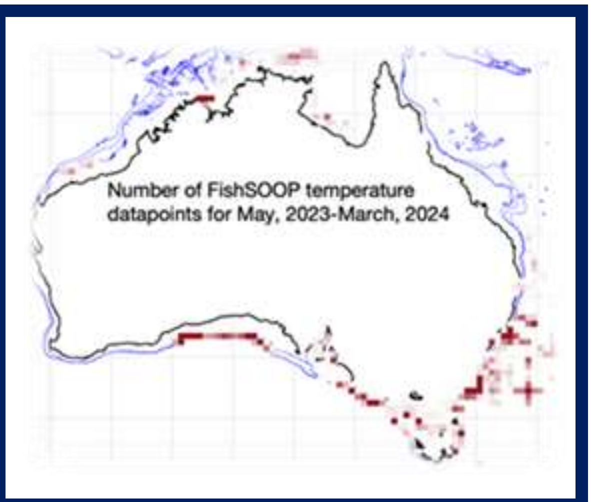
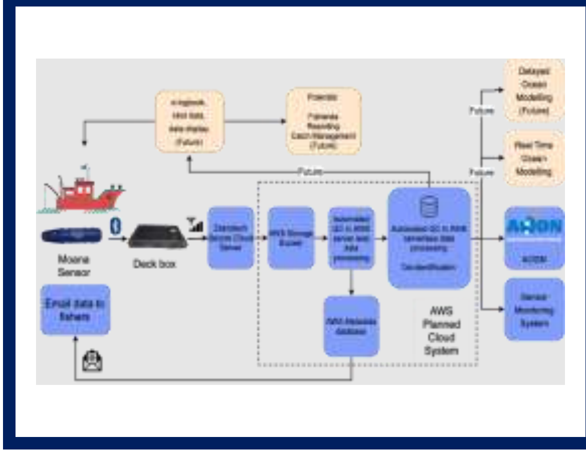
Trials of Oceanographic Data Collection on Commercial Fishing Vessels in SE Australia





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- Bass Strait Scallop Industry Association (Andrew Sullivan)
- Great Australian Bight Industry Association (GABIA – Neil McDonald)
- Gulf St Vincent Prawn Boat Owners Association (GSVPBOA – Neil McDonald)
- Northern Prawn Fishery Industry LTD (NPFI – Annie Jarrett)
- Spencer Gulf & West Coast Prawn Fisherman's Association Inc (Kelly Pyke-Tape, Tim Ferrell)
- SA Northern Zone Rock Lobster Fishermen's Association Inc (Kyri Toumazos)
- Southern Rock Lobster (SRL) – (Thomas Cosentino)
- South East Trawl Fishing Association (SETFIA – Simon Boag)
- Southern Shark Industry Alliance (SSIA – Simon Boag)
- Tuna Australia (Phil Ravanello and David Ellis)

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This work would not have been possible without the interest and cooperation of the many owners, skippers and crew of vessels both within and outside these associations that agreed to install the monitors.

Vessel	Fishery	Fishing methods
Anna Pearl	Gulf St Vincent Prawn Trawl	Prawn Trawl
Austral Hunter	Northern Prawn Fishery	Prawn Trawl
Bartalumba K	Spencer Gulf/West Coast Prawn Fishery	Prawn Trawl
Beachlands	Northern Prawn Fishery	Prawn Trawl
Brianna Rene Adele	Spencer Gulf/West Coast Prawn Fishery	Prawn Trawl
Carol Maree	Southern Squid Jig Fishery	Squid Jig
Dell Richey II	BSCZSF and Southern Squid Jig Fishery	Dredge and jig
Diana	Southern and Eastern Scalefish and Shark Fishery	Demersal longline
Francesca	Southern and Eastern Scalefish and Shark Fishery	Fish trawl
Gail Jeanette	Southern and Eastern Scalefish and Shark Fishery	Danish Seine
Gracie P	Eastern Tuna and Billfish Fishery	Pelagic Longline
Markarna	Eastern Tuna and Billfish Fishery	Pelagic Longline
Mira S	Eastern Tuna and Billfish Fishery	Pelagic Longline
Mustelus	Southern and Eastern Scalefish and Shark Fishery	Demersal gillnet
Noble Pearl	Southern and Eastern Scalefish and Shark Fishery	Fish trawl
Nor West Pearl	Southern and Eastern Scalefish and Shark Fishery	Traps / Pots
Northern Star	Bass Strait Central Zone Scallop Fishery	Dredge
Ocean Raider	WA Pilbara Fish Trawl	Fish Trawl
Pearl of the Sea	Eastern Rock Lobster	Traps / Pots
Rachel Maree	Bass Strait Central Zone Scallop Fishery	Dredge
Raptis Pearl	Northern Prawn Fishery	Prawn Trawl
Samantha J	Southern and Eastern Scalefish and Shark Fishery	Fish trawl
Sarriba	NT Demersal Fish Trawl	Fish Trawl
Saxon Onwards	Southern and Eastern Scalefish and Shark Fishery	Fish trawl
South Seas 1	Eastern Tuna and Billfish Fishery	Pelagic Longline
Straight Shooter	Eastern Tuna and Billfish Fishery	Pelagic Longline
Territory Achiever	Northern Prawn Fishery	Prawn Trawl
Territory Leader	NT Demersal Fish Trawl	Fish Trawl
Territory Spirit	Northern Prawn Fishery	Prawn Trawl
Torbay	WA Pilbara Fish Trawl	Fish Trawl
Wilderness	Eastern Rock Lobster	Traps / Pots
Zeehaan	Southern and Eastern Scalefish and Shark Fishery	Fish trawl

Abbreviations

ACT	Australian Capital Territory
AFMA	Australian Fisheries Management Authority
AFMF	Australian Fisheries Management Forum
AODN	Australian Ocean Data Network
AWS	Amazon Web Services
BSCZSF	Bass Strait and Central Zone Scallop Fishery
CF	Climate forecast
CPUE	Catch per unit Effort
CSV	Comma separated value (file)
CTS	Commonwealth trawl sector
DPIRSA	Department of Primary Industry and Regions (South Australia)
EEZ	Exclusive economic zone
FAQ	Frequently asked questions
FVON	Fishing Vessel Ocean Observing Network
GAB	Great Australian Bight
GABTS	Great Australian Bight trawl sector
GLMM	Generalised linear mixed model
GTS	Global telecommunication system
GVP	Gross value of production
IMOS	Integrated Marine Observing System
NetCDF	Network Common Data Form (file)
NSW	New South Wales
ROV	Remote operated vehicles
QC	Quality control
SA	South Australia
SESSF	Southern and Eastern Scalefish and Shark Fishery
SGSHS	Shark, Gillnet and Shark Hook sectors
SHS	Scalefish Hook sector
SOOP	Ships of Opportunity Program
SOP	Standard Operating Procedure
TAC	Total Allowable Catch
TD	Temperature Depth (sensor)
VFA	Victorian Fisheries Authority

Executive Summary

Working with IMOS and oceanographers at the University of New South Wales (UNSW), Fishwell Consulting engaged its established networks across the Australian commercial fishing community to harness the capacity of commercial fishing vessels in environmental data acquisition. Deployment of temperature/depth sensors on commercial fishing vessels was shown to augment and complement more expensive data collection platforms (e.g. ocean gliders, remote operated vehicles, Argo floats, dedicated research vessels) to provide much needed sub-surface temperature data to improve ocean circulation models and forecasting capacity. In proof-of-concept trials conducted over twelve months (from May 2023), more than 30 fishing vessels and their fishing gear were equipped with temperature sensors and data transmission equipment. These trials yielded more than 2.8 million data points from the sea surface to 1,214m depth considerably expanding existing data records. In particular, waters previously poorly observed, including the Great Australian Bight, Joseph Bonaparte Gulf, and the Gulf of Carpentaria, yielded valuable sub-surface temperature data.

This project had four objectives:

- Effective installation and operation of oceanographic data collection equipment on network of commercial fishing vessels using a range of common fishing gear
- To cost-effectively increase the spatial resolution of sub-surface physical data collected in Australia's inshore, shelf, upper-slope, and offshore waters by fitting commercial fishing equipment from a variety of gear types with low-cost temperature/pressure sensors
- To provide quality-controlled data direct to fishers in near real-time to assist in habitat characterisation and the targeting of effort
- To make the quality-controlled temperature depth data publicly available through the IMOS-AODN portal for uptake and use in ways that support safe maritime operations the sustainable management of marine resources, and improve understanding of drivers of change.

All objectives were successfully completed in this project. Temperature pressure sensors were successfully installed and deployed on a range of fishing gears including board trawls, scallop dredges, pelagic and demersal longlines, squid jig lines, seine nets, fish traps, rock lobster pots and gillnets. An attractive feature, given the active participation of the commercial fishing sector, is the maintenance-free nature of the system. Little training of vessel crews was required post-installation of the monitoring system. The sensor transmits data to a solar-powered deck box (via Bluetooth) upon surfacing. Data (temperature, depth, location, time) are uploaded automatically to the cloud in near real time without any intervention of the vessel crew. The data is then automatically passed through quality control tests. The quality controlled data are then available for near real-time transmission back to the fishing vessel along with a plot of the data and basic statistics, and subsequently transferred to the Australian Ocean Data Network (AODN)..

Operation and data acquisition were generally problem free except for the replacement of some sensors and 3 lost sensors. There was some level of concern from a few fishers about position data being revealed even though publicly available data were anonymous. Having a time lag before data was made available addressed this in all cases. However, participating fishers were generally receptive to involvement given that their catch data was not collected and data records were made available to them assisting in their evaluation of environmental effects on catch success (particularly temperature-depth profiles). In general, the positive engagement of stakeholders through peak bodies and established networks with the commercial fishing sector was a key driver of success in these data collection trials. These networks should continue to be engaged in increasing participation of commercial fishing vessels in the ships of opportunity program, now known as "FishSOOP".

Co-investment by IMOS, fishery agencies and the commercial fishing sector offers a cost-effective means of expanding subsurface data collection on a continuing basis. A fleet of more than 3,000 commercial fishing vessels regularly fish out to the shelf and shelf slope around Australia: regions sparsely monitored by IMOS. Increased participation in the FishSOOP program will provide a valuable, spatially and temporally extensive time-series of oceanographic data hitherto unavailable. Each fishing vessel is already paying for fuel and crew presenting a substantial in-kind contribution to data collection given the costs of equivalent chartered research vessels.

This successful proof-of-concept in expanding spatial coverage of subsurface temperature records presents a transformational change in ocean monitoring capacity and in the development of informative models of ocean circulation. This is particularly timely given that climate change is threatening beneficial uses of our oceans and near shore waters, particularly influencing commercial fishing. The Australian commercial fishing fleet presents a powerful potential resource for data acquisition. For example, 50 vessels fishing 200 days each year, each with say 1-10 deployments of gear each day, offers at least 10-100,000 deployments annually across Australian waters (each with 1,000s of temperature/depth measurements). In particular, the provision of subsurface temperature data will improve the reliability of ocean forecasting, the validity of ocean circulation models, and increase understanding of climate change impacts

Keywords

Oceanography, temperature, depth, commercial fisheries, ships of opportunity, IMOS, climate change, ocean circulation models.

Introduction

The Australian exclusive economic zone (EEZ) includes tropical, temperate and sub-polar waters covering an area of more than 8 million km^2. Coastal oceanography influences ecological processes important in the productivity of Australia's living marine resources and general wellbeing of most Australians who live near coastal environments. In addition, climate change is influencing the distribution, abundance and habitat range of species important to recreational, commercial and indigenous fishers. Yet knowledge of coastal oceanography in Australia is mostly informed by processes at the sea surface (with data sourced from surface buoys, ship-based measurement, and remote sensing). Sub-surface data (particularly temperature and salinity at depth) are limited by available sensors/measurements and the vastness of the Australian EEZ.

Models of ocean circulation and associated ecological models (Kerry *et al.* 2024, Fulton *et al.* 2016,2024) are strongly influenced by temperature. Sea surface temperature is readily measured by satellite, however, measurement of water temperature below the surface is not amenable to remote sensing (Kerry *et al.* 2024). Instead, specialised monitoring equipment including Argo floats, ocean gliders, remote operated vehicles, and mooring buoys are required to monitor temperature and salinity in the water column. However, such monitoring is expensive (requiring the use of specialised research vessels) and spatially limited, at least relative to Australia's vast territorial seas.

The relationship between water temperature and fish abundance is well known to commercial fishers. Fish aggregate at feed layers in the water column often at thermoclines (vertical shifts in temperature) (Gray and Kingsford 2003). Thus, the distribution and abundance of many species important to Australia's commercial fisheries are influenced by temperature and changes in temperature mediated by, among other factors, climate change (Pecl *et al.* 2014, Hobday *et al.* 2018, Fulton *et al.* 2024). Involving commercial fishers in ocean monitoring provides an opportunity to utilise the considerable capacity of fishing vessels across the Australian EEZ. In so doing, this will provide much needed data to improve knowledge of oceanic processes and the influence of climate change.

There is currently a disconnect between the resolution of the oceanographic data and models available, and the scales at which the fishing industry operates. Operational ocean models such as Ocean Maps (10km resolution) are of insufficient resolution and do not adequately resolve circulation of shelf waters. Higher resolution models exist for certain regions of the continental shelf, but they suffer from insufficient observations for data assimilation and validation (Kerry *et al.* 2024). There are very few real time/near real time, sub-surface ocean observations available for uptake by end users or assimilation into ocean circulation models. These data are even more sparse on the shelf where commercial fishing efforts are concentrated.

Australia's Integrated Marine Observing System (IMOS) is a collaborative program of ocean monitoring coordinating oceanographic data collection across numerous data collection platforms. It includes the Ships of Opportunity (SOOP) program which utilises a combination of volunteer commercial and research vessels to collect data relating to physical, chemical and biological oceanography and ecology (Van Vranken *et al.* 2023). The SOOP program collects mainly sea surface data, particularly temperature. Here we extend the SOOP program to the commercial fishing sector, potentially harnessing the capacity of thousands of vessels across Australia's territorial sea to collect much-needed oceanographic data including sub-surface data.

The notion that fishing vessels could assist in oceanographic monitoring of Australian waters was suggested to IMOS in 2010 following successful completion of FRDC project 2005-006 "*The* *influence of environmental factors on recruitment and availability of fish stocks in south-east Australia*". Environmental monitoring has been undertaken on fishing vessels in various programs around the world since the early 2000s (van Vranken *et al.* 2020). The Moana project in New Zealand, for example, has mobilised nearly a third of its commercial fishing fleet to collect environmental data (O'Callaghan *et al.* 2019, van Vranken *et al.* 2023, Jakoboski *et al.* 2024). Here we report on a proof-of-concept to show that commercial fishing vessels linked to enabling technology can vastly expand spatial coverage of sub-surface temperature measurements thereby improving ocean circulation models and forecasting capacity.

Objectives

1. Effective installation and operation of oceanographic data collection equipment on network of commercial fishing vessels using a range of common fishing gear.
2. To cost-effectively increase the spatial resolution of sub-surface physical data collected in Australia's inshore, shelf, upper-slope, and offshore waters by fitting commercial fishing equipment from a variety of gear types with low-cost temperature/pressure sensors.
3. To provide quality-controlled data direct to fishers in near real-time to assist in habitat characterisation and the targeting of effort.
4. To make the quality-controlled temperature depth data publicly available through the IMOS-AODN portal for uptake and use in ways that support safe maritime operations the sustainable management of marine resources, and improves understanding of drivers of change.

Methods

Project Steering Committee

At the inception of this project, a steering committee was established to facilitate project direction and coordinate engagement of the commercial fishing sector including state-based and Commonwealth fisheries. It comprised members from the project team, the Australian Fisheries Management Authority (AFMA), the Fisheries Research and Development Corporation (FRDC), the Integrated Marine Observing System (IMOS). and numerous representatives from peak industry organisations.

Vessel installations

Instrumentation

ZebraTech is a New Zealand based company that designs and supplies robust underwater instruments and equipment (https://www.zebra-tech.co.nz/). ZebraTech's Moana sensors and data transmission deckboxes were chosen for this project as they had been successfully deployed on fishing vessels in New Zealand. This equipment has been designed through a partnership between ocean scientists (led by Roughan) and the system is purpose-built for deployment on fishing vessels (van Vrancken *et al.* 2023, Jakoboski *et al.* 2024). It offers hands-free, light weight, cost effective equipment including the capability of attaching sensors to any fishing gear.

The sensor continuously monitors the pressure of its own environment, thus allowing it to automatically detect barometric pressure changes, enabling it to reliably detect the start of a fishing event and compensate for the baseline atmospheric pressure. During the event, the Moana TD sensor adapts its sampling strategy, switching between profiling mode and time series mode, and applying a passive wave filter in shallow water. There are two versions of the sensors: one has a maximum effective operating depth of up to 1,000m and the other has a maximum effective operating depth of up to 200m. The specifications of the Moana sensors are shown in Table 1. When submerged, the sensor records temperature and depth data at 1 m intervals from the sea surface down to 200 m, then every 4m down to 1,000 m (for the Moana TD1000). If the depth doesn't change significantly, for example if attached to a fish trap or rock lobster pot, time-series data are collected at longer intervals (5 minutes interval) until the pressure changes again by more than 1 meter (for upper 200 m) or 4 m (if deeper than 200 m).

The ZebraTech deck box is a solar powered, stand-alone device that automatically post-processes sensor data to incorporate precise position (depth and geographical location) linked to each datapoint's timestamp. When the sensor is retrieved, the sensor automatically offloads its data via Bluetooth to the deck box.. The deckbox then uploads the data to the cloud via the cellular network in near real time. The data collection system applied to each fishing vessel is designed to operate autonomously i.e., with no intervention from the crew and no disruption to normal fishing operations. This is a particularly attractive feature of the ZebraTech system applied in this project.

Table 1. Technical specifications of ZebraTech Moana temperature/pressure sensors and deck box data transfer (Moana TD - ZebraTech (zebra-tech.co.nz).

Moana specifications and requirements	
Temperature Range	-2 ^{o}C to 35 ^{o}C
Temperature Accuracy	0.05^{o}C
Temperature Resolution	0.001 ^{o}C
Temperature Response Rate	1 second
Pressure accuracy	0.5% of rated pressure range
Battery life and calibration duration	2 years
Weight with protective tough jacket	100g
Memory capacity	31,146 data records
Communication range	30 meters
Deck-box specifications and requirements	
Battery endurance without solar charge	4 weeks
Power sources	Solar and/or USB-C
Transmission	Cellular or Wi-Fi
Position accuracy	6.3 m error with 95% confidence interval of 13.8 m
Position logging rate	15 seconds
Memory capacity	8GB

Fisheries and fishing gear

Initially, the project was set up to target Commonwealth and state fisheries in southeast (SE) Australia. This region was chosen because of the variety of fishing methods used and because it is where the East Australian Current (EAC) is extending southwards, warming the ocean surface at a rate four times the global average and where climatic extreme events, such as marine heatwaves, are leading to critical impacts on fisheries (e.g. Hobday *et al.* 2016; Oliver *et al.* 2017). Fishing vessels using methods/gear that operate either mid-water or on the ocean floor from shallow inshore fisheries to those working off the outer continental shelf break were chosen for this proof-of-concept project. These fisheries were:

- Commonwealth Scallop vessels operating in Bass Strait (3 vessels);
- Commonwealth SESSF Trawl and GAB Trawl Sector (2 vessels);
- Commonwealth SESSF Scalefish Longline Sector (2 vessels);
- Commonwealth Squid Jig (2 vessels).
- Inshore SA Spencer Gulf Prawn Fishery (3 vessels)
- Inshore SA / Victorian Rock Lobster Fishery (3 vessels);

Through the Steering Committee, we contacted the fishing industry associations in the regions to identify fishing vessels that may be interested in being involved in the project. Once vessels were selected, the owners, skippers and crew on participating fishing vessels were trained in the system requirements together with installation and operation. All participants were provided with information presenting frequently asked questions (Appendix 1) and the background to the project (Appendix 2).

The initial trials of data collection were evaluated after one month's operation during May 2023. Project members met with crew members to discuss operational aspects of data collection. Downloading and visualisation of initial data were also undertaken at this time. Following revisions / improvements, further data collection trials were undertaken.

After these two trial months and review of operational aspects, the data collection equipment was operated by each vessel for a further six-month period. During this time, any operational issues emerging were logged for discussion with project team members.

Data transfer, quality control, and visualisation/delivery

Amazon Web Services (AWS) was chosen for data retrieval and storage as it is the ideal tool with which to operate all the different services required in one location (data storage, metadata database, data processing and email services) and to allow transfer across platforms with different stakeholders. Due to its interdisciplinary nature, it is best to use a platform that can more easily be linked across to receive the data from the cloud, transfer the data to the Australian Ocean Data Network (AODN) and global telecommunication system (GTS), to participating fishers, and other potential stakeholders. Furthermore, AWS allows for flexible scaling of resources as the program grows (following proof-of-concept), and monitoring of infrastructure (sensors and deck boxes) to track potential malfunction in real time.

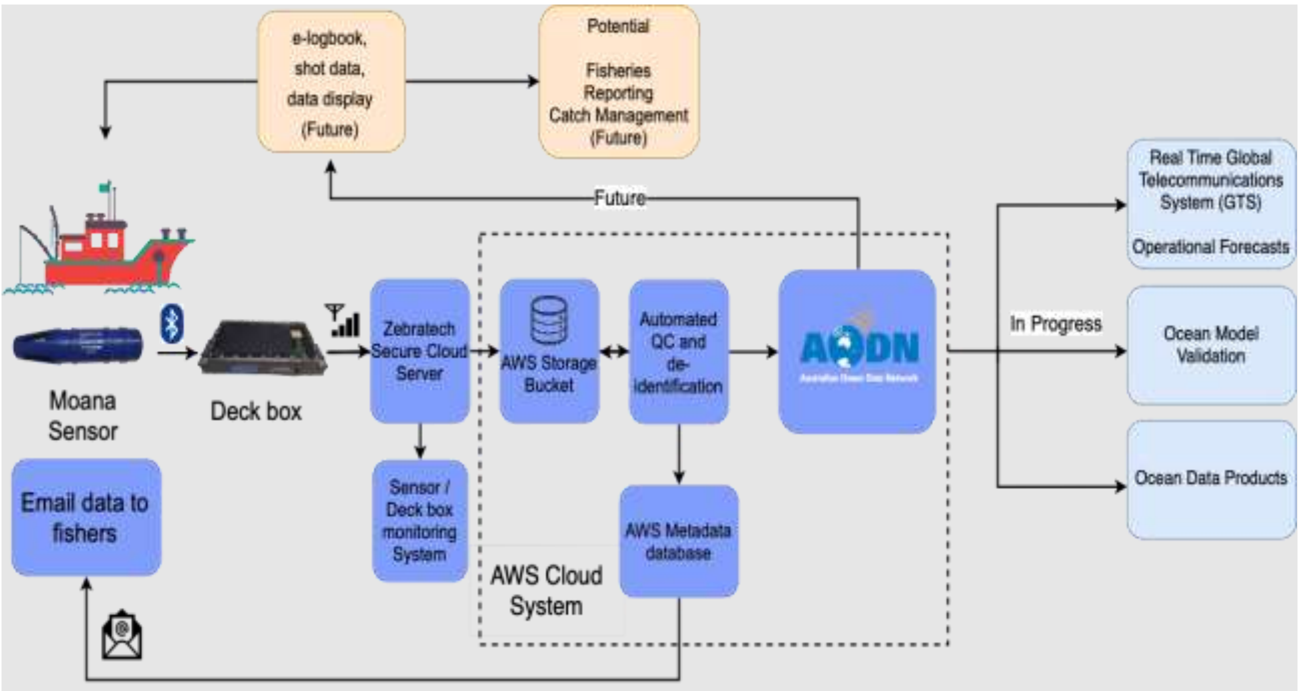


Figure 1. Schematic diagram showing the data flow for the project using Amazon Web Services (AWS) cloud computing services.

The system provides for data flow in the AWS with the raw data sent directly from the sensors manufacturer's cloud to an AWS storage bucket. The reception of data triggers the real time automated quality control in AWS data processing. The resultant quality-controlled data are associated with the relevant metadata information and can then be sent to the fishers via automatic email. Periodically, delayed-mode quality control checks are launched and the results written into climate forecast (CF) convention (Eaton *et al.* 2022). These data include compliant (netCDF) files that conform to the IMOS standards (IMOS 2021,2022). These data are then sent for publication on the Australian Ocean Data Network (AODN).

The schematic shown in Figure 1 includes the following steps (and time frames):

- Sensor to deck box (automated Bluetooth);
- Near real-time delivery to the cloud (via the mobile network);
- Near real-time automated quality control (QC);
- Near real-time delivery to fishers (data in a spreadsheet and a figure sent via email);
- Automated QC (originally done manually by a data scientist); and,
- Data delivery to the AODN (delayed).

Each of these data pathways and QC checks is described in detail below. During the trial, the data were collated, visualised and the results discussed with participating fishers and members of the steering committee. Feedback mechanisms were developed to show how the information may be relayed back to the fishers in a useful and informative manner.

Results

Objective 1: Installation on a network of commercial fishing vessels

The Steering Committee

The Steering Committee consisted of an FRDC representative (Josh Fielding), AFMA representatives (Dan Corrie and Mark Grubert) and numerous executive officers from the peak body associations operating in SE Australia:

- Bass Strait Scallop Industry Association (Andrew Sullivan, Renee Pearce), now disbanded;
- Great Australian Bight Industry Association (GABIA – Neil McDonald);
- Gulf St Vincent Prawn Boat Owners Association (GSVPBOA – Neil McDonald);
- Spencer Gulf & West Coast Prawn Fisherman's Association Inc (Kelly Pyke-Tape, Tim Ferrell);
- SA Northern Zone Rock Lobster Fishermen's Association Inc (Kyri Toumazos);
- Southern Rock Lobster (SRL – Thomas Cosentino);
- South East Trawl Fishing Association (SETFIA – Simon Boag);
- Southern Shark Industry Alliance (SSIA – Simon Boag);

With the expansion of the project, we also invited the following peak bodies to have input into the project:

- Northern Prawn Fishery Industry Ltd (NPFI – Annie Jarrett)
- Tuna Australia (Phil Ravanello and David Ellis)

We had the first online Steering Committee meeting on 2nd February 2023 at the start of the project. Industry members were requested to nominate suitable skippers/vessel from their fisheries for involvement in the project. The project team then liaised directly with those nominees. Another Steering Committee meeting was held near the completion of the project on 8th April 2024 to discuss the results and potential future directions of the program.

Additionally a Face to Face workshop was held in Melbourne in Dec 2023 where we gathered the core team (Fishwell, UNSW, IMOS and FRDC) to discuss results and future outlook.

The network of vessels

There was an enthusiastic response to the project with 13 vessels joining in the first proof-of-concept stage during the first six months. Word of the project quickly spread to the broader Australian fishing industry and there was keen interest to expand the project beyond SE Australia. The only fishing method initially targeted for involvement in SE Australia that did not proceed was rock lobster trap fishing, although a lobster fisher from NSW joined at a later date. This, together with extra funding from the Australian Fisheries Management Authority (AFMA), Northern Territory (NT) Fisheries and U Sunshine Coast with Tuna Australia allowed expansion of the project to fisheries and vessels around Australia. Ultimately, within 12 months, the project attracted more than 30 vessel installations encompassing a wide range of fishing methods: prawn trawl, gillnet, demersal and pelagic longline, traps and pots, fish-trawl, squid jig and scallop dredge (Table 2).

At the conclusion of this project, we are still receiving requests for vessel involvement from various fisheries around Australia. Just before the conclusion of the FRDC trial, we received funding and a request for a further three vessels' involvement in the project from NT Fisheries, taking the final number of vessels involved in the project to 35.

Instrumentation

The installation of both the deck box and Moana sensors on participating commercial fishing vessels was straight forward and few operational issues were encountered. With minimal guidance, the skippers/crew on vessels adapted installation of the data collection system to a range of gears (Table 2). With the stainless-steel U-bolt fasteners, attachment of the deck boxes to infrastructure on the top of wheelhouse presented few problems (Figure 2).

Many of the installations were on board trawlers (fish and prawn), which was generally trouble free with the sensors placed within a tough housing and simply bolted onto a protected area of the otter boards (Figure 3).

Attachment of the sensors to some fishing gears required a bit more trial and error. Placement of sensors on scallop gear was initially problematic because the sensor mounted on the dredge encountered large amounts of sand/grit during operation. Furthermore, the sensor required protection as the dredge occasionally overturned during deployment. This issue was addressed by moving the sensor forward and to the side on the top of the dredge. Skippers instigated construction of steel covers because of concern of rubble (mobilised during trawling) striking and damaging the sensor casing. With such protective measures in place, the sensor has subsequently performed well on scallop dredges (Figure 4).

Sensors were not placed on the actual squid jig lines because lines are vulnerable to loss. Some jig vessels use submersible lights to attract squid from deeper waters to the depth where the jigs are operating. This light is very expensive and attached to the vessel by a strong cable that ensures the electrical connection is not damaged. The sensor was attached to this cable (Figure 5).

During the system trials, few operational issues have been encountered. Of 59 sensors deployed on fishing gear, three had batteries that failed, three had a system malfunction, and three sensors were lost. Once installed, the sensors and data transmission system required little to no hands-on or ongoing maintenance. The application of Standard Operating Procedures (SOPs) has therefore been unnecessary. Instead, skippers were provided with simple, illustrated information sheets (Appendix 3) and they were easily able to adapt them to their particular requirements.

Table 2. Jurisdictions, fisheries, fishing methods and participating commercial fishing vessels.

Jurisdiction	Fishery	Fishing method	Vessel	Sensor type (m)
Commonwealth	Bass Strait Central Zone Scallop Fishery	Dredge	Northern Star	200
Commonwealth	Bass Strait Central Zone Scallop Fishery	Dredge	Rachel Maree	200
Commonwealth	BSCZSF and Southern Squid Jig Fishery	Dredge and jig	Dell Richey II	200
Commonwealth	Eastern Tuna and Billfish Fishery	Pelagic Longline	Gracie P	200
Commonwealth	Eastern Tuna and Billfish Fishery	Pelagic Longline	Markana	200
Commonwealth	Eastern Tuna and Billfish Fishery	Pelagic Longline	Mira S	200
Commonwealth	Eastern Tuna and Billfish Fishery	Pelagic Longline	South Seas	200
Commonwealth	Eastern Tuna and Billfish Fishery	Pelagic Longline	Straight Shooter	200
Commonwealth	Northern Prawn Fishery	Prawn Trawl	Austral Hunter	200
Commonwealth	Northern Prawn Fishery	Prawn Trawl	TBA	200
Commonwealth	Northern Prawn Fishery	Prawn Trawl	Beachlands	200
Commonwealth	Northern Prawn Fishery	Prawn Trawl	TBA	200
Commonwealth	Northern Prawn Fishery	Prawn Trawl	Territory Spirit	200
Commonwealth	SESSF* Gillnet Hook & Trap	Demersal longline	Diana	1000
Commonwealth	SESSF Commonwealth Trawl	Fish trawl	Francesca	1000
Commonwealth	SESSF Commonwealth Trawl and GAB	Danish Seine	Gail Jeanette	1000
Commonwealth	SESSF Gillnet Hook & Trap	Demersal gillnet	Mustelus	200
Commonwealth	SESSF Great Australian Bight Trawl	Fish trawl	Noble Pearl	1000
Commonwealth	SESSF Gillnet Hook & Trap	Traps / Pots	Nor West Pearl	1000
Commonwealth	SESSF Commonwealth Trawl	Fish trawl	Samantha J	1000
Commonwealth	SESSF Commonwealth Trawl	Fish trawl	Saxon Onwards	1000
Commonwealth	SESSF Commonwealth Trawl	Fish trawl	Zeehan	1000
Commonwealth	Southern Squid Jig Fishery	Squid Jig	Carol Maree	200
New South Wales	Eastern Rock Lobster	Traps / Pots	Pearl of the Sea	200
New South Wales	Eastern Rock Lobster	Traps / Pots	Wilderness	200
Northern Territory	NT Demersal Fish Trawl	Fish Trawl	Sarriba	200
Northern Territory	NT Demersal Fish Trawl	Fish Trawl	Territory Leader	200
Northern Territory	NT Demersal Fish Trawl	Fish Trawl	TBA	
Northern Territory	NT Timor Reef Fishery	Fish Trap	TBA	200
Northern Territory	NT Timor Reef Fishery	Fish Trap	TBA	
Queensland	Gulf of Carpentaria Demersal Fish Trawl	Fish Trawl	Territory Leader	200
South Australia	Gulf St Vincent Prawn Trawl	Prawn Trawl	Anna Pearl	200
South Australia	Spencer Gulf/West Coast Prawn Fishery	Prawn Trawl	Bartalumba K	200
South Australia	Spencer Gulf/West Coast Prawn Fishery	Prawn Trawl	Brianna Rene Adele	200
Western Australia	WA Pilbara Fish Trawl	Fish Trawl	Ocean Raider	200
Western Australia	WA Pilbara Fish Trawl	Fish Trawl	Torbay (N/A)	200

* SESSF is the Southern and Eastern Scalefish and Shark Fishery

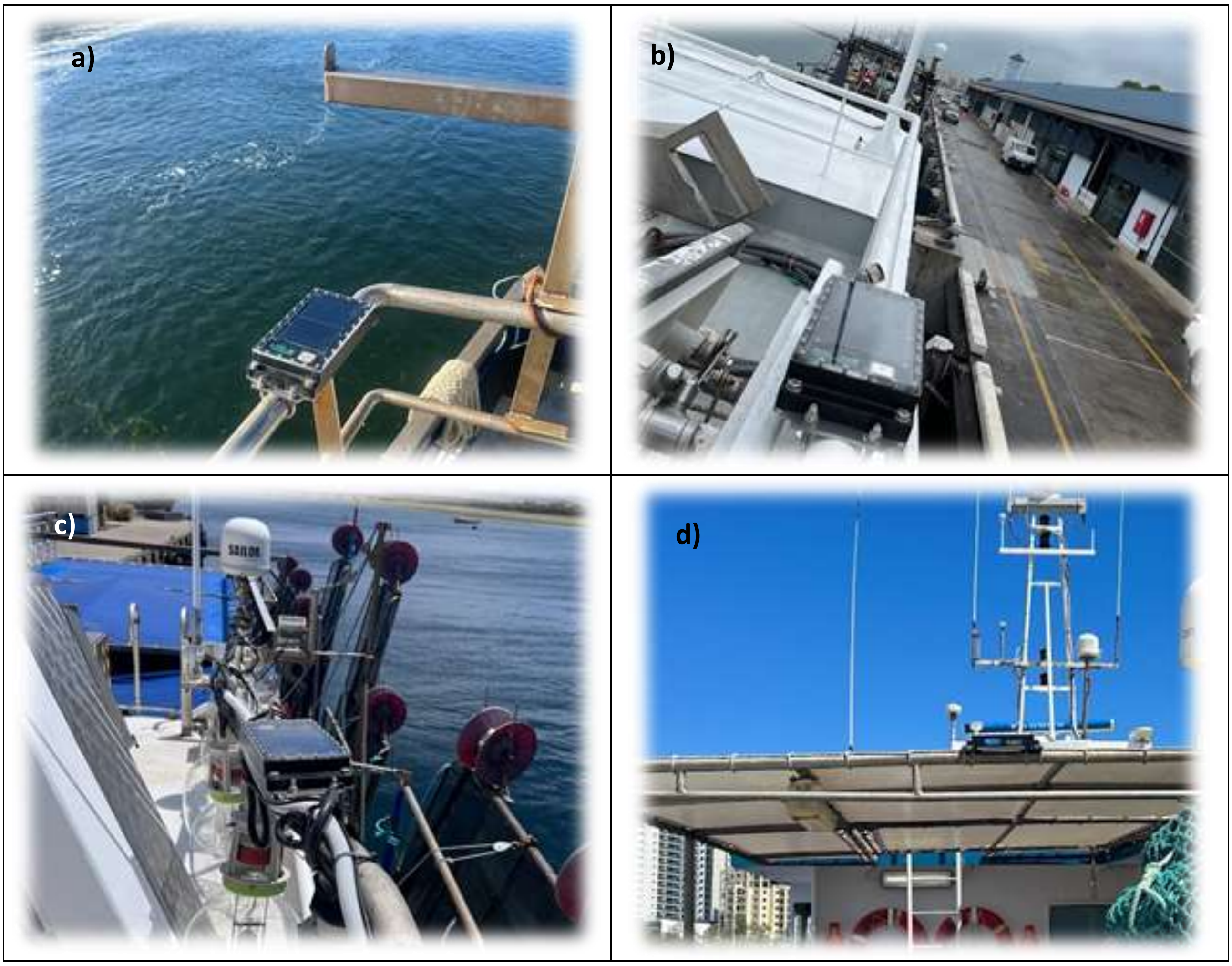


Figure 2. Various installations of deck boxes on commercial fishing vessels: a) scallop dredge vessel, b) prawn trawler, c) squid jig vessel, d) fish trawler.

Figure 3. Sensors within tough housings mounted on trawl boards.

Sand and shell grit filling the sensor casing openings

Initial position of sensor on dredge

Sensor and casing filled with sand and shells

Trial casing to protect sensor impeded water flow

Final placement of sensor and Stainless Steel casing on dredge

Figure 4 Trial and error placement of sensors on a scallop dredge.

Figure 5 Placement of a sensor on the reinforced cable attached to the deepwater light on a squid jig vessel.

Objective 2: Increase spatial coverage of oceanographic data

The second objective of this project was to increase the spatial resolution of sub-surface physical data (temperature and depth) in Australian waters by harnessing the spatial and temporal capacity of commercial fishing vessels. This was achieved well beyond the initial SE Australian focus of the project.

Spatial coverage of data collection was extensive and involved instrumentation of both active (e.g. trawls, dredges) and passive (e.g. pots, traps) gear. Participating vessels included those from: the Southern and Eastern Scalefish and Shark Fishery (SESSF) Commonwealth Trawl Sector (CTS, Figure 6); the SESSF Great Australian Bight Trawl Sector (GABTS Figure 7); the SESSF Gillnet hook and Trap Sector (GHaT shark, Figure 8); the SESSF Gillnet Hook and Trap Sector (GHaT Scalefish, Figure 9); the Commonwealth Bass Strait and Central Zone Scallop Fishery (BSCZSF, Figure 10); the Commonwealth Squid Jig Fishery (Figure 11), the Commonwealth Northern prawn fishery (NPF, Figure 12); the Commonwealth Eastern Tuna And Billfish Fishery (ETBF, Figure 13), the NSW eastern rock lobster fishery (Figure 14); the NT Timor reef fishery (Figure 15), the NT Demersal Fish Trawl Fishery (Figure 16); the Queensland Gulf of Carpentaria Fin Fish Trawl Fishery (Figure 17); the South Australian Gulf of St Vincent Prawn Trawl Fishery (Figure 18), the South Australian

Spencer Gulf Prawn Trawl Fishery (Figure 19); and the WA Pilbara demersal trawl fishery (Figure 20).

Temperature records collected from commercial vessels augment databases already available for ocean circulation models. For public databases managed by IMOS as part of its ships of opportunity (SOOP) program, a netCDF file that is climate forecast (CF) compliant (Eaton *et al.* 2021) is created . These files conform to the IMOS data standards (IMOS 2021) and filename convention (IMOS 2022). These consolidated data have been published on the Australian Ocean Data Network (AODN) (Appendix 4). The details of these data are described below as part of Objectives 3 and 4.

After 12 months of operation, data collection from commercial fishing vessels has been successfully undertaken from every coastal state and territory. As the program has progressed, spatial coverage of data acquisition has increased, filling in the many gaps in regions of low to no historical data, such as in the Joseph Bonaparte Gulf, the Gulf of Carpentaria, and in the Great Australian Bight (Figure 21). These waters have historically yielded relatively few temperature records. During this proof-of-concept program, more than 2.8 million data points have been recorded in more than 12,500 fishing sets from the sea surface to 1214 m depth (Figure 22), including over 460,000 datapoints in the Top End and over 870,000 datapoints in the Great Australian Bight. A summary of the expansion of data collection by region is provided in Figure 21. We have also provided a breakdown of domestic commercial vessel (DCVs) and the size of Class 3 fishing vessels (Table 3), There are about 3000 vessels >7.5m that could potentially collect data across the continental shelf and shelf slope noting that while they are capable of working out to the EEZ, very few do.

SESSF Commonwealth Trawl

Jurisdiction:	**Commonwealth**
Season:	All year
Gear:	Single rig fish trawl Danish seine
Depth:	50m to 700m trawl 20m to 100m Danish seine
Vessels:	Samantha J (Eden) Zeehan (Portland) Saxon Onwards (Portland) Francesca (Bermagui)

Figure 6. Spatial extent of the SESSF Commonwealth Trawl Sector together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

SESSF Great Australian Bight Trawl

Jurisdiction: **Commonwealth**

Season: All year

Gear: Single rig fish trawl
Danish seine

Depth: 120m to 700m trawl
50m to 200m Danish seine

Vessels: Noble Pearl (Port Lincoln) trawl
Gail Jeanette (Port Lincoln) Danish seine

Figure 7. Spatial extent of the Commonwealth SESSF Great Australian Bight trawl sector together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

SESSF Gillnet Hook & Trap - shark

Jurisdiction: Commonwealth

Season: All year

Gear: Gillnet
Demersal longline

Depth: 180m

Vessels: Mustelus (Stanley) gillnet

Figure 8. Spatial extent of the Commonwealth SESSF Gillnet Hook and Trap (shark) sector together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

SESSF Gillnet Hook & Trap – Scalefish

Jurisdiction: Commonwealth

Season: All year

Gear: Demersal longline

Depth: 180 - 500m

Vessels: Diana (Hobart) longline

Figure 9. Spatial extent of the Commonwealth SESSF Gillnet Hook and Trap (scalefish) sector together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

Bass Strait Central Zone Scallop Fishery

Jurisdiction: Commonwealth

Season: July to December

Gear: Scallop dredge

Depth: ~30 – 80m

Vessels: Rachel Maree (Queenscliff)
Nothern Star (Lakes Entrance)
Del Richey II (Devonport)

Figure 10. Spatial extent of the Commonwealth Bass Strait and Central Zone Scallop Fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

Squid Jig Fishery

Jurisdiction: Commonwealth

Season: All year but generally January to July

Gear: Squid jig machines
(Some vessels use a submersible light to attract squid up from deeper waters)

Depth: 80m on the submersed light

Vessels: Carol Maree (Queenscliff)

Figure 11. Spatial extent of the Commonwealth Squid Jig Fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

Northern Prawn Fishery

Jurisdiction: Commonwealth

Season: Banana: April to mid-June
Tiger: August to the end of November

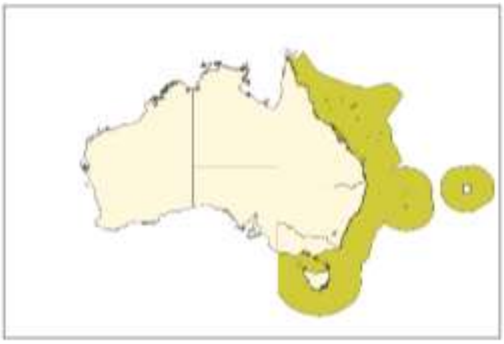
Gear: Quad-rig prawn trawl

Depth: ~30 – 80m

Vessels: Austral Hunter (Cairns)
Territory Achiever (Darwin)
Territory Spirit (Darwin)
Beachlands (Cairns)
Raptis Pearl (Cairns)

Figure 12. Spatial extent of the Northern Prawn fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

Eastern Tuna and Billfish Fishery



Jurisdiction:	Commonwealth
Season:	All year
Gear:	Pelagic longline
Depth:	Surface to 50m
Vessels:	Mira S (Nelson Bay) Gracie P (Ulladulla) Markana (Ulladulla) Straight Shooter (Mooloolaba) Esbjorn (Mooloolaba) South Seas 1 (Mooloolaba)

Figure 13. Spatial extent of the Commonwealth eastern tuna and billfish fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

NSW Rock Lobster Fishery

Jurisdiction:	New South Wales
Season:	All year
Gear:	Rock lobster Pot
Depth:	10 - 80m
Vessels:	Pearl of the Sea Wilderness

Figure 14. Spatial extent of the NSW Eastern rock lobster fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

NT Timor Reef Fishery

Shaded pink

Jurisdiction:	Northern Territory
Season:	All year
Gear:	Fish trap
Depth:	Surface to 50m
Vessels:	TBA

Figure 15. Spatial extent of the NT Timor reef fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

NT Demersal Fish Trawl

Jurisdiction: Northern Territory

Season: All year

Gear: Single-rig fish trawl

Depth: 80m

Vessels: Territory Leader (Darwin)
Sarriba (Darwin)

Figure 16. Spatial extent of the NT Demersal Fish Trawl Fishery (shaded green) together with main gear type(s) used, season duration, potential depth range of fishing and fishing vessels involved.

QLD Gulf of Carpentaria Fish Trawl

Jurisdiction: **Queensland**

Season: All year

Gear: Single-rig fish trawl

Depth: 80m

Vessels: Territory Leader (Darwin)

Figure 17. Spatial extent of the Queensland Gulf of Carpentaria Fin Fish Trawl Fishery together with main gear type(s) used, season duration, potential depth range of fishing and fishing vessels involved.

SA Gulf of St Vincent Prawn Trawl

Jurisdiction: South Australia

Season: Nov – Dec and Mar to Oct
over New Moon period

Gear: Twin-rig prawn trawl

Depth: 40m

Vessels: Anna Pearl (Adelaide)

Figure 18. Spatial extent of the South Australian Gulf of St Vincent Prawn Trawl Fishery together with main gear type(s) used, season duration, potential depth range of fishing and fishing vessels involved.

SA Spencer Gulf Prawn Trawl

Jurisdiction: South Australia

Season: Nov – Dec and Mar to Oct over New Moon period

Gear: Twin-rig prawn trawl

Depth: 50m

Vessels: Brianna Renee Adele (Port Lincoln)
Bartalumba K (Port Lincoln)

Figure 19. Spatial extent of the South Australian Spencer Gulf Prawn Trawl Fishery together with main gear type(s) used, season duration, potential depth range of fishing and fishing vessels involved.

WA Pilbara Fish Trawl

Jurisdiction: Western Australia

Season: All year

Gear: Single rig fish trawl

Depth: 100m

Vessels: Ocean Raider
Torbay (not operational)

Figure 20. Spatial extent of the WA Pilbara demersal trawl fishery together with main gear types used, season duration, potential depth range of fishing and fishing vessels involved.

Table 3. Breakdown of domestic commercial vessel (DCV) fleet and the size of Class 3 fishing vessels that could potentially use gear that could collect data across the continental shelf and shelf slope.

Class	Sub-group	Number	% DCVs	% Fishing
Total Domestic Commercial vessels (DCVs)		31,000		
Removed:	Human powered or sail vessels	7,000		
	Remaining DCVs	24,000	100.0%	
Passenger (Class 1)		2,280.0	9.5%	
Non-passenger (Class 2)		10,560.0	44.0%	
Hire & Drive (Classs 4)		3,264.0	13.6%	
Fishing Vessels (Class 3)		**7,896**	**32.9%**	**100%**
Small inshore vessels	0 - 7.5m	4,872	20.3%	61.7%
Medium size coastal vessels	7.5 - 12m	1,272	5.3%	16.1%
Large vessels working shelf and EEZ	**12 - 24m**	**1,728**	**7.2%**	**21.9%**
Large vessels working shelf and EEZ	**24 - 35m**	**96**	**0.4%**	**1.2%**
Large vessels working shelf and EEZ	**35 - 45m**	**24**	**0.1%**	**0.3%**

Data source https://www.amsa.gov.au/domestic-commercial-vessels-fleet-profile

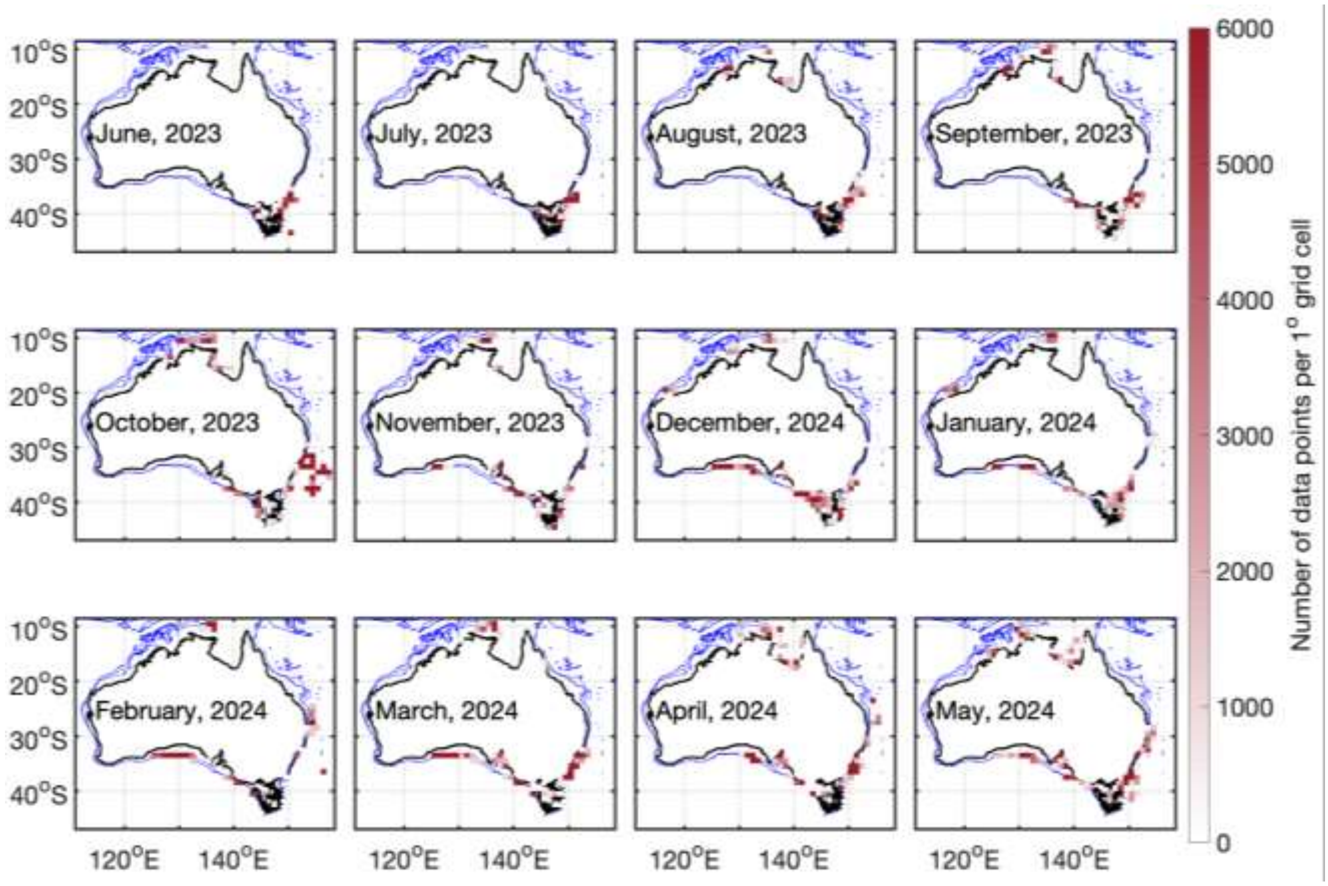


Figure 21. The spatial expansion of data collection from participating commercial fishing vessels around Australia through the period of the trial project.

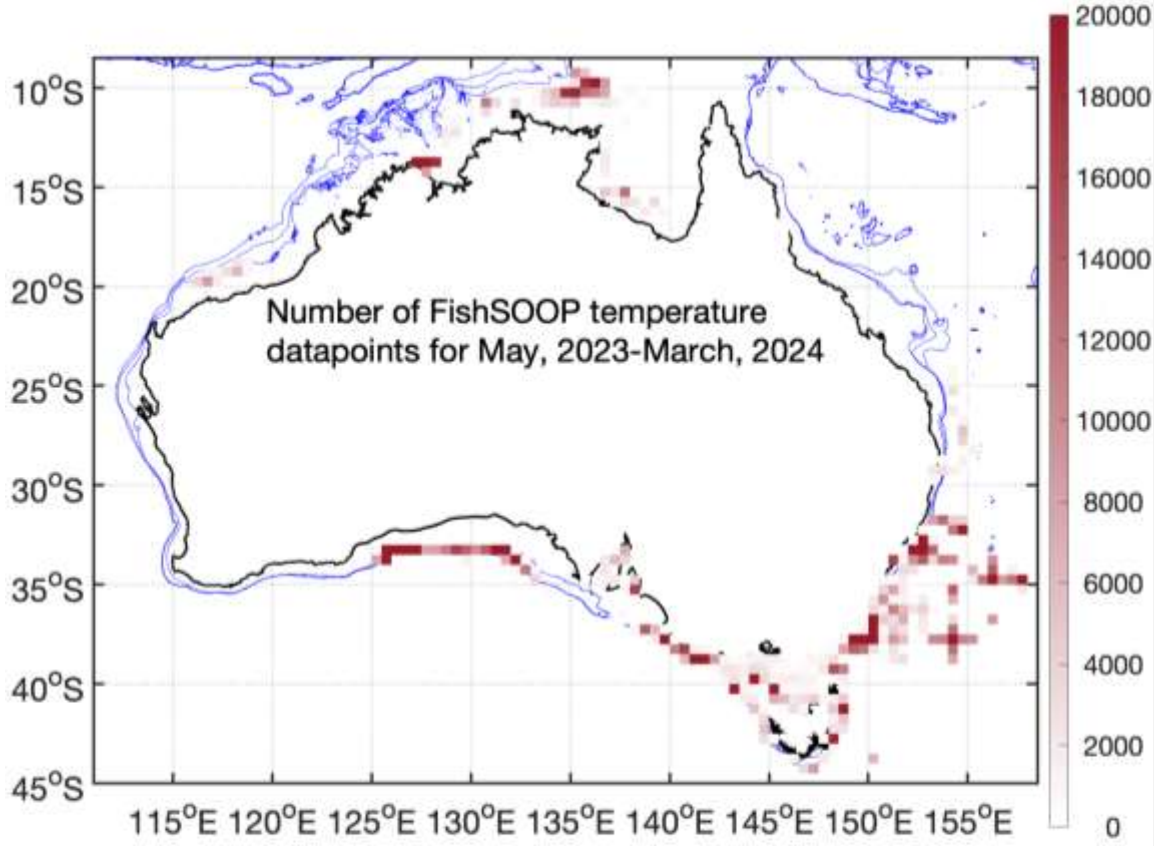


Figure 22. Summary of total data collection from participating commercial fishing vessels around Australia through the period of the trial project.

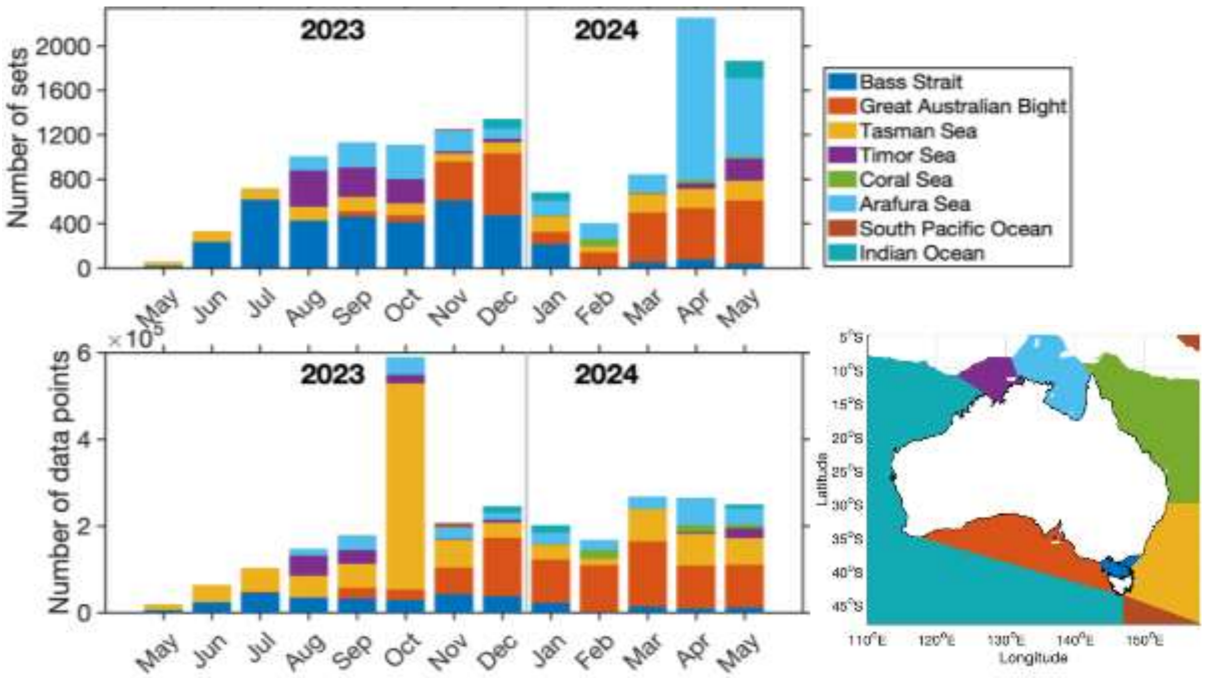


Figure 23. **Number of sets and data points (million) for each month per region. Note the peak in October 2023 was due to an installation for a sensor comparison study on the Australian National Facility, the RV Investigator.**

Objectives 3 and 4: Provide quality-controlled data to fishers and the AODN portal

These project objectives were focussed on providing quality-controlled (QC'd) data directly to fishers and to make the data publicly available on the Australian Ocean Data Network portal.

Database security

When joining the program, fishers must complete an online form (Appendix 5) which includes a legal contract (Appendix 6). The information provided includes their contact information, fishing gears, months active, location range of fishing, among other details. This information is kept in table and summary form on jotform (Figure 24). All of the fishers' metadata is kept private in a database only accessible through layers of security. According to the agreement signed by the vessel owner, the data collected can be shared into publicly available databases, i.e. the date and time, latitude and longitude, pressure (depth), and temperature, plus their associated QC flags.

A database of the raw data and QC'd data is kept on UNSW private cloud servers. A copy of the anonymised QC'd data is sent to the AODN for public access via their online portal and THREDDS catalog (https://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-FishSOOP/catalog.html).

Data Pathway

The temperature, pressure, and time data collected on the fishing gear is automatically sent via Bluetooth to the deck box on the boat (Figure 1). The deck box then uploads the time- and position-stamped temperature data to a cloud server via the cellular network (if available depending on the location of the vessel) in near real time. We have successfully implemented automatic quality control of sensor data in near real-time when a data file is received from a fishing vessel. The data are sent to the manufacturer, Zebratech, who redirects to the UNSW-IMOS

AWS cloud server. When a file is received in our servers it is matched with the vessel metadata database and automatically triggers QC evaluation for each datapoint. The QC'd data are saved in netCDF files automatically in the AWS cloud servers. From there on, there are two data pathways: Near Real Time and Delayed Mode. The Zebratech dashboard provides real-time information on the fleet of vessels and deckbox status (Figure 24) including with overview of deck box location and battery level, alarms, and an example deck box detailed metrics.

We also use a Monday database to track operational aspects of the vessels and sensors. When a vessel submits their information in the Jotform, it automatically creates a new vessel item in our metadata database (Monday) and gear type can be associated with the vessels to keep track of participating vessels, the sensor and deck box inventory, and where each sensor is currently located (Figure 25 and Figure 26).

Near Real Time Pathway

To Fishers via Email

The QC'd data are converted into csv files on our servers and an html email personalised for the corresponding vessel is automatically created and sent to the fishers' nominated email address. The emails are automatically sent directly from the UNSW cloud server's system to the fisher. An example email is shown in Figure 27. The data pathway is operational 24 hours a day and 7 days a week for use by vessel operators in near real-time.

To the AODN

The QC'd data are pushed to the AODN cloud server, to be made available in near real time for public access in standardised IMOS netCDF format as displayed in Figure 28. The data are available here: https://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-FishSOOP/catalog.html.

To the global telecommunications system (GTS)

The advancement for Q3/Q4 2024 is collaboration with the global Fishing Vessel Observing Network (FVON) community to establish real time data delivery to the global telecommunications system (GTS) so that the data can be ingested into operational ocean forecasts in near real time. We are working on an Australian FVON path to the GTS through the Bureau of Meteorology and/or IMOS. Data sent to the GTS in near real time cannot be accessed by Lay people, only by registered Met Services.

Delayed Mode Data Pathway

To the AODN

Data that fail the automated QC are flagged for delayed mode and expert QC. We are working on having delayed QC run on our cloud servers and the data will be converted in a standardised format for publication to the IMOS Australian Ocean Data Network with more thorough expert QC tests. Expert QC will also be conducted when instruments are returned from calibration if/as required.

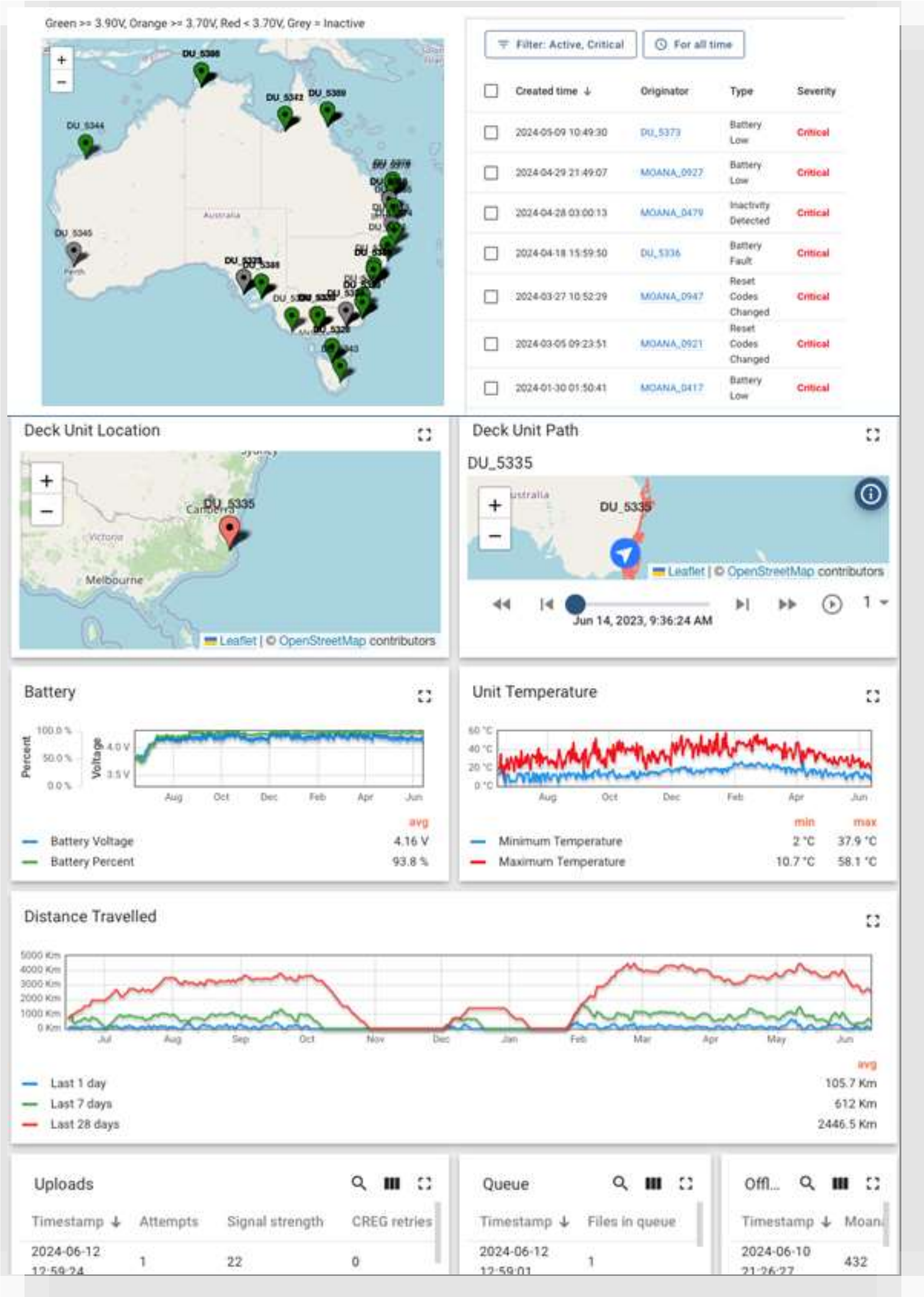


Figure 24. Example views from the Zebratech dashboard, with overview of deck box location and battery level, alarms, and an example deck box detailed metrics.

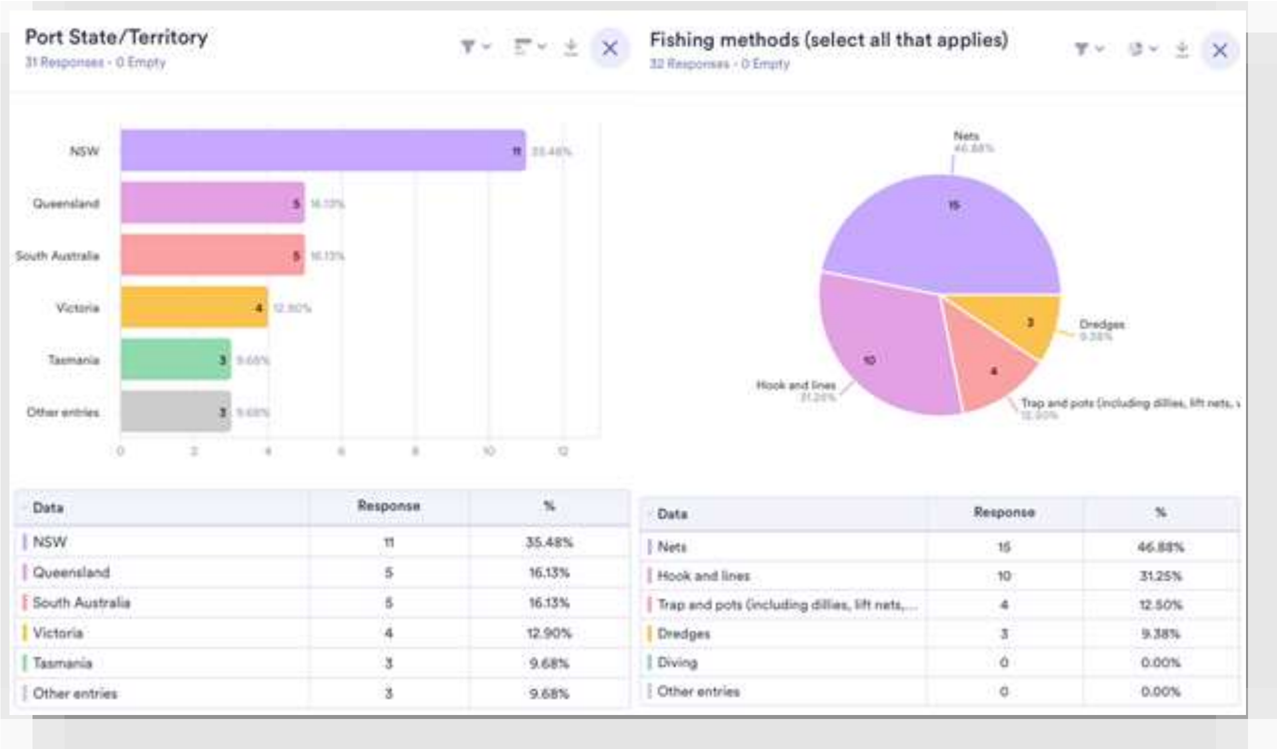


Figure 25. Example of summary views of the metadata entered directly by the fishers in Jotform.

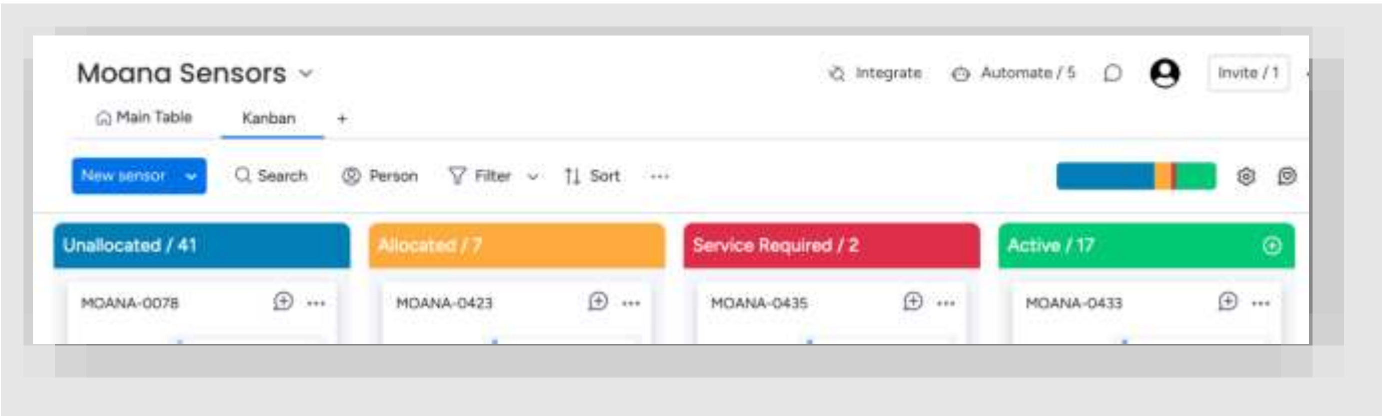


Figure 26. Example of sensor allocation in the Monday database.

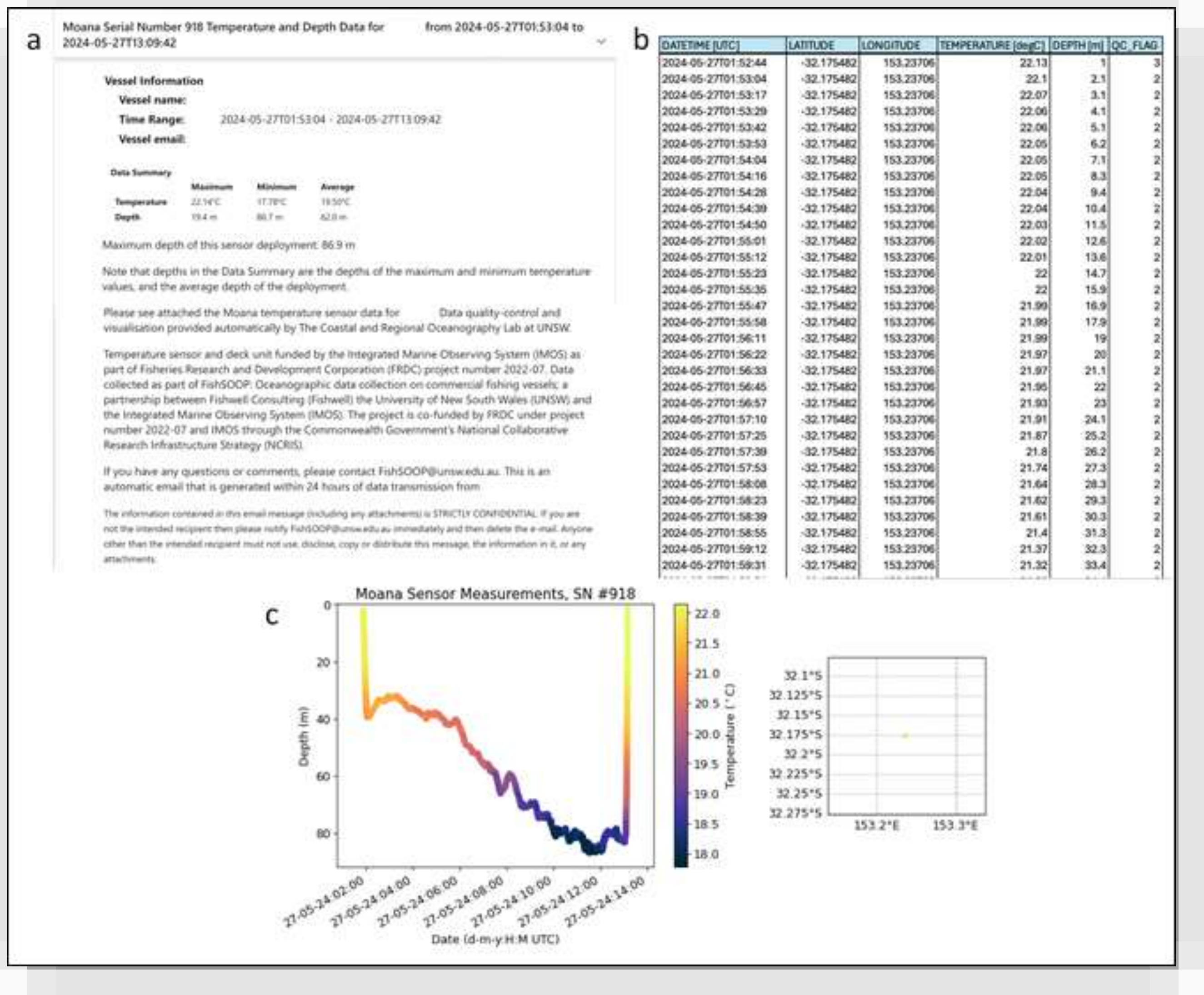
Data processing and quality control flags

For quality control, the data are matched with types of fishing gears, which are attributed as either a “passive” or “towed” category (Table 3). The “towed” gear category applies to gear which remains attached to the fishing vessel. Thus, the location recorded by the deck box on the vessel matches the location at which the temperature data are recorded by the Moana sensor on the gear. The “passive” category means that the gear is not attached to the boat. Thus, the location is not recorded throughout the gear deployment. The position is therefore calculated as the average between the first and last good quality data reading, assumed to be at deployment and recovery, when the deck box is at the same location as the sensor. If the first or last good quality data reading isn’t near the surface, the position cannot be calculated and the data processing will fail. Additionally for passive gear, if the first and last location is too large, the data flag is raised. Additional data processing includes ensuring that the measurements are associated with the correct vessel from the metadata database, in particular, the fishing gear type.

The depth is currently calculated from the pressure using the TEOS-10 method from the Gibbs Seawater Oceanographic Toolbox (IOC *et al.* 2010).

Table 4. Classification of fishing gear types for data processing.

Gear Type	Category	
	Passive	Towed
Bottom Trawl		✔
Potting	✔	
Long Lining	✔	
Trawling		✔
Midwater Trawl		✔
Purse Seine Netting	✔	
Bottom Trawling		✔
Research		✔
Education		✔
Bottom Trawler		✔
Bottom Long Line		✔
Waka		✔
Danish Seining	✔	
Netting	✔	
Set Netting	✔	
Dredge		✔
Instrument Deployment		✔
Potting, Long Lining	✔	
Diving	✔	
Trolling		✔



DATETIME [UTC]	LATITUDE	LONGITUDE	TEMPERATURE [degC]	DEPTH [m]	QC_FLAG
2024-05-27T01:52:44	-32.175482	153.23706	22.13	1	3
2024-05-27T01:53:04	-32.175482	153.23706	22.1	2.1	2
2024-05-27T01:53:17	-32.175482	153.23706	22.07	3.1	2
2024-05-27T01:53:29	-32.175482	153.23706	22.06	4.1	2
2024-05-27T01:53:42	-32.175482	153.23706	22.06	5.1	2
2024-05-27T01:53:53	-32.175482	153.23706	22.05	6.2	2
2024-05-27T01:54:04	-32.175482	153.23706	22.05	7.1	2
2024-05-27T01:54:16	-32.175482	153.23706	22.05	8.3	2
2024-05-27T01:54:28	-32.175482	153.23706	22.04	9.4	2
2024-05-27T01:54:39	-32.175482	153.23706	22.04	10.4	2
2024-05-27T01:54:50	-32.175482	153.23706	22.03	11.5	2
2024-05-27T01:55:01	-32.175482	153.23706	22.02	12.6	2
2024-05-27T01:55:12	-32.175482	153.23706	22.01	13.6	2
2024-05-27T01:55:23	-32.175482	153.23706	22	14.7	2
2024-05-27T01:55:35	-32.175482	153.23706	22	15.9	2
2024-05-27T01:55:47	-32.175482	153.23706	21.99	16.9	2
2024-05-27T01:55:58	-32.175482	153.23706	21.99	17.9	2
2024-05-27T01:56:11	-32.175482	153.23706	21.99	19	2
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2024-05-27T01:56:33	-32.175482	153.23706	21.97	21.1	2
2024-05-27T01:56:45	-32.175482	153.23706	21.95	22	2
2024-05-27T01:56:57	-32.175482	153.23706	21.93	23	2
2024-05-27T01:57:10	-32.175482	153.23706	21.91	24.1	2
2024-05-27T01:57:25	-32.175482	153.23706	21.87	25.2	2
2024-05-27T01:57:39	-32.175482	153.23706	21.8	26.2	2
2024-05-27T01:57:53	-32.175482	153.23706	21.74	27.3	2
2024-05-27T01:58:08	-32.175482	153.23706	21.64	28.3	2
2024-05-27T01:58:23	-32.175482	153.23706	21.62	29.3	2
2024-05-27T01:58:39	-32.175482	153.23706	21.61	30.3	2
2024-05-27T01:58:55	-32.175482	153.23706	21.4	31.3	2
2024-05-27T01:59:12	-32.175482	153.23706	21.37	32.3	2
2024-05-27T01:59:31	-32.175482	153.23706	21.32	33.4	2

Figure 27. Example email automatically sent to the fishers a) an email with data statistics and funding information, b) a copy of the QC'd data in .csv format and c) a plot of the data and the position as an attachment.

Catalog https://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-FishSOOP/REALTIME/2024/05/catalog.html

Dataset	Size	Last Modified
05		--
IMOS_SOOP-FishSOOP_TP_20240501T003621Z_FV00_442.nc	41.83 Kbytes	2024-05-31T06:26:23Z
IMOS_SOOP-FishSOOP_TP_20240501T040320Z_FV00_442.nc	42.90 Kbytes	2024-05-31T06:26:15Z
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IMOS_SOOP-FishSOOP_TP_20240501T143111Z_FV00_834.nc	60.99 Kbytes	2024-05-31T06:02:43Z
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IMOS_SOOP-FishSOOP_TP_20240502T152947Z_FV00_421.nc	35.18 Kbytes	2024-05-31T06:38:52Z
IMOS_SOOP-FishSOOP_TP_20240502T162921Z_FV00_786.nc	61.66 Kbytes	2024-05-31T06:33:36Z
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IMOS_SOOP-FishSOOP_TP_20240502T180414Z_FV00_421.nc	37.28 Kbytes	2024-05-31T06:38:06Z
IMOS_SOOP-FishSOOP_TP_20240502T192610Z_FV00_421.nc	35.41 Kbytes	2024-05-31T06:38:47Z
IMOS_SOOP-FishSOOP_TP_20240502T203736Z_FV00_421.nc	37.28 Kbytes	2024-05-31T06:37:46Z
IMOS_SOOP-FishSOOP_TP_20240502T213142Z_FV00_421.nc	35.18 Kbytes	2024-05-31T06:40:48Z
IMOS_SOOP-FishSOOP_TP_20240502T230056Z_FV00_786.nc	59.70 Kbytes	2024-05-31T06:33:34Z
IMOS_SOOP-FishSOOP_TP_20240503T021147Z_FV00_786.nc	54.30 Kbytes	2024-05-31T06:32:52Z
IMOS_SOOP-FishSOOP_TP_20240503T094314Z_FV00_421.nc	35.18 Kbytes	2024-05-31T06:37:29Z
IMOS_SOOP-FishSOOP_TP_20240503T103658Z_FV00_786.nc	59.31 Kbytes	2024-05-31T06:33:24Z
IMOS_SOOP-FishSOOP_TP_20240503T104330Z_FV00_421.nc	35.18 Kbytes	2024-05-31T06:42:04Z

Figure 28. Example list of the Near Real Time QC'd netCDF FishSOOP data files available on the AODN for May 2024 from https://thredds.aodn.org.au/thredds/catalog/IMOS/SOOP/SOOP-FishSOOP/catalog.html.

Quality control

Temperature/depth records are quality-controlled in near real-time to provide high-quality, reliable data suitable for scientific and operational use. Standard temperature and pressure quality-control tests are based on the IOOS Quality Assurance for Real Time Oceanographic Data (U.S. Integrated Ocean Observing System 2020) and Argo quality-control procedures (Wong *et al.* 2021), and developed in collaboration with the Fishing Vessel Ocean Observing Network (FVON) (Van Vranken *et al.* 2023) (Table 4,Table 5). The additional processing of assigning position to individual measurement is fishing method (gear) and sensor-specific. Tests are applied to temperature, pressure, time and position, and are based on ocean processes and dynamics, sensor specifications, and fishing method (Jakoboski et al, 2023, 2024). Test results are categorised into QC flags associated with each variable and are all included in the resulting data files (Table 6).

A scalable NoSQL encrypted metadata database is kept on cloud servers with sensors and fish gear inventory, and fishers' information. The metadata on the cloud server is necessary to customise the automatic QC for the fishing gear type that the sensors are attached to, and then to send the data automatically in real time via email to the fishers' nominated email addresses. All the metadata information on the AWS cloud server is kept behind multiple layers of security.

A basic monitoring system has also been established for cloud servers to troubleshoot in real time when problems arise. Information about the latest data transfer from each vessel, battery status and communication is updated in an html table when files are transferred to the server. This system can be expanded to a more comprehensive view, especially as participation (i.e. number of vessels) grows and it becomes more crucial to keep automatically updating records and to respond to potential issues as they arise.

The project team are collaborating with the international FVON team (https://fvon.org) on data pathways, data QC and data methodologies. Code for the pathway is shared for collaborative advances:

https://github.com/metocean/moana-qc (MetService, New Zealand)

https://oceandata.net/ (Ocean Data Network, USA)

Table 5. List of Quality Control tests currently applied for the near real-time QC

QC Test	Description
Impossible Date	Checks that the observations are within a specific valid range (between January 1st 2010 and offload date).
Impossible Location	Checks that the latitude is between -90 and 90, and longitude between -180 and 360.
Impossible Speed	Checks that the speed, calculated from data location, is lesser than 100 knots.
Timing Gap	If the observations are more than 60 minutes apart with less than 5 datapoints on either side of the gap, flag the smaller cluster of datapoints, usually due to splashes of water on the sensor.
Global Range	Checks that the pressure and temperature variables are within their defined expected range and absolute range.
Remove Reference Location	Remove the location of the ZebraTech lab to not account for data that might have not offloaded from the manufacturer's lab testing.
Spike	Flag spikes in the temperature and pressure data.
Temperature Drift	Checks that all the temperature data in 0, 10, 20, 50, 100, 200, 400, 600, 1000 and 2000 depth bins have a standard deviation lesser than between 1.5ºC and 3.5 º C, and a difference between the largest and lowest temperature lesser than between 5 and 8 (the thresholds vary as a function of depth and bin sizes).
Stationary Position Check	If the fishing gear is passive, check that the first and last "good data" (flag = 1) are near the surface, in order to use the average location between those 2 good data as the location for all the data, otherwise flag all the data.
Start and End Distance Check	Checks that the distance between the first and last position for passive fishing gears is lesser than 5 or 50 km. This is to flag data that was not recovered exactly at the same place it was deployed, in case of passive gears, as either failed but probably still good data (flag=2 for 5 km) or failed and probably bad data (flag=3 for 50 km).

Table 6. Ranges used for the Global Range QC test for the pressure and temperature variables. The lower limit has only one limit for both the absolute and expected range. Data outside the expected range will be given a flag=3, data outside the absolute range will be given a flag=4.

Variable	Absolute/expected lower limit	Expected upper limit	Absolute upper limit
Pressure	0	1600	2000
Temperature	-2	36	40

Table 7. QC flag values and their meaning.

QC flag value	Meaning
0	QC not performed
1	Test passed; good data
2	Test failed, but probably still good data
3	Test failed, probably bad data
4	Test failed; bad data
5	Overwritten

Discussion

In this proof-of-concept project, we have collected temperature data across the breadth of Australian shelf seas revealing insights into the sub-surface structure of temperature throughout the water column. Comparison with the SEA-COFS ocean forecast models shows the potential for improving forecasts of upper ocean heat content and bottom temperatures by filling the gaps in observational data coverage. FishSOOP has driven a step-change in the amount of open access temperature data available at low cost and provides critical information on sub-surface temperature metrics, essential for future proofing marine industries.

The results of a related project show that sub-surface temperature data can be cost-effectively collected from fishing vessels substantially increasing the spatial coverage of oceanographic data and the utility of ocean circulation models (Gwyther *et al.* 2022, Kerry *et al.* 2023). Such data yields valuable information on climate change effects and the relationship of oceanographic variables, particularly temperature and depth, on the distribution and abundance of commercial fish species. Furthermore, all fisheries use time-series of commercial catch per unit effort (CPUE) from fishing logbooks as a proxy for fish abundance. Having a direct link between catch and the oceanographic variables that may affect catch rates at the same spatial and temporal scale, would be extremely valuable in better understanding this link and reducing the uncertainty of CPUE as an index of abundance.

The positive reception of the trials described here was further exemplified by additional co-investment by the fishing agencies and industry for a further 17 vessels within a year of program operation. This resulted in a total of 35 vessels to the IMOS SOOP program. The simplicity, reliability, and maintenance free nature of the system deployed in data collection trials is an attractive feature important in encouraging further participation in the FishSOOP program.

A range of fishing methods was represented in this proof-of-concept project including: prawn trawling, gillnet, pelagic and demersal longlining, potting and trapping, fish-trawling, squid jigging, scallop dredging, and purse seine. Data acquisition included more than 1.7 million measurements (temperature and depth) from the sea surface to more than 1,200 m depth.

Operation and data collection was generally problem free except for initial issues with sand and shell grit blocking water flow through sensors on scallop dredges and also the need to replace some sensors due to battery failure. There was some level of concern from a few fishers about position data being revealed even though publicly available data were anonymous, but this was able to be addressed in all cases by having a time lag before data was made publicly available. If skippers remained concerned about position data, we suggested that the vessel best not be involved in the project, rather than compromise the spatial precision of the temperature-depth data. However, participating fishers were generally receptive given that their data records were made available to them assisting in their evaluation of environmental effects on catch success (particularly temperature-depth profiles). In general, the positive engagement of stakeholders through peak bodies and established networks with the commercial fishing sector was a key driver of success in these data collection trials. These networks should continue to be engaged in expanding the FishSOOP.

Although participation was positive and the spatial coverage extensive, there were some issues emerging from the trials. Confidentiality of data remains a concern and a barrier to participation for a number of skippers. In relation to future participation, the trials revealed five groups of fishers:

- Fishers willing to be involved and comfortable that their vessel's precise location is available (anonymously) in real time (GTS, AODN);
- Fishers willing to be involved and comfortable that their vessel's precise location is available (anonymously) on the AODN Portal after a short delay (e.g. < 7 days, the time taken for manual QC and data to get to the AODN);
- Fishers willing to be involved and comfortable that their vessel's precise location is available (anonymously) on the AODN Portal after the fishing season is completed. These data could be held at the facility until the after the delay period upon consultation with the AODN;
- Fishers willing to be involved but are not comfortable that their precise location is available but would be willing for lower resolution spatial data to be made available (anonymously) on the AODN Portal; and,
- Fishers not willing to be involved.

There is a need to convince the last three groups of fishers to be involved and that existing concerns can be addressed. An overarching concern is that skippers fear that others will take advantage of information indicating favourable fishing areas (the intellectual property of individuals). This can be overcome by delaying data upload to the AODN. Furthermore, the amount of data sent from the boat in near real time is extensive. Some vessels can complete up to 40 sets/day. This generates lots of email and data transfer. Potential data bottlenecks may be addressed by specifying download frequency. Thus, skippers can choose to download data daily or weekly.

Despite some barriers to participation as summarised above, extending the IMOS ships of opportunity program to commercial fishing vessels has been successful. A key success factor is the linkage of fishing vessel monitoring capacity through enabling technology to oceanographers and improved ocean circulation models. All of this is mediated by trusted linkages to the commercial fishing sector established by decades of engagement in industry-driven fisheries research in Australia. Indeed, the idea for extending the ships of opportunity program followed FRDC Project 2005/006 "*The influence of environmental factors on recruitment and availability of fish stocks in south-east Australia*" (Knuckey et al 2010) in which it was stated that temperature-at-depth data was one of the most important parameters for potential inclusion in catch rate standardisations for a broad range of species. A key recommendation from this project at the time was "To facilitate this, we would recommend that a select group of vessels continue to collect basic environmental data together with temperature and depth information from data-loggers placed on the fishing gear". The current project realised that vision. Independent of this, Roughan designed and implemented a ground-breaking program in New Zealand (The Moana Project 2017-2022) to develop the sensor technology, instrument 200 vessels and develop the initial real time data pathway. The success of which enabled us to progress the conversation with IMOS, who committed to the project in 2022-2023. Since then, climate change has continued to affect beneficial uses of Australia's living marine resources including commercial fishing. Further to this FRDC project 2024-012 "*Capturing fisher ecological knowledge of climate change: a Southern and Eastern Scalefish and Shark fishery case study*" consolidates fisher knowledge and observations collected over decades of involvement in fishing off Australia's south east. Harnessing this knowledge and observational capacity not only provides useful information for formal assessments (fisheries stock assessments, ecological models, coastal oceanography) but it directly involves the commercial fishing sector in formal information exchange reinforcing and consolidating relationships between fishers, managers, and scientists. As such, many of the barriers to participation in the FishSOOP project will be removed.

An advancement following successful proof-of-concept demonstrated in the current project is collaboration with the global FVON community to establish real time data delivery to the global telecommunications system (GTS). This provides for integration of fisher data into operational ocean forecasts in near real time. An Australian FVON pathway to the GTS through the Australian Bureau of Meteorology and/or IMOS is important future work.

The successful trials described here presents a transformational change in ocean monitoring capacity and in the development of informative models of ocean circulation. The availability of inexpensive and accurate temperature/pressure sensors linked to remote data transfer platforms such as commercial fishing vessels presents a cost-effective and powerful opportunity in data collection capacity for Australian shelf and upper-slope waters. Although installations could be made on very small vessels, of the ~8,000 domestic commercial fishing vessels operating around Australia, about 3,000 are of a size >7.5m that could safely work inshore, and ~1,800 > 12m that could safely deploy fishing gear across the continental shelf and upper slope with the temperature-depth monitoring equipment successfully trialled in the current project. There is obvious capacity for expansion of the project to cover seasons and regions not sampled during the current project. Many of these vessels use demersal fishing gear that transits from the sea surface to the ocean floor multiple times a day. Many of these vessels operate up to 250 days per year. Such a spatially and temporally extensive data acquisition platform will illuminate the link between temperature, depth and the distribution, abundance and catchability of commercial fish species. This additional information will also provide real time evaluation of changes to oceanographic processes important in tuning forecasting models (meteorological, ocean circulation) and predictions of climate change impacts on coastal and ocean ecosystems.

The value of using commercial fishing vessels as an ocean monitoring platform is that they can considerably expand spatial and temporal coverage compared with the current monitoring platforms. Expansion of subsurface data acquisition will follow from anticipated further participation by commercial fishing vessels. For example, 50 vessels fishing 200 days each year, each with say 1-10 deployments of gear each day, offers at least 10,000-100,000 deployments annually across Australian waters (each with 1000's of temperature/depth measurements). In particular, the provision of subsurface temperature data will improve the reliability of ocean forecasting, the validity of ocean circulation models, and understanding of climate change impacts.

Looking forward, and applying the lessons learned from this project, co-investment by IMOS and the commercial fishing sector offers a cost-effective means of expanding subsurface data collection on a continuing basis. This will provide a valuable, spatially and temporally extensive time-series of oceanographic data hitherto unavailable. Each fishing vessel is already paying for fuel and crew presenting a substantial in-kind contribution to data collection. Ongoing data management including quality control and compatibility with the AODN can be coordinated and supported through IMOS building on the positive outcomes already achieved. Recognising the success of the pilot project IMOS have committed long term funding to the data pipeline and have contracted the team led by UNSW to continue running the existing program out to June 30 2027.

Conclusion

We have shown that engagement of the Australian commercial fishing fleet is a cost-effective data acquisition strategy to improve spatial coverage of subsurface temperature data particularly for coastal waters out to the continental shelf slope. Trials across a range of fisheries deploying different gears has collectively shown that robust temperature/pressure sensors can be successfully deployed with maintenance free data transmission capacity (to the cloud) in near real time (generating millions of data points including many from sparsely informed regions of Australia's territorial seas). Barriers to participation including fears of disclosure of valuable intellectual property (preferred fishing sites) can be overcome with existing data security provisions and consolidation of individual records into anonymous metadata. The link to end users (oceanographers and forecasters) through enabling technology via participating vessels is reinforced with trusted agents reflecting decades of successful liaison with the Australian commercial fishing sector. Expanded engagement of Australian fishing vessels, given the successful proof-of-concept, to the IMOS ships of opportunity presents a transformational change in data available for integration into ocean circulation models. This is a critical opportunity to further develop cost-effective data acquisition at a time when climate change is threatening beneficial uses of Australia's living marine resources.

Implications and recommendations

There are clear and attractive opportunities to expand participation of the Australian commercial fishing fleet in IMOS ships of opportunity program. In particular, FRDC Project 2024-012 "*Capturing fisher ecological knowledge of climate change: a southern and eastern scalefish and shark fishery case study*" further empowers the commercial fishing sector in information gathering and knowledge development. Recognition of informal knowledge through such program helps build trusted working relationships with science end users such as the oceanographers in the current project. In return, fishers gain understanding of the utility of data acquisition and utility in ocean circulation and ecosystem models reinforcing participation.

Data acquisition can be extended to other parameters such as salinity with the development of new sensors as well as a 2000m capable sensor in development for fisheries active in the deeper Southern Ocean. We are exploring these options with the manufacturer.

Extension and Adoption

Extension and adoption is a key component and outcome of this project. The simplicity of installation and operation of the monitoring system (with minimal maintenance and involvement of the vessel crew) is a key driver of further adoption of the data acquisition program. Additional participation will emerge following removal of existing barriers (including concerns over security of intellectual property).

FishSOOP is now part of FVON[1], an international network of projects which seek to enhance our understanding of the oceans through collaborations between the fishing industry and academia. The aim of the network is to raise the profile and impact of fishing vessel based observations, support existing projects, and encourage the growth of new initiatives in the areas of greatest data need. Key to this is understanding long-term funding, data standards, data impact, governance, future collaborations, and capacity building in areas without established ocean observing programmes. FVON has recently been endorsed as an emerging network[2] by the Global Ocean Observing System (GOOS[3]), as part of the UN's Decade of Ocean Science for Sustainable Development.

Critical to the long-term funding issue, IMOS has now agreed to fund a further three years of the core FishSOOP project with Prof. Moninya Roughan as the Chief Investigator and University of NSW as the lead agency with Fishwell Pty Ltd conducting the prime liaison role with the Australian commercial fishing industry. This project will run alongside IMOS' wide range of observing equipment deployed throughout Australia's vast and valuable coastal and open ocean estate. IMOS will continue to make all of its data openly and freely accessible to the marine and climate science community, other stakeholders and users, and international collaborators. IMOS is enabled by the National Collaborative Research Infrastructure Strategy (NCRIS[4]). It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent.

Project Materials Developed

Information exchange was an important component of this project. Accordingly, nine newsletters were produced and circulated over the course of the trial period (Appendix 7).

[1] FVON
[2] Three emerging observing networks join the Global Ocean Observing System | UNESCO
[3] Global Ocean Observing System – GOOS is the global home of ocean observing expertise and systematic coordination.
[4] National Collaborative Research Infrastructure Strategy (NCRIS) - Department of Education, Australian Government

References

Eaton, B., Gregory, J, Drach, B., Taylor, K., Hankin, S., Blower, J., *et al.* (2022). NetCDF Climate and Forecast (CF) Metadata Conventions. https://cfconventions.org

Elzahaby, Y., Schaeffer, A., Roughan, M., & Delaux, S. (2021). Oceanic circulation drives the deepest and longest marine heatwaves in the East Australian Current system.. *Geophysical Research Letters*,Vol 48, August 2021.

Fulton, E.A., Mazloumi, N., Puckeridge, A., Hanamseth R. (2024). Modelling perspective on the climate footprint in southeast Australian marine waters and its fisheries. *ICES Journal of Marine Science*. https://doi.org/10.1093/icesjms/fsad185

Fulton, E.A., Punt, A.E., Dichmont, C.M., Harvey, C.J., Gorton, R. (2019). Ecosystems say good management pays off. *Fish and Fisheries* 20, 66-96. doi.org/10.1111/faf.12324

Gwyther, D. E., Kerry, C., Roughan, M., and Keating, S. R. (2022). Observing system simulation experiments reveal that subsurface temperature observations improve estimates of circulation and heat content in a dynamic Western Boundary Current. *Geoscientific model development* 15, 6541–6565. https://doi.org/10.5194/gmd-15-6541-2022

Hobday, A. J., G. T. Pecl, B. Fulton, H. Pethybridge, C. Bulman and C. Villanueva (2018). Climate change impacts, vulnerabilities and adaptations: Australian marine fisheries. Impacts of Climate Change on fisheries and aquaculture: Synthesis of current knowledge, adaptation and mitigation options. *In:* M. Barange, T. Bahri, M. Beveridge, K. Cochrane, S. Funge-Smith and F Poulain FAO Fisheries Technical Paper 627: 347.362. http://www.fao.org/3/i9705en/I9705EN.pdf

IMOS (2021). IMOS NetCDF Conventions. IMOS, version 1.4.2, June 30th, 60 pp.

IMOS (2022). IMOS NetCDF File Naming Convention. IMOS, version 1.5.3, November, 14 pp.

IOC, SCOR and IAPSO (2010). The international thermodynamic equation od seawater – 2010: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No.56, UNESCO (English), 196 pp.

Jakoboski, J., M. Montano, and C. Castro Muniain, 2023: Mangopare quality control python package (Moana-qc). Zenodo, https://doi.org/10.5281/zenodo.7955568.

Jakoboski, J., M. Roughan, J. Radford, J.M. Azevedo Correia de Souza, M. Felsing, R. Smith, N. Puketapu-Waite, M. Montaño Orozco, K.H. Maxwell, C. Van Vranken (2024). Partnering with the commercial fishing sector and Aotearoa New Zealand's ocean subsurface temperature monitoring program. Progress in Oceanography, https://doi.org/10.1016/j.pocean.2024.103278

Kerry, C., Roughan, M., and de Souza, J.M.A,C. (2024). Assessing the impact of subsurface temperature observations from fishing vessels on temperature and heat content estimates in shelf seas: a New Zealand case study using observing system simulation experiments. *Frontiers in Marine Science* 11, 1358193 https://doi.org/10.3389/fmars.2024.1358193

Knuckey, I., Day, J., Zhu, M., Koopman, M., Klaer, N., Ridgway, K. And Tuck, G. (2010). The influence of environmental factors on recruitment and availability of fish stocks in south-east Australia. Final Report to Fisheries Research and Development Corporation - Project 2005/006. Fishwell Consulting and CSIRO, 300pp.

Li, J., Roughan, M. and Kerry, C. (2021). Dynamics of interannual eddy kinetic energy modulations in a Western Boundary Current. *Geophysical Research Letters* 48

Malan, Neil, Moninya Roughan, and Colette Kerry. (2021). The rate of temperature rise adjacent to a warming western boundary current is nonuniform with latitude. *Geophysical Research Letters* 48, January 2021

Martinelli, M., Guicciardi, S., Penna, P., Belardinelli, A., Croci, C., Domenichetti, F., *et al.* (2016). Evaluation of the oceanographic measurement accuracy of different commercial sensors to be used on fishing gears. Ocean Eng. 111, 22–33. https://doi.org/10.1016/J.OCEANENG.2015.10.037

O'Callaghan, J., Stevens, C., Roughan, M., Cornelisen, C., Sutton, P., Garrett, S., *et al.* (2019). Developing an integrated ocean observing system for New Zealand. *Frontiers in Marine Science* 6. https://doi.org/10.3389/fmars.2019.00143

Patterson, H, Bromhead, D, Galeano, D, Larcombe, J, Woodhams, J and Curtotti, R 2021, Fishery status reports 2021, Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra. CC BY 4.0. https://doi.org/10.25814/vahf-ng93

Pecl, G. T., Ward, T., Doubleday, Z. A., Clarke, S., Day, J., Dixon, C., Frusher, S., Gibbs, P.J., Hobday, A.J. Hutchinson, N., Jennings, S., Jones, K., Li, X., Spooner, D., and Stoklosa, R. (2014). Rapid assessment of fisheries species sensitivity to climate change. *Climatic Change*: https://doi.org/10.1007/s10584-10014-11284-z

Simons, R.A., and Chris John (2022). ERDDAP. https://coastwatch.pfeg.noaa.gov/erddap. Monterey, CA: NOAA/NMFS/SWFSC/ERD.

U.S. Integrated Ocean Observing System (2020). Manual for Real-Time Oceanographic Data Quality Control Flags. Version 1.2. Silver Spring, MD, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Ocean Service, Integrated Ocean Observing System, 24pp. https://doi.org/10.25923/w8y6-d298

Van Vranken, C., Jakoboski J., Carroll, J.W., Cusack, C., Gorringe, P., Hirose, N., Manning, J., Martinelli, M., Penna, P., Pickering, M., Piecho-Santos, A.M., Roughan, M., de Souza, J. and Moustahfid, H. (2023). Towards a global Fishing Vessel Ocean Observing Network (FVON): state of the art and future directions. *Frontiers in Marine Science* 10, 1176814. https://doi.org/10.3389/fmars.2023.1176814

Van Vranken, C., Vastenhoud, B.M.J., Manning, J.P., Plet-Hansen, K.S., Jakoboski, J, Gorringe, P., Martinelli, M. (2020). Fishing Gear as a Data Collection Platform: Opportunities to Fill Spatial and Temporal Gaps in Operational Sub-Surface Observation Networks. Front. Mar. Sci. 7, https://doi.org/10.3389/fmars.2020.485512

Wernberg, T., Bennett, S., Babcock, R.C., de Bettignies, T., Cure, K., Depczynski, M., Dufois, F., Fromont, J., Fulton, C.J., Hovey, R.K., Harvey, E.S., Holmes, T.H., Kendrick, G.A., Radford, B., Santan-Garcon, J., Saunders, B.J., Smale, D.A., Thomse, M.S., Tuckett, C.A., Tuya, F., Vanderklift, M.A., and Wilson, S. (2016). Climate-driven regime shift of a temperate marine ecosystem. *Science* 353, 169-172.

Wong, A. P. S., and Coauthors, 2020: Argo data 1999–2019: Two million temperature-salinity profiles and subsurface velocity observations from a global array of profiling floats. *Frontiers in Marine Science* 7, https://doi.org/10.3389/fmars.2020.00700.

Appendix 1. FAQs

FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels

Our oceans are changing and we need measurements to model the future

Recently, marine heatwaves have hit Australian waters leading to temperatures well above normal. These higher temperatures may impact fish populations, and currently we do not know how deep they extend or how they affect fished species.

As part of an FRDC co-funded pilot project, we are working with fishers to collect real-time ocean observations where they matter most. Just like weather stations help increase the accuracy of atmospheric weather forecasting, getting more ocean observations helps us improve ocean models, and help the fishing industry optimise its resources by gaining a better understanding of the relationship between catches and sea temperature.

Sensor attaches to commercial fishing gear

Our technology partner, Zebra-Tech, has developed a compact, low-cost temperature sensor (the Moana sensor) that can be attached to many types of commercial fishing gear. It operates with minimal human intervention and communicates directly to a solar powered deck box.

Fishers collect ocean temperatures

Fishers have always been ocean experts. The Moana sensor puts ocean data collection back into the hands of those who work on, and depend upon, the sea.

We need subsurface marine measurements within Australia's EZZ to understand how the ocean is changing below the surface. International ocean observing programmes such as Argo (www.argo.net) provide some deepwater data offshore but our subsurface coastal waters are not well monitored. Fishing vessels operate in areas where we have few subsurface ocean measurements, and where environmental change is having a huge impact.

There are ~6500 active fishing vessels in Australian waters. This network of fishing vessels can collectively provide cost-effective, real-time subsurface data in our vast EEZ.

What are we asking fishers to do?

We are looking for participants who want to deploy small self-contained temperature sensors on their fishing gear Australia-wide. Participating fishers install the sensor on fishing gear and a standalone, solar-powered deck unit on the vessel. After the installation, the system needs no intervention.

What do fishers get in return?

You will be able to access your individual vessel temperature data. Sensor measurements will be made available online as downloadable files, sent via email within 24 hours, and may be made available via an elogbook platform in the future.

You can compare sensor data with your catch information and understand relationships between catch and temperature.

The data will benefit Australian fisheries & fishers

Small and lightweight: the sensor measures 14.5 cm by 4 cm.

We are working to further the understanding of the link between water temperature at depth and fish distribution and abundance. The fishing industry can provide very valuable ocean observations on an unprecedented scale, which can be used to answer a range of questions. We can use the data in near real time to improve our ocean forecast models. In the longer term, we hope the data will assist in standardising catch rates in our fisheries stock assessment models. Furthermore, better ocean data will improve our understanding of general ocean warming, marine heatwave events, temperature impacts on the relative or total abundance of species, species range shift, and the impact of this on fisheries productivity.

FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels

Frequently Asked Questions

Can I attach the sensor to any type of fishing gear?

We can attach the sensors to longlines, netting, pots, and trawling equipment. We have a range of protective housings and brackets to simplify sensor mounting.

What does it cost?

There is no fee for the first 20 vessels to participate in the trial. The deck unit transmits using the mobile network and the data transmission cost is covered by the project.

What data are collected?

The only information collected and shared will be temperature, depth, time and position at regular intervals during your fishing operations. Detailed vertical temperature profile measuring every 1m depth between the surface and 200m, every 4m between 200m and 1000m on the way up and down, and data every 5 mins while at a constant depth (such as in a pot, or on a line).

What about catch information?

No catch information is collected or shared. This is your private information and we do not have access to it.

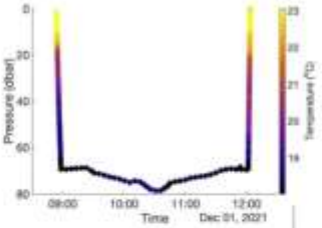
How are the data offloaded?

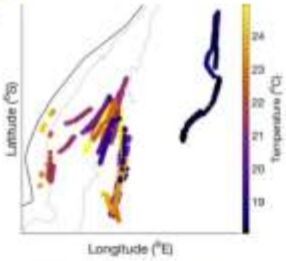
When the Moana sensor comes out of the water, it automatically offloads its data via Bluetooth to a small, standalone, weather-proof, deck unit. You do not need to do anything during this process. Data are then automatically transferred to our secure, cloud-based servers.

The deck unit.

Where are the measurements stored?

Data are stored on our UNSW database for processing before being publicly share, under the Creative Commons License 4.0, on the Australian Ocean Data Network (AODN; https://portal.aodn.org.au/)





Measurements collected by the sensor are emailed back to the vessel that collected them within 24 hours as a plot and in spreadsheet format.

Will you send details of my fishing to others?

We will share the temperature, depth, time and position data collected publicly on the AODN under the Creative Commons License 4.0. Data sharing can be delayed in time, or aggregated if there are sensitivity issues.

If you are concerned about your fishing location being shared, please speak with us before installing the sensor and deck unit.

How long will the sensor be on my vessel?

The trial period will last for 6-12 months. If additional funding is sourced for ongoing data management and the trial is successful, we can continue the program. The sensor's battery lasts for two years, after which you will need to send it back to us for battery change and sensor recalibration.

Contact details

Project and installations:	Ian Knuckey	ian@fishwell.com.au	0408 581 599
Data questions:	Moninya Roughan	FishSOOP@unsw.edu.au	

Appendix 2. Project Background

Trials of oceanographic data collection
on commercial fishing vessels in SE Australia
FRDC Project 2002-007

Summary

Australia's fisheries span a large area of ocean. Australia has the world's third largest Exclusive Economic Zone (EEZ), with an area of over 8 million km2. This zone contains mainly Commonwealth managed fisheries, with State jurisdictions mainly in coastal waters up to the 3 nautical mile limit. Australia's total wild-catch fisheries gross value of production is $1.6 billion, of which 28% is from Commonwealth fisheries and 72% from the smaller coastal inshore fisheries managed by state jurisdictions. The wildcatch fisheries sector employs about 10,000 people across Australia (https://www.awe.gov.au/abares/research-topics/fisheries/fisheries-and-aquaculture-statistics/employment).

The commercial fishing industry has a network of thousands of vessels working mainly in inshore waters around Australia. They can supply a potential platform for extensive and fine scale spatial and temporal monitoring of the waters of the continental shelf (0 - 1200m), from the surface to the ocean floor. Given that their livelihoods depend on it, they have a keen understanding of oceanographic conditions with respect to fish behaviour, feeding and spawning and the various oceanographic factors that may influence this. In some fisheries (e.g. surface tuna longlining), fishers eagerly seek and use readily available fine-scale oceanographic data such as sea surface temperature and sea level, to improve their targeting and achieve higher resultant catch rates. For many other fisheries, however, it is the fine-scale sub-surface oceanographic conditions (feed layers, thermoclines, temperature at depth etc) that have a critical influence on their fishing dynamics. Unfortunately, this type of oceanographic data is far less readily available. Although fishers and scientists know these factors are important, the time series of fine scale spatial and temporal data relevant to fishery operations is not available to include in stock assessments. As a result, it is often assumed that variations in catch rates reflect changing stock abundance, when it may simply be a result of changing oceanographic conditions.

Marine scientists collect a vast range of oceanographic data using satellites, subsurface drones, and static and drifting buoys. Sea surface data, however, is much easier and more cost-effective to collect at high spatial and temporal resolutions than sub-surface data. Hence, understanding of sub-surface oceanographic conditions tends to be derived from modelling more than actual measurement. This may be sufficient at a wide-scale global or continental level, but it is not adequate at the fine-scale spatial and temporal resolution required for fisheries management.

The use of commercial fishing gear as a research data platform has been increasing in popularity internationally (https://www.frontiersin.org/articles/10.3389/fmars.2020.485512/full). A number of groups in Europe have been doing this for a decade (e.g Martinelli et al 2016),

and New Zealand are also now involved (https://www.moanaproject.org/te-tiro-moana). However, this approach has yet to be implemented in Australia in a coordinated way. In particular, our approach dictates open access data served through the IMOS Australian Ocean Data Network (www.aodn.org.au) that can be collected once and used many times.

In this project we intend to instrument seafood sector assets (e.g Trawl Nets, longlines, pots) with fit-for- purpose quality-controlled (QC'd) temperature/pressure sensors to increase the sub-surface temperature data coverage around Australia's shelf and upper slope regions (0-800m) at low cost. Not only will this assist in the collection of data at relevant spatial and

temporal scales for use by fishers, but it will also provide a far more extensive level of QC'd data to oceanographers in near real time (NRT) for evaluation and ingestion into data-assimilating coastal models that will provide improved analysis and forecasts of oceanic conditions. In turn, this will also be of value to the fishing sector when used to standardise stock assessments.

Objectives

1. Effective installation and operation of oceanographic data collection equipment on network of commercial fishing vessels using a range of common fishing gear
2. To provide QC'd data direct to fishers in near real-time to assist in habitat characterisation and the targeting of effort
3. To cost-effectively increase the spatial resolution of sub-surface physical data collected in Australia's inshore, shelf, upper-slope, and offshore waters by fitting commercial fishing equipment from a variety of gear types with low-cost temperature/pressure sensors
4. To make the QC'd temperature depth data publicly available through the IMOS-AODN portal for uptake and use in ways that support safe maritime operations the sustainable management of marine resources, and improves understanding of drivers of change.

Background

Oceanographic processes and habitat characteristics are a critical aspect influencing fisheries stock abundance and the distribution of key species. Such factors as water temperature, current speed and direction, depth of feed layers, and the depth of the thermocline have a great influence on fish feeding, aggregation, and distribution. Climate change and related oceanographic conditions have had, and will continue to have, an important influence on the distribution and abundance of key fisheries around Australia. Over the next twenty years Australia's marine ecosystems are expected to exhibit some of the largest climate-driven changes in the Southern Hemisphere (https://research.csiro.au/cor/wp-content/uploads/sites/282/2021/09/CSIRO-2018-Nontechnical_summary_climate_projections_Australian_fisheries.pdf). Australia's oceans off south-east and south-west Australia are particular hotspots, undergoing rapid change, warming. There has been long-term warming at both the surface and at depth (Malan et al 2021), and southward transport of warmer waters has increased as the East Australia Current has strengthened, and eddies move further south (LI et al 2021) driving marine heatwaves (Elzahaby et al 2021). Other physical variables, such as salinity, and nutrient availability have also changed. These can have various effects either by directly impacting the animal's physiology (particularly on growth and reproduction), affecting their habitat, or a combination of factors. Future projections suggest abundance of some species will decline, some will increase, and some will be largely unchanged. Over 100 Australian marine species have already started migrating south towards cooler southern waters. There have also been a series of marine heatwaves and other extreme events that have harmed Australia's seagrass, kelp forests, mangroves and coral reefs. These changes in the distribution, abundance and species composition in Australia's marine ecosystems mean that Australia's commercial fisheries are being affected by climate change.

Many valuable fisheries operate in SE Australia (see Patterson et al 2021). The Commonwealth-managed Southern and Eastern Scalefish and Shark Fishery (SESSF) operates in the centre of Australia's oceanographic climate change hot spot. Across its four main sectors, the Commonwealth Trawl Sector (CTS), Great Australian Bight Trawl Sector (GABTS), Shark Gillnet and Shark Hook sectors (SGSHS) and Scalefish Hook Sector (SHS) total catch is it has a combined GVP of about $90 million and provides most of the fresh fish into the Sydney and Melbourne markets. Other impacted Commonwealth fisheries in the

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region include the Bass Strait and Central Zone Scallop Fishery (BSCZSF), with a GVP of about $6 million, the Squid Jig Fishery, worth $3 million, and the Small Pelagic Fishery with a GVP ranging $1 to 5 million. Across South Australia, Tasmania and Victoria commercial rock lobster fishers operate licenses, vessels, pots and harvest infrastructure with an estimated capital value of $2.3 billion, landing over 3,000 tonnes of premium Southern Rock Lobster annually with a GVP of around $250 million (https://www.southernrocklobster.com/). Temperate prawn trawl fisheries in South Australian gulfs are worth a combined $40 million GVP (https://www.bdo.com.au/en-au/econsearch/safisheriesreports).

Numerous studies have investigated the environmental drivers of fish abundance and distribution to improve fisheries outcomes, but there is currently a disconnect between the resolution of the oceanographic data and models available, and the scales at which the fishing industry operates.
o Operational ocean models such as Ocean Maps (10km resolution) are of insufficient resolution and do not adequately resolve circulation of shelf waters
o Higher resolution models exist for certain regions of the continental shelf, but they suffer from insufficient observations for data assimilation and validation
o There are very few real time/near real time, sub-surface ocean observations available for uptake by end users or assimilation into models. These data are even more sparse on the shelf where fishing efforts are concentrated.

Globally, sub-surface observations are the biggest gap in information required for habitat characterisation and fisheries management, particularly in shelf waters. Many fishing methods in SE Australia operate below the surface (e.g. mid-water trawls for small pelagics or squid jigging), or are focused on the benthos (e.g. demersal fish trawling, scallop dredging, rock lobster potting), making sub-surface oceanographic information a critical piece of the puzzle for understanding fishery dynamics and catch rates.

An increase in the amount of sub-surface data available for SE Australian waters, particularly in near real time, will provide critical information to marine industries that will assist in better targeting fishing effort, thereby reducing costs and increasing productivity. Furthermore, all fisheries use time-series of commercial catch per unit effort (CPUE) from fishing logbooks as a proxy for fish abundance. Often, variations in CPUE as an index of abundance are not well explained by the information that is available. Having a direct link between catch and the oceanographic variables that may affect it at the same spatial and temporal scale, would be extremely valuable in better understanding this link and reducing the uncertainty of CPUE as an index of abundance. What better way to achieve this than to have the fishing vessels themselves collect oceanographic data (temperature-depth at a minimum) to improve oceanographic models and catch rate standardisation to improve estimates of fish abundance?

The overarching goal of this project is to develop a proof of concept methodology to 'crowd source' oceanographic data to achieve smart and sustained nation-wide ocean observing capability in areas that the fishing sector routinely fish. We will deploy fit for purpose temperature sensors on 17 vessels across south- eastern Australia (Spencer Gulf/eastern GAB – Sydney) which auto download to a central database. These data will provide a step change in spatial and temporal coverage of in situ ocean temperature data which could be used in oceanographic modelling or against which the fisheries models could be validated. The idea behind this project began in 2010, following completion of FRDC project 2005-006 "The influence of environmental factors on recruitment and availability of fish stocks in south-east Australia". The Principal Investigator - Ian Knuckey - emailed then IMOS Director Tim Moltmann, suggesting that temperature-at-depth information that could be collected on fishing vessels to better inform catch rate standardisations for use in assessments. His idea was that 10-20 vessels across southern Australia (GAB – Sydney but potentially right around Aus) could be fitted with calibrated TDRs which are regularly downloaded to a central

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database. These would provide significant spatial and temporal coverage of real data which could be used in oceanographic modelling or against which the models could be ground-truthed. Since this time, numerous attempts to progress this idea in Australia have been floated to no avail, yet it has commenced internationally. Already it is operational in NZ, through Moana Project with $11M funding led by Roughan in 2018. Through this project (show cased as a plenary talk at the Seafood New Zealand Conference in 2019), purpose-built sensors were developed and trials began. Additionally consultation began with the Australian seafood sector and IMOS in earnest. A similar project It is also operating in Europe through Berring Data Collective. Australia is lagging behind. The time has come for IMOS, universities and the fishing industry to partner in this project, particularly given the impact of climate change on oceanography and fisheries in SE Australia.

Project personnel

Contact	Contact Details	Company Name
Principal Investigator	Dr Ian Knuckey Director Email: ian@fishwell.com.au Mobile: 0408 581 599	Fishwell Consulting Pty Ltd
Co-Investigator	Professor Moninya Roughan Senior Lecturer Email: mroughan@unsw.edu.au Mobile: Business Ph: 02 9385 7067	UNSW Sydney
Co-Investigator	Dr Paul D. van Ruth Senior Science Officer Email: paul.vanruth@utas.edu.au Mobile: 0413 886 360	Integrated Marine Observing System (IMOS)

Ian Knuckey

Dr Ian Knuckey is a fisheries biologist with 35 years' experience as a researcher in fisheries around south east Australia, including extensive work with, and knowledge of the Southern and Eastern Scalefish and Shark Fishery's Commonwealth Trawl Sector and Great Australian Bight Trawl Sector, the Southern Squid Jig Fishery, Small Pelagic Fishery, Scallop Fishery and the southern Rock Lobster Fishery. Ian has worked closely with industry members in all of these fisheries run numerous research projects looking at the relationship between fisheries catches and CPUE and environmental variables. He was PI of a FRDC project on "The influence of environmental factors on recruitment and availability of fish stocks in southeast Australia".

Moninya Roughan

Since 2008 Prof Roughan has led the oceanography component of NSW- IMOS, Australia's ocean observing programme, along the coast of southeastern Australia. She also led the regional modelling effort in the East Australian Current (EAC). Moninya's team has used a combination of oceanographic observations (in-situ, autonomous and remote sensed observations) and numerical models to understand the dynamics of the EAC System and the impact on biological productivity. Diverse observational platforms such as current meter and temperature moorings, autonomous underwater gliders, profiling CTDs, HF coastal radar, drifters and boat based measurements. Data from these platforms is used in combination with numerical models to explain fundamental coastal ocean physical dynamics, and to gain an integrated, quantitative understanding of their impacts on coastal ocean bio-geo-chemical processes.

Paul van Ruth

Dr Paul van Ruth is an oceanographer with expertise in plankton ecology and food web dynamics. His research focuses on the way variations in physical and chemical environmental parameters, whether driven by anthropogenic or climatic factors, shape marine planktonic communities and food web structure from global to local scales. Paul is currently the Senior Science Officer for Australia's Integrated Marine Observing System (IMOS). Prior to this appointment he spent 18 years at the Aquatic Sciences branch of the South Australian Research and Development Institute, finishing as a Senior Research Scientist in Oceanography, and leading the South Australian Node of IMOS from 2015 – 2020. During this time he worked on/led projects with outcomes that promoted the sustainable management of prawn, rock lobster, and sardine fisheries, and Southern blue-fin tuna and oyster aquaculture industries.

Methods

This project is a proof of concept that will demonstrate that common commercial fishing vessels operating around Australia can collect quality controlled sub-surface oceanographic data during normal fishing operations and return the data to the cloud in near real time with minimal intervention. SE Australia was chosen for the case study due to the wide range of fishing gears that are used in both coastal inshore state fisheries and deeper offshore Commonwealth fisheries through the area. Further, the SE region of Australia is known to be a global hotspot for ocean warming, and is impacted by increasingly frequent marine heatwaves. High quality data on oceanographic conditions is of critical importance to the fisheries that operate in this region. All of the fishing methods assessed in this project are commonly used around Australia, and if this proof of concept is successful, the program could be readily scaled up and expanded to a national level.

1) Development of a Project Steering Committee

The Committee will be composed of representatives from organisations such as Seafood Industry Australia, Australian Fisheries Management Authority (AFMA), Victorian Fisheries Authority (VFA), Department of Primary Industries and Regions SA (PIRSA), NSW Department of Primary Industries - Fisheries Division (NSW Fisheries), Australian Fisheries Management Forum (AFMF), Fisheries Research and Development Corporation (FRDC), and MOS (Michelle Heupel).

2) Installation of oceanographic data collection equipment on a range of different commercial fishing vessels

2a) Instrumentation

Collection of sea-surface oceanographic data is readily straight forward through a range of platforms including satellites, buoys, fixed monitoring stations and "ships of opportunity". We therefore focus on collecting sub surface observations which are extremely sparse.

We will use the ZebraTech Moana Temperature depth sensors and solar powered deck boxes (https://www.zebra-tech.co.nz/moana/). These sensors have been purpose built for deployment on fishing vessels as ships of opportunity and have been trialed extensively in New Zealand and Europe over the past few years. Their accuracy is better than +/- 0.1 deg C with resolution of 0.0001 deg C and response rate of 1 second. Ensuring fit for purpose.

The Moana TD has been designed to work fully autonomously. Because of this, it can be integrated into existing commercial fishing operations without disrupting workflow. High precision data is effortlessly collected, and transmitted back to land based servers from the solar powered deck box, fully autonomously.

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The sensor monitors its operating environment, enabling it to reliably perform adaptive profile sampling and time series sampling schemes, under varying atmospheric and environmental conditions found in commercial fishing operations.

When submerged, profile temperature and depth data is collected at 1m intervals from the surface down to 200m, and then every 4 meter intervals between 200m and 1000m (Moana TD 1000). If the depth doesn't change significantly, for example, when deployed on a pot, time series data is collected. Moana TD features a wave filtering algorithm to prevent wave induced depth change logging in shallow water.

On surfacing, Moana automatically offloads its data over Bluetooth, to the ZebraTech Deck Unit. The ZebraTech Deck Unit is a solar powered stand alone device that automatically post processes Moana data to incorporate historical position stamping, and then uploads the data via the cellular network when available, or the vessels Wi-Fi network if available.

2b) Fishing Vessels

The project will focus on sub-surface fishing methods that operate either mid-water or on the ocean floor from shallow inshore fisheries to deepwater fisheries operating on the outer continental shelf break. The fisheries we have chosen for the proof of concept are:

- Inshore SA Spencer Gulf Prawn Fishery (3 vessels, 3 deck boxes, 2 sensors per vessel)
- Inshore SA / Vic Rock Lobster Fishery (3 vessels, 3 deck boxes, 5 sensors per vessel)
- Commonwealth Scallop vessels operating in Bass Strait (3 vessels, 3 deck boxes, 2 sensors per vessel)
- Commonwealth SESSF Trawl and GAB Trawl Sector (4 vessels, 4 deck boxes, 2 sensors per vessel)
- Commonwealth SESSF Scalefish Longline Sector (2 vessels, 2 deck boxes, 5 sensors per vessel)
- Commonwealth Squid Jig (2 vessels, 2deck boxes, 5 sensors per vessel)

3) Training of crew in equipment installation, maintenance and trouble shooting .

Development and documentation of Standard Operating Procedures (SOP) for sensor and deck box installation, maintenance, and troubleshooting for each vessel/gear type.

4) Data collection during normal commercial fishing operations

The initial trials of data collection will be evaluated after a one month duration. Project members will meet with crew members to discuss operational aspects of data collection and download and visualisation of the initial data. They will identify aspects that are working well operationally and those which will drive the revision of the SOPs.. Following any revisions / improvements, a further trial of data collection over one month will be conducted and again reviewed between the crew and the project team. The SOP will again be revised if necessary.

Following these two trial months, the data collection equipment will be operated by each vessel for a six month period. During this time, any issues will be logged for discussion with project team members.

5). Data offload, QC, and visualisation and delivery

a) Sensor to deck box (automated)
b) Near real time delivery to the cloud
c) Near real time automated QC
d) Near real time delivery to fishers (data via PDF within 24 hrs)
e) expert QC (data scientist) and data delivery to the AODN (delayed).

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At the end of the 6-month period, the data will be collated, visualised and the results discussed with the crew members and steering committee. We will develop feedback mechanisms as part of the SOP which include show the information may be relayed back to the fishers in a useful and informative manner.

Outputs & Outcomes

Outputs:

1. Quality controlled temperature, pressure (depth), and position data (vertical profiles and horizontal tows) collected from each of the different fishing vessel types

2. Development of real time data flow pathways into the open access IMOS data base (AODN) and the GTS (global telecommunication system – for real time model validation/assimilation) as appropriate.

3. Documented, standardised, best practice protocols registered on the Ocean Best Practices System

4. Report documenting – success, strengths and areas for improvement, to be published in appropriate journal

Outcomes:

1. An evaluation of the efficacy of deploying temperature/pressure sensors in commercial fishing operations to provide quality sub-surface data across a range of habitats

2. Increased spatial and temporal resolution of sub-surface temperature data in shelf and coastal waters with new data streams that improve habitat characterisations, inform fishing operations for better targeted effort, and increase the accuracy of stock assessments.

3. New ways for the seafood sector to engage with IMOS, providing opportunities for further collaboration, and generating impact by promoting the sustainable management of fisheries.

4. Opportunities for collaboration with groups working internationally on similar projects (e.g. Europe and NZ) with a view to developing international best practice protocols for the collection of oceanographic data during commercial fishing operations.

In the longer term, the outcomes will be:

- A better understanding of drivers of change in abundance for more accurate stock assessments
- A better understanding of environmental variation/habitat characteristics to promote better targeting of fishing effort
- improved oceanographic models to support maritime safety and operations and the sustainable management of marine resources

Performance Indicators

1. Monitoring equipment installed on 17 commercial fishing vessels operating a range of gear types
2. Data collection standard operating procedures (SOPs) developed for each of the vessels operating different gear types
3. Development and documentation of IMOS quality control (QC) standards and protocols for data collection, transfer and storage – published on international best practice website
4. Data downloads from different commercial fishing vessels that meets IMOS QC requirements

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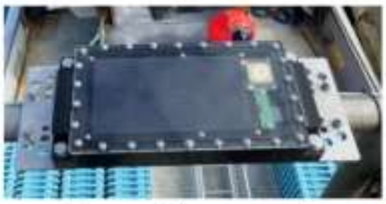
Appendix 3. Instruction sheets.

FRDC Project 2022-007
Trials of oceanographic data collection on commercial fishing vessels

Thank you for agreeing to participate in the FRDC project Trials of oceanographic data collection on commercial fishing vessels – a collaboration between Fishwell Consulting, UNSW Sydney and IMOS. The data you collect will greatly assist with our understanding of how the sea temperature around SE Australia is changing, where marine heatwaves are occurring, and it will also vastly improve our abilities to provide accurate marine and land weather forecasts. We also hope that in time, it can be used to improve the data that underpins the accuracy of our fishery stock assessments.

What you will get

Deck Unit. This is attached to the vessel. It is solar charged and fully self-contained. The Deck Unit receives data from the Moana sensor, and transmits it to the Australian Ocean Data Network (AODN).



Moana sensor. The blue sensor attaches to your fishing gear either with or without the yellow protective cover. It is fully automatic, and measures water depth and temperature very accurately.

Installation of the Deck Unit:

a. Has clear sky view for solar charging and GPS reception
b. Is within 20 meters of the working deck
c. Has clear line of sight to the working deck

Installation of the Moana sensor

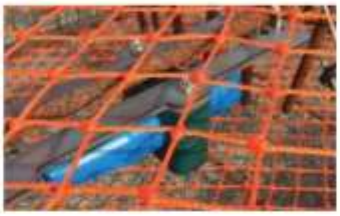
Your Moana sensor will be supplied with the appropriate mounting hardware for your fishing method. Please refer to the images below as to how they may be mounted for different fishing methods.

Trawl

Line / Jig

Net

Trap



Operating instructions

Once installed, the system is fully automated and does not require any battery charging or operating, except:

1. Please check the Deck Unit solar panel is kept clean
2. After 12 months we will contact you and arrange the return of the sensor for re-calibration and battery change

Deck Unit Flashing lights

The Deck Unit has flashing lights on the top. These are labelled GPS, Bat, Data

Bat flash	GPS flash	Meaning
Green	Green	Operating normally
Green/Yellow	Green	Battery getting low
Red	Green	Battery critically low
Red	Red	Low battery shutdown
Data		
Blue flash		Data has not yet been uploaded
Solid Blue		The Deck Unit has connected to the sensor and is offloading data

Data

Can you get the data?

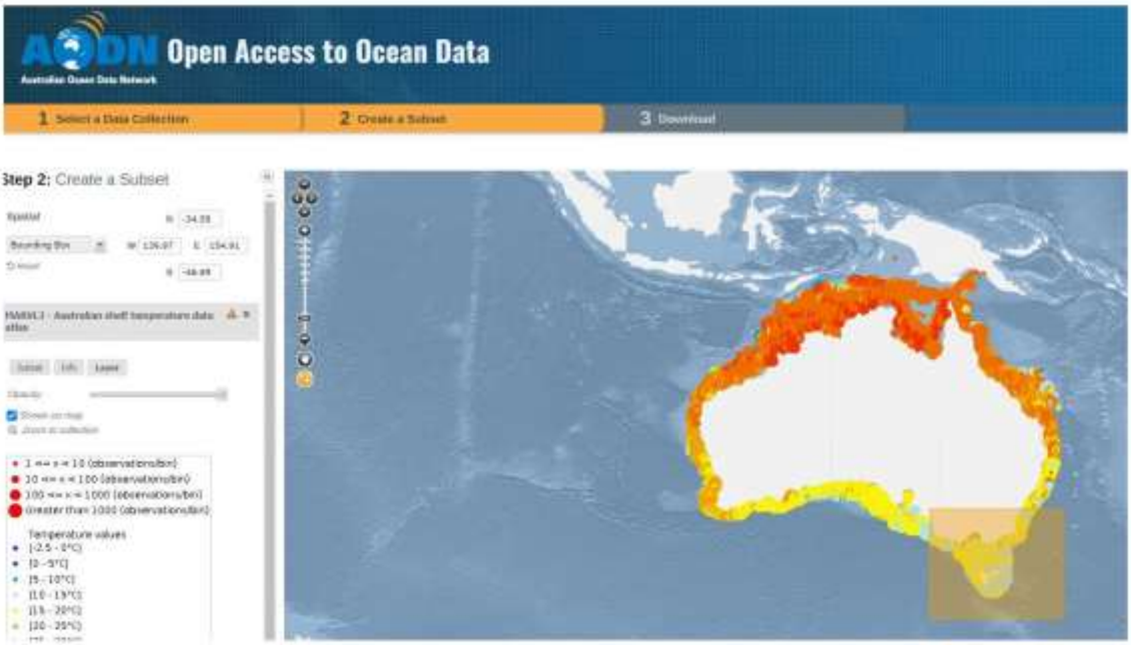
Most fishers receive the data collected by the Moana sea temperature equipment by email. It may take up to 24 hours for the data to arrive, or longer depending on cellular coverage.

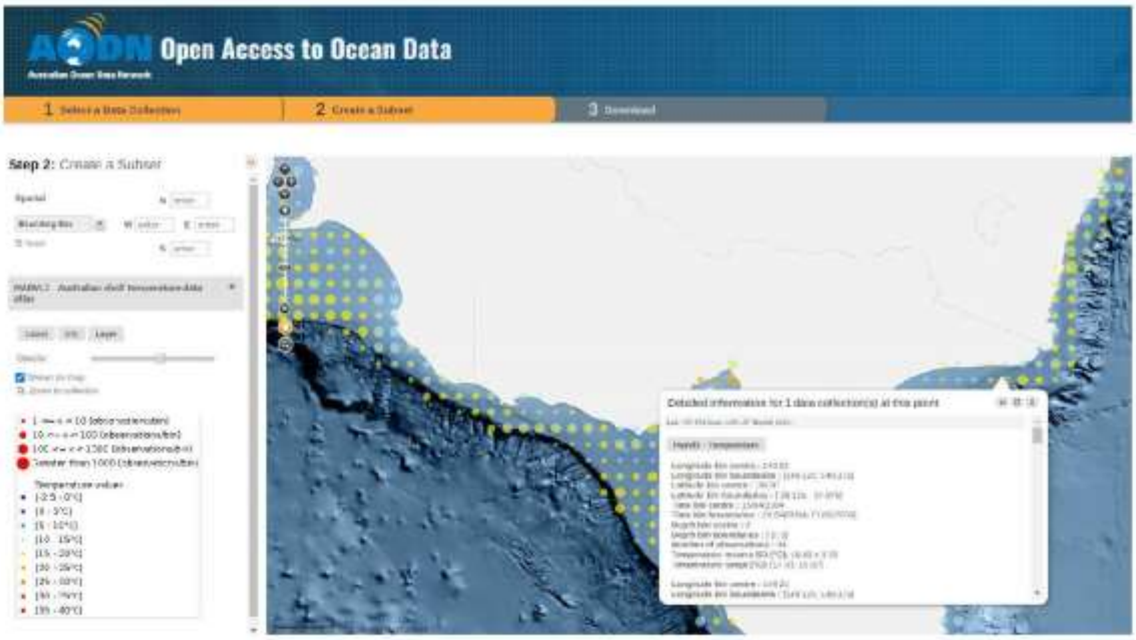
Contact details

Project & installations:	Ian Knuckey	ian@fishwell.com.au	0408 581 599
Data questions:	Moninya Roughan	FishSOOP@unsw.edu.au	

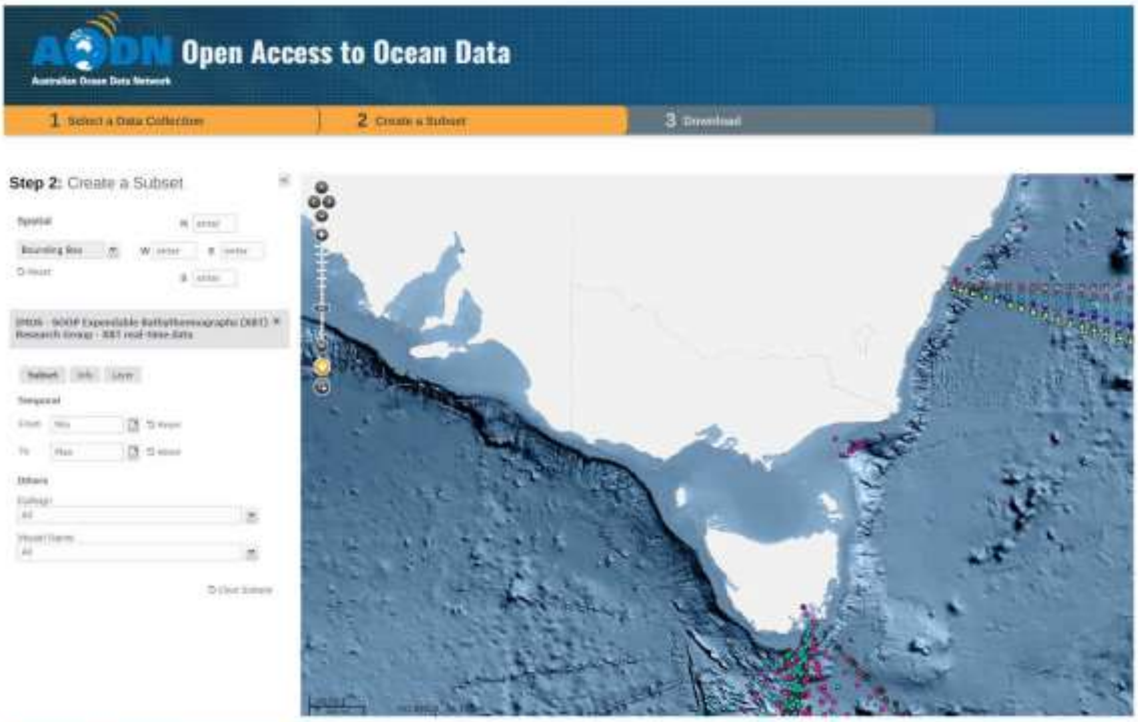
Appendix 4. AODN Portal Images

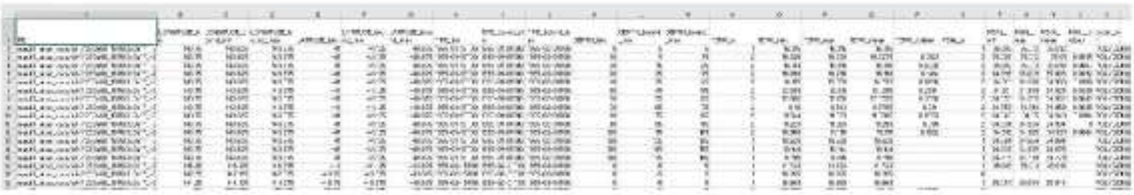
Modelling data



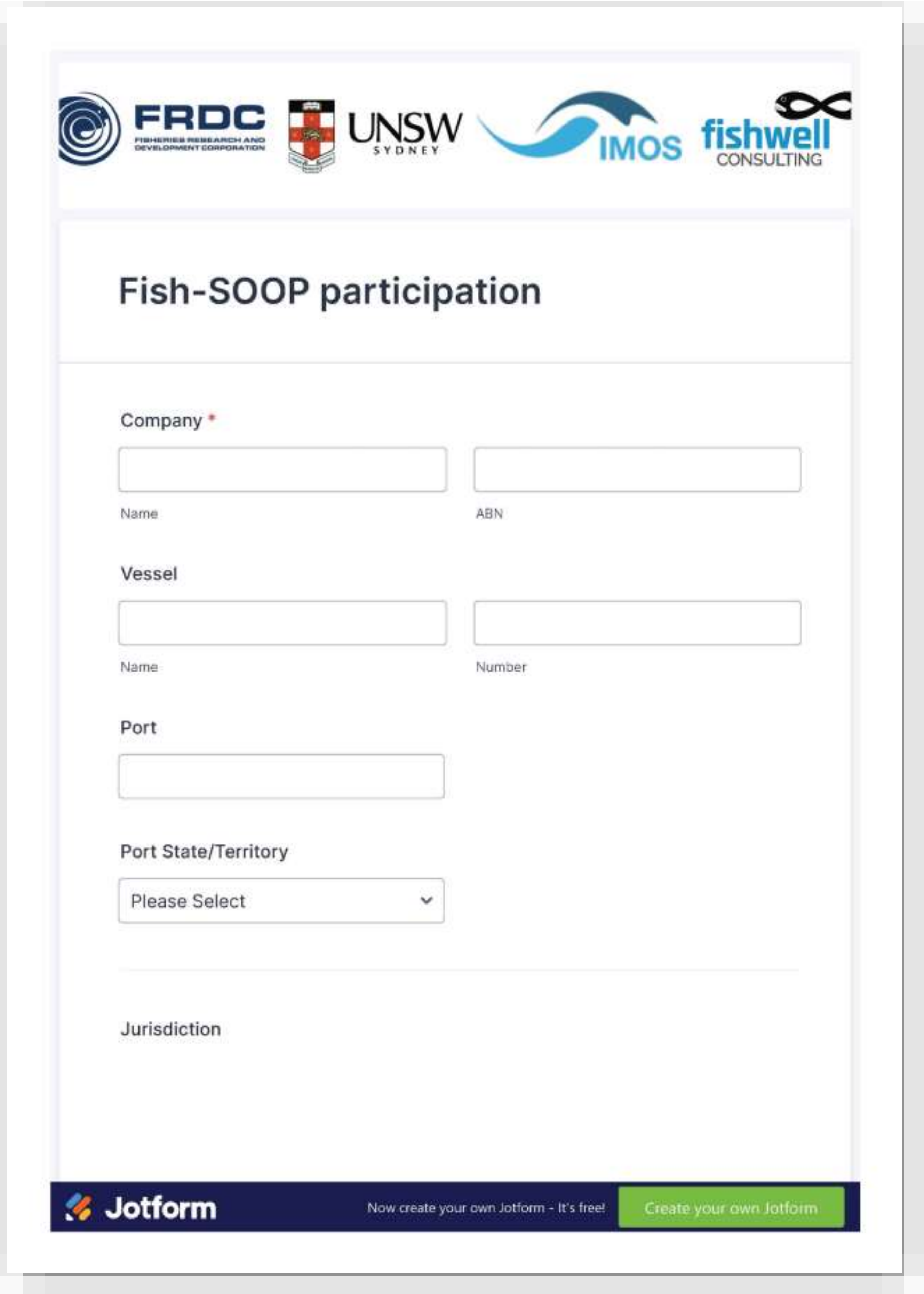


Individual vessel data





Appendix 5. Online participant registration form.



FRDC FISHERIES RESEARCH AND DEVELOPMENT CORPORATION
UNSW SYDNEY
IMOS
fishwell CONSULTING

Fish-SOOP participation

Company *

Name

ABN

Vessel

Name

Number

Port

Port State/Territory

Please Select

Jurisdiction

Jotform

Now create your own Jotform - It's free!

Create your own Jotform

- [ ] Commonwealth
- [ ] New South Wales
- [ ] Victoria
- [ ] Queensland
- [ ] South Australia
- [ ] Tasmania
- [ ] Western Australia
- [ ] Northern Territory

Where do you fish?

Approximative Latitude Range

Minimum

Maximum

Approximative Longitude Range

Minimum

Maximum

Trip types (select the closest to the average trip type)

- ◯ 1-day
- ◯ Multi-day
- ◯ Weeklong
- ◯ Longer than a week

Fishing methods (select all that applies)

- ☐ Nets
- ☐ Hook and lines
- ☐ Trap and pots (including dillies, lift nets, witches hat nets and spanner crab nets, and fish nets used as traps)
- ☐ Dredges
- ☐ Diving
- ☐ Hand-held implements

Maximum fishing depth

- ◯ 200 meters
- ◯ 1000 meters
- ◯ > 1000 meters

Months actively fishing

- ☐ All months
- ☐ Select which months

Deckbox serial number (leave blank if unknown)

e.g., 23

4 digits number

Moana sensor(s) serial number (leave blank if unknown)

Sensor 1

Email to receive data

email address 1

Do you want to receive a monthly newsletter providing updates?

- Yes
- No

Address

Street address

City

Please Select

State/Territory

Postcode

☐ I agree that the equipment remains the property of UNSW. *

☐ I agree that the data will be made available on the AODN after 7 days. *

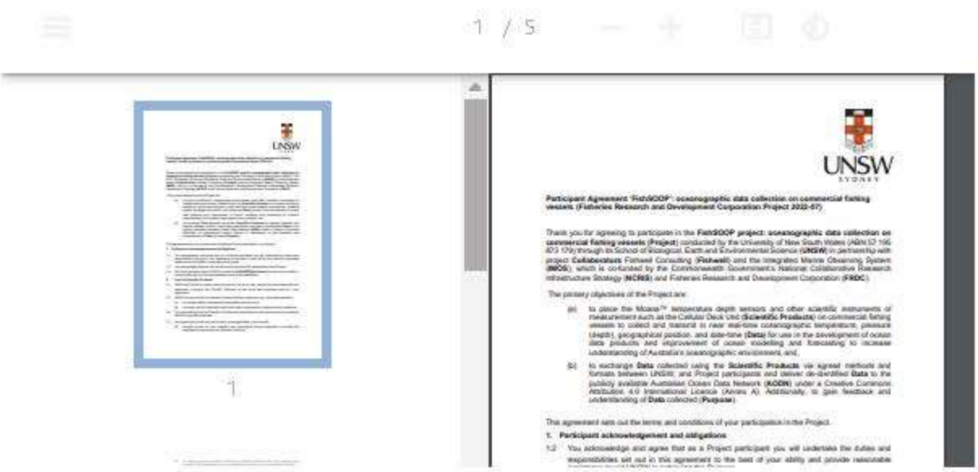
Terms and Conditions

The legal agreement below describes the terms and conditions during your participation in the FishSOOP: oceanographic data collection on commercial fishing vessels (Project) conducted by the University of New South Wales (ABN 57 195 873 179).

☐ I agree to the terms and conditions below. *

Submit

Terms and conditions



Appendix 6. FishSOOP participation contract

UNSW
SYDNEY

Participant Agreement 'FishSOOP': oceanographic data collection on commercial fishing vessels (Fisheries Research and Development Corporation Project 2022-07)

Thank you for agreeing to participate in the **FishSOOP project: oceanographic data collection on commercial fishing vessels** (**Project**) conducted by the University of New South Wales (ABN 57 195 873 179) through its School of Biological, Earth and Environmental Science (**UNSW**) in partnership with project **Collaborators** Fishwell Consulting (**Fishwell**) and the Integrated Marine Observing System (**IMOS**), which is co-funded by the Commonwealth Government's National Collaborative Research Infrastructure Strategy (**NCRIS**) and Fisheries Research and Development Corporation (**FRDC**).

The primary objectives of the Project are:

(a) to place the Moana™ temperature depth sensors and other scientific instruments of measurement such as the Cellular Deck Unit (**Scientific Products**) on commercial fishing vessels to collect and transmit in near real-time oceanographic temperature, pressure (depth), geographical position, and date-time (**Data**) for use in the development of ocean data products and improvement of ocean modelling and forecasting to increase understanding of Australia's oceanographic environment, and,

(b) to exchange **Data** collected using the **Scientific Products** via agreed methods and formats between UNSW, and Project participants and deliver de-identified **Data** to the publicly available Australian Ocean Data Network (**AODN**) under a Creative Commons Attribution 4.0 International Licence (Annex A). Additionally, to gain feedback and understanding of **Data** collected (**Purpose**).

This agreement sets out the terms and conditions of your participation in the Project.

1. Participant acknowledgement and obligations

1.2 You acknowledge and agree that as a Project participant you will undertake the duties and responsibilities set out in this agreement to the best of your ability and provide reasonable assistance to aid UNSW in achieving the Purpose.

1.3 You acknowledge that you will not receive any payment for participation in the Project.

1.4 You must promptly inform UNSW by email to **FishSOOP@unsw.edu.au** if you are not able to continue with any of your responsibilities as a Project participant.

2. Loan of Scientific Products

2.1 UNSW will provide or procure the provision to you, at its cost, as soon as practicable after this agreement is signed, the Scientific Products on the terms and conditions set out in this Agreement.

2.2 UNSW will ensure that the Scientific Products will be installed on your nominated vessel(s):

(a) by suitably skilled, experienced and qualified persons; and

(b) to comply with all applicable health and safety requirements, processes and procedures.

2.3 You acknowledge that the Scientific Products are provided as a loan and remain the property of UNSW or our subcontractors.

2.4 You agree that you will and ensure that, where applicable, your crew will:

(a) provide access to your vessel(s) and associated fishing equipment to enable the installation or removal of the Scientific Products;

(b) on request, promptly install or remove the Scientific Products from your vessel(s) and provide UNSW photographs of such installation and removal of the Scientific Products;

(c) follow the reasonable directions of UNSW and/or Fishwell subcontractors regarding the storage, installation and use of the Scientific Products, including, on request, returning the Scientific Products for calibration;

(d) ensure the Scientific Products are always protected from misuse, damage and destruction (with the exception of usual wear and tear or damage caused by fishing and/or vessel operations) or any form of unauthorised use;

(e) notify UNSW promptly if any Scientific Products are damaged or not functioning; and

(f) return the Scientific Products within 21 days of expiry or termination of this agreement.

2.5 You must ensure that you and any person who gains access to the Scientific Products while they are in your custody and control must not except as expressly provided for in this agreement:

(a) rent, sell, lease, sublicense, or otherwise transfer the Scientific Products to any third party;

(b) disassemble or reverse engineer the Scientific Products (or any part of them); or

(c) modify or service the Scientific Products (except at UNSW's express direction).

3. Data Transfer

3.1 You must use reasonable efforts to ensure the Data is available to UNSW in accordance with this agreement.

3.2 UNSW will use best endeavours to promptly provide Data collected from your vessel to you.

3.3 You acknowledge that it is possible that on occasion Data may be unavailable due to maintenance or other reasons beyond UNSW's reasonable control.

3.4 The parties acknowledge and agree that it is intended that all Data and data products based on the Data (**Data Products**) will be openly available as set out in clause 4 below.

4. Intellectual Property

4.1 Nothing in this agreement transfers any Intellectual Property Rights except as set out in this agreement. "**Intellectual Property Rights**" means all rights resulting from intellectual activity whether capable of protection by statute, common law or in equity and including copyright, discoveries, inventions, patent rights, registered and unregistered trademarks, design rights, circuit layouts, plant varieties, trade secrets, know-how and rights in confidential information and all rights and interests of a like nature.

4.2 UNSW remains and is the owner of any new Intellectual Property Rights created or developed in the Project relating to installation of Scientific Products and exchange of Data.

4.3 The Data (in anonymised form) and Data Products will be made available under the auspices of IMOS on an unencumbered, free, timely and open access basis via the AODN Portal. All such Data will be licensed under a Creative Commons By Attribution (CC BY) licence (https://creativecommons.org/licenses/by/4.0/).

5. Confidentiality and Personal Information.

5.1 Each party may use Confidential Information of the other party for the purposes of this agreement.

5.2 Each party will keep secure and maintain the confidentiality of all Confidential Information (in any format) disclosed under this agreement and not directly or indirectly disclose, copy, release, sell, alter or destroy such confidential information, except as required for the Purpose or the Project and if required by any law or order of any government agency provided that it only discloses what is necessary to comply with the requirements and notifies the disclosing party as soon as practicable after such a disclosure. "**Confidential Information**" includes any personal information disclosed in the course of conducting the Project.

5.3 Where applicable, each party must comply with and must ensure that its personnel comply with:

(a) applicable privacy laws with respect to all personal information that it collects, uses, processes or handles as part of this agreement, irrespective of whether or not it is otherwise bound by the privacy laws, and

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(b) the reasonable directions of each other party in relation to the handling of any personal information that the party holds or has held.

6. Publication and publicity

6.1 You acknowledge and agree that UNSW:

(a) is entitled to publish the Data and the results of the Project,

(b) may deposit a publication that includes the Data and/or results of the Project into an open access institutional repository, and

(c) make the de-identified" (will not have any of your vessel details) Data available on an open access basis on an online platform such as the Integrated Marine Observing System (IMOS) Australian Ocean Data Network (AODN) under a Creative Commons Attribution 4.0 International Licence after a minimum delay of 7 days of collection.

6.2 You must not use UNSW's trade mark, name, trade name, logo or other designation in any way without our prior written consent.

7. Exclusion of liability

7.1 To the maximum extent permitted by law, you acknowledge and agree that access and use of the Scientific Products, is at your own risk; and that UNSW is not liable or responsible to you or any other person for any loss, damage or expense under or in connection with this Agreement, including access to or use of the Data, Scientific Products or any operations platform related to the Project (**Platform**). This exclusion applies regardless of whether UNSW's liability or responsibility arises in contract, tort (including negligence), equity, breach of statutory duty, or otherwise.

7.2 UNSW does not make or give any express or implied representation, undertaking or warranty relating to the Scientific Products, the Data or Platform. Without limiting the foregoing, there are no express or implied warranties:

(a) of merchantability or fitness for a particular purpose;

(b) that the use of the Scientific Products or the Data will not infringe any third party's rights, including Intellectual Property Rights;

(c) that the Scientific Products will not pose a safety or health risk; or

(d) that the Scientific Products or the Data is or will be complete, accurate or up to date.

7.3 To the extent permitted by law, no party is liable to any other party under or in connection with this agreement for any special, indirect or consequential damages, loss of profit (whether direct or indirect) or loss of business opportunity arising out of or in connection with this agreement.

8. Insurance

8.1 Each party must take out at its own cost, maintain and keep current, at its own cost necessary insurance in relation to its activities in connection with this agreement and on request, must provide evidence to the other party of the currency of such insurance policies.

9. Termination

9.1 You acknowledge and agree that failure to comply with this agreement may result in the immediate termination by UNSW of your participation in the Project.

9.2 A party may terminate this Agreement with 10 business days' notice in writing for any reason.

9.3 The parties may also terminate this Agreement by mutual agreement in writing.

10. Dispute resolution

10.1 Each party must use its best endeavours to co-operatively resolve any dispute in connection with this agreement before it commences litigation or takes similar action, except to seek an urgent injunction or declaration.

11. General matters

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11.1 Nothing in this agreement may be construed as creating a relationship of partnership, joint venture, employment, principal and agent or trustee and beneficiary between you and UNSW, or other Project collaborators.

11.2 You must take all steps, execute all documents, and do everything reasonably required by UNSW to give effect to any of the transactions contemplated by this Agreement.

11.3 A notice or other communication connected with this agreement must be in writing.

11.4 This Agreement may be executed in any number of counterparts. All counterparts together constitute one agreement.

11.5 The laws of New South Wales, Australia governs this Agreement.

You warrant that you have the power and authority to enter into this agreement and to perform your obligations under this agreement.

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Appendix 7. Project newsletters

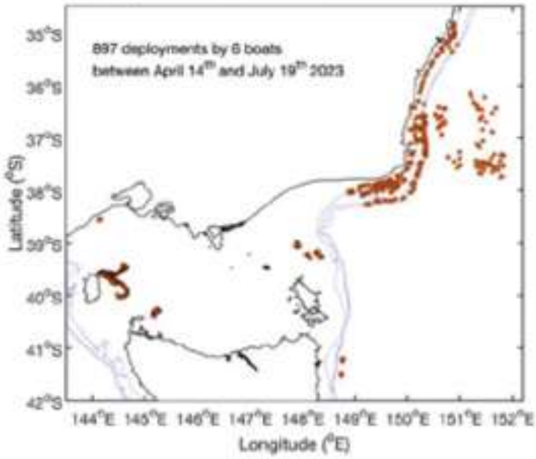
FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels in SE Australia

FishSOOP (Fisheries Ships of Opportunity Observing Program)
Newsletter # 1, July 2023

In the first 3 months of the program, we have equipped 8 commercial fishing boats with the Moana sensors and deck units. We want to take the time to thank each of you for your valuable contribution and highlight how valuable the data you collect is for improving our environmental understanding.

We have instrumented 4 types of fishing gears: scallop dredges, tuna longline, shark gillnet and otter board trawlers. With imminent plans to deploy on lobster pots and prawn trawlers. We have had additional interest from the Northern Territory Prawn Trawl and Tuna Australia resulting in further co-investment, also from AFMA.



We already have a total of 897 sensor deployments from 6 fishing boats, including an astonishing 396 deployments from a single boat alone. The deepest cast is to 750m, with 758 casts in waters shallower than 200m.

Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types. Please get in touch with us at FishSOOP@unsw.edu.au or ianknuckey@fishwell.com.au.

Moanas around the world

Similar programs around the world use the same Moana sensors for similar purposes, and we highlight a case in the USA.

On the East Coast of the USA, FV Hannah Boden, hosts a Zebratech Moana temperature sensor. The Hannah Boden is a very famous boat in the area, as it was the sister boat that survived a severe weather event that the film 'A Perfect Storm' was based on.

The Hannah Boden and some of her crew featured in this short clip about the fishing industry in the area; be sure to check it out! Watch here.

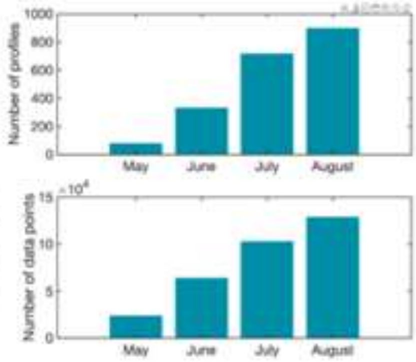
FRDC Fisheries Research and Development Corporation · UNSW Sydney · IMOS · fishwell consulting

FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels in SE Australia

FishSOOP (Fisheries Ships of Opportunity Observing Program) Newsletter # 2, September 2023

The number of temperature profile and datapoints collected has been increasing every month since the start of the project, four months ago. In August alone, we have nearly doubled the total number of sensor deployments we have received.



This month, we have expanded the geographical range of the project to include the very under-sampled Gulf of Carpentaria and Joseph Bonaparte Gulf. These regions have been historically under-sampled and we have already received temperature from 355 shots within them.

The photo on the left shows an example of the installation of a deck unit in full sunlight and sky view on The Rachel Maree, which is part of this project. The deck unit sends us the data through the cellular network.

Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

Part of a global program

In New Zealand, a similar program with the MetService was launched a few years ago and has now reached over 50,000 total deployments. That is over 18 million temperature measurements, the deepest of which was 1,795m. Through the integration of these measurement in their forecasting models, they recently added a publicly available coastal marine heatwaves forecasting map which includes marine heatwave intensity. Marine heatwaves are having disastrous consequences on marine life hence are impacting fish catches. Therefore being able to contribute temperature data to these products is of great value.

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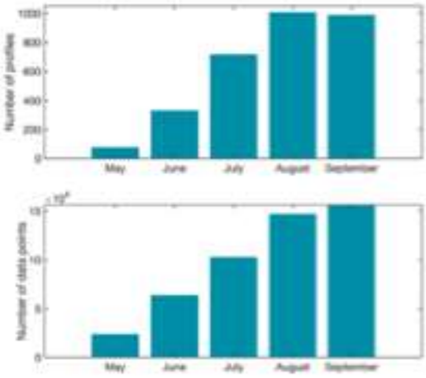
FRDC Project 2022-007

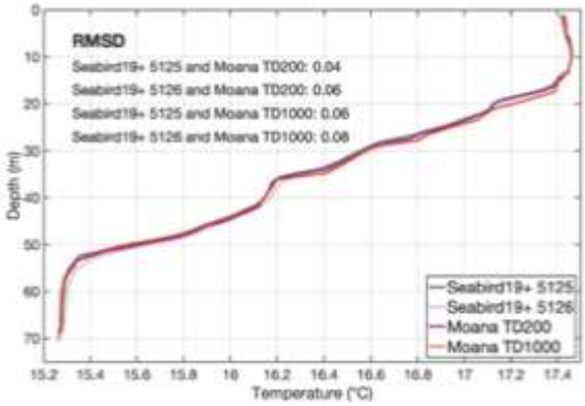
Trials of oceanographic data collection on commercial fishing vessels in SE Australia

FishSOOP (Fisheries Ships of Opportunity Observing Program) Newsletter # 3, October 2023

We again had a successful month, with just under 1000 profiles by 12 vessels in September. This amounts to 148,961 datapoints. The deepest cast in September was 1127m. You can see from the graph that the number of profiles decreased in September, this was when just one boat stopped collecting data, so you can see how valuable every single boat is. But the number of data points continued to increase. Thanks for your efforts. We are awaiting for some fishing seasons to start shortly and we'll welcome a number of new boats in the program then.



This month the UNSW oceanography team will be aboard Australia's Marine National Facility the Research Vessel, 'Investigator' owned and operated by CSIRO on behalf of the nation. Keep an eye out for them chasing eddies as part of an international effort off the southeast coast. They will be taking some Moana sensors out with them and doing some sensor comparisons with a Moana sensor attached to a towed undulating body to show how the sensor performs when profiling from the surface to 300m. In the meanwhile, we did a comparison of the Moana sensor in a classic up and down profile with a SeaBird CTD, the results show that the Moana sensors compare very well with other temperature sensors. We are looking forward to seeing the comparison in a towed format as that is a more realistic representation of how the Moana sensors are used on fishing vessels



Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

Part of a global program

In Alaska, a Moana sensor is mounted on a king crab pot in the Bering Sea. These were deployed as part of an industry funded survey to understand the collapse of this iconic fishery, one that you might recognise from the show The Deadliest Catch.

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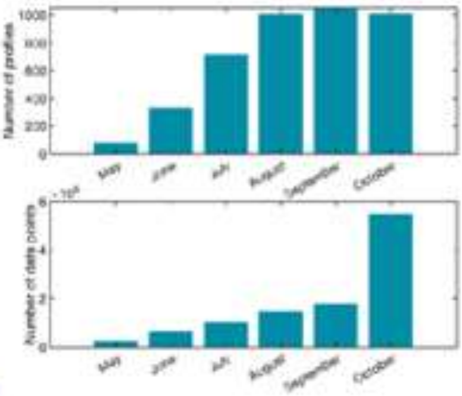
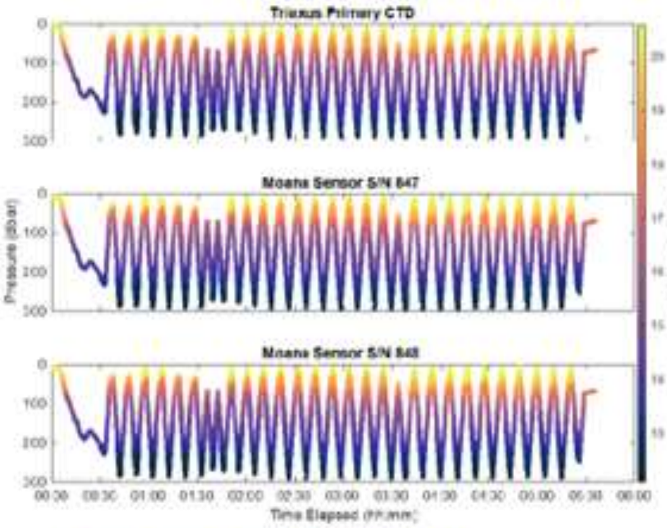
FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels

FishSOOP (Fisheries Ships of Opportunity Observing Program)
Newsletter # 4, November 2023

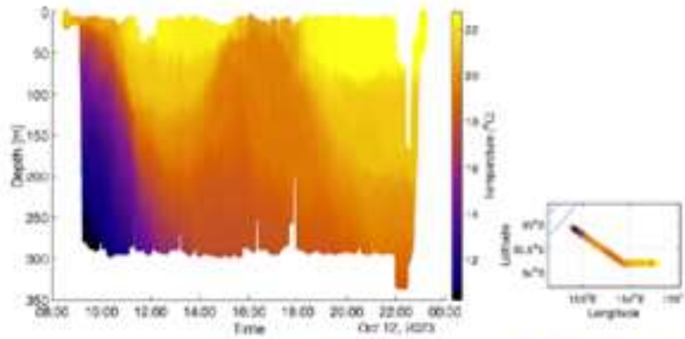
We again had a successful month, with more than 1000 profiles by 14 vessels in October, including the CSIRO research vessel 'Investigator'. This amounts to over 500,000 datapoints. The deepest cast in October was 1016m. The number of data points more than tripled this month thanks to the Moana sensor attached to the towed undulating triaxus on Australia's Marine National Facility the Research Vessel, the Investigator, owned and operated by CSIRO. The Moana sensors took continuous profiles when the vessel was in transit to compare with the triaxus Seabird CTD.





The comparison shows that the Moana temperature sensors are providing reliable temperature data on both the downcast and upcast when towed. This helps build confidence in the sensors capabilities, beyond lab testing, when attached to fishing gears and used in similar fashion.

An example of a transect done with the triaxus shows how a detailed, high resolution, view of the temperature structure can be seen in near real-time. The data can be sent to forecast models in real-time to improve the forecast in regions of high sensibility and variability, and where it matters most for fishers, the coastal shelf.



Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

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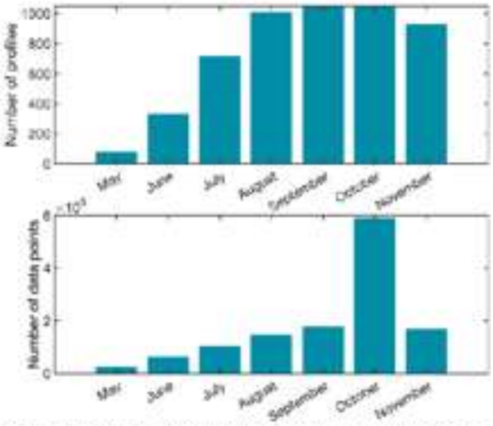
FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels in SE Australia

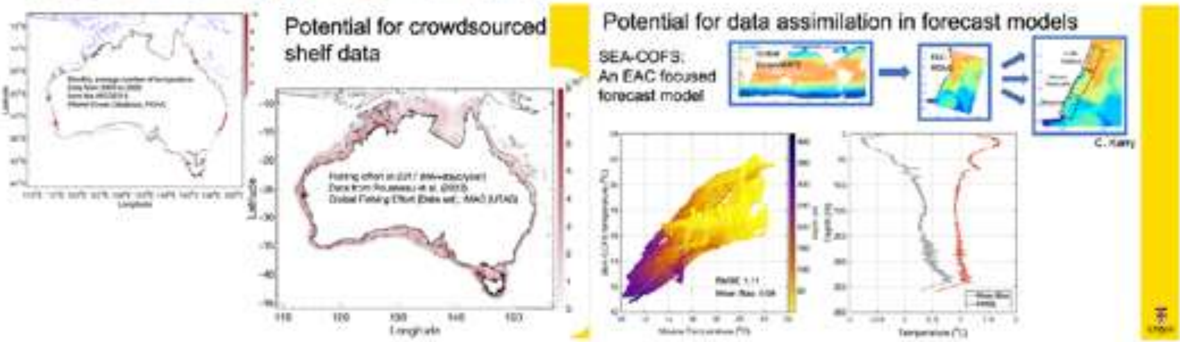
FishSOOP (Fisheries Ships of Opportunity Observing Program) Newsletter # 5, December 2023

This month we received about 1000 profiles by 14 vessels in November. This amounts to over 160,000 datapoints. The deepest cast in November was 1214m. A few more boats have joined our fleet and we are looking forward to receive some valuable data from them.



The FishSOOP project was featured this month at the Forum for Operational Oceanography (FOO) in Fremantle and at an Ocean Research Showcase in Sydney on the use of technology in research-industry partnerships for ocean science. The FOO conference had attendees from research institutes, universities, government departments, and industries around Australia. There was some real interest to expand the project in remote regions, and to assimilate the data in ocean forecast models, such as OceanMaps.

We have just received more sensors, bought through collaborations with the Sunshine Coast University and Tuna Australia for more data density in the South-East of Australia, and through the Northern Territory, the Fisheries Research and Development Corporation (FRDC) and the Australian Fisheries Management Authority (AFMA). With the addition these sensors, our fleet can expand to more than double its current size.



Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

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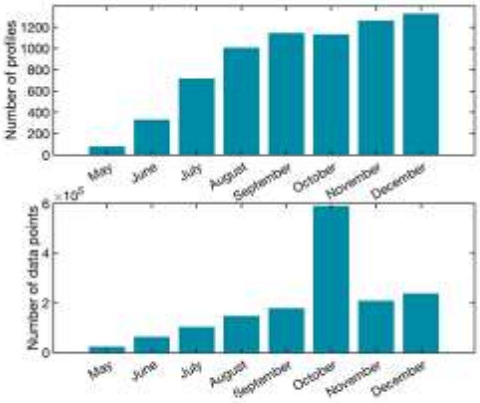
FRDC Project 2022-007

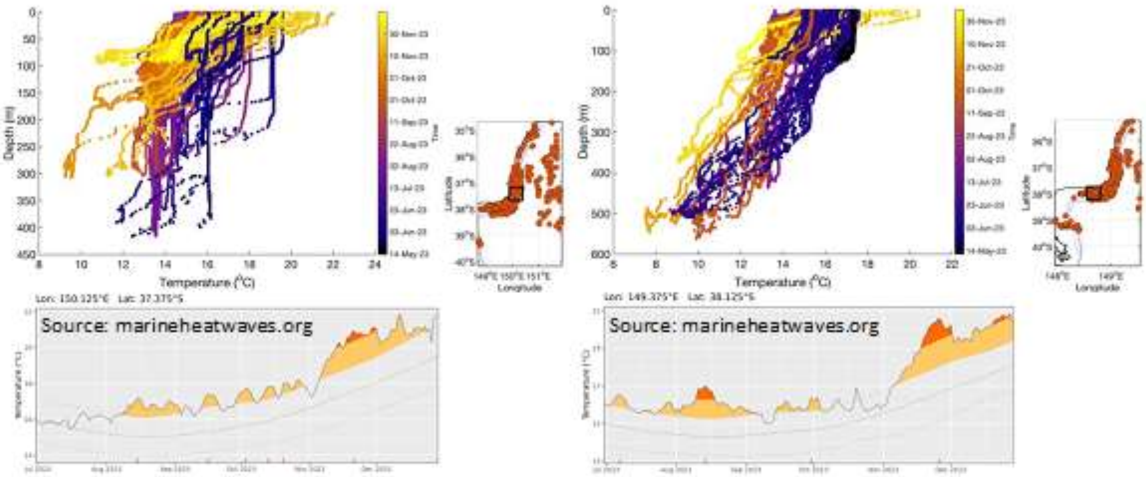
Trials of oceanographic data collection on commercial fishing vessels in SE Australia

FishSOOP (Fisheries Ships of Opportunity Observing Program)
Newsletter # 6, January 2024

First of all, we want to thank everyone involved in the FishSOOP project in 2023, we had a very successful first year. We wish you all a very happy new year 2024 and are looking forward to continuing growing the project together in this new year.

This month we received the most amount of monthly profiles so far, finishing well the year with about 1300 profiles by 19 vessels in December. This amounts to over 230,000 datapoints. The deepest cast in December was 941m. A few more boats have joined our fleet this month and we are hoping to continue growing our fleet in this new year.





Using the high temporal and spatial density of data in the South-East of Australia that was collected in the FishSOOP project, we can see the time evolution and formation of a marine heatwave on the continental shelf in near real-time. The waters off southern NSW reached about 3°C above normal in December and about 4°C above normal off eastern Victoria at the end of November. We received enough subsurface data in this region to see the formation, evolution, and subsurface pattern of this marine heatwave through November and December.

Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

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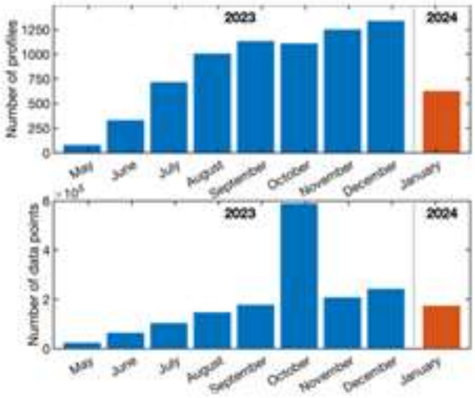
FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels in Australia

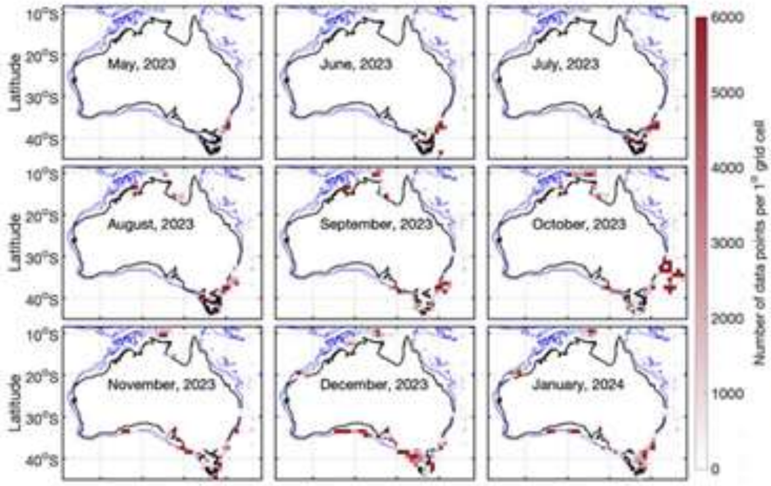
FishSOOP (Fisheries Ships of Opportunity Observing Program) Newsletter # 7, February 2024

We hope you had a good holiday and a rest over January. This month we received less data than the previous few months because many fisheries are off-season for a well-deserved break after the holidays. Nonetheless, we continued to grow the ocean temperature database with about 627 profiles by 9 vessels active in January. This amounts to ~174,000 datapoints, which is a lot from 9 vessels. The deepest cast in January was 873 m.



Since the beginning of the project, we have continued to grow the quantity of data collected by our growing fleet, and also the spatial coverage. We have now vessels signed in from every state and territory, except for the ACT! The data are starting to fill in the gaps of historically very low or no data coverage, such as off the Northern Territory and the Great Australian Bight. We have already gathered unprecedented amount of data for these regions and looking forward to get more insight into the ocean physics and fisheries impact in these coastal shelf regions and around Australia.

This upcoming month, the FishSOOP project will be highlighted at the IMOS NSW annual meeting, the Ocean Science international conference in New Orleans and in a Fishing Vessel Ocean Observing Network workshop with international collaborators who have similar programs in New Zealand, United States, Portugal, Italy, and more. Stay tuned for outcomes of these upcoming international events.



Number of data points gridded in 1° resolution boxes for each month from March 2023 to January 2024.

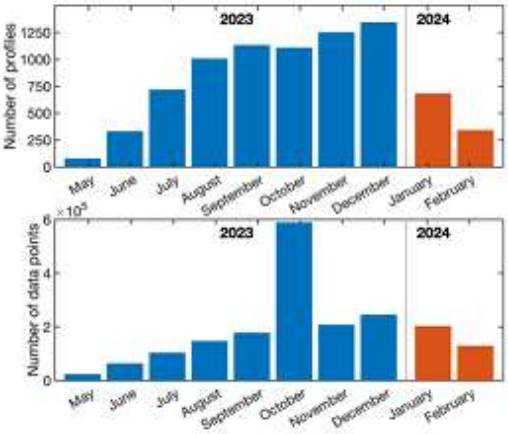
Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

FRDC Project 2022-007

Trials of oceanographic data collection on commercial fishing vessels in SE Australia

FishSOOP (Fisheries Ships of Opportunity Observing Program)
Newsletter # 8, March 2024

We had 9 vessels active during February, amounting to ~130,000 datapoints and 342 profiles. We received less data than the previous months because many fisheries are off-season for a well-deserved break, and we had a few sensors batteries needing replacing. The deepest cast in February was 888 m. We are looking forward to having several fishing seasons kicking off again this month and having those vessels joining in the program again for another successful season.



This month the FishSOOP project has been highlighted at the AGU Ocean Science Meeting in New Orleans, which brought together nearly 6000 attendees from around the world. Dr Véronique Lago presented the inner workings and successes of our Australian project to this international audience. Following the Ocean Science meeting, Prof. Moninya Roughan (UNSW) and Veronique met with our international collaborators for a Fishing Vessel Observation Network (FVON) workshop. FVON has been officially endorsed by the UNESCO Ocean Decade as an action part of a global effort towards better knowledge of our oceans. Through FVON, we are working collaboratively towards best practices in data collection from fishing vessels, including data and instrument standards.

Photo credit: Dr. Julie Jakoboski

Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.

Part of a global program

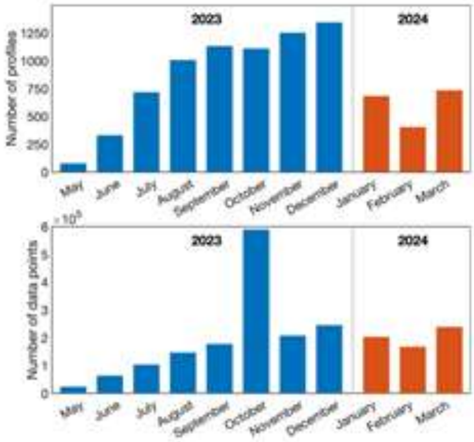
In Ghana, fishers are using our Moana sensors to guide them towards better fishing strategies in a changing world. This is part of a project by the Ocean Data Network, based in the United States, through the Environmental Defense Fund; be sure to check it out! Watch here This project clearly highlights the potential of these fully hands-free sensors with solar-powered deckboxes to provide useful insights in remote areas.

FRDC Project 2022-007

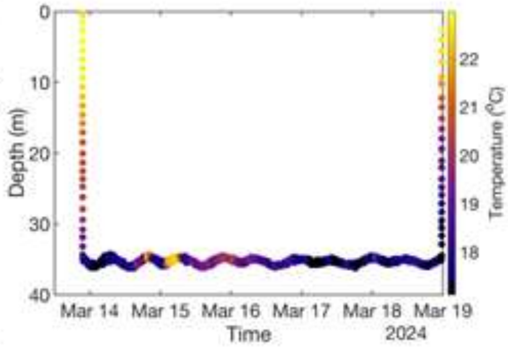
Trials of oceanographic data collection on commercial fishing vessels

FishSOOP (Fisheries Ships of Opportunity Observing Program) Newsletter # 9, April 2024

We hope you had a nice break over Easter. We had 15 vessels active during March, amounting to 735 profiles. We have now collected over 2 million data points since the inception of the project. The deepest cast in March was 948 m. We now have 24 vessels in the program We would like to welcome back the crews that are kicking off their season again this month and wishing them another successful season.



We recently had a few sensors installed on some lobster pots and fish traps, which record bottom temperature on the shelf over a longer period from hours to days. This stationary monitoring allows us to see the changes in bottom temperature associated with the tidal currents and possibly river discharge. Here the bottom temperature varied from ~17.1°C to 22.6°C over just a few days! Bottom temperature is very much needed to include in ocean forecast models to better predict these types of short-term variations in subsurface temperature.



Bottom temperature recorded from a trap on the coastal shelf.

Get to know us

We would like to introduce ourselves to you. This month, let us introduce you to Dr. Véronique Lago, our Ocean Data Scientist. She is the one behind the FishSOOP data pathway for you to receive the Quality Controlled data you collect in near real-time. Véronique is originally from Québec, in Canada, but has been with us, in Australia, for the past 13 years. With a true passion for nature and the ocean, and a background in Physics, she decided to become an oceanographer in 2005 after joining a research voyage to the Canadian Arctic aboard a Canadian icebreaker.

Thanks for your efforts in the important pilot phase of the project. We appreciate the feedback and the interest. We are actively looking for new recruits to the program as we are wanting to trial a range of gear types on vessels around Australia. Please get in touch with us at FishSOOP@unsw.edu.au or ian@fishwell.com.au if you know of anyone that may be interested.