Fishing Vessel Ocean Observing Network: An Emerging Collaborative Global Network

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Abstract

There is a growing need for enhanced surface and subsurface coastal observations to enable integrated modelling and decision-support tools. Fishing vessels can serve as platforms for hosting and deploying an assortment of oceanographic instrumentation. Furthermore, many types of fishing gear already profile through the water column, presenting a unique subsurface data collection opportunity. Integrating ocean data collection with fishing vessel operations complements existing ocean observing networks by enabling the cost-effective acquisition of surface and subsurface ocean data, significantly expanding coverage in data-sparse regions. Counterintuitively, the shelf and coastal regions, where most fisheries operate, are among the most data scarce areas, especially for subsurface physical oceanographic data, which fishing vessels are so well suited to collect. These data can benefit fisheries science by coupling environmental information with catches, improving physical coastal and ocean models, and encouraging greater involvement of fishery stakeholders in the scientific process. This approach creates a win–win because the fishing industry can leverage the data to adopt innovative solutions to improve fisheries sustainability, profitability, and community resilience. To maximize these benefits and complement existing ocean observing networks, an emerging global network: the Fishing Vessel Ocean Observing Network (FVON), has been formed. FVON aims to foster the proliferation of collaborative cost-effective ocean data collection, democratize ocean observations, establish community standards and best practices, and facilitate observation uptake to improve ocean predictions while promoting sustainable fishing practices.

Keywords

Ocean observation · Fishing vessels · Science-industry collaboration · Citizen science · FVON

This is a contribution to projects UIDB/04326/2020, UIDP/04326/2020 and LA/P/0101/2020 funded by FCT

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Z. Zhang et al. (eds.), *Dynamic Evolution of Atmospheric, Ecological, and Hydrological Systems in Circum-Mediterranean Regions*, Advances in Science, Technology & Innovation, https://doi.org/10.1007/978-3-031-86777-4_18

1 Introduction

Integrated, multidisciplinary ocean observations are essential for understanding ocean processes, variability and changes, factors that have profound implications for robust climate and ocean forecasting, prediction, and projection. These insights are critical to guiding sustainable fisheries management, developing adaptation strategies to reduce risk, and enhancing coastal resilience. However, the observational tools currently in use are limited and cost-inefficient for scalable deployment. Fishing vessels offer a valuable solution, serving as platforms to host and deploy an assortment of oceanographic instrumentation. Moreover, the fact that many fishing gear types inherently profile through the water column presents a unique subsurface data collection opportunity. Fishing vessel ocean data collection integration complements existing ocean observing networks by enabling the cost-effective collection of subsurface ocean data to dramatically increase coverage in data-sparse regions. Paradoxically, shelf and coastal regions, where most fishing occurs, are among the most under-sampled areas, particularly in terms of subsurface physical oceanographic and biogeochemical data, which fishing vessels are especially well suited to collect (Patti et al. 2016; Vranken et al. 2020; Piecho-Santos et al. 2021; Rosa et al. 2021; Penna et al. 2023). This approach benefits all stakeholders: it supports the fishing industry, informs fisheries scientists and managers, and contributes to more sustainable, profitable, and resilient coastal communities. To maximize these benefits and complement existing ocean observing networks, a new global initiative, the Fishing Vessel Ocean Observing Network (FVON), was formed to foster the proliferation of ocean data collection integrated with fishing, by learning from local programs, maximizing data value and impact, establishing best practices and common standards, as well as facilitating observation uptake (Vranken et al. 2023). The aim of this paper is to briefly summarize FVON and highlight selected activities currently underway.

2 Two Examples of Recent Technological Developments for Collecting Subsurface and Surface Data

The Moana project (https://www.moanaproject.org/), in collaboration with ZebraTech Ltd. and the commercial fishing industry, developed the cost-effective Moana Temperature and Depth (TD) smart sensor (Fig. 1a) that can be deployed on fishing gear to record thermal profiles. This sensor is paired with a solar-powered deck unit (Fig. 1b) that automatically downloads measurements via Bluetooth when the sensor resurfaces with the fishing gear. Data transmission from the deck unit to the cloud is in near real-time via vessel Wi-Fi or a cellular connection. The system is fully automated and has been successfully used even on fishing vessels with limited power and electronics infrastructure.

A compact ferrybox-type style flow-through system (Fig. 2a) developed by Undersee, a Portuguese SME, was installed on the cod trawler "Coimbra" (Fig. 2b). This system has been collecting physical and biogeochemical parameters along routes from Portugal to the Grand Banks of Newfoundland and the Barents Sea (Fig. 2c). The "ferrybox" continuously measured temperature, salinity, chlorophyll, Dissolved Oxygen (DO), pH, Oxidation–Reduction Potential (ORP) and turbidity from surface water pumped through the system (UNDERSEE 2023).

3 Examples of the Ongoing Activities Under FVON and Related Projects

3.1 Crab Fisheries off New England

ZebraTech Moana TD (Mangōpare) sensors were installed in rab traps used by the fishery operating off New England, USA (Fig. 3a). The fishing vessels provide data coverage along the shelf break and improved the resolution of water column temperature measurements. A comparison between a crab trap deployed Moana TD1000 sensor and a wire crawling CTD moored in the Pioneer Array revealed good agreement between both systems (Fig. 3b).

3.2 The Ferrybox-Like Flow-Through System

The first experiments using the Undersee ferrybox system installed on the cod trawler MV "Coimbra" were conducted in 2022. On May 6th, 2022, she set sail from the harbour of Aveiro (Portugal) to the Grand Banks of Newfoundland, and on September 1st to the Barents Sea (Fig. 2c) for about 20 days. Figure 4 presents data from these two experiments. Table 1 summarizes the measurement statistics. It seems that pH values are slightly higher (~0.2) than it is expected for the Atlantic Ocean (Chierici et al. 1999). However, the pattern of spatial variability is in accordance with previously observed trends (Applications 2023).

4 Discussion

The results demonstrated that fishing vessels can provide data coverage up and down the shelf break and accurately resolve water column temperatures. Further, they an serve as

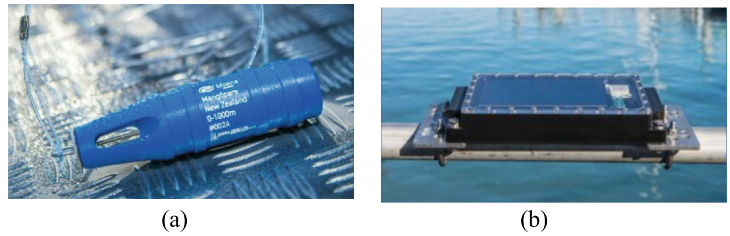


Fig. 1 The ZebraTech temperature-depth (TD) system: **a** Moana TD1000 sensor; and **b** solar power deck unit

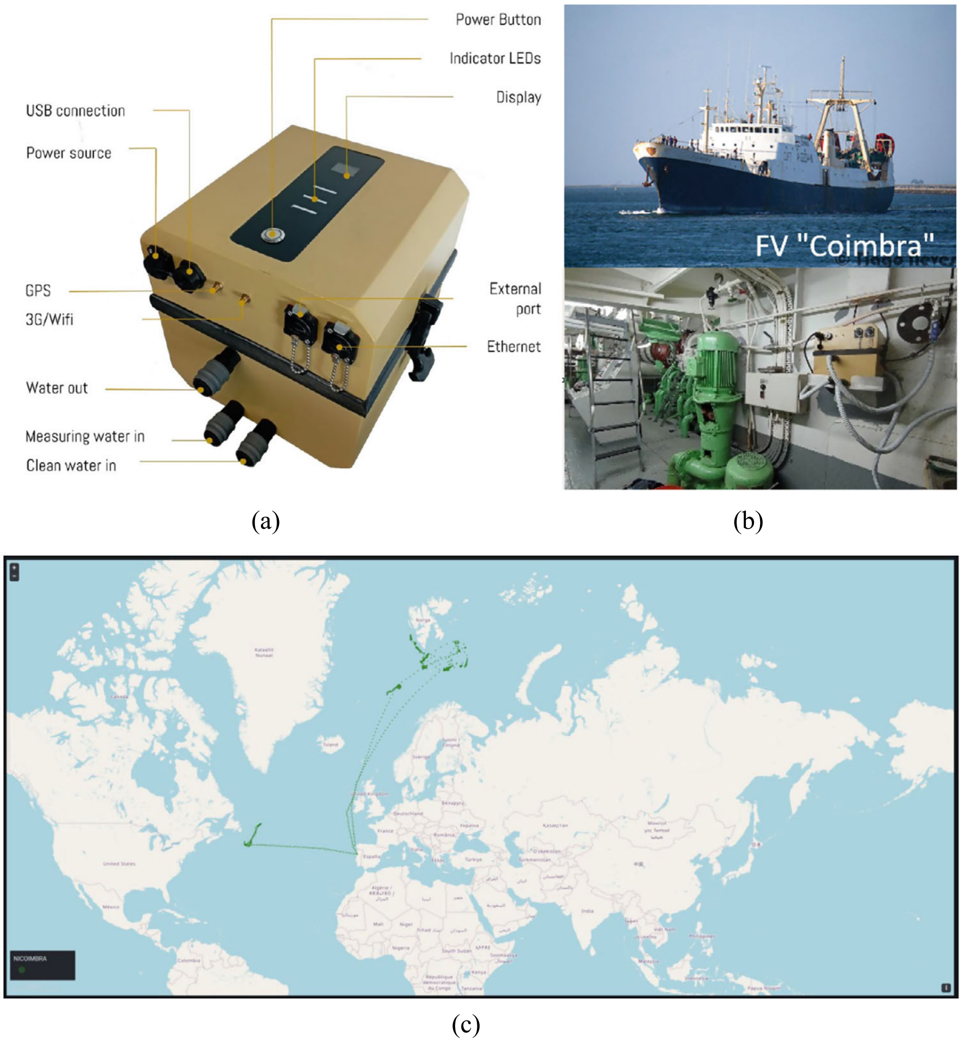
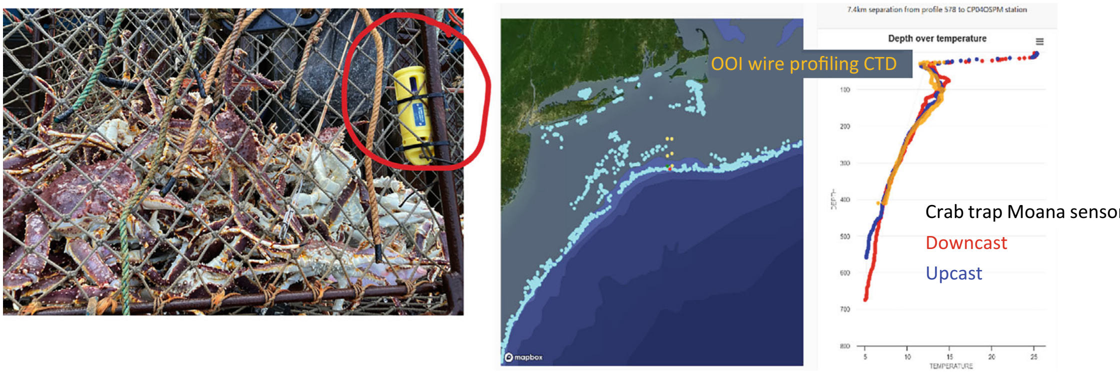


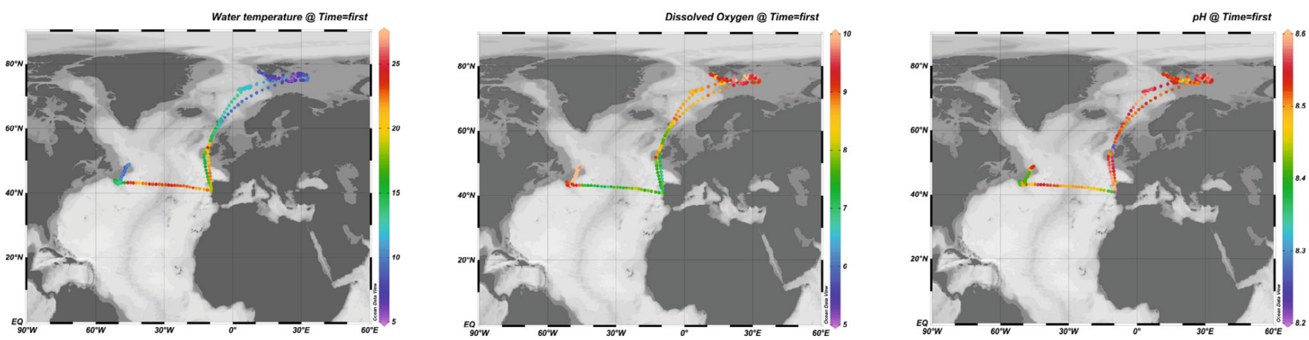
Fig. 2 The ferrybox program: **a** the Undersee system; **b** the system installed in the MV "Coimbra"; and **c** routes where the ferrybox was measuring every 6 h

Vessels Of Opportunity (VOOs) for collecting long-duration measurements while underway to the fishing grounds, such as during a transatlantic crossing. While the quality of the data was found to be good, as with any observing system, the development of rigorous quality control procedures is essential. Several past examples highlight successful collaborations between scientists and the fishing industry (Vranken et al. 2023). For instance, data off the U.S. East Coast from the Environmental Monitors on Lobster Traps and Large Trawlers (eMOLT) Program (http://www.emolt.org/) (Manning and Pelletier 2009) are used to improve forecasts for the US Coast Guard search and rescue operations, and to support the American lobster (*Homarus americanus*) stock assessment. The Moana Project (https://www.moanaproject.org/) was a 5-years research initiative aimed at improving the understanding of coastal circulation, marine heatwaves, and connectivity, providing related analyses and ocean forecasts to New Zealand's seafood industry and other stakeholders. Here, hydrodynamic models assimilated TD data collected by fishing vessels and citizen scientists in coastal areas (Fig. 5a), as well as Argo float data in the open ocean (Fig. 5b). The Italian CNR AdriFOOS (Adriatic Fishery and Oceanography Observing System) Programme is one of the longest-standing efforts to use fishing boats as VOOs for



(a) (b)

Fig. 3 ZebraTech Moana TD1000 sensor operating off New England, USA: **a** Moana TD1000 sensor (red circle; the yellow cage protects the sensor for mechanical impacts) installed in a crab trap; **b** temperature profiles measured by the Moana TD1000 sensor (red and blue lines) and by the wire-following CTD profiling of the U.S. Ocean Observatory Initiative (orange). In the map the blue dots are the location of instrumented traps deployed by the crab fishery off New England and the yellow and green dots are the Pioneer Array. The comparisons are made with the green dot as the profiling mooring, and the red dot as the selected fishing profile



(a) (b) (c)

Fig. 4 A map of the North Atlantic and the Arctic Oceans automatically generated using Ocean Data View (ODV) software, showing surface measurements (every 6 h) using a ferrybox-like flow-through system installed on a cod trawler: **a** temperature (ºC); **b** dissolved oxygen (mg/l); and **c** pH. Time = first means the time series is represented from the beginning

Table 1 Statistics of the measurements using a ferrybox-like flow-through system in a cod trawler

Parameter		Newfoundland	Barents Sea
Surface temperature (ºC)	Minimum	6.0	5.1
	Average	14.0	9.7
	Maximum	25.4	23.9
Surface DO (mg/L)	Minimum	6.6	6.9
	Average	9.5	9.0
	Maximum	11.4	11.0
Surface pH	Minimum	8.3	8.3
	Average	8.5	8.5
	Maximum	8.6	8.6

collecting scientifically valuable datasets (Patti et al. 2016; Penna et al. 2023), which proved to be useful across a range of applications (e.g., (Aydoğdu et al. 2016)). Fishers may also benefit directly from these data streams. For example, Japan's Kyushu University leads the Smart Fisheries Network (SFiN), which collects CTD and ADCP data from over 200 small-scale vessels that are assimilated into coastal ocean models (Research structure 2023). The resulting improved ocean prediction and accompanying visualizations are designed for fishers and delivered via mobile application. This programme is popular with participating fishers, enabling some of them to operate both more safely and efficiently (Research structure 2023).

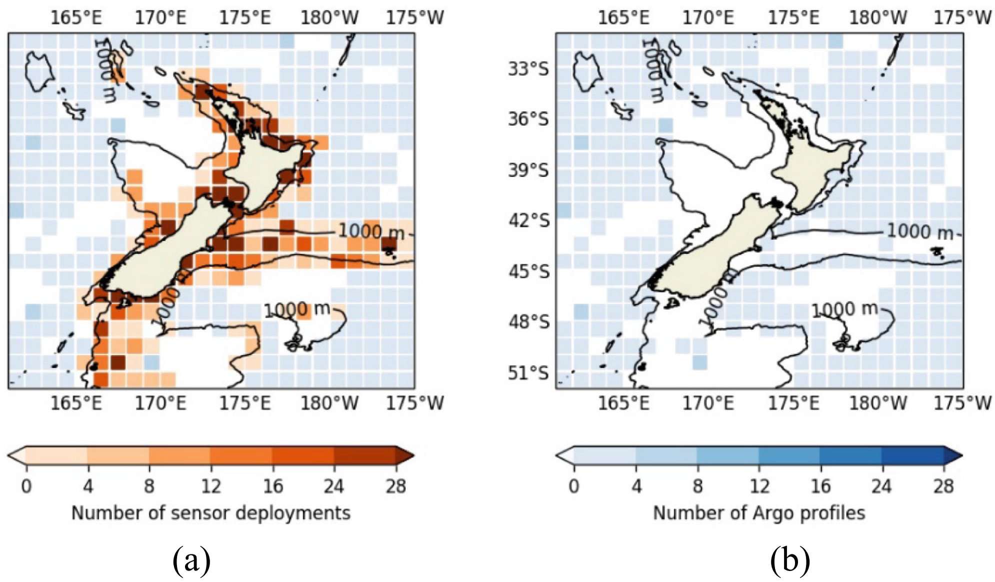


Fig. 5 Ocean subsurface observations in the New Zealand region within the Moana Project's hydrodynamic ocean model domain for the one-year period from 1 January 2022 through 31 December 2022: **a** monthly average number of fishing vessel and citizen science TD sensor deployments (orange); and **b** monthly average number of Argo temperature and salinity profiles (blue) (adapted from Vranken et al. (2023)). This pattern is repeated, with few exceptions, around the world

5 Conclusions

Fishing vessels and fishing gear offer a wide array of data collection opportunities, including surface meteorological and oceanographic observations, as well as subsurface measurements. Sensors going along for the ride on nets and traps to gather subsurface data presents a unique opportunity compared to other oceanographic platforms.

Fishing vessels collecting ocean data is an inclusive way to complement existing observing networks by enabling the cost-effective collection of vast amounts of ocean information in data-sparse regions. The Fishing Vessel Ocean Observing Network (FVON; https://fvon.org/) aims to maximize data value by establishing community-wide standards for data, metadata, and best practices, while also facilitating observation uptake. FVON seeks to become a GOOS Coastal, Shelf and Boundary Network serving as a global complement to the Argo Program. Its objectives are to foster collaborative fishing vessel-based observations, democratize ocean data collection, improve ocean predictions and forecasts, promote sustainable fishing practices, and power a data-driven blue economy.

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