

## Harmonised ocean monitoring from the UK large research vessels (I/Ocean)

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More than 40% of the human population live within 100 km of the sea. Many of these communities intimately rely on the oceans for their food, climate and economy. However, the oceans are increasingly being adversely affected by human-driven activities such as climate change and pollution. Many targeted, marine monitoring programmes (e.g. GOSHIP, OceanSITES) and pioneering observing technologies (e.g. autonomous underwater vehicles, Argo floats) are being used to assess the impact humans are having on our oceans. Such activities and platforms are deployed, calibrated and serviced by state-of-the-art research ships, multimillion-pound floating laboratories which operate diverse arrays of high-powered, high-resolution sensors around-the-clock (e.g. sea-floor depth, weather, ocean current velocity and hydrography etc.). These sensors, coupled with event and environmental metadata provided by the ships logs and crew, are essential for understanding the wider context of the science they support, as well as directly contributing to crucial scientific understanding of the marine environment and key strategic policies (e.g. United Nation's Sustainable Development Goal 14). However, despite their high scientific value and cost, these data streams are not routinely brought together from UK large research vessels in coordinated, reliable and accessible ways that are fundamental to ensuring user trust in the data and any products generated from the data.

The National Oceanography Centre (NOC) and British Antarctic Survey (BAS) are currently working together to improve the integrity of the data management workflow from sensor systems to end-users across the UK National Environment Research Council (NERC) large research vessel fleet, as part of a UK initiative, I/Ocean. In doing so, we can make cost effective use of vessel time while improving the FAIRness, and in turn, access of data from these sensor arrays. The initial phase of the solution implements an Application Programming Interface (API) framework (Fig. 1) with endpoints tailored towards different end-users such as scientists on-board the vessels as well as the public on land. The framework is interfaced with a web portal, used to register ships and sensors, as well as their associated metadata. An innovative API-based NMEA data logging system, located on the ships (RVDAS), will be used to harmonise on-board access while mediating automated sensor triage in real-time, assuring sensors are working correctly and only the best data are obtained. This system will be supported with a standardised digital event logging API and web interface, allowing data quality issues to be identified and resolved quickly. Novel open-source, data transport formats will be produced that are embedded with well-structured metadata, common standards and provenance information (such as controlled vocabularies), allowing end-users of all abilities to access and understand data across platforms. These will include an extension to SeaDataNet Climate Forecast NetCDF conventions for trajectory data. To allow scientists and data managers to improve the quality of this data, an open-source, community-driven data processing application will be developed that applies quality control to international standards (SAMOS, IOOS Qartod, GoSUD). Data will be democratised through shore-based open data APIs including the National Oceanic and Atmospheric Administration's (NOAA) ERDDAP and the Open Geospatial Consortium's (OGC) Sensor Observation Service (SOS), part of the

Sensor Web Enablement (SWE) standard specification. This will allow end-users to discover and access data or layer their own tools to meet their own needs. To preserve provenance throughout the pipeline, each sensor will be unambiguously identified using novel instrument persistent identifiers (PID), part of the latest recommendations from the Research Data Alliance (RDA).

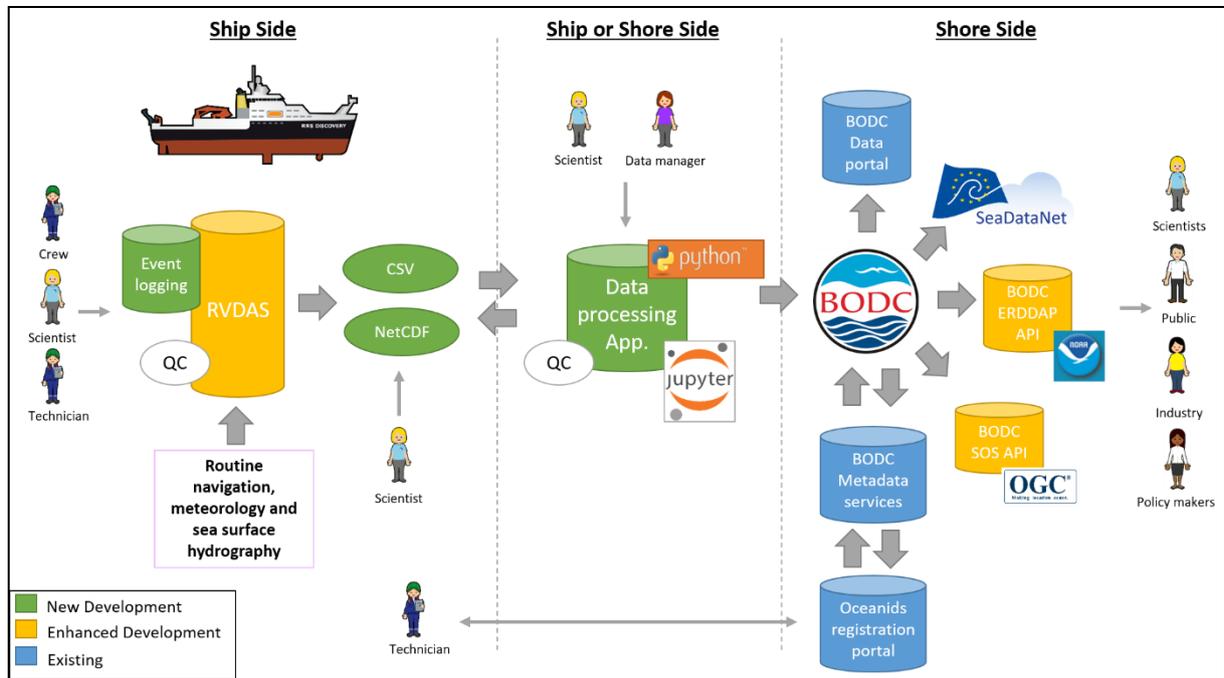


Figure 1: Initial phase of the I/Ocean initiative to improve the integrity of the data management workflow from sensor systems to end-users across the UK National Environment Research Council (NERC) large research vessel fleet.

While the initial phase of I/Ocean is focused on routine navigation, meteorology and sea surface hydrography variables in delayed-mode, our vision is to extend to near real-time data delivery and other strategic data types such as complex swath bathymetry that supports the Seabed 2030 global initiative. Access to universally interoperable oceanic data, with known quality and provenance, will empower a broad range of stakeholder communities (including academia, government and industry), creating opportunities for innovation and impact through data use, re-use and exploitation.