iFADO project Newsletter PAAnoramic

ABSTRACT

Implementation of the EU Marine Strategy Framework Directive (MSFD) and extension of periodic monitoring programs to offshore waters is costly and technically challenging. The iFADO (innovation in the Framework of the Atlantic Deep Ocean) project addressed this through integrating fixed point observatories with satellite, modelling, and novel technologies. The consortium proposed a high-impact mission covering the Atlantic Arc using autonomous underwater and surface vehicles as a project extension, and the objective was to demonstrate the collaborative capacity to monitor the Atlantic area with international collaborations using different technologies, vehicles, and sensors. Three institutes deploying gliders in 3 legs of a 'relay' from the Porcupine Abyssal Plain Sustained Observatory (PAP-SO) to the shelf off Ireland (managed by MI, Ireland); then from Ireland to Portugal (covered by NOC, UK); then from Portugal to Gran Canaria (PLOCAN, Spain). This article covers some of the data obtained and lessons learnt from this demonstration of the collaborative capacity to monitor the Atlantic area with gliders.

INTRODUCTION

The aim of the European Union's ambitious Marine Strategy Framework Directive (MSFD; Directive 2008/56/EC) is to protect the marine environment more effectively across Europe. Its implementation in the European Atlantic Region (EAR) and the need to extend periodic monitoring programs to offshore waters is very challenging due to its surface extension and large deep-water areas. To overcome these difficulties, the iFADO project (innovation in the Framework of the Atlantic Deep Ocean; https://www.ifado.eu; 2017-2023) combined traditional monitoring with cost-effective state-of-the-art technologies: remote sensing, numerical modelling, and emerging observation platforms such as gliders and oceanic buoys.

After several successful international glider missions, the consortium proposed a flagship action for the project's final year: the PAAnoramic mission. This mission was built on the already established and successful glider endurance line between mainland Portugal and the Canary Islands (Spain) and expanded it Northward into the wider NE Atlantic Area. Since 2018, this endurance line, established during the iFADO project, has been monitoring the southern part of the Atlantic Area on an annual basis. The PAAnoramic mission traversed the European Atlantic using autonomous underwater vehicles combined with in-situ monitoring cruises and was supported by satellite imagery and operational numerical modelling. This is the first international multi-platform ocean monitoring mission meridionally covering the entire European Atlantic area.

The main goal of the mission was to demonstrate how international collaboration is key for monitoring the ocean, to implement MSFD, achieve Good Environmental Status, and contribute to the UN Sustainable Development goals such as SDG14: Life Below Water. This ambitious action will set a milestone for a future Atlantic Area international unmanned monitoring strategy.

PAANORAMIC MISSION PLANNING

The PAAnoramic mission was planned to cover a linear distance of more than 3000 km across three countries' exclusive economic zones (Ireland, Portugal, and

Spain) and international waters. Due to the current logistical and budget limitations, the mission was divided into coordinated legs. Teams from different countries designed a suitable approach to cover this large region. The scientific payload installed in the glider (CTD, DO and bio-optics) allowed collection of data related to physical and biogeochemical essential ocean variables. On their way, the gliders crossed various offshore Marine Protected Areas, such as the Savage Islands and the Gorringe Bank among other seamounts and visited open ocean sustained observatories (moored buoys) such as PAP-SO (Porcupine Abyssal Plain Sustained Observatory) and the ESTOC (European Station for Time-Series in the Ocean Canary Islands).

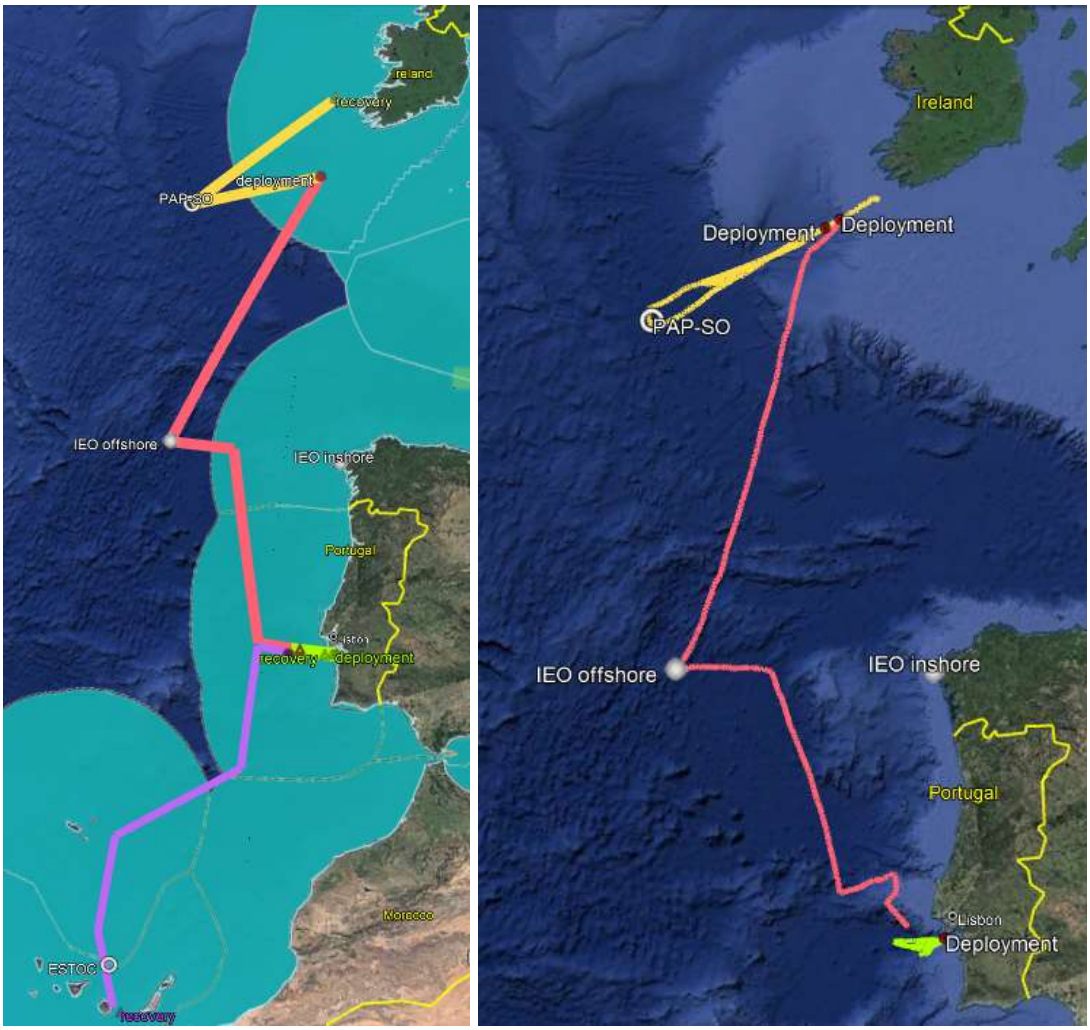

Fig. 1. Left: PAAnoramic planned legs on its final configuration: Leg 1 Ireland-PAP-SO (yellow line), Leg 2 Ireland-Mainland Portugal (pink line) and Leg 3 EShed-iFADO (green line) and Leg 4 Mainland Portugal-Gran Canaria (purple line). The exclusive economic zones in the Atlantic Area are displayed in light blue. Right: Performed paths for the first three PAAnoramic legs. The deployment location for each leg is indicated with red markers.

PAAnoramic mission preparation

This was a complex mission both conceptually and logistically. It was a lengthy process given the need to coordinate efforts from many international partners and contend with limited resources in terms of vehicles, budget and available ship

time. From the bureaucratic point of view, efforts were made to guarantee diplomatic clearance for the vehicles. +ATLANTIC designed a communication plan to the general public to cover the different tasks performed during the preparation, launch and recovery of the autonomous vehicles through the iFADO social networks (Twitter, LinkedIn and Facebook) and webpage (https://www.ifado.eu/).

PAAnoramic mission legs

The PAAnoramic glider mission was divided into four legs (Fig 1 left):

- Leg 1 (Ireland-PAP-SO): Marine Institute covered a two-way transect between Ireland and PAP-SO. This leg took place from the 9th of December 2022 to the 10th of February 2023.
- Leg 2 (Ireland-Mainland Portugal): National Oceanographic Centre covered the section from the Irish coast to mainland Portugal. This leg started simultaneously with Leg 1 (9th of December 2022 to the 15th of March 2023)
- Leg 3 (EShed-iFADO): IPMA designed a zonal mission to Western Iberia from the coastal area to the deep submarine canyons. The mission performed by PLOCAN took place between the 15th of June 2023 to the 12th of July 2023. This leg named EShed-iFADO ("Eddy shedding monitoring off Setúbal Bay") aimed to achieve a better understanding of the effects of the Lisbon and Setubal submarine canyons to the ocean circulation.
- Leg 4 (Mainland Portugal-Gran Canaria): PLOCAN will complete the mission with the route from mainland Portugal to the Canaries. The launch is planned for the 6th of September 2023 and will arrive in Gran Canaria by November 2023.

PAAnoramic mission vehicles

Three gliders were used to perform the PAAnoramic mission (Fig. 2):

- *Aisling na Mara* from Marine Institute is a 1000m operation rated Teledyne Webb Slocum G3 glider. This glider is part of EirOOS – the Irish Ocean Observing System which is a component of the European Ocean Observing System (EOOS).
- SG152 is a Seaglider® operated by Cyprus Subsea Consulting and Services (CSCS) in coordination with NOC.
- P302 is Seaglider® operated by PLOCAN. This glider performed the two last PAAnoramic legs consecutively. This same glider previously performed the endurance line missions between mainland Portugal and the Canary Islands in 2019, 2020 and 2021.

PAANORAMIC MISSION DEVELOPMENT

The PAAnoramic mission began on the 9th of December 2022 with the simultaneous deployment of 2 gliders (the Aisling na Mara and SG152) off the southwest Irish coast by the Marine Institute. The first glider, SG152, was deployed around 130 km off the Irish coast (50.8860 °N; 11.4747 °W) while the second glider, Aisling na Mara was deployed about 35 km away to the southwest at coordinates (50.7372 °N; 11.8905 °W). The last glider, P302, performed Leg 3 during June-July 2023 and this same glider will be relaunched in September

2023 for the 4th leg, and complete the PAANORAMIC mission in the Canary Islands with an expected recovery around November 2023. The actual glider paths during the first three legs were close to the original plan (Fig. 1 right). However, logistical constraints in vehicle availability, deployment opportunities (including weather) and technical malfunctions affected the timing of the glider launches. Overall mission modifications to the original paths and dates were needed to ensure glider batteries could provide enough energy to rendezvous with available boats for deployment and collection.

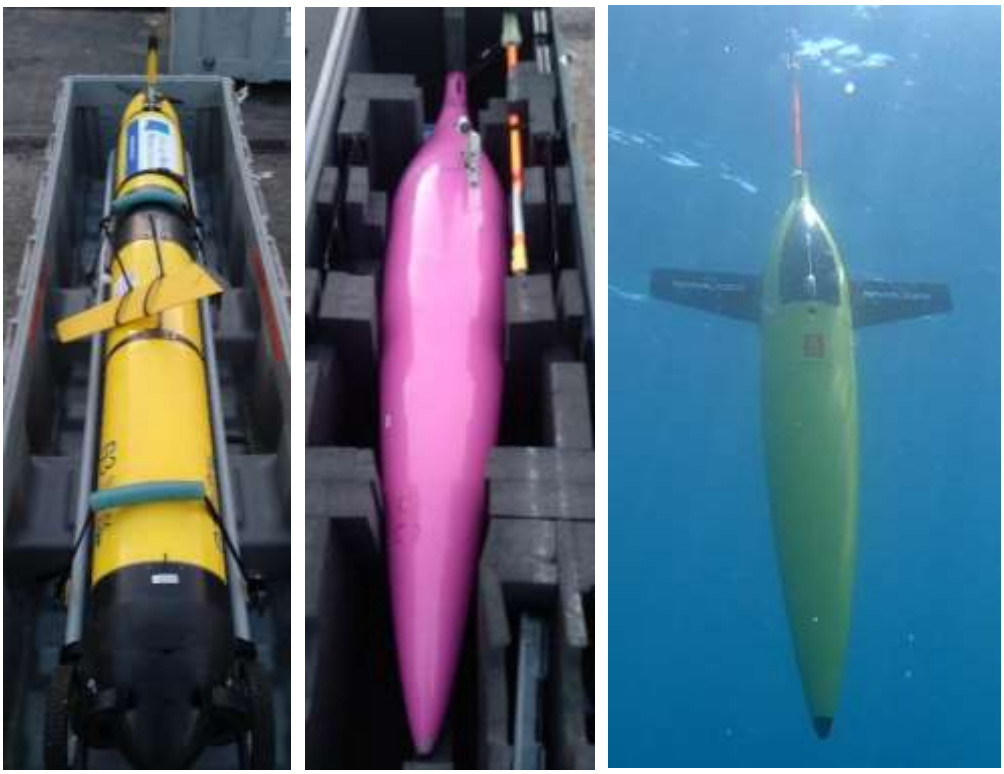

Fig. 2. Aisling na Mara Teledyne Webb Slocum G3 glider (left), SG152 Seaglider (centre) and P302 Seaglider (right).

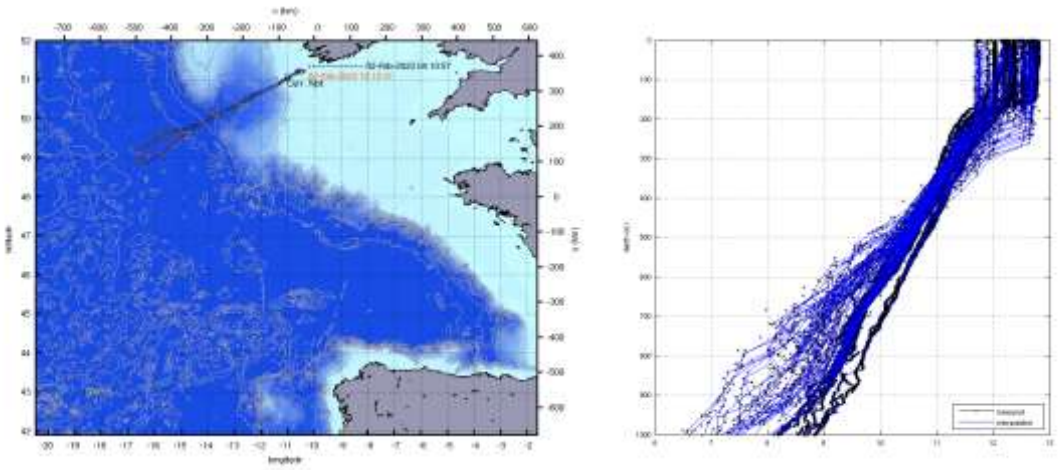

Fig. 3. Full path (top, left) and temperature vertical profiles (top, right) for Leg 1 Ireland-PAP-SO automatically generated and displayed on the EGO initiative webpage.

Data collected along the mission were distributed using standards and supported by international programmes. The latest position and samples of observed data were distributed in near-real-time through the EGO Initiative (Everyone's Gliding Observatories; https://www.ego-network.org). This initiative provides access to the datasets via Coriolis Data Centre and automatically plots the data collected (see Fig 3 for Leg 1 plots).

CONCLUSIONS AND LESSONS LEARNT

The PAAnoramic mission will set a milestone for a future Atlantic Area international unmanned monitoring strategy. The ambitious mission can be considered as a best practice for offshore monitoring of good environmental status (MSFD). Regular missions could support scientific data to monitor changes in ocean circulation and water mass dynamics. As an example, Fig 4 shows potential temperature, salinity and dissolved oxygen for the entire Leg 2 where different water masses can be clearly identified.

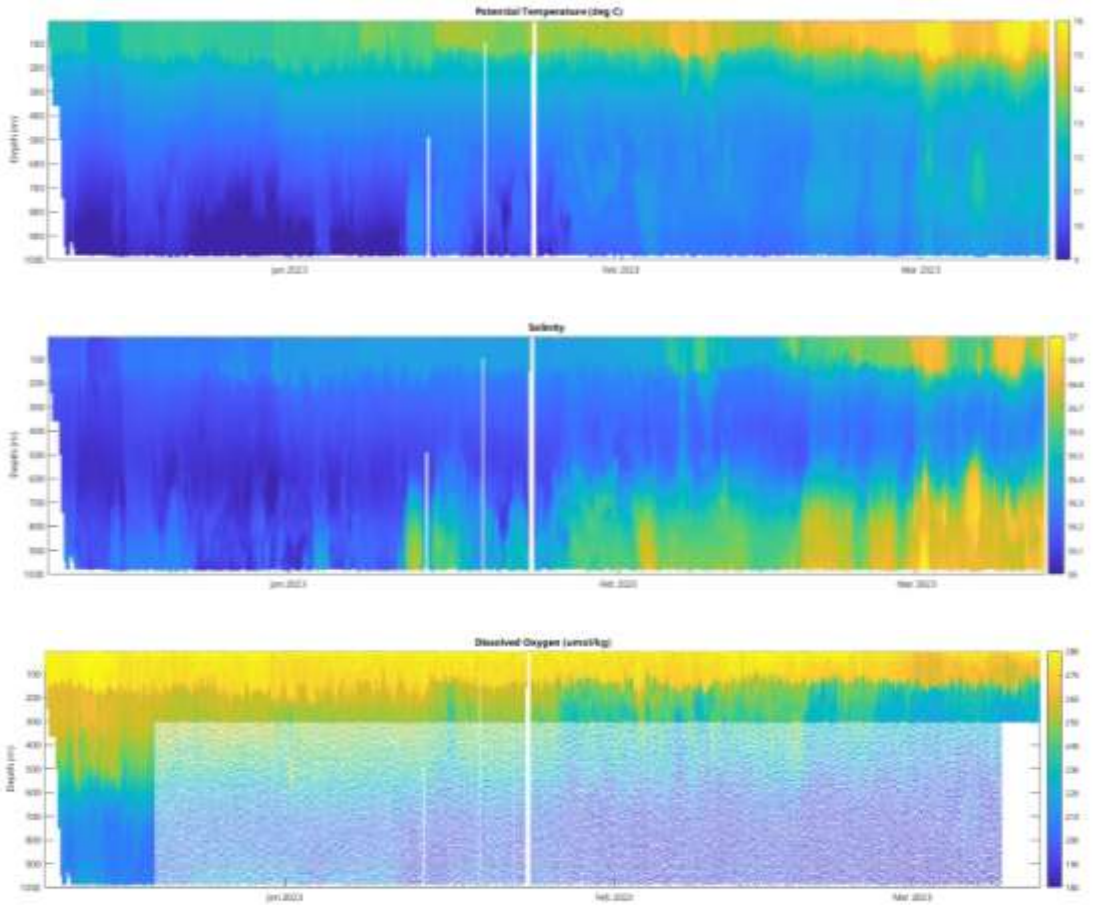

Fig. 4. Leg 2 potential temperature (top), salinity (centre) and dissolved oxygen (bottom) observations. Note: PAAnoramic mission data has not been fully processed yet and the displayed data are raw and thus subject to minimal quality control.

This mission involved participation of four Atlantic Area countries (Ireland, UK, Portugal and Spain), including two archipelagos (Madeira and Canary Islands). The mission was also supported by two non-iFADO project partners: Cyprus Subsea (Cyprus) and Instituto Hidrográfico (Portugal). This collaboration

demonstrated the capacity to monitor the Atlantic area with gliders though international collaborations using different technologies, vehicles and sensors.

The mission also demonstrated how gliders can reduce logistics, costs, and risks of ocean monitoring and cover remote areas during harsh weather conditions. Future missions could also fit novel biogeochemical sensors, (such as nutrients, pCO2, biology, particles, radiometry, underwater noise etc) to provide a wider spectrum of observations.

From the technical perspective, the mission was an opportunity to show initiatives, such as GROOM II, that it is possible to have operational data flowing in near-real-time. The EGO data visualization for both Slocum and Seaglider missions' can be regarded as a reference point for tracking progress and collaborating on the results as they come in. The data was distributed through Coriolis and ready to feed numerical models and improve forecasts.

As a principal legacy of the iFADO project, the PAAnoramic mission aimed to demonstrate the possibility to establish a coordinated endurance line between M6, PAP, IEO, ESTOC sites and support cross-calibration. In the future, to have built in capabilities to allow quick response missions would cover both unexpected funding opportunities and/or unplanned natural events that require quick action.

ACKNOWLEDGEMENTS

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