

USE OF THE SEAEXPLORER GLIDER FOR OCEANOGRAPHIC DATA COLLECTION ON THE ROMANIAN CONTINENTAL SHELF

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ABSTRACT

This study presents the deployment of the SeaExplorer autonomous underwater glider and the results of two monitoring campaigns conducted on the Romanian continental shelf in 2024, as part of the ILIAD Project. The glider collected high-resolution data on important oceanographic parameters such as temperature, salinity and current velocities along transects extending up to 130 km offshore and reaching depths up to 700 metres. The data confirmed the presence of strong vertical stratification in the Black Sea water column and revealed spatial variability in marine currents and particle concentrations. These results demonstrate the effectiveness of autonomous gliders for sustained and cost-efficient ocean observation in regions where data is scarce and geopolitical sensitivity is high. The paper also outlines the SeaExplorer platform's advantages in terms of spatial coverage, sensor versatility, and remote mission management.

Keywords: SeaExplorer, autonomous glider, Black Sea, hydrographic conditions

INTRODUCTION

In the current context of climate change and mounting human-driven pressure on marine ecosystems, it is essential to continuously monitor oceanographic parameters at high resolution in order to assess environmental conditions and support sustainable management strategies. Modern technologies, such as autonomous underwater vehicles (AUVs) and oceanographic gliders, provide a more efficient and flexible alternative to traditional ship-based observation methods, and other manned marine vehicles (Constantinoiu, Bernardino & Rusu, 2023).

Over the past decade, gliders have proven their usefulness in scientific and environmental monitoring missions (Constantinoiu, *et al.*, 2024). AUVs can collect large volumes of oceanographic data over extended periods and across wide areas, even in adverse weather conditions.

As a semi-enclosed basin, the Black Sea presents unique physical and biogeochemical characteristics that make it highly susceptible to eutrophication, pollution and changes to its hydrological regime. The Romanian continental shelf is of particular interest due to its exposure to various environmental stressors, including riverine discharges, industrial activities and maritime traffic.

The Romanian continental shelf is a particular area of interest for marine research as it is exposed to multiple sources of impact, such as waves, river spills, industrial activities and shipping (Makarynskyy *et al.*, 2005).

In this context, the present study evaluates the use of the SeaExplorer autonomous glider in two research campaigns conducted along the Romanian continental shelf. The objective is to evaluate the performance and data quality of this platform in collecting oceanographic information relevant for characterizing the state of the marine environment. This paper outlines the glider's technical characteristics, the data collection strategy and the types of parameters measured in the field.

MATERIALS AND METHODS

During field investigations carried out by the National Institute for Marine Research and Development (NIMRD) “Grigore Antipa” as part of the Iliad (Digital Twins of the Ocean) project, new automatic monitoring methods were employed using an autonomous underwater vehicle (AUV) equipped with precision oceanographic sensors. This glider-type mini submersible was used to record hydrodynamic and marine physico-chemical parameters in offshore areas, on the continental shelf, and at its edge.

The SeaExplorer glider, which was developed by ALSEAMAR in France, is an autonomous underwater vehicle (AUV) that is designed to carry out long-term monitoring missions in coastal and oceanic marine environments. This type of vehicle uses a passive propulsion system based on buoyancy modification, enabling it to travel slowly but efficiently in vertical zigzag (yo-yo) trajectories optimized for collecting oceanographic data (Rudnick *et al.*, 2024).

Depending on the mission objectives, the SeaExplorer can be equipped with a variety of sensors. Notably, these include CTD sensors; a SUNA sensor for measuring nitrates and bisulfides; dissolved oxygen (DO) sensors; fluorometers for estimating chlorophyll *a* and phytoplankton; a turbidity sensor for measuring suspended particulate matter; a pH sensor; an optional pCO₂ sensor; a miniature acoustic Doppler current profiler (ADCP) for measuring vertical currents; and a PAR light radiometer (Mayer, 2016; Álvarez *et al.*, 2013).

The maximum operating range of this system is 1250 m depth, and it can remain operational for up to 110 days (depending on payload and configuration). Depending on the configuration, it weighs between 55 and 60 kilograms, measures approximately 2 meters in length and 30 centimeters in diameter and can move at a speed of between 0.3 and 0.4 meters per second. Communication is facilitated via an Iridium satellite communication system on the surface and acoustically underwater (Fig. 1).

Operators can track and reconfigure the mission in real time via the Iridium satellite network. This enables them to adjust the trajectory according to the data collected. The vehicle then returns to the surface at the programmed point, where it can be manually or automatically retrieved by a vessel. Key benefits include low energy usage, enabling extended missions, the ability to gather high-resolution data in challenging weather conditions, reduced operational expenses compared to traditional research vessels and the capacity to cover large areas with limited human resources.

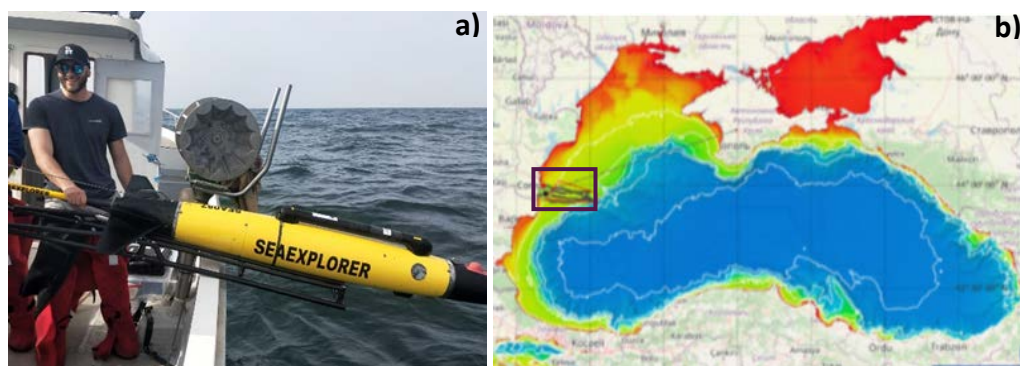


Fig. 1. The SeaExplorer glider was launched (a) in the Romanian southern survey area, which is cross-border with Bulgaria (b)

The CTD and ADCP sensors allowed the collection of oceanographic data characteristic of the western Black Sea, in the area of the Romanian southern sector, across Mangalia. Two missions, involving around 2,300 profiles, were carried out over two working sessions (April-May and September-October 2024) from 40 m depth to ca. 700 m and back, on an alignment of about 130 km offshore from the coastline (Fig.2).

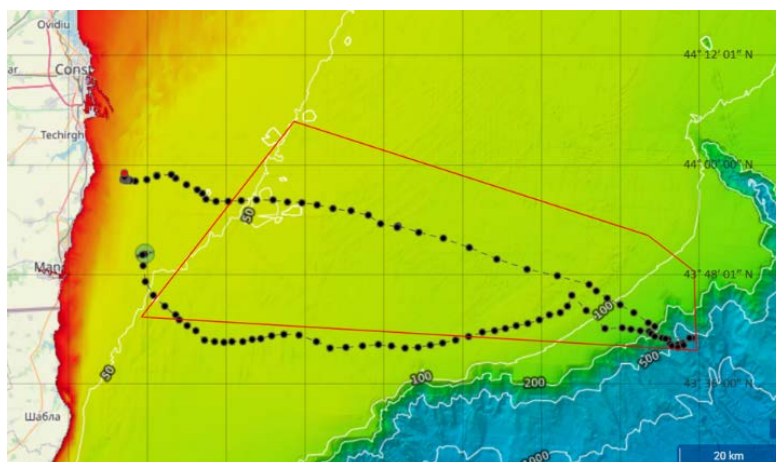


Fig. 2. The Seaexplorer/Alseamar glider's trajectory during its second mission, from 24.09 to 08.10.2024, cover the transboundary area across Mangalia at depths ranging from 40 to 700 meters, i.e up to approximately 130 kilometers from the shore

The continental shelf edge can facilitate the exchange of water masses between layers and the isolation of features across spatial-temporal boundaries. Current velocity measurements in this area allow crossflows associated with macroscale circulation in the geostrophic or turbulent domain to be estimated. In the western basin of the Black Sea, oceanographic measurements carried out by the glider equipped with CTD and ADCP sensors provided valuable data on the potential for operational oceanography in

the region, despite being exploratory. These data confirm the pronounced stratification of water masses on the Romanian continental shelf.

RESULTS AND DISCUSSION

The glider recordings enabled temperature measurements to be taken both vertically within the water column and spatially across the shoreline. Thus, the recorded temperature varied within the climatological range specific to the end of the warm season, from 27 to 7°C (Fig.3).

This highlights the mixing processes in the upper layers related to the continental shelf, which corresponds to the point at which the device returns to the shore. It also highlights the high density near this point.

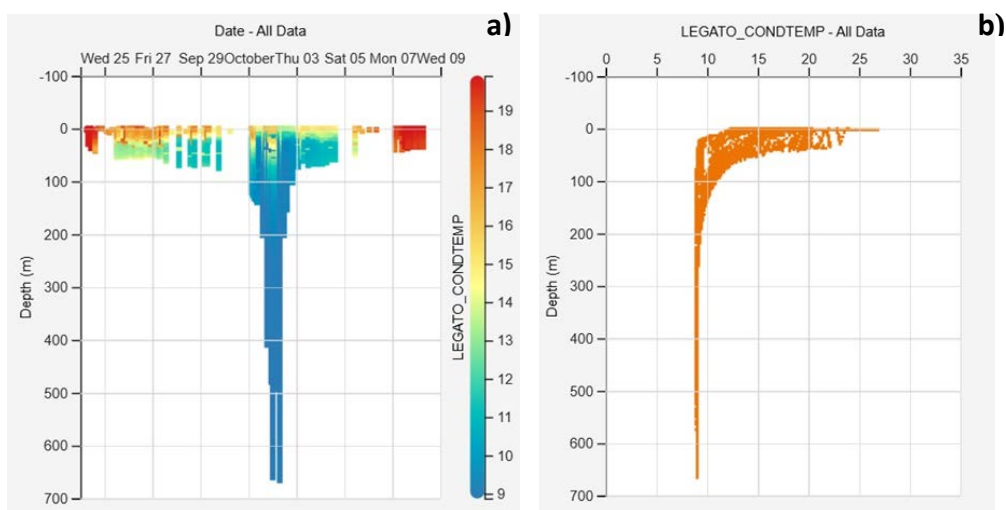


Fig. 3. Vertical profile of seawater temperature (°C) as recorded by the SeaExplorer glider during its 2024 missions on the Romanian continental shelf. The dataset includes ~2,300 profiles collected over multiple transects (a). The strong thermocline is visible below 50–100 m, followed by a quasi-isothermal layer (~9°C) beyond 300 m depth (b)

In the surface layer (0–100 m), the salinity value, approximately 16–18 Practical Salinity Units (PSU) indicates the inflow of fresh water from rivers in the northwestern part of the basin, especially the Danube (Fig.4).

At greater depths (over 200 m), salinity gradually increases, reaching values of over 20 PSU at around 600 m. This is a well-known feature of the Black Sea, where deep water masses are saltier and more stable from a physicochemical point of view. This profile confirms the specific saline stratification of the Black Sea, where deep waters are saltier and more thermodynamically stable, as well as being anoxic, starting at around 150–200 m. This vertical gradient confirms the classical halocline structure of the western Black Sea, driven by freshwater inputs in the surface layer and the presence of highly saline, stable deep waters below 200 m (Fig.4).

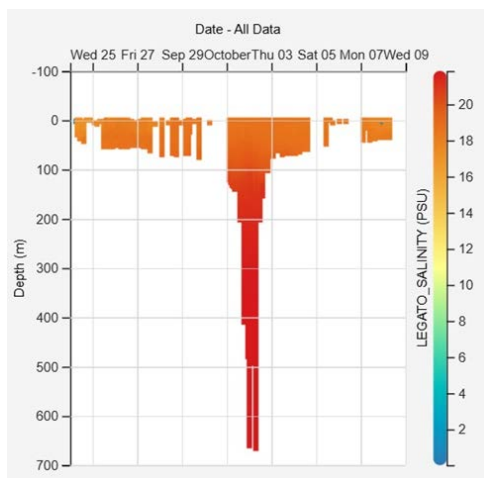


Fig. 4 Vertical salinity section (measured in PSU) recorded by the SeaExplorer glider between 25 September and 9 October 2024 in the Romanian shelf and slope region

In addition to marine physico-chemical parameters, marine currents were monitored from September to October 2024 (Fig. 5). The vertical distribution of the current velocity component (ADCP_V1_CN2, in m/s), as measured by the SeaExplorer and represented by a color scale, shows the directional component of water velocity projected along one ADCP beam axis.

Values range from 0 m/s (red) to -0.5 m/s (blue), where the negative sign indicates the beam coordinate system's negative direction. This spatial pattern reveals a generally consistent flow regime in the deeper layers, with greater variability in the upper 100 meters, related to water stratification and wind-driven processes (Fig. 5a). Most values are concentrated between -0.3 and $+0.3$ m/s within the top 150 meters, suggesting moderate near-surface dynamics. Deeper layers exhibit lower and more stable values. (Fig. 5b).

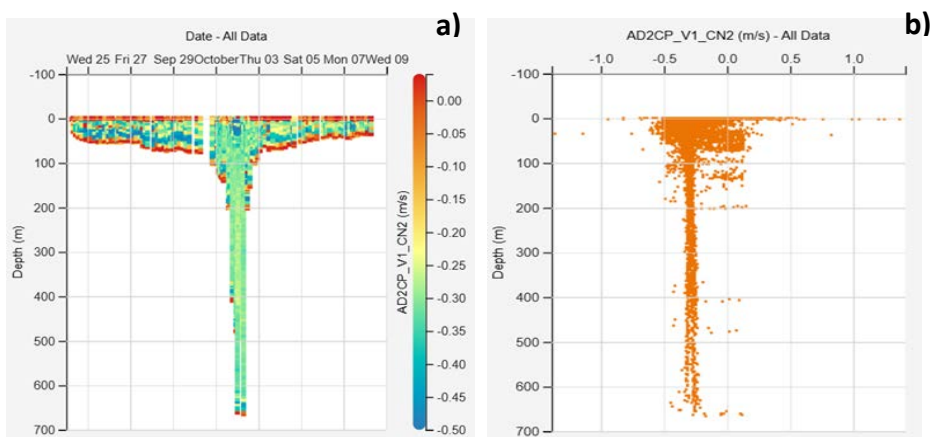


Fig. 5. Vertical profile of the along-beam current velocity, as measured by the SeaExplorer glider (m/s) between 25 September and 9 October (a). Scatterplot of current velocity values - each point corresponds to a single velocity measurement at a given depth (b)

During its gliding motion from the surface to the seabed and back again, the glider took around 2.300 measurements. During this interval, measurement of currents was undertaken in the speed range of 0.05–1.9 m/s, corresponding to depths of up to around 700 m below the sea surface.

The echo strength data measured by the ADCP enables the density of particles in the water column to be assessed quantitatively. The color scale represents relative backscatter strength (dB), where high values (red) in the upper 100 m suggest increased particle concentration or biological activity.

The surface layer (0–100m) shows a high intensity (red-orange color bar), which indicates a high concentration of particles (suspended material), increased biological activity or even air bubbles generated by waves. Below 150–200 meters, the echo intensity gradually decreases (yellow – green color bar), suggesting fewer suspended particles and cleaner water, as well as a transition to an anoxic zone. Below 400 metres, the signal becomes weak and almost uniform and is often considered to be background noise. (Fig. 6 a and b).

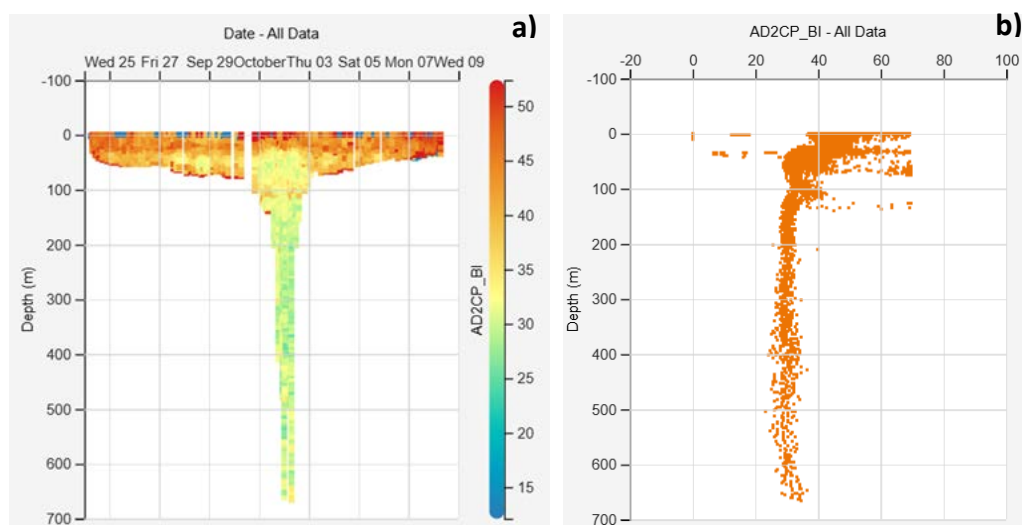


Fig. 6. Amplitude distribution of echo intensity measured by the ADCP onboard the SeaExplorer glider during the 2024 survey (a). Envelope graph, show the total signal range without temporal or spatial interpolation, each point represents an individual backscatter measurement at a given depth (b)

CONCLUSIONS

The SeaExplorer glider missions conducted as part of the ILIAD Project have made a significant contribution to our understanding of the hydrodynamic and thermohaline structure of the Romanian continental shelf and slope areas. Despite technical limitations, the two deployments successfully captured key features such as vertical stratification, current velocities and water mass structure under variable seasonal conditions.

The glider's capacity to operate autonomously over long periods in different environmental conditions demonstrates its potential as an additional tool for conventional ship-based monitoring. The spatial and temporal resolution achieved provides valuable insights into the Black Sea's dynamic processes, supporting both research and operational oceanography.

Deploying autonomous platforms such as gliders is becoming increasingly important in the context of data scarcity and regional geopolitical constraints. Their use can help to bridge monitoring gaps, improve marine forecasting systems, and inform marine spatial planning and ecosystem management.

Acknowledgement. This research was carried out in the frame of the Iliad Project/ Integrated Digital Framework for Comprehensive Maritime Data and Information Services, no. 101037643/2021

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