CNR IRBIM
ISTITUTO PER LE RISORSE BIOLOGICHE E LE BIOTECNOLOGIE MARINE

NATIONAL BIODIVERSITY FUTURE CENTER

PELASeam survey: Pelagic dynamics and Biodiversity of Tyrrhenian Seamount Ecosystems

Cruise Report

RV Gaia Blu – Napoli 23 July 2024 – Civitavecchia 08 August 2024

CNR ISMAR
ISTITUTO DI SCIENZE MARINE

OGS

UNIVERSITÀ POLITECNICA DELLE MARCHE

UNIVERSITÀ DEGLI STUDI DI PALERMO

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doi: https://doi.org/10.32095/PELASeam2024

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1 Background

Seamounts are distinctive topographical formations that rise from the ocean floor and are present across all oceanic basins. These structures are known to support unique ecosystems and have been considered as “oases” of pelagic biodiversity and productivity (Morato et al., 2010, Pitcher et al., 2008; Consalvey et al., 2010; Ramirez-Llodra et al., 2010; Kvile et al., 2014; Würtz & Rovere, 2015; Rogers, 2019). This enhanced productivity is reflected on different levels of the pelagic trophic chain, from phytoplankton up to top predators. In the Mediterranean Sea seamounts are widespread and account for approximately 230 structures, many of which are located in the Tyrrhenian Sea given the complex geological history of the basin.

Despite the importance of these ecosystems, they remain among the least explored and least protected marine ecosystems globally and especially in the Mediterranean where to our knowledge, no comprehensive studies have been conducted on the dynamics of the seamounts’ pelagic ecosystem. Recent data suggests that out of approximately 30,000 seamounts globally identified, less than 2% fall within the scope of current marine protected areas, and less than 4% have undergone scientific exploration (Yesson et al., 2011; Kvile et al., 2014). Our understanding is primarily based on a limited number of extensively researched examples. Consequently, it's critical to prioritize the study and protection of seamounts within national territories, where effective management can be implemented swiftly. The PELASeam survey aimed to unravel the unique features and potential ecological significance of the seamounts, providing valuable insights into their role in supporting marine life, influencing local currents, and contributing to the overall health of the marine ecosystem in the Tyrrhenian Sea.

1.1 NBFC

The PELASeam survey fell within the scopes of the NBFC (National Biodiversity Future Center). The National Biodiversity Center is the first national research center dedicated to biodiversity, coordinated by the National Research Council (CNR). Over 1500 researchers and 48 partner organizations committed to studying and preserving the ecosystems and biodiversity of our country. The NBFC Project is funded by the European Union – NextGenerationEU, established and funded by the National Recovery and Resilience Plan (PNRR), and is one of five national centers dedicated to frontier research. The Center has received funding of 320 million euros for three years, from 2023 to 2025 and carries out an activity of strategic importance with a view to contributing to achieving the goals of the United Nations Agenda 2030 for sustainable development.

2 Objectives

The primary objective of the survey was to investigate the ecological dynamics and biodiversity of pelagic ecosystems associated with the Vavilov and Vercelli seamounts in the Tyrrhenian Sea. The study aimed to understand how the unique physical, biological, and oceanographic characteristics of these seamounts influence productivity, species distribution, and trophic interactions across multiple levels of the marine food web, with a particular focus on their role in supporting biodiversity hotspots, attracting top predators, and enhancing pelagic ecosystem functioning.

The specific aims of the survey were to:

- **Investigate the overall pelagic productivity of 2 seamounts in the Tyrrhenian Sea exploring different trophic levels**: The main questions we want to answer are: (1) Do the seamounts in the Tyrrhenian Sea support high density and diversity of pelagic fauna? (2) Does the abundance and/or biomass of organisms vary between the summit of the seamount and areas distant from it? (3) Is the diversity or taxonomic composition of pelagic assemblages different over the summit as opposed to away?

- **Investigate the spatial distribution, abundance and composition of fish early life stages over the 2 seamounts to understand if these habitats can act as spawning and/or nursery areas for the fish species distributed in these areas.**

- **Investigate the underlying mechanisms of the enhanced productivity detected over seamounts with different morphological characteristics**: The increased productivity at the seamounts is a characteristic that has been observed widely but the origin of this productivity is often not clear and is related to the characteristics of the seamount and the surrounding area. Our aim is to understand whether pelagic productivity is supported by an increased primary production originated from local sources (e.g. through the formation of Taylor column) or from the influx of energy through the advection of zooplankton and micronekton from the surrounding areas.
- **Evaluate the attractiveness of seamounts for the pelagic megafauna and top predators (large pelagics, marine mammals and sea birds).** Seamounts play a crucial role for large pelagic animals, frequently supporting high concentrations of species that are both endangered and of commercial value, including sharks, tunas, and billfishes (Morato et al., 2008; Wright et al., 2021). A wide range of seabird and marine mammal species have also been observed to densely aggregate and make use of resources associated with seamounts. Although these species are typically very mobile, they often exhibit significant site fidelity to these underwater structures. The role of the seamounts in aggregating megafauna and the underlying mechanisms are largely unknown. During the cruise we want to estimate the relative density and composition of megafauna assemblages at the seamounts in relationship with the overall pelagic productivity and environmental conditions detected in the study area using visual, camera, eDNA metabarcoding and acoustic observations.

- **Investigate biodiversity of the pelagic communities on and around seamounts using net samples and eDNA***:* We want to answer to the following questions*:*
  - is eDNA a valuable tool to describe the pelagic biodiversity around seamounts and what is the difference with the traditional net sampling?
  - Is the pelagic biodiversity significantly different at the seamounts as opposed to the open ocean?

3 List of participants

LEG 1 (23/07/2024 – 29/07/2024)

Name	Role on board	Affiliation
Fabio Campanella	Scientist in Charge (Acoustics, net sampling)	CNR - IRBIM
Andrea Miccoli	Water sampling (eDNA)	CNR - IRBIM
Federico Calì	Net sampling	CNR - IRBIM
Martina Scanu	Net sampling	CNR - IRBIM
Daniel Li Veli	Net sampling/visual census	CNR - IRBIM
Sara Bonanomi	Net sampling/visual census	CNR - IRBIM
Naomi Krauzig	Oceanography	UNIVPM
Francesco Memmola	Oceanography	UNIVPM
Alessandra Campanelli	Water sampling (nutrients)	CNR - IRBIM
Giuseppe Caccamo	Water sampling (nutrients)	CNR - IRBIM
Claudia Sacchetti	Water sampling (nutrients, eDNA)	CNR - IRBIM
Antonia Chiaino	Water sampling ((nutrients, eDNA, chlorophyll)	UNIVPM
Gabriele Turco	BRUVS	UNIPA
Rocco De Marco	Acoustics	CNR - IRBIM
Gaspare Avanzato	Acoustics	CNR - IRBIM

LEG 2 (29/07/2024 – 08/08/2024)

Name	Role on board	Affiliation
Andrea Miccoli	Scientist in Charge (Water sampling - eDNA)	CNR - IRBIM
Federico Calì	Net sampling	CNR - IRBIM
Martina Scanu	Net sampling	CNR - IRBIM
Daniel Li Veli	Net sampling/visual census	CNR - IRBIM
Deborah D'Angelo	Net sampling	CNR - IRBIM
Maria Chiara Catta	Oceanography	CNR - IRBIM
Naomi Krauzig	Oceanography	UNIVPM
Sara Bonanomi	Water sampling/visual census	CNR - IRBIM
Luca Bolognini	BRUVS/ water sampling	CNR - IRBIM
Monica Panfili	Water sampling	CNR - IRBIM
Claudia Sacchetti	Water sampling (nutrients, eDNA)	CNR - IRBIM
Antonia Chiaino	Water sampling (nutrients, eDNA, chlorophyll)	UNIVPM
Gabriele Turco	BRUVS	UNIPA
Rocco De Marco	Acoustics	CNR - IRBIM
Gaspare Avanzato	Acoustics	CNR - IRBIM

4 Narrative

On the evening of 22nd of July the whole scientific staff joined the vessel. Mobilization was completed on the 23rd but departure was delayed to the 24th because of poor weather conditions. The RV sailed on the morning of the 24th at 08:30 local time. At 12:30 the vessel stopped just off the Gulf of Naples to attempt the calibration of the scientific echosounder EK60. The calibration sphere was lowered below the transducers, but we could not detect it within the acoustic beam due to strong currents and wind that picked up throughout the morning. At 16:00 a decision was made to abort the calibration and make another attempt in the following days with better conditions.

At 20:00 we arrived at the start of the first EK60 acoustic transect on the Vavilov seamount. The acoustic sampling was carried out during the whole night and stopped at first light when the first CTD cast was performed. After the CTD, the acoustic sampling was resumed and continued throughout the day. At dusk we moved to station VAV5 where we carried out the first net sampling using both the WP2 and tucker trawl and repeated during the rest of the night on station VAV6 and VAV8.

On the morning of July 26 BRUVS were deployed at station VAV8. After the retrieval of the cameras, CTD casts and water sampling were performed at station VAV14 and VAV15. Overnight net sampling was performed successfully on station VAV1, VAV3, VAV4.

On July 27 BRUVS were deployed at first light at station VAV5. CTD and rosette were also deployed at the same station while the BRUVS were in the water, making sure the rosette was located upstream of the dominant current to avoid potential eDNA contamination from the bait. After the retrieval of the CTD and BRUVS we moved to station VAV9 where BRUVS were deployed and another CTD was performed. Before net sampling operation commenced in the evening, an EK60 transect was also completed.

On July 28 operations continued as the previous day with 2 BRUVS deployment at stations VAV10 and VAV4 and 3 CTD casts at station VAV10, VAV4 and VAV11. In the evening/night 1 acoustic transect was completed and net sampling performed at station VAV8 and VAV9.

The 29th of July was the last day of operations at the Vavilov seamount. 3 CTD casts were performed (VAV3, VAV12, VAV13) and one WP2 deployment was completed at station VAV13. After the last deployment at 21:00 the RV commenced the steam toward Gaeta for the planned staff change where we arrived on the morning of 30 July.

The second leg of the PELAseam expedition commenced on July 30, 2024 at 14:20 local time, with the transfer to station VER15 and an estimated time of arrival of 12 hours. The EK60 started recording during the night of July 30-31, maintaining an average speed of 7 knots. Plankton sampling by means of WP2 and Tucker trawl, along with microplastics sampling with an additional casting of the WP2 net immediately after the first one, were successfully conducted at VER15 and VER14.

At VER5, at dawn of July 31, an incident occurred, and an event report was redacted and signed by both the Ship Master and the Chief Scientist. In brief, due to the bathymetry of 65 meters and the objective difficulty of accurately controlling the deployment of the Tucker Trawl net over multiple depth layers caused by the lack of a line counter on the aft winch, the zooplankton research team and the Chief Scientist decided to equip the net with a SIMRAD PI 50 altimeter, which would communicate with a SIMRAD scanning hydrophone secured to the ship by a rope and connected to a computer via an electrical cable of approximately 20 meters in length. A communication misunderstanding between deck and bridge likely occurred, leading to the deployment of the instrument by the starboard crane. The electrical cable and rope securing the hydrophone to the computer intertwined with the starboard propeller. The intervention of divers was deemed necessary: accordingly, all operations involving deployment of instruments were stopped during navigation towards the nearest port of Civitavecchia. The team rescheduled operations and acoustic transects 3, 1 and 4 were conducted at an average speed of 6 knots, omitting transect 5. Marine observation from the upper deck occurred in concomitance with daytime acoustic investigation.

On August 1, following the recovery of the hydrophone and the transfer to station VER1, operations resumed at 17:30 local time with a CTD profile and water sampling. Acoustic transect 2 was completed at 10 knots, and a further CTD profile and water sampling were taken at VER8. On the night of August 1-2, plankton and microplastics samples were taken at VER8 with two WP2 and a Tucker trawl casts. At VER7, only a WP2 cast was performed.

On August 2, BRUVs were deployed at VER2 and VER18, and CTD profiles and water sampling were also conducted at these stations. On the same day, the concomitant use of the EK60, the MBES and vessel-mounted ADCP was tested by dedicated research staff aided by the research technician, in preparation of operations scheduled for the following days. The EK60 and the MBES test worked smoothly as no mutual interference were recorded thanks to the k-sync functionality. On the contrary, the concomitant use of EK60 and vessel-mounted ADCP required greater optimization. The last operation of the daytime was a CTD cast (water profile only) at VER17. Throughout the night of August 2-3, extensive plankton and microplastics sampling was carried out across stations VER1 to VER5.

On August 3, a further testing of both the MBES and the EK60 acoustic system was performed on the summit of the Vercelli seamount: the possibility of their concomitant employment was verified. BRUVs were deployed at VER4 towards VER5 and at VER12. CTD casts at VER3 (profile), VER4 (profile) and VER5 (profile and water sampling), originally scheduled for the previous day but aborted because of the close proximity of an operative fishing vessel with which the bridge could not establish communications, were also conducted. Plankton was sampled only by means of Tucker Trawl net casts at VER11, VER12 and VER13 throughout the night. Poor sea conditions did not allow the ship to maintain position and heading, and WP2 net casts were rescheduled.

Bad sea conditions persisted on August 4, and some CTD casts had to be rescheduled.

The survey proceeded with the acoustic investigation of the 10 km^2-flat platform of the seamount localized at a depth of 200–250 m by means of EK60 and MBES systems. Water column profiles and water sampling was achieved at VER14 and VER15.

Plankton sampling during the nighttime was only possible at VER16 because the aft winch stopped working at 21:45 local time following the deployment of the WP2 net. The night schedule was therefore immediately adjusted to nighttime acoustics using the EK60 on transects 1 and 2.

On August 5, due to continued poor sea conditions, operations were rerouted to the acquisition of bathymetry and water current velocities profiling on the Vercelli summit by means of MBES and vessel-mounted ADCP. BRUVs were deployed at VER13 following the water column profile and water sampling by CTD. A further CTD (profile and water sampling) was deployed at VER6. The aft winch was repaired.

On the night of August 5-6, nighttime acoustic investigations were obtained along transects 3 and 4, starting from VER9. WP2 net casts were deployed at VER12 and VER13.

On August 6, BRUVs were deployed at VER16, while particular attention was given to CTD casts. On this day, water was profiled and sampled at VER16, VER7 and VER11, while VER9 was a profile-only CTD station. Throughout the night, plankton was sampled at VER6 and VER7 by WP2 net and at VER-16 by Tucker Trawl nets.

Daytime of August 7 was the last day allocated to operations. Fractions of MBES transects were partially re-run for optimal bathymetry data acquisition. BRUVs were deployed at VER7, while CTD casts were deployed at VER19 (profile and water sampling), and VER20 and VER10 (profile only), ensuring that all stations along the four main transects were sampled for comprehensive ecosystem data collection.

5 Study area

Two seamounts with distinct morphological and ecological characteristics were targeted during the survey: the Vavilov and the Vercelli Seamounts. These seamounts were chosen due to their contrasting habitat features, which influence hydrodynamics, environmental conditions, and potentially varying levels of pelagic productivity.

The Vavilov Seamount, located at approximately 39.88° latitude and 12.62° longitude, is an isolated volcano situated in the central part of the Tyrrhenian basin. It rises from the flat, 3600 m-deep abyssal plain -home to the deepest point of the Tyrrhenian Sea, at around 3785 m depth (Sartori, 2003) - to a summit at approximately 800 m water depth. With a length of ~30 km and a maximum width of ~14 km, its N-S elongated structure plays a pivotal role in regional oceanography. A detailed hydrographic investigation in the central Tyrrhenian Sea revealed that the Vavilov Seamount contributes to the persistence of anticyclonic eddies, as observed during July and December 2005, interacting with the weak mean current in the region (Budillon et al., 2009). These semi-permanent or permanent eddies, influenced by the seamount's topography, significantly impact local hydrodynamic and biological processes. Despite its importance, there is currently no information available about its pelagic and benthic communities.

The Vercelli Seamount, located at approximately 41.11° latitude and 10.90° longitude, is the dominant feature of a complex ridge system in the northern Tyrrhenian Sea. Its summit consists of a shallow plateau with a pinnacle that reaches into the euphotic zone at about 60 m depth. This seamount lies in a transitional area between a cyclonic gyre, which promotes vertical mixing and potential increases in primary productivity, and an anticyclonic gyre, which creates a convergence zone leading to oligotrophic conditions. Vetrano et al. (2010) suggested that the Vercelli Seamount constrains semi-permanent or permanent eddies, and additional glider observations in 2009 revealed slanted sub-mesoscale structures below the thermocline in the southern region of the seamount (Mauri et al., 2018). Recent studies on its benthic communities highlighted a rich macrofaunal assemblage with high abundance, biomass, and diversity, but information on pelagic communities remains sparse or absent. The maps of the study areas with acoustic transects and sampling stations are shown in Figure 1 - Maps of the acoustic transects and sampling stations.

Both seamounts are integral to understanding the complex dynamics of the Tyrrhenian Sea. Their topographies influence circulation patterns, generate turbulence, and promote upwelling, which collectively shape local ecosystems. Due to their significant dimensions, these seamounts are likely to affect a range of hydrodynamic and biological processes, including eddy generation and trapping (Royer, 1978; Bashmachnikov et al., 2009; Sokolovskiy et al., 2013). Furthermore, seamounts can create Taylor caps, intensify flows, deflect currents, and drive upwelling, turbulence, and internal waves. These processes alter water properties, nutrient distribution, and biological activity (Noble and Mullineaux, 1989; Eriksen, 1991; Dower et al., 1992; Beckmann and Mohn, 2002).

The study of the Vavilov and Vercelli Seamounts through campaigns like PELASeam provides valuable insights into the interaction between physical oceanography and marine biology. Such research enhances the understanding of seamount ecosystems and their broader environmental impacts, contributing to our knowledge of the Tyrrhenian Sea's intricate ecological and oceanographic dynamics.

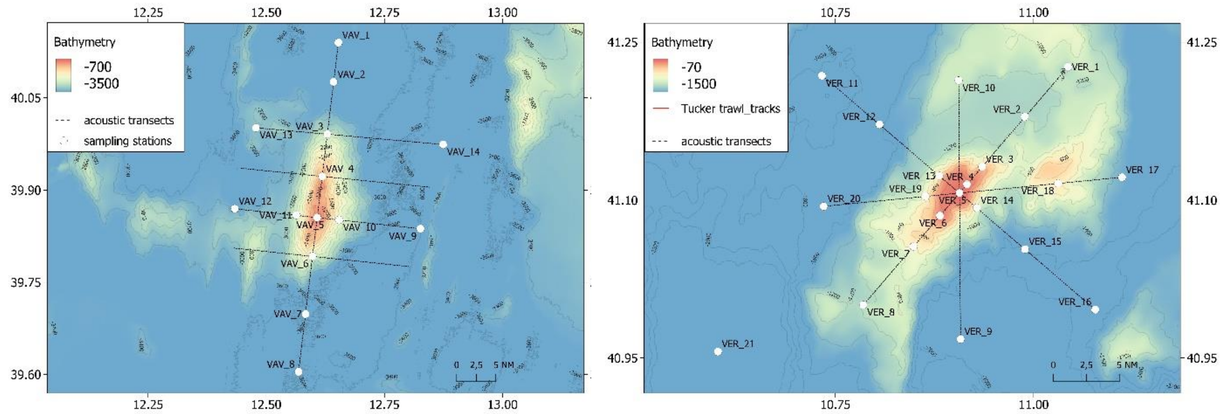

Figure 1 - Maps of the acoustic transects and sampling stations.

6 Activities and preliminary results

6.1 Fisheries acoustics

Fisheries acoustic sampling was used to characterise the overall pelagic fish and zooplankton biomass (used as proxy) and was conducted using the Simrad EK60 system hull-mounted at 5 frequencies (18, 38, 70, 120, 200 kHz) running transects over the seamounts. The echosounder settings used are listed in Table 1.

Table 1- EK60 settings used during the survey

Frequency (kHz)	**18**	**38**	**70**	**120**	**200**
Transducer type	ES18	ES38B	ES70-7C	ES120-7C	ES200-7C
Transducer draft setting (m)	5.8	5.8	5.8	5.8	5.8
Transducer power (W)	2000	2000	700	200	100
Pulse length (ms)	1,024	1,024	1,024	1,024	1,024
Ping rate (1/s)	variable based on depth range				
Max recorded depth (m)	1500	1500	800	400	300

Transects at the Vercelli seamount followed a star-shaped design with transects starting from the summit and running away from the seamounts in different directions (see Figure 1). The Vavilov was surveyed running parallel transects perpendicular to the longitudinal axis of the seamount and one transect along its length. The transects extended up to 20 nautical miles away from the summits to capture any possible gradient. The surveys were run in daylight and repeated during nighttime to detect any diel variability and investigated DVMs. Vessel speed was kept between 6 and 9 knots. Initial analysis of the echograms revealed well-defined scattering layers at both seamounts, with variations in density and depth depending on time of day and proximity to the seamount. The summit of the Vercelli was characterised by the presence of discrete fish aggregation primarily distributed at the start of the slope. The integration of acoustic data with net sampling and eDNA analyses will allow for the identification of the key species contributing to these scattering layers.
While the acoustic survey was largely successful, some technical challenges were encountered. A calibration of the EK60 system was attempted at the start of the survey near Naples but could not be

completed due to strong currents and poor weather conditions, and the tight schedule of the expedition did not allow a second attempt. This limited the ability to derive precise quantitative estimates of biomass. Future surveys should prioritize calibration under optimal conditions to ensure data accuracy. Additionally, variations in vessel speed and heading, influenced by weather and operational constraints, occasionally affected data consistency across transects. Example of echograms recorded along the transects are shown in Figure 2 and *Figure 3*. The acoustic transects sampled during the survey and the distribution of the volume backscatter (SV, proxy for pelagic density) for the surface layer (15-100 meters) are shown in Figure 4 and Figure 5.

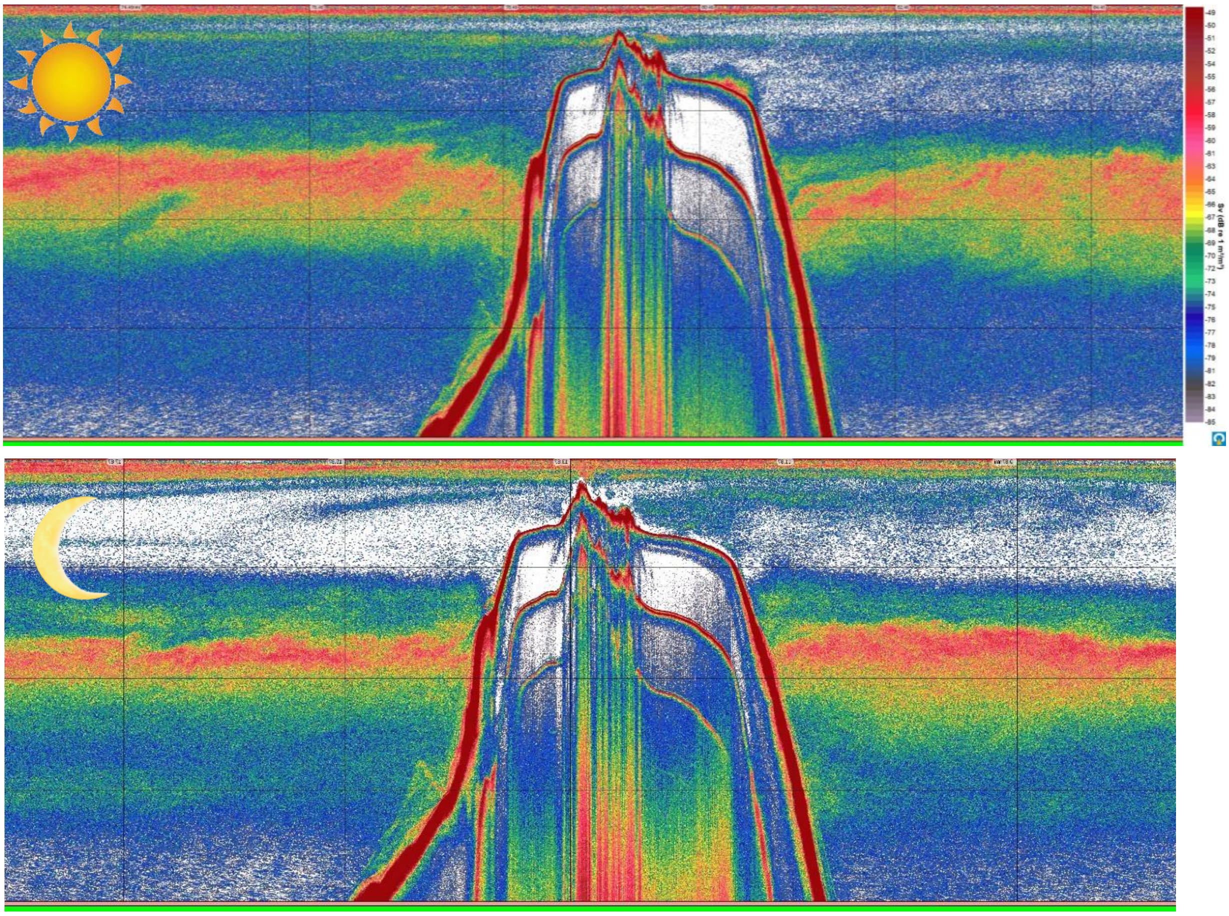

Figure 2 - Echogram at 38 kHz of the North-South transect at the Vercelli seamount carried out in daylight (top) and nighttime (bottom)

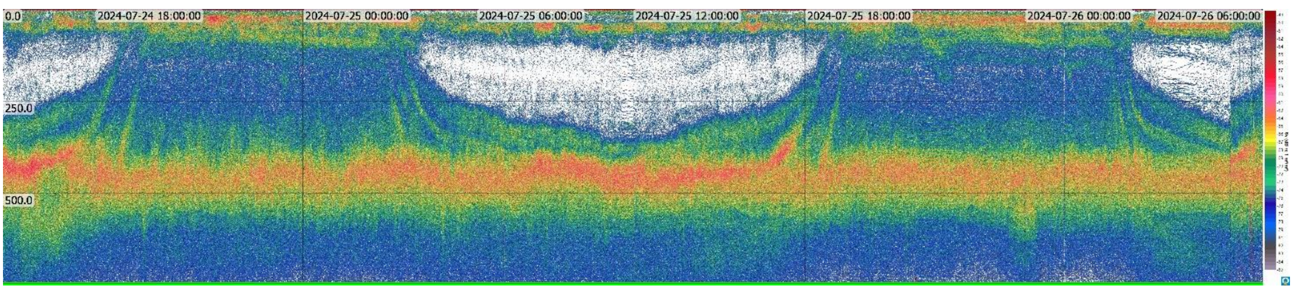

Figure 3 - Example of Diel Vertical Migration (DVM) detected around the Vavilov seamount at 38 kHz

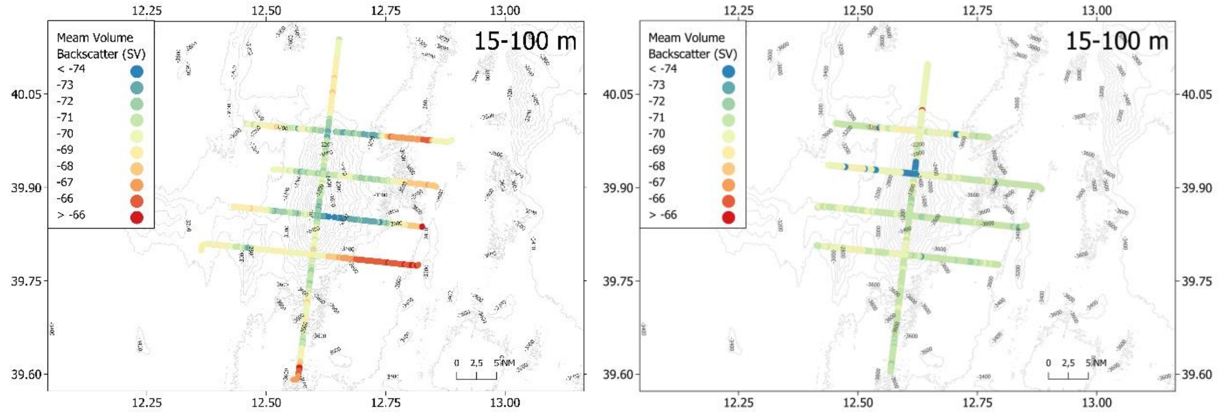

Figure 4 – Mean volume backscattering (volumetric density) of the 15-100 meters layer for the Vercelli seamount during the day (left) and night (right).

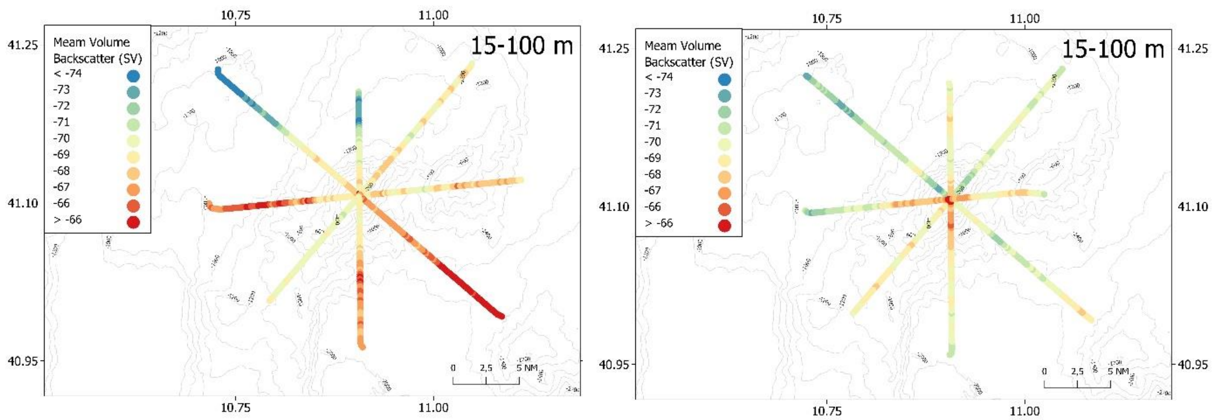

Figure 5 – Mean volume backscattering (volumetric density) of the 15-100 meter layer for the Vercelli seamount during the day (left) and night (right).

6.2 Oceanography

During the PELASeam campaign, a comprehensive suite of oceanographic activities was conducted to measure physical and biogeochemical properties of the water column. These activities included high-resolution profiling using a CTD (Conductivity, Temperature, Depth) system with Niskin bottle water sampling, current velocity measurements from vessel-mounted and lowered ADCPs (Acoustic Doppler Current Profilers), and continuous surface hydrography observations from a thermosalinograph. These systems provided a multi-faceted approach to characterizing the water column and current dynamics.

CTD and Water Sampling

The water mass properties were sampled using a pump-controlled Sea-Bird Electronics SBE 911plus CTD system, consisting of an SBE 9plus CTD Unit and an SBE 11plus V2 Deck Unit, which was deployed to collect high-resolution vertical profiles of key oceanographic properties. The CTD was equipped with primary and secondary sensors, including high-accuracy temperature sensors (SBE 3plus), conductivity sensors (SBE 4C) for salinity calculations, and a Digiquartz® pressure sensor for precise depth measurements. Auxiliary sensors included a dissolved oxygen sensor (SBE 43), a turbidity sensor (WET

Labs ECO), a fluorometer (WET Labs ECO-AFL/FL), a Photosynthetically Active Radiation (PAR) sensor, and an altimeter (04-C) for bottom detection and safe operation near the seafloor.
All sensors were mounted on a Rosette frame with an SBE 32 Carousel Water Sampler, equipped with 24 Niskin bottles for water sampling. This system enabled real-time triggering of Niskin bottles at predefined depths and the simultaneous collection of in-situ water samples and vertical profiles of key oceanographic variables. The entire system was deployed using an electro-mechanical cable connected to an IBERCISA ocean winch, equipped with a slip-ring and a Launch and Recovery System (LARS). This configuration ensured safe deployment and retrieval of the equipment, enabling comprehensive vertical profiling from the surface to near the seafloor.

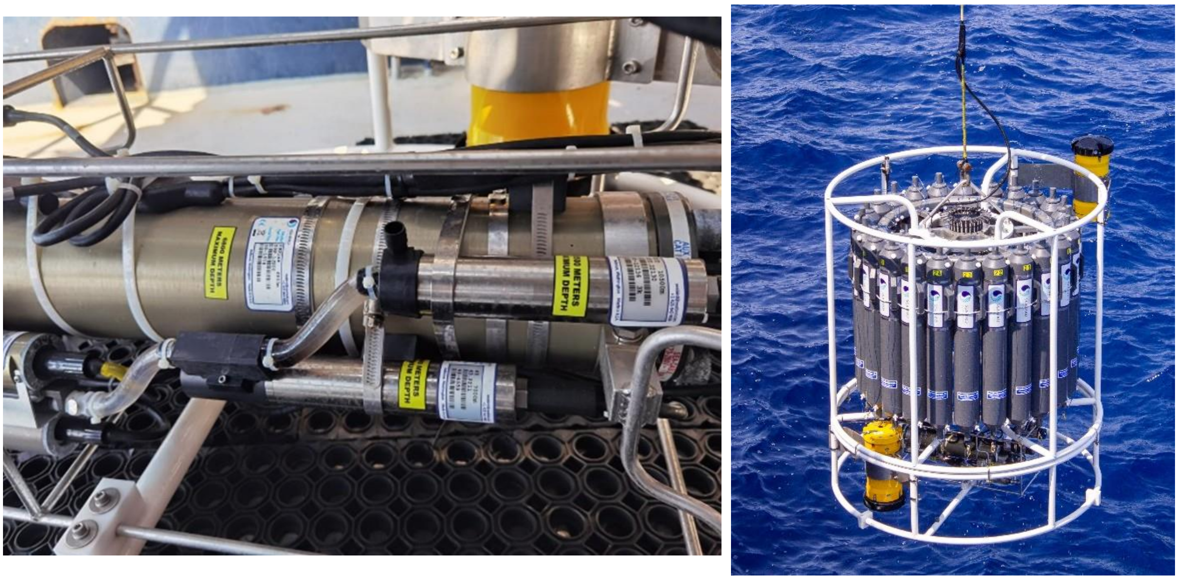

Figure 6 - Details of the CTD sonde with equipped auxiliary sensors (left) and the Rosette frame with the Niskin bottles and the both L-ADCPs (right) used onboard for the characterization of the water column.

32 CTD casts were performed at predefined stations across the seamounts (see Fig. 7), targeting sampling depths from the surface to approximately 5 meters above the seafloor. The raw data collected at 24 Hz were processed using Sea-Bird's SBE Data Processing software. The processing workflow involved several steps to ensure data quality and accuracy. Initially, raw binary data were converted to engineering units, followed by the removal of extreme outliers through the Wild Edit function. A low-pass filter was applied to reduce high-frequency noise, and the Align CTD function corrected for any sensor lag by aligning conductivity with temperature and pressure. The Cell Thermal Mass Correction improved salinity accuracy, and the Loop Edit removed data affected by ship motion. Additional oceanographic variables, such as salinity and density, were calculated using standard equations, and data were converted to thermodynamic variables using the Gibbs Seawater (GSW) Oceanographic Toolbox. Finally, data were averaged at 1-meter intervals to create smoothed vertical profiles. This setup allowed for the simultaneous collection of water samples and in-situ profiling of key oceanographic variables.

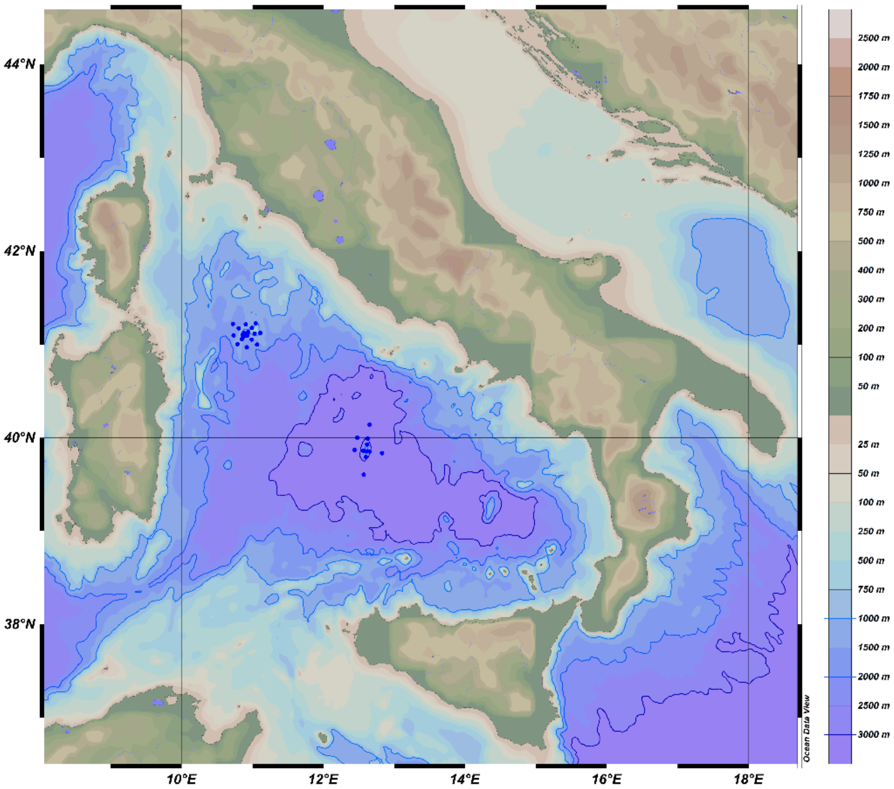

Figure 7 - Bathymetric map of the Tyrrhenian Sea with the sampling stations of the CTD/LADCP casts around both seamounts: Vavilov in the deepest part of central basin and Vercelli in the shallower northern part.

The preliminary assessment, based on onboard processing of CTD and auxiliary data, revealed significant hydrographic differences between the Vavilov and Vercelli Seamounts. Notably, the deep area surrounding the Vavilov Seamount exhibited well-defined and highly stable thermohaline staircases with exceptionally clean high-gradient interfaces and mixed layer thickness up to 400 m.

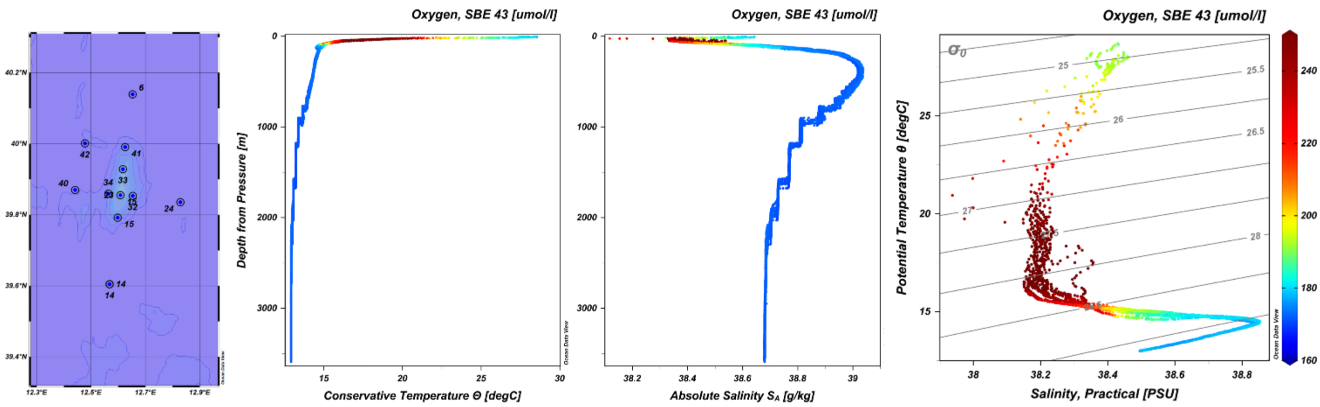

Figure 8 - Overview of the thermohaline and biochemical properties of the sampled stations surrounding the Vavilov Seamount in the central Tyrrhenian Sea. From left to right: Map showing station locations; Conservative temperature profiles color-coded by dissolved oxygen concentrations; Absolute salinity profiles color-coded by dissolved oxygen concentrations; Theta-S diagram with overlaid isopycnals and color-coded by dissolved oxygen concentrations in order to separate the main water masses.

In contrast, the Vercelli Seamount was characterized by stronger, more persistent currents, especially in its shallower northern region. These contrasting hydrodynamic features highlight the influence of the distinct morphological and ecological characteristics of the two seamounts on local oceanographic processes.

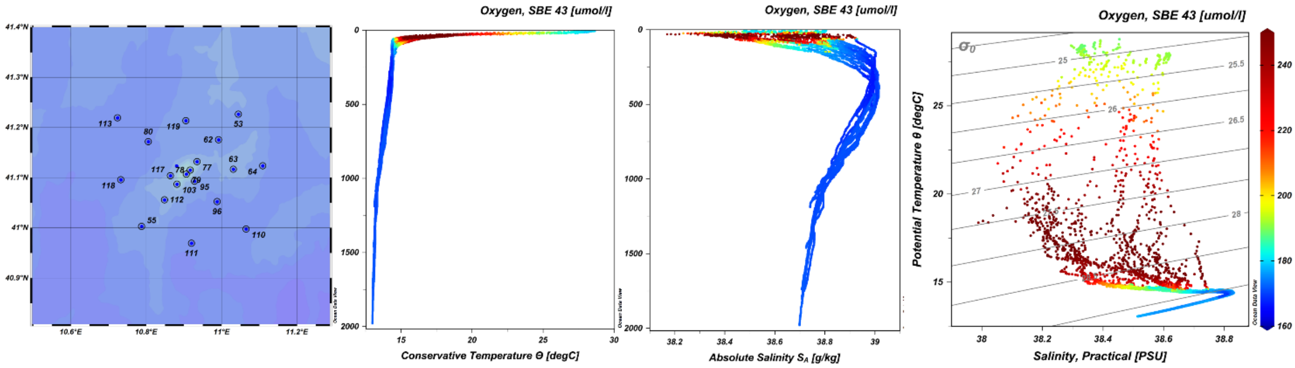

Figure 9 - Overview of the thermohaline and biochemical properties of the sampled stations surrounding the Vercelli Seamount in the northern Tyrrhenian Sea. From left to right: Map showing station locations; Conservative temperature profiles color-coded by dissolved oxygen concentrations; Absolute salinity profiles color-coded by dissolved oxygen concentrations; Theta-S diagram with overlaid isopycnals and color-coded by dissolved oxygen concentrations in order to separate the main water masses.

Lowered Acoustic Doppler Current Profiler (L-ADCP)

The Rosette was equipped with a dual-headed L-ADCP system, featuring two Teledyne RD Instruments (TRDI) Workhorse II ADCPs operating at 300 kHz. One ADCP was mounted downward-looking at the base of the Rosette frame, while the other was mounted upward-looking at the top. This dual configuration enabled the collection of high-resolution vertical profiles of horizontal current velocities throughout the water column. By synchronizing the pinging sequences of the upward- and downward-looking ADCPs, the L-ADCP system extended its profiling range, enabling comprehensive velocity measurements from near the surface to close to the seafloor. These measurements are crucial for understanding key hydrodynamic processes such as upwelling, mixing, and eddy formation, which influence nutrient transport and biological productivity in the region.

L-ADCP data were processed using the IX 15 version of the Lamont-Doherty Earth Observatory (LDEO) MATLAB software, developed by Thurnherr (2024), based on the velocity-inversion method introduced by Visbeck (2002). This approach allows for absolute velocity profiles by integrating data from multiple sources and applying robust processing techniques. The post-processing workflow relied on ADCP and navigational data from each L-ADCP cast. To ensure accuracy, the workflow incorporated depth and sound-speed corrections, with the necessary information derived from CTD measurements of salinity, temperature, and pressure. CTD down- and up-cast data were processed and bin-averaged on a 5-meter vertical grid, ensuring consistency with L-ADCP velocity profiles.

The processing workflow included data synchronization with corresponding CTD measurements and navigational information, speed correction using CTD-derived temperature, salinity, and pressure, and coordinate transformation to convert instrument measurements to Earth-referenced coordinates. The velocity inversion method combined various data sources (ship drift, bottom tracking, and water tracking) to compute absolute velocity profiles. Quality control procedures were implemented to remove erroneous data points caused by instrument malfunctions or environmental interference, and adjustments were made for instrument depth and range limitations to accurately represent the entire water column.

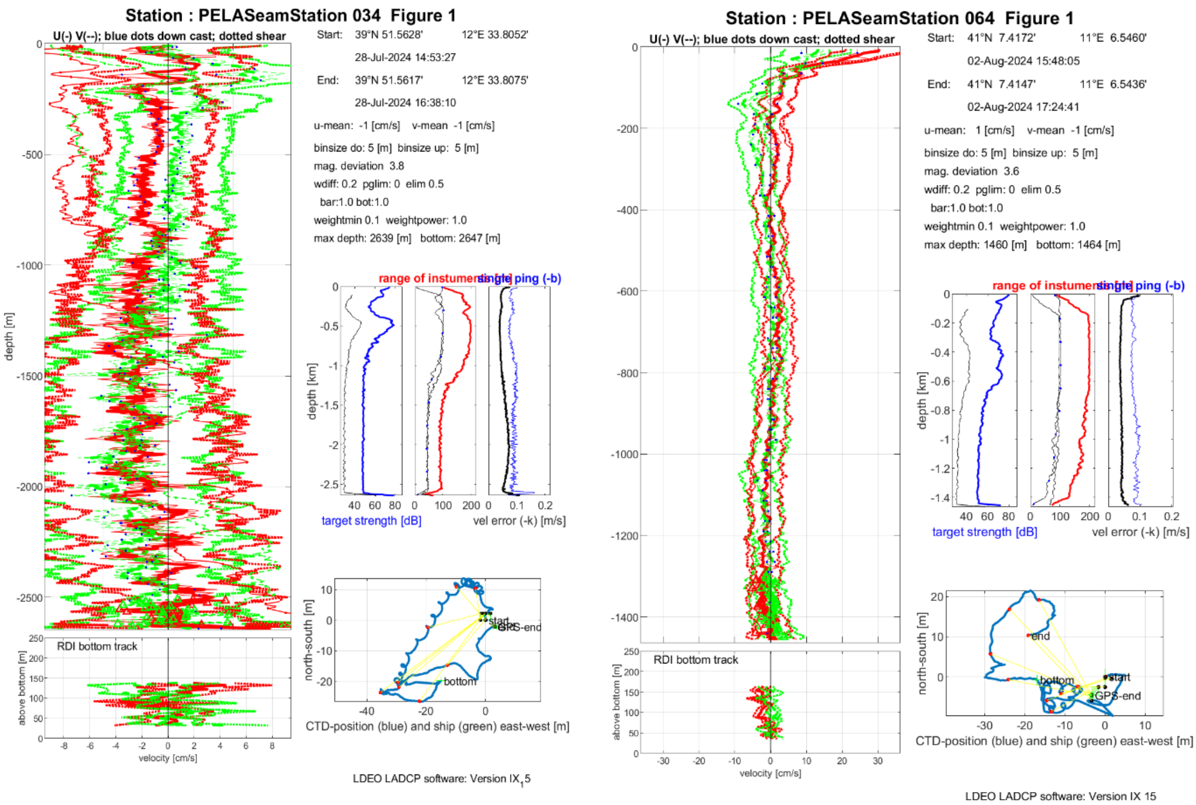

Figure 10 - Overview of characteristic current measurements at the Vavilov (left) and Vercelli (right) Seamounts. Note the high surface current speed up to 30 cm/s in the right panel, which is representative of the strong gyre that persists in the Northen Tyrrhenian Sea

This comprehensive approach to L-ADCP data processing ensured the production of high-quality absolute velocity profiles, enabling a comprehensive analysis of oceanographic processes. These profiles provide essential insights into the physical dynamics of the water column, supporting studies on ocean circulation, eddy dynamics, and water mass transport.

Vessel-Mounted ADCP

A vessel-mounted ADCP observations were also undertaken during the survey to provide continuous fine-scale view of current dynamics near the surface and through the upper portion of the water column. To avoid interference between instruments, the ADCP was paused during EK60 fisheries acoustic surveys, as the simultaneous operation of these systems affected data quality. Despite this limitation, the ADCP provided valuable insights into the hydrodynamic environment around the seamounts.

Two vessel-mounted ADCPs were employed during the campaign:

a Teledyne Pinnacle 45 kHz Phased-Array ADCP and a Teledyne Workhorse Mariner 300 kHz ADCP. The Pinnacle 45 kHz ADCP, operating at a lower frequency, was capable of profiling currents down to approximately 1000 meters, capturing deeper current structures with a compact design. The Workhorse

Mariner 300 kHz ADCP focused on high-resolution profiling in shallower waters, up to about 300 meters depth, with enhanced data quality in the upper 100 meters due to its 4-meter bin size configuration.

Figure 11 - Mounting locations of the two vessel-mounted ADCPs, the Pinnacle 45 kHz and the Workhorse Mariner 300 kHz, on the hull of the R/V Gaia Blu. Photo provided by Giovanni De Vita, Argo S.r.l.

Both ADCPs are hull-mounted on the Gaia Blu, allowing for continuous measurements of horizontal water currents. The data acquisition was managed using the Teledyne RDI Vessel-Mounted Data Acquisition System (VMDAS), which facilitated the configuration of key ADCP parameters and provided synchronized data recording from both ADCPs and ancillary sensors. The VMDAS system organized data storage with a consistent file-naming system, simplifying retrieval and ensuring all data were tagged with a common time base convertible to UTC. Real-time access to data allowed adaptive sampling during the survey, enabling adjustments in response to current structures observed along the transects. Detailed post-processing of the vmADCP data will be conducted using the CODAS3 Software System, which supports data extraction, coordinate assignment, and velocity data editing and correction. This processing step includes adjustments for variations in sound velocity, as well as correction for any misalignment of the ADCP with the vessel's axis, ensuring the highest accuracy in the final velocity profiles.

Thermosalinograph

Continuous surface temperature and salinity measurements were also collected using a thermosalinograph mounted on the vessel, providing additional data on near-surface hydrography.

More specifically, an SBE 21 SeaCAT thermosalinograph was used to collect continuous surface temperature and salinity measurements. Mounted near the ship's seawater intake, the thermosalinograph ensured a constant flow of surface water for accurate measurements. It was connected to an AC-powered interface box near a computer for real-time data output and was equipped with a NMEA 0183 port for appending navigation data.

The instrument provided high-resolution measurements of sea surface temperature, accurate to ±0.001°C, and conductivity, from which salinity is derived, accurate to ±0.0001 S/m. Data were simultaneously stored in internal memory and output in real-time, ensuring data integrity and availability for immediate analysis. These measurements offered additional data on near-surface hydrography, complementing the profiles obtained from the CTD and ADCP instruments.

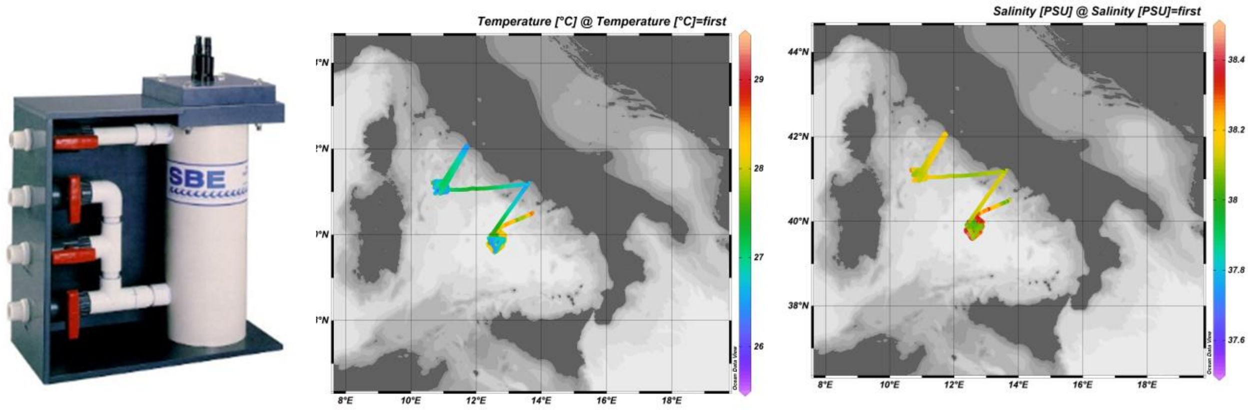

Figure 12 - Representation of the utilized SBE 21 SeaCAT thermosalinograph (left) and the sampled surface values of in-situ temperature (middle) and practical salinity (right) during the PELASeam campaign.

6.3 Water sampling

Water sampling was a key activity of the survey and was conducted to support three primary research objectives: the analysis of nutrients, phytoplankton, and environmental DNA (eDNA) metabarcoding. These analyses aimed to characterize the physical and biological properties of the water column at the surveyed seamounts, providing crucial data on the underlying mechanisms driving productivity, biodiversity, and trophic interactions in these ecosystems.

Water samples were collected using a CTD rosette system equipped with 24 Niskin bottles, allowing precise collection at predetermined depths. Sampling depths were selected to target key oceanographic features and were generally consistent across stations. For nutrient and phytoplankton analyses, water was collected from four primary depths: the surface (to capture upper-layer processes), the limit of the euphotic zone (representing the lower boundary of light availability for photosynthesis), the deep chlorophyll maximum (DCM, where phytoplankton concentrations are typically highest), and near the bottom (to capture nutrient dynamics and processes influenced by benthic-pelagic coupling). For eDNA analysis, samples were taken from the surface, the DCM, the deep scattering layer (DSL, as identified through acoustic surveys), and occasionally near the bottom.

Nutrient Analysis

Samples for nutrient analysis were filtered using GF/F Whatman filters (25 mm, nominal pore size 0.7 µm) and stored in polyethylene vials for subsequent laboratory processing. Key parameters, including ammonium (NH_4), nitrite (NO_2), nitrate (NO_3), orthophosphate (PO_4), and orthosilicate (SiO_4), will be analyzed colorimetrically (following Ivančić & Degobbis, 1984; Parsons et al., 1985) using an AxFlow QuAAtro AutoAnalyzer.

Nutrient concentrations will provide valuable insights into nutrient availability and distribution throughout the water column. These data will aid in identifying areas of enhanced primary productivity, nutrient cycling, and potential upwelling or mixing processes associated with the seamounts.

Phytoplankton and Chlorophyll Analysis

Water samples for phytoplankton analysis were preserved immediately upon collection in 4% buffered formaldehyde and stored for species composition analysis. Water samples for chlorophyll concentration analysis were filtered using F/F Whatman filters (25 mm, nominal pore size 0.7 µm). Filters were kept frozen (-20°) for subsequent laboratory analysis. Fluorescence data from the CTD sensors will be used to complement these samples, helping to identify the vertical structure of phytoplankton communities. The analysis of phytoplankton from different depths will help to identify any productivity patterns around the seamounts, particularly the extent to which these features enhance local phytoplankton growth through physical or biogeochemical mechanisms.

Environmental DNA

Water samples for eDNA metabarcoding were transferred from Niskin bottkes into 10 L carboys that had been bleach-sterilized on land as per NBFC Spoke 1 protocols, and that were subjected to a triple rinsing immediately prior to water collection. Carboys were moved to the wet lab, where filtering station had already been prepared and reserved to the three biological replicates of each depth quota. Water was filtered using swinnex filter holders loaded with 47 mm, 0.45 µm mesh polyethersulfone (PES) filter membranes, a vacuum pump and 4 L polypropylene heavy-duty vacuum bottles. The filtering criteria was set according to NBFC Spoke 1, i.e. 4 L volume or the maximum volume that could be filtered within 20 minutes. In total, 975.5 liters of water were filtered for eDNA collection in triplicates from 25 CTD stations (11 at Vavilov and 14 at Vercelli seamounts). The dataset is overall composed of 265 unique samples including negative controls. The range of DCM and DSL depths from which water was samples was 83-100 and 375-470 m at Vavilov seamount, and 60-102 and 35-460 m at Vercelli seamount. The maximum targeted depths at Vavilov and Vercelli seamounts were 2991 and 1751 m. The filters were then preserved at –20 °C for metabarcoding analysis, which will identify the diversity and composition of the pelagic communities at the seamounts. Consistent sampling at the surface, DCM, DSL, and bottom layers targeted specific habitats and depth-related assemblages, enabling qualitative comparisons of biodiversity metric across the water column or among stations. The integration of eDNA data with net sampling and acoustic observations will provide a comprehensive view of the community structure and dynamics.

Sampling Approach and Challenges

The sampling depths were selected based on in-situ observations, such as fluorescence and acoustic signals, ensuring that key oceanographic features were adequately captured. The rosette deployment was coordinated to avoid contamination and ensure high-quality samples.

Figure 13 - Water sampling operations and filtration in the wet lab for eDNA analysis

6.4 Net sampling

Plankton and micronekton were sampled at fixed plankton stations along the various transects using a WP2 net and tucker trawl. The sampling with both nets was conducted at night to avoid potential avoidance from the more mobile organisms. The WP2 is a vertical plankton net with a 57 cm diameter stainless steel ring and a 1.7 m long net bag (mesh size: 200 µm) and it is designed to sample mesozooplankton. The net was equipped with a mechanical flowmeter and temperature/depth data logger. The WP2 was deployed to a maximum depth of 150 m or at the bottom depth if bottom was less than 150 m. At each station, position, date, time, seabed depth, sampled depth (retrieved from data logger after deployment) and flowmeter reading were recorded. Samples were evenly split into 2 parts. One half was preserved in pure ethanol for metabarcoding analysis and the second half was further split into two parts. One part was filtered and kept frozen for biomass estimation (dry weight) and the other was preserved with 4% buffered formaldehyde for taxonomic analysis. During the second leg on each station the WP2 was deployed twice. The sample from the first cast was processed as described above while the sample from the second cast was kept frozen for microplastics analysis.

The tucker trawl was used to target ichthyoplankton and macrozoplankton from discrete depth strata. The Tucker trawl is a specialized, fine-mesh sampling net (500 μm) designed for stratified oblique or horizontal tows, allowing the collection of uncontaminated samples from specific layers of the water column. It consists of a squared rigid frame of 1 m^2 that supports the net structure and ensures stability during deployment and towing of three separate nets, each capable of independent operation via remotely controlled opening and closing mechanisms through the use of a messenger. Each net was terminated with a cod end, where collected organisms were concentrated for retrieval and analysis. The trawl was lowered to predetermined depths based on the identified scattering layers observed via onboard acoustic monitoring systems. The depth strata to sample were chosen based on the distribution of the scattering layers observed on the EK60 echosounder. The first depth stratum ranged between 300-600 m (depth of the Deep Scattering Layer). The second depth stratum ranged between 150-300 m and the third one between the surface and 150 m. Tow speed and duration, when possible, were standardized to ensure consistency across all sampling efforts. The Tucker trawl tracks conducted over the seamounts are shown in Figure 14. Samples collected using the Tucker trawl were preserved with 4% buffered formaldehyde for further taxonomic analysis. Figure 15 shows the deployment of the WP2 and tucker trawl carried out by the scientific staff. Some examples of the samples collected with the tucker trawl are shown in figure 16.

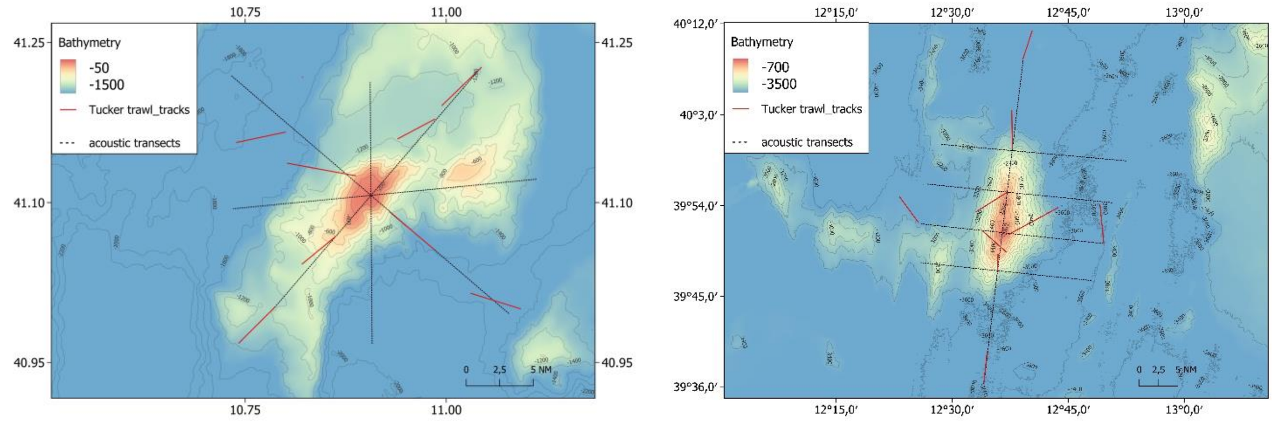

Figure 14 - Maps of the Tucker trawl tracks at the Vavilov (left) and Vercelli (right) seamounts.

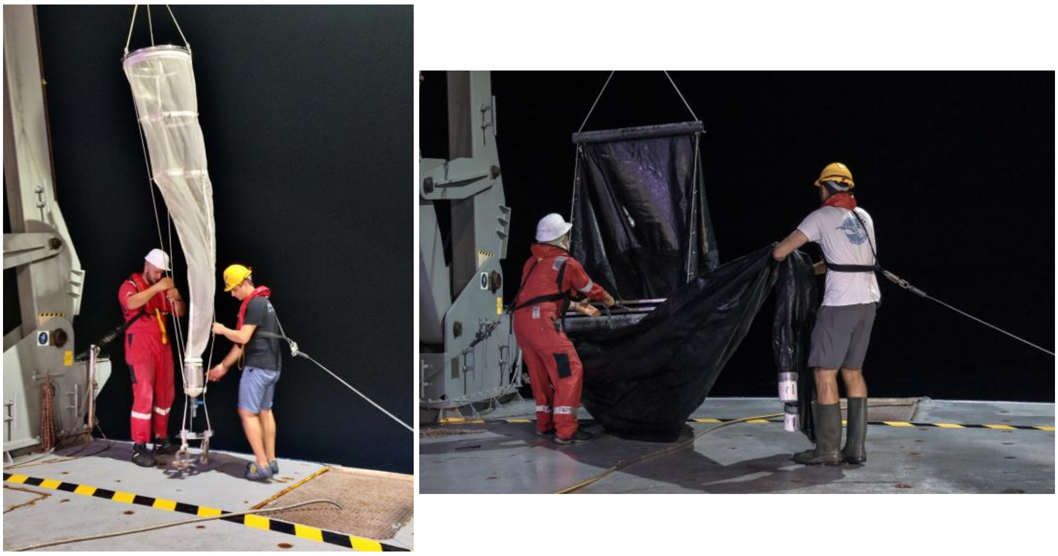

Figure 15 - Deployment of WP2 (left) and Tucker trawl (right)

Figure 16 - Examples of the samples collected using the Tucker trawl

6.5 Marine mammals and seabirds observation

Marine megafauna data were collected during daily visual observations following standardised protocols from ACCOBAMS (for cetaceans) and the European Seabirds At Sea (ESAS).

Marine megafauna observations was conducted along the acoustic transects at Vercelli and Vavilov seamounts during daytime following standardised protocols from ACCOBAMS (for cetaceans) and the European Seabirds At Sea (ESAS). The activity was carried out by 2 trained observers from the portside bridge of the R/V Gaia Blu. Observations focused on an arc of approximately 180°and alternated between either naked eyes or with binoculars. For each observation were recorded operational parameters (starting and ending hours) coordinate and sea state (Beaufort scale). Upon a marine megafauna sighting, the following information were recorded: species, number of individuals and distance from the vessel. A total of 24 hours of observation effort were made during approximately 7 days. The observations at Vercelli Seamount (Figure 1) were carried out along radial acoustic transects extending outward from the summit of the seamount. Visual sightings were mapped along these transects, revealing the presence of species such as *Calonectris diomedea* (Scopoli's shearwater), *Caretta caretta* (loggerhead sea turtle), and *Grampus griseus* (Risso's dolphin). Sighting intensity, represented by symbol size on the map, showed higher concentrations of *C. diomedea* on the western transect and scattered occurrences of the other species throughout the area. At Vavilov Seamount (Figure xxx), visual observations followed linear transects crossing the seamount's peak and flanks. Similar to Vercelli, *C. diomedea* was the most frequently observed species, with notable concentrations along the northern transects. Loggerhead sea turtles (*C. caretta*) and Risso's dolphins (*G. griseus*) were observed in smaller numbers. The visual observations provided valuable insights into the presence and activity of marine mammals and seabirds in the vicinity of the seamounts. However, the data collected represents only a snapshot of the ecosystem dynamics during the survey period. The observed patterns, require further verification through additional sampling efforts. To achieve a comprehensive assessment of marine mammal and seabird populations and their ecological roles in

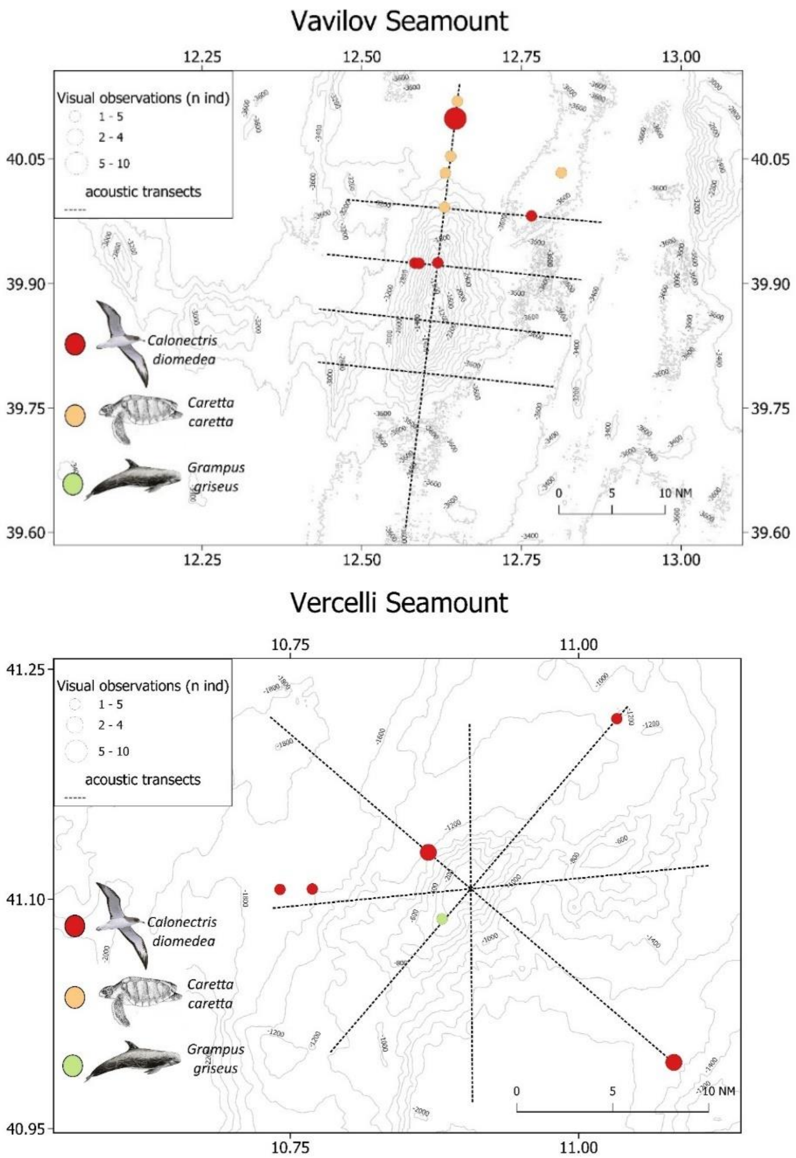

Figure 17 - Maps of the distribution of megafauna detected during the visual observation.

these regions, more extensive and systematic observation efforts are needed. These should include expanded temporal and spatial coverage.

6.6 BRUVS

Pelagic BRUVS (Baited Remote Underwater Video System) were deployed near the surface to capture the presence and estimate relative density of large pelagics at the seamounts and away from it. BRUVS consisted of a stainless steel frame equipped with a metal cage (20Lx10Wx10H cm) containing a fixed amount of bait (500 g of *Sardina pilchardus*) and placed at a standardized distance of 1.2 m from one camera (Water Wolf UW 2.0; 1920x1080p, 30 FPS). Each BRUV was attached to a surface buoy and to a weight of ~6 kg to reduce the drifting of the rig. The BRUV was suspended at a depth of about 20 m from the surface using a sub-surface buoy placed at a distance of about 5 m above the system to reduce movement due to wave action. For each station a set of 2-4 cameras were deployed at a distance of 500 m between each other. The number of cameras deployed depended on time availability and weather conditions. BRUVS soaking time was about 3 hours during which the boat moved away from the sampling site to avoid any effect of noise or shade. A schematic of the design of BRUVS setup is shown in Figure 18. The camera rigs were equipped with a passive acoustic recorder (URec-384k, Max sampling rate 384 Hz) to identify the potential presence of marine mammals in the study area. Map of the station sampled using the BRUVS is shown in Figure 19.

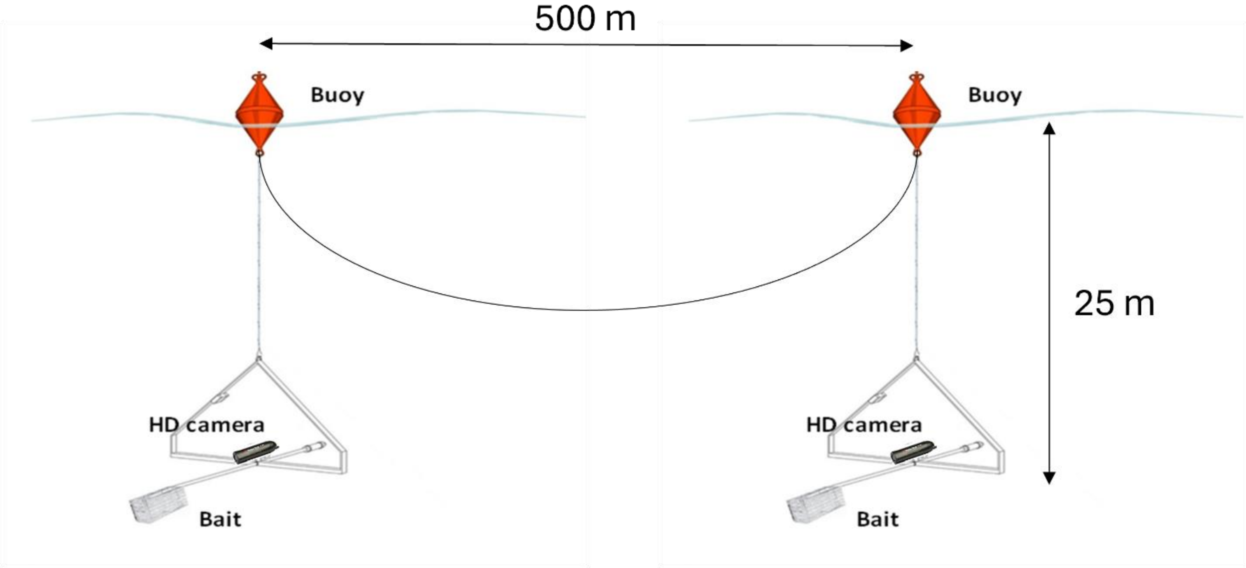

Figure 18 - Pelagic BRUVS systems schematics.

Some examples of the video frames captured during the sampling is shown in Figure 20.
The video will be analysed using the open-source software VLC. For each replicate, some response variables will be recorded as: *MaxN* (the maximum number of individuals of the same species observed in a single video frame) a conservative metric used to estimate the relative abundance of the species avoiding counting repetitively the same individual (Whitmarsh et al., 2017) and species richness. Additionally, for each pelagic species encountered during the video analysis, behavioural aspects such as the Time of First Arrival (TFA) in the field of view, the Time of First Feeding (TFF) at the bait and the number of sightings will be considered.

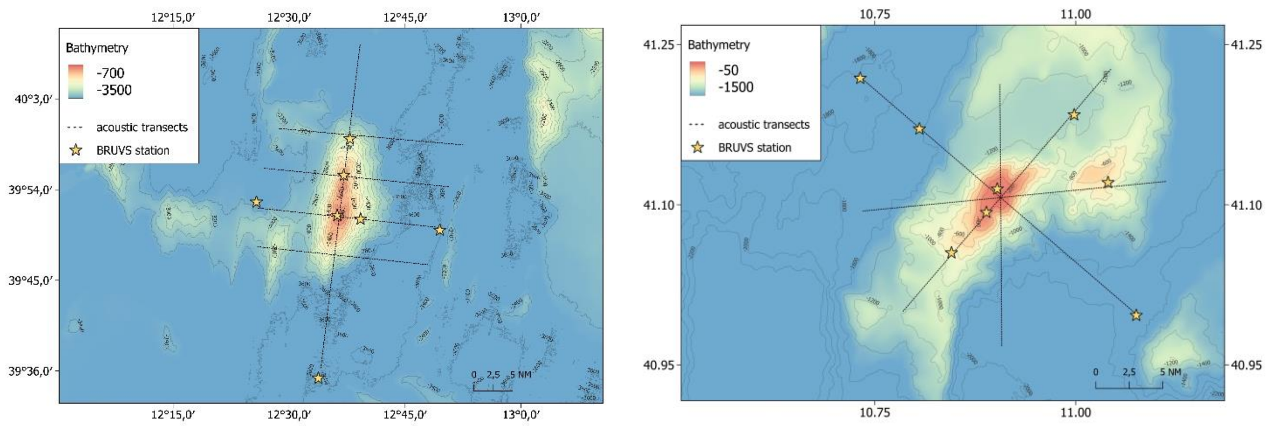

Figure 19 - Maps of the location of the BRUVS deployment

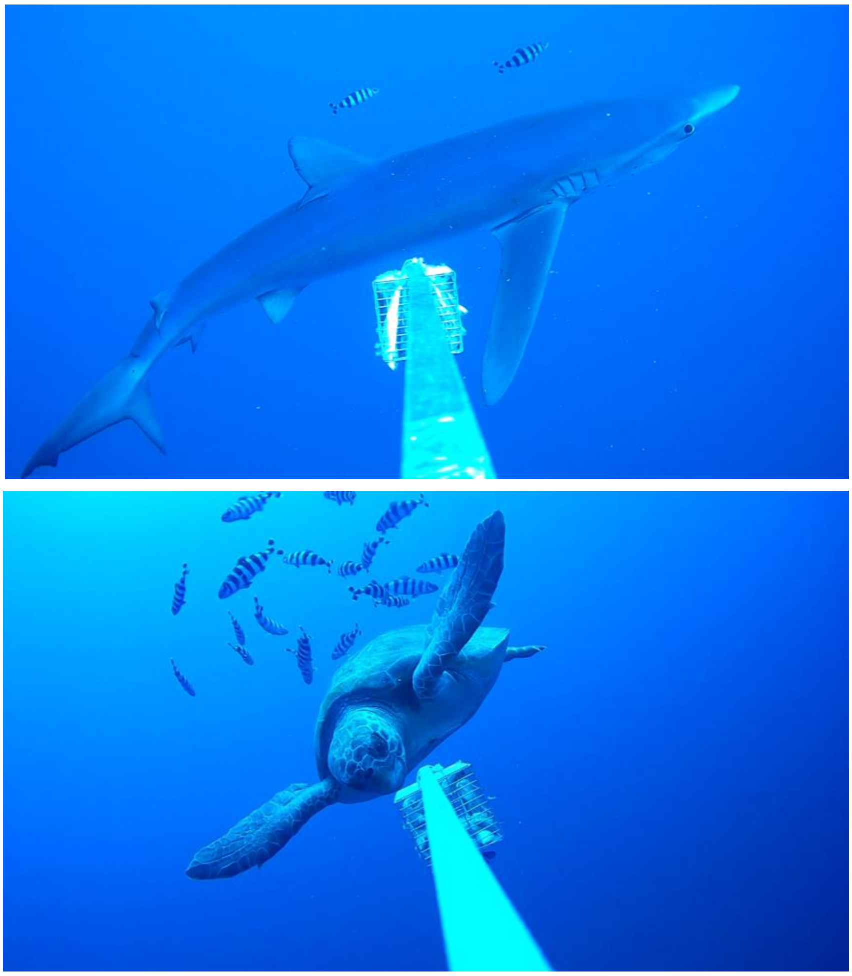

Figure 20 - Some examples of video frames captured during the BRUVS deployment

6.7 Multibeam

During the second leg of the PELASeam oceanographic campaign, a multibeam echosounder (MBES) survey was conducted near the summit of the Vercelli Seamount with two objectives. The main goal was to enhance and integrate the fishery acoustic data collected by the Simrad EK60 scientific echosounder with water column backscatter data acquired by the MBES, performing simultaneous and combined surveys from both systems. In order to cover additional vessel time, a secondary survey was carried out to collect high-resolution morphobathymetric data of the Vercelli seafloor. Both surveys employed two hull-mounted multibeam systems, the Kongsberg EM2040, used for shallow waters, and EM712 installed on the vessel's keel (Fig. 21). The MBES configurations used during the survey are detailed in Table 2.

Figure 21 - Keel-mounted installation of EM2040 and EM712 MBES systems on GAIA BLU N/R (left: starboard side, right: port side). Photo credit: Giovanni De Vita, Argo S.r.l.

Table 2 – EM2040 and EM712 MBES settings used during the survey.

Configuration setting	**EM2040**	**EM712**
Frequency	200 kHz / 300kHz	70-100 kHz
Angular coverage mode	Manual	Manual
Swath angle	65° / 70°	65° / 70°
Beam spacing	Equidistance	Equidistance
Dual swath mode	Dynamic	Dynamic
Depth setting	Deep	Shallow
Max ping rate	2 Hz	2 Hz

Positioning and motion correction were ensured by a Kongsberg Seapath 380 with Fugro Marinestar™ NV HP DGPS (GNSS accuracy <10 cm) and Kongsberg Discovery Motion Reference Unit (MRU) 5 for real-time attitude corrections (roll, pitch, yaw, and heading). A Kongsberg K-Sync system was used to synchronize MBESs and EK60 acquisitions, preventing interferences between instruments. Data were recorded via the Kongsberg System Information Seafloor (SIS 5) software and navigation support was provided by QPS (Quality Positioning Services) QINSy software. Continuous sound velocity monitoring at the MBES heads was performed using a miniSVS (Sound Velocity Sensor), and daily Sound Velocity Profiles (SVPs) were obtained using the Valeport MIDAS SVP system to account for variations in sound propagation caused by density and temperature changes. Before each acquisition, system calibration included verifying alignment between the Seapath 380 system, attitude sensors, and transducers, as well as conducting path tests to ensure accurate seabed profiling using navigation lines with varying orientations and speeds. Navigation plan for combined EK60 and MBES acquisitions (Fig. 22) covered a total area of about 16 km2, with 9 transects counting a mean length of 5.4 km and a total length of about 48.7 km. For morphobathymetric mapping, navigation plan (Fig. 22) covered a total area of about 20 km2, comprising 16 transects of a mean length of 6 km and a maximum distance range between transects of 0.3 km to ensure a minimum overlapping coverage of 20%.

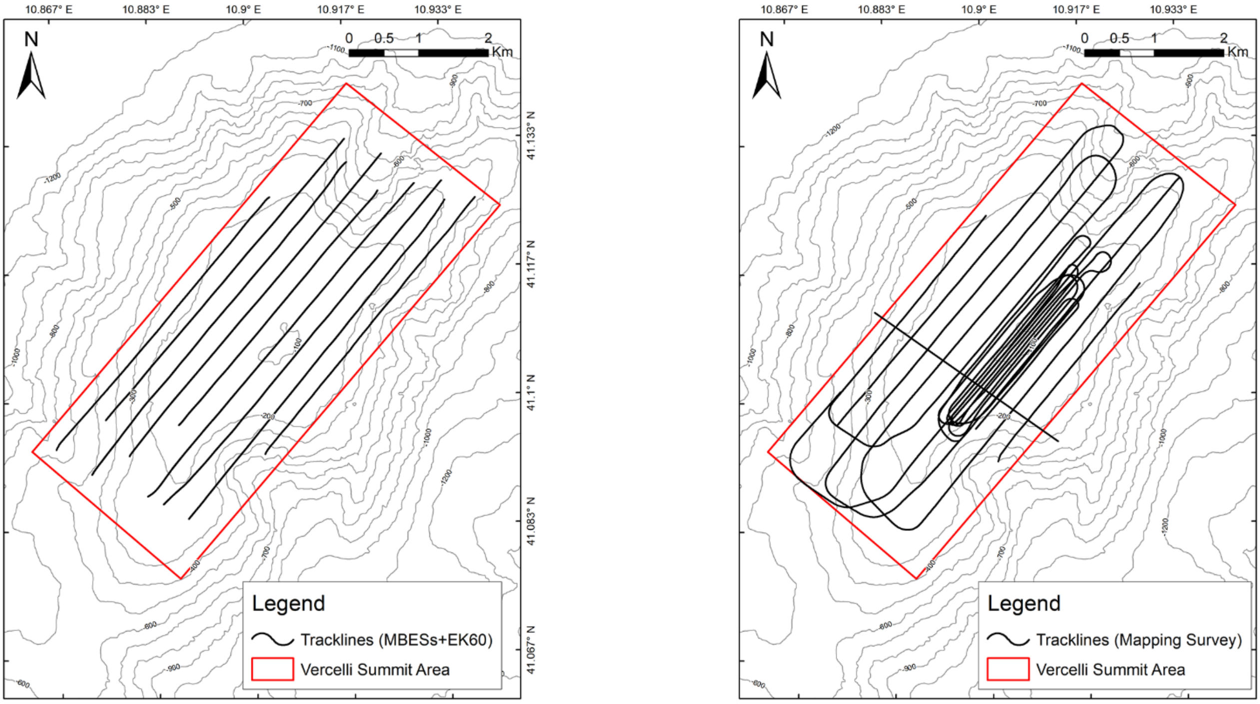

Figure 22 - Navigation tracklines for MBES surveys over the Vercelli Seamount summit area: combined MBES+EK60 survey (left) and seafloor mapping (right).

7 Conclusions and future work

The survey conducted on the Vavilov and Vercelli seamounts provided a preliminary understanding into the structure, dynamics, and biodiversity of their pelagic ecosystems. These seamounts, with their distinct morphological and oceanographic characteristics, serve as focal points for enhanced biological productivity and biodiversity, making them critical sites for further study. The preliminary analysis on the data collected during this survey highlighted the importance of these underwater structures in supporting complex trophic interactions and attracting a wide range of marine life.

The initial analysis of data indicates significant biological activity, with observable diel vertical migration patterns and potential trophic linkages between prey species and top predators. Acoustic data highlighted areas of increased scattering layer density, suggesting zones of enhanced biological activity potentially linked to the seamount-induced hydrodynamic processes. Visual observations of marine mammals and seabirds further confirmed the ecological importance of these areas. Key datasets still require thorough processing and analysis to validate the preliminary findings and address the survey's broader research questions.

To build on this work, further surveys are essential. Repeated expeditions across different seasons will provide crucial information on temporal variability in pelagic ecosystems, including seasonal shifts in productivity, species composition, and trophic interactions. Expanding the coverage of future surveys to other seamounts will also be critical to understanding how seamount ecosystems may interact with each other and the surrounding marine habitats. Additionally, integrating advanced technologies, such as autonomous underwater vehicles (AUVs), remotely operated vehicles (ROVs), will improve data resolution and allow for deeper investigations into seamount dynamics.

Collaboration with regional and international research initiatives could enhance the scope and impact of future work. By sharing data and methodologies, scientists can build a more comprehensive understanding of Mediterranean seamount ecosystems and their role in global marine biodiversity. Efforts to engage with policymakers and stakeholders will also be necessary to translate scientific

findings into effective management and conservation strategies. Seamounts are highly vulnerable to anthropogenic pressures, including overfishing and climate change, making it critical to prioritize their protection within marine protected areas (MPAs) and sustainable management frameworks.
In conclusion, while this survey represents an important step toward a better understanding of the ecological role of the Vavilov and Vercelli seamounts, it also highlights the considerable work that remains.

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9 Acknowledgements

The PELASeam survey was a collective effort made possible by the dedication and collaboration of scientists and technicians from various organizations, including CNR IRBIM, CNR ISMAR, OGS, UNIVPM, and UNIPA. In particular we would like to thank Valentina Tirelli and Diego Borme (OGS), Elisa Camatti (CNR ISMAR), Marco Milazzo (UNIPA), Pierpaolo Falco and Cecilia Totti (UNIVPM), Mario La Mesa (CNR ISP) and Pierluigi Penna (CNR IRBIM) for their invaluable support, expertise, and funding, as well as their contributions to the survey design. We extend our heartfelt gratitude to the captain and crew of the R/V Gaia Blu for their exceptional professionalism and support in ensuring the success of this expedition, even in the face of challenging conditions and logistical difficulties.

Finally, we are grateful to the National Biodiversity Future Center (NBFC) and its partner organizations for their support and funding, which made this ambitious scientific survey possible.

Funder: Project funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.4 - Call for tender No. 3138 of 16 December 2021, rectified by Decree n.3175 of 18 December 2021 of Italian Ministry of University and Research funded by the European Union – NextGenerationEU;

Award Number: Project code CN_00000033, Concession Decree No. 1034 of 17 June 2022 adopted by the Italian Ministry of University and Research, CUP B83C22002930006, Project title “National Biodiversity Future Center - NBFC” .

10 Annexes

10.1 Annex 1: Sample metadata per activity

10.1.1 BRUVs

Seamount	Prime station number	Date	Start time (UTC)	Start Latitude	Start Longitude	Depth
Vavilov	VAV_8	27/07/2024	05:50	39°35.25'	12°33.77'	3600
Vavilov	VAV_5	27/07/2024	05:20	39°51.44'	12°36.22'	1028
Vavilov	VAV_9	27/07/2024	12:48	39°49.98'	12°49.48'	3600
Vavilov	VAV_10	28/07/2024	05:19	39°51.07'	12°39.23'	2200
Vavilov	VAV_4	28/07/2024	10:15	39°55.42'	12°37.06'	1340
Vavilov	VAV_12	29/07/2024	04:23	39°52.77'	12°25.77'	3550
Vavilov	VAV_3	29/07/2024	11:45	39°59.02'	12°37.86'	2630
Vercelli	VER_2	02/08/2024	05:42	41°11.05'	10°59.88'	1235
Vercelli	VER_18	02/08/2024	11:00	41°07.25'	11°02.41'	946
Vercelli	VER_5	03/08/2024	08:37	41°06.89'	10°54.14'	164
Vercelli	VER_12	03/08/2024	15:56	41°10.26'	10°48.33'	1700
Vercelli	VER_13	05/08/2024	14:04	41°05.57'	10°53.33'	190
Vercelli	VER_16	06/08/2024	05:36	40°59.78'	11°04.52'	ND
Vercelli	VER_11	06/08/2024	14:45	41°13.10'	10°43.91'	ND
Vercelli	VER_7	07/08/2024	04:39	41°03.30'	10°50.72'	ND

10.1.2 WP2

Seamount	Prime station	Date	Depth station	Time (UTC)	Depth deployment
Vavilov	VAV_5	25/07/2024	900	21:55	150
Vavilov	VAV_6	26/07/2024	2435	1:18	150
Vavilov	VAV_1	26/07/2024	3586	20:13	150
Vavilov	VAV_3	26/07/2024	2799	23:42	150
Vavilov	VAV_4	27/07/2024	1341	2:47	150
Vavilov	VAV_12	27/07/2024	3493	19:26	150
Vavilov	VAV_11	27/07/2024	2497	22:34	150
Vavilov	VAV_10	28/07/2024	2335	1:14	150
Vavilov	VAV_9	28/07/2024	3597	20:05	149
Vavilov	VAV_8	29/07/2024	3599	0:35	149
Vavilov	VAV_13	29/07/2024	3237	19:23	149
Vercelli	VER_15	31/07/2024	1591	0:41	150
Vercelli	VER_15	31/07/2024	1591	0:54	149
Vercelli	VER_14	31/07/2024	800	2:56	150.12
Vercelli	VER_14	31/07/2024	800	3:07	149.9
Vercelli	VER_8	01/08/2024	1213	21:16	147.4
Vercelli	VER_8	01/08/2024	1213	21:27	146.99
Vercelli	VER_7	02/08/2024	778	0:16	149.89
Vercelli	VER_6	02/08/2024	778	2:44	149.9
Vercelli	VER_1	02/08/2024	1175	18:48	147.7
Vercelli	VER_1	02/08/2024	1175	18:59	147.7
Vercelli	VER_2	02/08/2024	1236	20:57	150.6
Vercelli	VER_2	02/08/2024	1236	21:10	150.7
Vercelli	VER_3	03/08/2024	2799	0:43	149.03
Vercelli	VER_3	03/08/2024	2799	0:53	149.2
Vercelli	VER_4	03/08/2024	157	1:47	140.5
Vercelli	VER_4	03/08/2024	157	1:57	139.4
Vercelli	VER_5	03/08/2024	97	2:31	57.4
Vercelli	VER_5	03/08/2024	97	2:39	57.4
Vercelli	VER_11	03/08/2024	1808	20:17	151.42
Vercelli	VER_11	03/08/2024	1808	20:28	152
Vercelli	VER_16	04/08/2024	1711	19:23	148.4
Vercelli	VER_16	04/08/2024	1711	19:49	150.5
Vercelli	VER_12	05/08/2024	1707	23:02	150.9
Vercelli	VER_12	05/08/2024	1707	23:14	151
Vercelli	VER_13	06/08/2024	583	0:08	150
Vercelli	VER_13	06/08/2024	583	0:20	149.2
Vercelli	VER_6	06/08/2024	223	20:21	148
Vercelli	VER_7	06/08/2024	778	21:08	150.77

10.1.3 Tucker Trawl

Seamount	Prime station	Date	layer net 1	layer net 2	layer net 3	lat net 1	lon net 1	lat net 2	lon net 2	lat net 3	lon net 3
Vavilov	VAV_5	25/07/2024	500	250	150	39°52.28'	12°36.4735'	ND	ND	ND	ND
Vavilov	VAV_6	26/07/2024	500	300	200	39°47.5560'	12°35.8809'	ND	ND	39°49.116'	12°35.927'
Vavilov	VAV_1	26/07/2024	500	300	150	40°09.2344'	12°39.6303'	40°10.3471'	12°40.0640'	40°10.8056'	12°40.2038'
Vavilov	VAV_3	27/07/2024	500	300	150	40°00.4452'	12°37.8046'	40°01.6894'	12°37.7327'	40°02.4784'	12°37.7327'
Vavilov	VAV_4	27/07/2024	500	300	150	39°54.783'	12°36.094'	39°54.253	12°34979'	39°53.827'	12°34.045'
Vavilov	VAV_12	27/07/2024	500	300	150	39°52.3205'	12°25.6307'	ND	ND	39°54.8470'	12°23.2244'
Vavilov	VAV_11	27/07/2024	500	300	150	39°50.9574'	12°34.6467'	39°50.479'	12°35.304'	39°49.952'	12°36.117'
Vavilov	VAV_10	28/07/2024	500	300	150	39°51.600'	12°40.111'	39°52.4014'	12°41.4097'	39°52.7487'	12°41.9617'
Vavilov	VAV_9	28/07/20224	600	300	150	39°51.5127'	12°49.4137'	39°52.7123'	12°49.2881'	39°53.702'	12°49.2067'
Vavilov	VAV_8	29/07/2024	600	300	150	39°37.519'	12°34.436'	39°38.606'	12°34.374'	39°39.468'	12°34.513'
Vercelli	VER_15	31/07/2024	500	300	150	41°04.48'	10°58.120'	41°04.5659'	10°57.2209'	41°09.9657'	10°56.5970'
Vercelli	VER_8	01/08/2024	450	300	150	40°45.533'	10°41.507'	40°57.055'	10°45.853'	40°58.0929'	10°44.530'
Vercelli	VER_7	02/08/2024	430	300	150	41°03.30'	10°50.76'	41°02.86'	10°50.14'	41°02.5476	10°49.8610'
Vercelli	VER_1	02/08/2024	450	300	150	41°12.927'	11°2.6092'	ND	ND	41°11.903'	11°0.305'
Vercelli	VER_2	02/08/2024	ND	ND	ND	41°10.63'	10°57.600'	41°09.728'	10°56.747	41°09.5902'	10°56.4019'
Vercelli	VER_3	02/08/2024	ND	ND	ND	ND	ND	41°08.102'	10°56.118'	ND	ND
Vercelli	VER_4	03/08/2024	ND	ND	ND	41°07.633'	10°55.747'	ND	ND	ND	ND
Vercelli	VER_11	03/08/2024	450	300	150	41°13.100	10°43.513	41°13.137	10°42.724'	41°13.156	10°41.748
Vercelli	VER_12	03/08/2024	450	300	150	41°09.962'	10°48.010'	41°09.8553'	10°46.970	41°09.7333	10°46.0977'
Vercelli	VER_13	04/08/2024	400	300	150	41°07.843'	10°51.435'	41°07.9521'	10°50.4768'	41°08.051'	10°49.572'
Vercelli	VER_16	06/08/2024	450	300	150	41°00.026'	11°04.303'	41°00.5076'	11°02.8807'	41°00.6086'	11°02.600'

10.1.4 CTD

Seamount	prime station number	Date	Start time (UTC)	eDNA	nutrients	phytoplankton	depth start
Vavilov	VAV_1	25/07/2024	10:24	y	y	y	3580
Vavilov	VAV_8	26/07/2024	7:32	n	n	n	3504
Vavilov	VAV_8	26/07/2024	12:32	y	y	y	3503
Vavilov	VAV_6	26/07/2024	14:49	y	y	y	2623
Vavilov	VAV_5_test	27/07/2024	6:29	n	n	n	856
Vavilov	VAV_5	27/07/2024	8:05	y	y	y	856
Vavilov	VAV_9	27/07/2024	13:20	y	y	y	3522
Vavilov	VAV_10	28/07/2024	6:29	y	y	y	2485
Vavilov	VAV_4	28/07/2024	10:38	y	y	y	1404
Vavilov	VAV_11	28/07/2024	11:31	y	y	y	2600
Vavilov	VAV_12	29/07/2024	6:20	y	y	y	3505
Vavilov	VAV_3	29/07/2024	12:31	y	y	y	2800
Vavilov	VAV_13	29/07/2024	16:46	y	y	y	3204
Vercelli	VER_1	01/08/2024	15:57	y	y	y	1190
Vercelli	VER_8	01/08/2024	19:52	y	y	y	1225
Vercelli	VER_2	02/08/2024	6:38	y	y	y	1168
Vercelli	VER_18	02/08/2024	11:52	y	y	n	667
Vercelli	VER_17	02/08/2024	15:48	n	n	n	1458
Vercelli	VER_3	03/08/2024	6:18	n	n	n	604
Vercelli	VER_4	03/08/2024	7:38	n	n	n	164
Vercelli	VER_5	03/08/2024	9:18	y	y	y	65
Vercelli	VER_12	03/08/2024	14:26	y	y	y	1734
Vercelli	VER_14	04/08/2024	15:03	y	y	y	956
Vercelli	VER_15	04/08/2024	16:59	y	y	y	1596
Vercelli	VER_13	05/08/2024	13:01	y	y	y	653
Vercelli	VER_6	05/08/2024	14:58	y	y	n	220
Vercelli	VER_16	06/08/2024	6:26	y	y	y	1756
Vercelli	VER_9	06/08/2024	9:43	n	n	n	1982
Vercelli	VER_7	06/08/2024	12:17	y	y	y	7999.9
Vercelli	VER_11	06/08/2024	15:25	y	y	y	1804
Vercelli	VER_19	07/08/2024	11:26	y	y	n	785
Vercelli	VER_20	07/08/2024	13:17	n	n	n	1742
Vercelli	VER_10	07/08/2024	16:31	n	n	n	1095

10.1.5 EK60+MBES

Seamount	Prime station number	Date	Start time (UTC)	Start Latitude	Start Longitude	depth start	Echosounder
Vavilov	10	24/07/2024	18:15	40°08.26'	12°39.15'	3500	EK60
Vavilov	6	24/07/2024	23:08	39°46.54'	12°48.01'	3070	EK60
Vavilov	7	25/07/2024	1:21	39°52.17'	12°26.01'	3450	EK60
Vavilov	8	25/07/2024	3:55	39°54.28'	12°50.68'	3520	EK60
Vavilov	9	25/07/2024	6:20	40°00.05'	12°28.78'	3100	EK60
Vavilov	10	25/07/2024	13:13	40°07.97'	12°39.10'	3580	EK60
Vavilov	6	25/07/2024	18:19	39°48.49'	12°23.85'	3530	EK60
Vavilov	7	27/07/2024	17:07	39°50.20'	12°49.70'	3597	EK60
Vavilov	8	28/07/2024	17:41	39°56.1153'	12°50.6994'	3580	EK60
Vercelli	3	31/07/2024	6:50	41°06.1757'	10°54.3164'	180	EK60
Vercelli	3	31/07/2024	8:18	41°05.663'	10°44.2816'	1723	EK60
Vercelli	1	31/07/2024	11:43	40°59.71'	11°04.72'	1700	EK60
Vercelli	4	31/07/2024	16:08	41°13.17'	10°54.21'	1086	EK60
Vercelli	2	01/08/2024	17:20	41°13.53'	11°02.60'	1219	EK60
Vercelli	TR_1	04/08/2024	7:07	41°07.37'	10°54.01	213	EK60+MBES
Vercelli	TR_2	04/08/2024	7:36	41°05.73'	10°53.08'	186	EK60+MBES
Vercelli	TR_4	04/08/2024	8:22	41°07.29'	10°54.45'	184	EK60+MBES
Vercelli	TR_5	04/08/2024	9:04	41°05.35'	10°53.31'	204	EK60+MBES
Vercelli	TR_3	04/08/2024	9:54	41°07.07'	10°55.81'	302	EK60+MBES
Vercelli	TR_6	04/08/2024	11:44	41°05.59'	10°53.32'	191	EK60+MBES
Vercelli	TR_7	04/08/2024	12:23	41°07.15'	10°55.55'	207	EK60+MBES
Vercelli	TR_8	04/08/2024	13:06	41°05.72'	10°52.90'	245	EK60+MBES
Vercelli	TR_9	04/08/2024	13:44	41°07.64'	10°54.58'	202	EK60+MBES
Vercelli	TR_1	04/08/2024	20:40	40°59.75'	11°04.66'	1690	EK60
Vercelli	TR_2	05/08/2024	1:32	41°13.62'	11°02.62'	1100	EK60
Vercelli	TR_4	05/08/2024	19:59	40°58.05'	10°54.49'	1981	EK60+MBES
Vercelli	TR_3	06/08/2024	1:26	41°05.64'	10°64.12'	1400	EK60+MBES

10.2 Annex 2 - Gaia Blu track for the whole survey