton.

Micronekton is the term used to collectively describe a group of relatively small organisms (~2–20 cm) including fish, squid, crustaceans, siphonophores and gelatinous organisms, which inhabit open-ocean pelagic ecosystems. In the pelagic food web, micronekton is at the mid-trophic level (MTL) and plays a key role linking primary and tertiary consumers. Despite their importance, our knowledge of MTL organisms is still very limited. Micronekton species contribute to ecosystem resilience and may be affected by both top-down (e.g., fishing) and bottom-up (e.g., climate change) stressors (e.g., Brodeur et al., 2019). Spatially explicit time-series of MTL species are required for ecosystem models to be developed under project ZBD2018-05.

Fisheries acoustics is the sampling technique most commonly used to study micronekton communities because it provides continuous, high-temporal and spatial resolution information, and data collection is relatively straightforward. Although acoustic data has been collected routinely in the Sub-Antarctic region during trawl surveys, and these data have been used to estimate mesopelagic abundance (McClatchie & Dunford 2003, O'Driscoll et al 2011), there have been no dedicated surveys of micronekton in this region.

Acoustic data will be collected continuously throughout the voyage using *Tangaroa*'s suite of multi-frequency Simrad EK60 echosounders (18, 38, 70, 120, and 200 kHz). Acoustic data will be used to estimate the relative abundance of micronekton in the Sub-Antarctic region following the methodology developed by Escobar-Flores et al., (2019) for micronekton on the Chatham Rise east of New Zealand. This methodology uses multifrequency acoustic data to classify acoustic marks (schools or layers) and disaggregate backscatter collected at 38 kHz into groups or taxa using principal component analysis and classification trees. A key aspect of this approach is the mark identification trawling to 'ground-truth' detected acoustic marks (school or layers), which requires dedicated survey information (see Objective 2).

The timing of the survey overlaps with the historical period of the biennial trawl survey in Southern Plateau to estimate the abundance of hoki and middle depth fish. Acoustic data collected during bottom and midwater trawls at each stratified random station (red points in Figure 1) will be used to extend the time series of micronekton relative abundance derived from multi-frequency acoustic data on bottom trawl surveys since 2008 (8 surveys).

In addition to the collection of acoustic data during bottom and midwater trawls, we will also monitor acoustic data collected during transit or steams between stations in the survey area to search for pelagic acoustic marks to ground-truth by midwater trawling (Objective 2).

Objective 2: Undertake mark identification sampling to ground-truth acoustic data and to collect biological information of micronekton.

The main purpose of the midwater trawls will be to identify the taxonomic composition of acoustic marks or scattering layers observed in the echosounders, and to assist with their classification. Mark identification (mark ID) trawls will be carried out at each random station and also opportunistically, as acoustic marks of interest are encountered in the vessel path. Mark ID tows will principally be carried out during day to avoid periods of dusk and dawn when animals are vertically migrating and form mixed layers.

Three trawls will be used:

1. A fine mesh mesopelagic trawl ('myctophid' trawl), with a 10 mm mesh codend, a headline height of 12–15 m, and a door spread of around 140– 160 m to target mesopelagic fish;
2. A large mesopelagic trawl (NIWA '119' trawl) with a 40 mm mesh codend to target larger pelagic fish;
3. A fine mesh (13 mm) rectangular midwater trawl (RMT) with a PVC codend to sample crustaceans (e.g. euphausiids).

For mark ID trawls, the net will be towed at the depth of the scattering layer of interest at speeds of 3 to 4 knots. An RBR temperature-depth logger will be attached to the trawl on each deployment to provide an accurate time/depth profile for each trawl and to match the trawl path with the acoustic data. The temperature information collected by the RBR will also be used to estimate the sound speed and frequency-dependent absorption coefficient (Doonan et al., 2003).

The catch of each mark ID trawl will be sorted and, where possible, identified to species or family onboard the RV *Tangaroa*. The total sample of each taxon will be weighed on Marel motion-compensating electronic scales accurate to about 0.1 kg, and enumerated. For small organisms (e.g. euphausiids) a weighed subsample will be taken and enumerated, and this information will be used to provide an estimated number for the total catch. An approximately random sample of up to 100 individuals of each species of fish in successful mark ID trawls will be measured using digital measuring boards, accurate to about 1 mm.

The efficiency and selectivity of trawl gear can misrepresent the community composition and bias catches towards larger specimens (Brodeur and Yamamura, 2005; Davison et al., 2015; Kaartvedt et al., 2012; Pakhomov and

Yamamura, 2010; Rodhouse, 2013). We will use NIWA's acoustic-optical system (AOS) and the DIDSON imaging sonar on some tows to allow for more comprehensive sampling of micronekton communities.

NIWA's AOS combines echosounders and stereo cameras and can be mounted on the hoki bottom trawl or lowered as a stand-alone system. The DIDSON imaging sonar is currently on loan from the University of Hawaii, and can be used to observe and measure pelagic organisms without the use of lights, providing an advantage over more traditional optic equipment with lights, which may influence the organisms' behaviour. The DIDSON can be deployed as a standalone instrument (or together with the AOS), using the CTD winch to collect near-video quality high-definition and high-frequency sonar data (1.1-1.8 MHz) from acoustic marks while drifting.

In addition to the 38 mark ID trawls associated with each random station, we aim to do another 20 tows on acoustic marks detected opportunistically (e.g. while steaming).

Objective 3: Carry out a bottom trawl survey, using the same randomised spatial design as Objective 1, to provide information for assessing the spatial coupling of focal fishery species with their mesopelagic prey

A bottom trawl survey will be undertaken to assess the spatial density of hoki, southern blue whiting and southern arrow squid relative to their prey species. This will provide information for estimating habitat preference functions that can be used by spatial multispecies models developed by project ZBD2018-05. Prior information suggests that there will be a very strong relationship between hoki density and acoustic backscatter at frequencies that will be dominated by mesopelagic fish (O'Driscoll et al. 2011).

The bottom trawl survey will use a stratified random trawl survey approach (after Francis 1984), using the same 38 survey stations as the acoustic and micronekton trawls (Figure 1, Table 1). The same eight-seam hoki trawl (Chatterton & Hanchet 1994) will be used as previous surveys in the summer series of Sub-Antarctic and Southland trawl surveys. The trawl procedures, the recording of tow parameters and species caught will follow the standardised guidelines recommended by Hurst et al. (1992), and the timing of this survey is consistent with previous surveys in the summer series which have been carried out from 12 November to 24 December (Bagley et al. 2013),

The bottom trawl survey does not aim to produce a biomass estimate to extend the summer series of hoki relative abundance in the Sub-Antarctic and Southland region, as it will only cover a part of the full survey area. No target CVs will be specified by this project.

The survey will aim to complete a minimum of three bottom trawls per stratum, with five stations in Stratum 14 to provide adequate numbers of southern blue whiting for dietary sampling of this species (see later).

Although the estimation of biomass is not a primary objective of this survey, standard survey methods will be followed. A list of randomised trawl survey locations has already been developed for each survey stratum (see Figure 1 and Appendix 2). All stations are a minimum of 3 n. miles apart. Tows will be 3 n. miles long and will either follow the bottom contour (weather permitting) or be in the direction of the next tow if time is limiting. Bottom trawling will be restricted to daylight hours. If foul ground is encountered at a random station a search within 5 n. miles radius for suitable ground will be made. If the ground is still unsuitable for trawling, the next station from the random station list within practical steaming distance (i.e. one which does not involve significant backtracking) will be chosen. Station records will be kept by the officer of the watch and include recordings of doorspread, headline height and speed made every 5 minutes during the trawl shot.

The catch will be sorted and weighed on motion compensated scales by species on every successful tow. If the catch is too large to be weighed, back-calculation will be used from product weight (conversion factors may need to be calculated). Weights of large fish that remain on the deck will be estimated. Large catches of rattails may be sub-sampled and the total catch estimated from the proportional mix in the sub-sample.

The primary goal of this survey objective is to estimate the relative spatial density of different age-stages of hoki, southern blue whiting and southern arrow squid, and to collect dietary observations for informing the development of habitat preference models (under project ZBD2018-05). A secondary goal will be to estimate the relative doorspread biomass for hoki, hake and ling within the surveyed strata, by the swept area method, using the NIWA custom software SurvCalc (Francis 2009).

Dietary sampling will also be undertaken on fish obtained from survey trawls in order to:

- Estimate the diet composition of focal fish species, e.g. hoki, southern blue whiting, and southern arrow squid, by life stage;
- Assess the spatial agreement between diet composition and the relative spatial density of the respective prey species (from the outputs of sampling under Objective 2); and
- Direct the development of habitat preference functions for focal fish species (the ultimate objective of this research for project ZBD2018-05).

Dietary samples will be collected from hoki, southern blue whiting and southern arrow squid. At each trawl station, the first 20 stomachs for each of these species containing prey items will be retained for NIWA laboratory-based dietary sampling (funded already obtained under project ZBD2018-05). Subsequent hoki and southern blue whiting stomachs containing prey (at each trawl station) will be subject to dietary analysis in the *Tangaroa* wet lab.

Objective 4: Carry out acoustic transects of selected regions of the Subtropical Front and the western Auckland Islands shelf break for determining the relative spatial density of mesopelagic taxa in megafauna foraging hotspots and high productivity regions adjacent to the survey strata.

Non-random acoustic sampling will be undertaken in known regions of high productivity and marine megafauna foraging, adjacent to the standard hoki trawl survey area (Figure 1). A recent project that developed habitat models for New Zealand sea lions at the Auckland Islands (PRO2017-12; Large et al. 2019) was hampered by a lack of information about prey density in regions of steep seafloor, particularly to the northeast of the Islands—a known foraging hotspot for this population (Large et al. 2019).

Another Fisheries New Zealand project, currently underway, is developing habitat models for fur seals, which are frequently captured in surface longline fisheries to the west of Fiordland (PMM2018-04A; Dragonfly 2019) (Figure 2). This region sits at the leading edge of the Sub-Tropical Front as it moves to the south of New Zealand, and is known to be dynamic and highly productive (Pinkerton 2016) (Figure 2). In addition, it is a putative spawning region for southern arrow squid (Uozumi 1998), and could potentially provide foraging habitat for hoki. However, this region is too deep for bottom trawl survey sampling, and has not previously been covered by acoustic surveys.

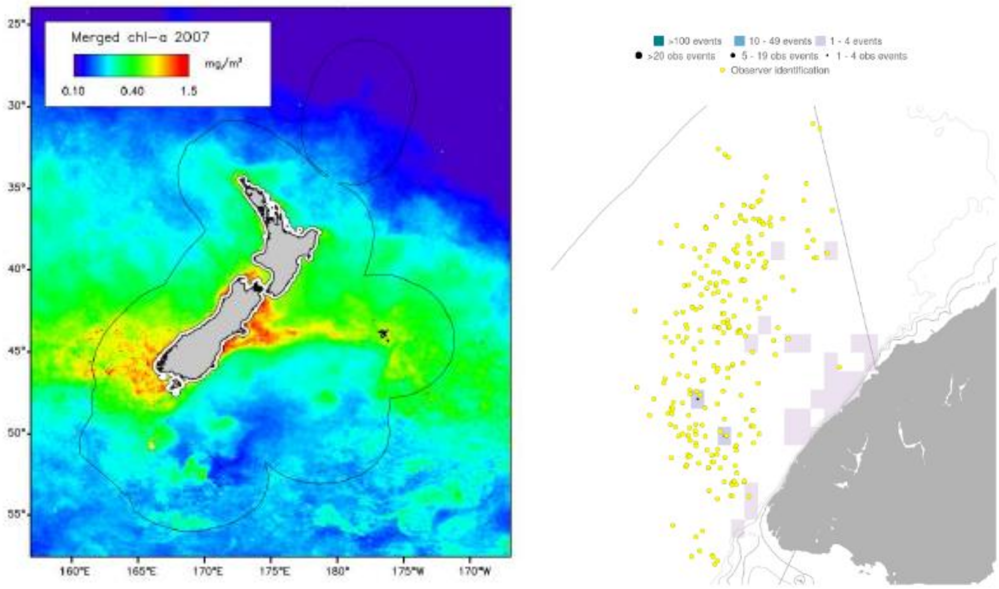

Figure 2: A snapshot of chlorophyll-a concentration derived from satellite data, and highlighting a region of high productivity to the west of Fiordland (left) (reproduced from Pinkerton 2016); and observed fur seal captures in surface longline fisheries to the west of Fiordland (right) (reproduced from Dragonfly 2019).

A non-random acoustic survey will be undertaken along a pre-determined path that will zig-zag away from the coast then back towards the coast (i.e. from shallow to deep water. The design will assess for potential changes in micronekton taxonomic composition with varying depth, distance from the coast, and changes in environmental conditions.

Sampling using mesopelagic mark-ID trawls will be undertaken on an opportunistic basis along the path of the acoustic transect, when patches of high backscatter are encountered, to collect information on species composition. The mesopelagic trawls will be mounted with an in-trawl stereo-camera system with which it might be possible to identify focal fish stock species (primarily hoki and southern blue whiting), and assess trawl selectivity for micronekton taxa. The in-trawl stereo-camera system belongs to the Institute of Ocean Sciences (Canada), and although there is a collaboration agreement, this equipment will be on board if this is in good condition after its use on the Pacific Hake survey off the West coast of Canada during September 2019. We will aim to complete a total of three mark ID trawls in each area, weather and time-permitting.

Note this objective is lower priority than Objectives 1-3 and will only be completed if good progress is made with these other objectives, i.e., they are not disrupted by poor sea conditions. Given the exploratory nature of this objective, the acoustic transects could potentially be run day and night.

Objective 5: Collect environmental data for developing ocean climate predictors of mesopelagic and focal fish density in space and time

Environmental data will be collected to provide a physical context for biological observations made under Objectives 1 to 4, such as identification of oceanic fronts and hydrographic features. The environmental data collected by this and previous surveys may also be used as predictor variables in spatial multi-species models developed by project ZBD2018-05.

Objective 5 consists of two main components:

1. collection of underway data in transit; and
2. water column sampling with a trawl-mounted Conductivity-Temperature and Depth (CTD) and fluorometer recorders (measures primary production).

Both these components will contribute to global datasets that are used for a variety of purposes. The NZ Sub-Antarctic is under-sampled and oceanographically dynamic, so every opportunity will be taken to address the data deficiency in this region. In particular, data from this voyage will be used to understand processes in the NZ Sub-Antarctic and how these are represented in regional circulation models.

Underway water sampling is used to provide continuous spatial coverage of the easily accessible surface waters. Water is collected via a seawater intake in the ship's hull. It is then processed through a series of inline electronic instruments (R.V. *Tangaroa* Underway Flow-through System (TUFTS)) to measure water properties.

A Seabird MicroCAT CTD recorder will be mounted on the headline of the trawl. While in the water the CTD takes electronic measurements of ocean temperature and conductivity (from which salinity is derived), returning a vertical profile for the whole water column which will be used to complement data from underway sampling of the surface water.

In addition, a net-mounted fluorometer will be used to monitor levels of primary production in the water column. Fluorometer-based measurements of primary production in the water column will be related to surface estimates derived from satellite data, to assess the degree to which the latter can be used as a proxy for productivity through the water column.

Objective 6: Recover acoustic mooring previously deployed in the Campbell Plateau to monitor the abundance and vertical distribution of pelagic organisms.

An upwards looking Simrad autonomous echosounder was deployed in the Campbell Plateau on 3 September 2019 (EPA permit number: NIWPA45), to monitor the abundance and vertical distribution of pelagic organisms (i.e., micronekton). The instrument, deployed by NIWA staff from RV *Tangaroa* during its transit towards Campbell Island to carry out the southern blue whiting acoustic survey (TAN1905, Fisheries New Zealand Research Project SBW201901), was programmed to collect acoustic data almost continuously between September and December from the ocean floor up to the surface. Though its operation is expected to cease within the first days of December, the recovery of the instrument can take place at any time during the voyage when the RV *Tangaroa* is near the mooring.

The mooring consists of an autonomous echosounder mounted on a ADCP sub-surface buoy anchored on the seabed using railway wheels weighing ~500 kg and a single short (less than 40 m long) dyneema. The exact deployment location is 50°16.951' S 170° 2.811'E, at a bottom depth of 613 m.

To retrieve the mooring, the vessel will return to the deployment location, a deck unit for the acoustic releases will be lowered over the side and a release code sent. This will release the anchor weight and allow the instrument string to rise to surface under its own buoyancy. At the surface, it will be hauled onboard the ship, dismantled, and data downloaded. The mooring anchor weights (an iron railway wheel of approximately 500 kg weight for each mooring) will remain on the seabed.

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<u>Risk identification</u>

Generic Risks	Contingencies
Key staff unavailable	NIWA has a pool of very experienced fisheries analysts to draw on if required.
Data loss (including through natural disasters)	Full disaster recovery and data backup system in NIWA (see Inshore and HMS RfP for ICT disaster recovery plan).
General Health and Safety	NIWAsafe: Pathway to zero harm is NIWA's Strategy to improve safety systems, leadership and behaviour as well as curative and preventative care in all NIWA business activity. Our aspiration is a zero harm safety target. We continuously strive to achieve this through: (1) improving our safety leadership, (2) focusing on personal decision making, and (3) proving excellence in safety and wellbeing management.

	NIWAsafe is a central mechanism around which our project management work is planned and implemented. We maintain and actively update comprehensive safety information on our intranet. Information regarding NIWAsafe: Pathway to zero harm including critical risk safety management controls is available by contacting NIWA Wellington Regional Manager Alison MacDiarmid (alison.macdiarmid@niwa.co.nz) In July 2016, NIWA submitted a draft top-level H&S plan to meet what we perceive to be the requirements for H&S reporting from research providers under the new Workplace Safety legislation (4 April 2016). The latest version sent to MPI was Draft Version 5, sent to MPI Contracts on 22 May 2019.
Breakdown of vessel	The survey is planned from the R.V. *Tangaroa*. For the *Tangaroa* the risk is considered to be low and manageable. NIWA has a range of policies and operational procedures and requirements in place to mitigate maritime risks. These mitigation measures are compliant with national (Maritime NZ) and international standards (DnV, International Safety Management, ISM) and ensure that the vessel is kept to a high level of maintenance and condition and operated by experienced and qualified personnel. These measures are under constant review and, together with a risk averse approach to operations at sea, NIWA effectively minimises the risk of inoperability of its vessels. Over the past 20 years of inshore and deepwater trawl surveys, NIWA's vessels have successfully completed all voyages.
Project Specific Risks	**Contingencies**
Breakdown of equipment	▪ Always carry spares and backup (e.g., spare trawls and panels). ▪ High technical capability, including at sea, and equipped to undertake rapid repairs.
Bad weather	The proposed sampling programme is ambitious. There is little allowance for bad weather conditions, and the steaming speed allowance is optimistic. It should therefore be recognised that even without delays for bad weather, there may still be difficulties completing the proposed sampling programme. In the event that the voyage is unable to complete some of the proposed sampling during the survey. This is subject to discussion and agreement with Fisheries New Zealand. Any significant changes to the voyage schedule will be discussed first with Fisheries New Zealand and NIWA. Voyage objectives in priority order are 6, 1, 2, 3, 5, 4
The specific categories of the NIWA draft top-level H&S plan risk identified for this project are: 1. Land-based operations (NZ) • 1.1 Office work • 1.4 Road travel 2. Air travel and aerial surveys • 2.1 Air travel 3. Marine operations • 3.1 Surveys on NIWA research vessels (*Tangaroa* and *Kaharoa*) Task/hazard ID, Possible harm, Risk evaluation, Prevention Controls, and Residual risk evaluation are provided in the top-level H&S plan.	

Science Media Communications

During the voyage, various communication, education and outreach activities will occur. Three representatives from the Sir Peter Blake Trust (two students and the coordinator) will participate in the voyage

Processing or disposal of catch

All catch will be taken as specified in the NIWA Special Permit No. 665. We anticipate that less than 20 t of fish is likely to be taken during the voyage. Where possible, saleable fish will be processed onboard (head-and-gut) for later sale by open tender. Other fish will be discarded overboard as specified in the NIWA Special Permit No. 665. Proceeds from sale of fish (less costs of processing) will go to Fisheries New Zealand. Care will be taken that no fish will be discarded while trawling and mitigation devices will be deployed to reduce the likelihood of seabird mortality.

VESSEL GEAR AND SCIENTIFIC EQUIPMENT

Bottom trawl gear:
- 2 standard hoki trawls with 60 mm cod-ends, 58 m ground rope, 100 m sweeps, and 50 m bridles
- Spare groundrope, cod-end, panels, mesh, floats, sweeps, and bridles

Midwater trawl gear:
- 2 Mesopelagic (myctophid) midwater trawls (10 mm codend)
- Mesopelagic 119 midwater trawl (40 mm codend).
- Rectangular midwater trawl (RMT) (7x5 m) (13 mm fine mesh and PVC codend).

Acoustic equipment:
- EK60 systems for hull-mounted transducers (18, 38, 70, 120, and 200 kHz)
- Wideband dual-frequency Acoustic stereo Optical System (AOS) (38 and 120 kHz)
- DIDSON imaging sonar (1.1-1.8 MHz)

Mooring recovery equipment:
- Acoustic releases and deck units
- Magnets for beacon
- WBAT pelican case and data download cable
- ADCP buoy cage and car tyre
- Tools for dismantling the mooring components (inc. snips & wrench)

Safety equipment
- Personal safety gear (protective clothing and footwear, hard-hat, hearing protection, eye wear)

Other equipment:
- Wetlab data acquisition system and Seaway scales with back-up
- Knives and biological sampling gear
- Two net-mounted Seabird CTD dataloggers
- Laptops for CTD
- One net-mounted fluorometer
- SIMRAD net monitoring system including doorspread sensors and paravanes
- In-trawl stereo-camera system

TIMETABLE

The proposed survey period from 11 November to 8 December 2019 (28 days) allows 6 days for mobilisation, demobilisation, and steaming. There is no explicit allowance for bad weather or other equipment/vessel delays.

Dates (2019)	Activity
11-12 Nov	Mobilisation – Wellington
12 Nov	Depart Wellington
12-14 Nov	Transit to survey area
14 Nov-6 Dec	Working science objectives as conditions allow in the survey area
6 Dec	Depart survey area and commence transit to Wellington
8 Dec	Arrive Wellington - demobilisation

Acknowledgements

Thank you to Darren Stevens for reviewing this Voyage Programme.

Pablo Escobar-Flores, Jim Roberts, & Richard O'Driscoll
24 September 2019

Appendix 1: Random survey station locations

Stratum	Station	Phase	Latitude	Longitude
1	1.1	1	-46.4559	166.3777
1	1.2	1	-46.3743	166.0772
1	1.3	1	-46.3449	166.2247
1	1.4	2	-46.2848	166.3382
1	1.5	2	-46.5183	166.2265
1	1.6	2	-46.3256	166.5043
1	1.7	2	-46.2831	166.2328
1	1.8	2	-46.7333	167.0905
1	1.9	2	-46.4802	166.5576
2	2.1	1	-46.9018	165.9416
2	2.2	1	-46.5565	166.2867
2	2.3	1	-46.6837	165.6171
2	2.4	2	-46.9326	167.0619
2	2.5	2	-46.8852	165.6891
2	2.6	2	-46.4931	166.316
2	2.7	2	-46.5821	166.4996
2	2.8	2	-46.6543	166.1839
2	2.9	2	-46.7699	166.8741
3	3.1	1	-48.7163	167.6107
3	3.2	1	-47.2341	169.3268
3	3.3	1	-48.8025	167.2059
3	3.4	2	-48.908	166.7897
3	3.5	2	-48.5971	167.8664
3	3.6	2	-48.7976	167.1374
3	3.7	2	-47.624	169.2186
3	3.8	2	-47.5826	169.3802
3	3.9	2	-47.5879	169.0054
4	4.1	1	-48.0414	169.5417
4	4.2	1	-46.3461	170.6649
4	4.3	1	-47.7571	169.4615
4	4.4	2	-46.7141	170.2064
4	4.5	2	-48.9269	168.4876
4	4.6	2	-48.6216	169.7279
4	4.7	2	-48.8575	169.5339
4	4.8	2	-48.8947	168.2074
4	4.9	2	-48.6884	169.6343
5	5.1	1	-49.4197	167.4482
5	5.2	1	-49.3159	167.8459
5	5.3	1	-49.1856	167.78
5	5.4	2	-49.2752	166.8527
5	5.5	2	-49.3809	167.8961
5	5.6	2	-49.1706	166.956
5	5.7	2	-49.3185	166.6127
5	5.8	2	-49.5876	167.9159
5	5.9	2	-49.1578	167.2926
6	6.1	1	-51.1936	167.897
6	6.2	1	-51.3183	166.7227
6	6.3	1	-50.7961	166.9532
6	6.4	2	-50.7861	167.4153
6	6.5	2	-49.5822	167.8009
6	6.6	2	-50.6749	167.4507
6	6.7	2	-51.1178	166.066
6	6.8	2	-50.9435	166.9669
6	6.9	2	-49.7268	167.6866
7	7.1	1	-51.5114	166.6465
7	7.2	1	-51.2373	166.3723
7	7.3	1	-51.6133	166.6393
7	7.4	2	-51.3148	165.7101
7	7.5	2	-51.3732	166.7227
7	7.6	2	-52.0926	167.8021
7	7.7	2	-51.5931	166.7187
7	7.8	2	-51.8999	167.2156
7	7.9	2	-51.7263	166.4669
8	8.1	1	-49.7217	169.4974
8	8.2	1	-50.3463	169.3857
8	8.3	1	-49.8241	169.8544
8	8.4	2	-49.7408	168.7437
8	8.5	2	-50.2925	169.3197
8	8.6	2	-49.3818	169.4919
8	8.7	2	-50.4531	169.9946
8	8.8	2	-49.3138	169.837
8	8.9	2	-49.8526	169.2628
9	9.1	1	-51.555	169.2461
9	9.2	1	-50.2322	168.0476
9	9.3	1	-53.281	169.1029
9	9.4	2	-50.8687	168.7955
9	9.5	2	-50.5473	168.3576
9	9.6	2	-51.0078	168.7254
9	9.7	2	-51.0487	168.1588
9	9.8	2	-51.0496	169.3508
9	9.9	2	-51.6268	169.1391
10	10.1	1	-53.0544	168.3628
10	10.2	1	-52.0132	168.2501
10	10.3	1	-51.6307	168.0235
10	10.4	2	-53.5907	170.9542
10	10.5	2	-52.9707	168.7905
10	10.6	2	-53.5274	169.2244
10	10.7	2	-53.1895	168.7441
10	10.8	2	-52.6414	168.3448
10	10.9	2	-53.4746	170.4124
14	14.1	1	-52.6834	171.714
14	14.2	1	-53.5646	172.5644
14	14.3	1	-52.2797	172.1435
14	14.4	1	-52.774	172.6689
14	14.5	1	-52.7801	170.5465
14	14.6	2	-52.8562	170.713
14	14.7	2	-52.4107	172.0374
14	14.8	2	-52.6512	170.1718
14	14.9	2	-52.9798	170.5741
14	14.1	2	-52.3286	170.6796
14	14.11	2	-52.7614	170.1843
14	14.12	2	-52.2325	171.1093
14	14.13	2	-52.0982	170.4935
14	14.14	2	-53.2856	172.3297
14	14.15	2	-52.8167	171.702
28	28.1	1	-47.551	169.8857
28	28.2	1	-46.5493	170.532
28	28.3	1	-47.2314	170.1807
28	28.4	2	-46.498	170.4847
28	28.5	2	-46.715	170.5945
28	28.6	2	-48.2858	170.1665
28	28.7	2	-47.7719	169.9114
28	28.8	2	-46.6212	170.7143
28	28.9	2	-46.7911	170.5246

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