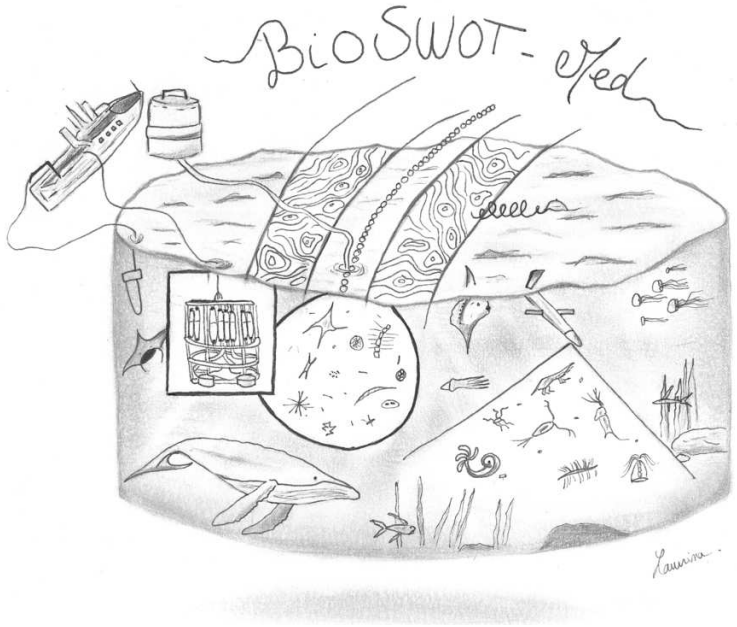
Biological applications of the satellite Surface Water and Ocean Topography in the Mediterranean



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1. **Cruise details**

(from https://campagnes.flotteoceanographique.fr)

Dates (Harbor): 21/04/2023 (La Seyne-sur-Mer) - 15/05/2023 (La Seyne-sur-Mer)

Sea/Ocean: Mediterranean Sea, Western Basin

Limits: North: 43.1°N South: 39.4°N East: 6.0°E West: 3.5°E

Scientific Authority: Mediterranean Institute of Oceanography
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13288 MARSEILLE CEDEX 9
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Ship owner: IFREMER

Discipline(s): PHYSICAL OCEANOGRAPHY
MARINE BIOGEOCHEMISTRY and BIOLOGY
OCEAN REMOTE SENSING

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Onboard *(colors correspond to Work Packages)*

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3. Scientific background and goals

The oceanic fine scales (1-100 km) have relatively short lifetimes (days to weeks) but crucially affect ocean physics and ecology up to the climate scale, due to the strong gradients created by their energetic dynamics. These gradients are associated with strong vertical transport connecting the ocean's upper layer to its interior. Moreover, the temporal scale associated with this horizontal and vertical dynamics is the same as that of many important oceanic processes including biogeochemical cycles, biodiversity, fish distribution, and even foraging strategies of the mega-fauna.

Over the past few decades, numerous numerical studies with physical and biophysical configurations for km-scale processes allowed significant progress in characterizing this regime. Field campaigns have also shown that individual fine-scale features may be experimentally targeted, but these in situ studies are usually biased by the choice of targeting the stronger and longer-lived features. Then, an important lack of empirical evidence for fine-scale processes remains.

To overcome this gap, the scientific community has been focusing large efforts on novel platforms. Among these are satellite missions that provide extended coverage and high spatio-temporal resolution of the ocean surface. Obviously, remote sensing does not provide ground truth of all fine-scale physical and biophysical processes, but can provide a critical resource that helps to define the synoptic context of fine-scale features, helping to disentangle spatial from temporal variability, supporting adaptive in situ sampling strategies, and assessing the representativeness of field data. In this context, the NASA-CNES SWOT (Surface Water and Ocean Topography) satellite launched on 16 December 2022 is the most ground-breaking mission for ocean science at the present time and in the near future. Indeed, with respect to current nadir measurements the new SWOT altimeter sees two-dimensional scenes, like sea surface temperature and ocean color, but without being affected by clouds. Moreover, during its initial so-called “fast sampling phase”, it associated a high spatial resolution with a 1-day revisit period over ~150 km wide oceanic regions, a feat never achieved in the past, and not expected from other planned missions in the future.

The BioSWOT-AdAC project (PIs: F. d'Ovidio, A. Doglioli, S. Speich and P. Garreau), funded by the NASA-CNES joint call for the SWOT Science Team, focused on the specific opportunities of the SWOT fast sampling phase, promoting the international SWOT ‘Adopt-A-Crossover’ (SWOT AdAC) Consortium which was endorsed by CLIVAR and coordinated several field campaigns during this specific period of the satellite mission.

The BioSWOT-Med campaign contributed to this international effort, focusing on the Western Mediterranean Sea. The latter is the ideal area to verify the hypothesis considering fine-scale circulation as the driver of the plankton biodiversity. Indeed, here a high biodiversity is associated with conditions of oligotrophy and moderate energy, unlike oceanic areas as western boundary currents or eastern boundary upwellings that are largely explored and where intense dynamics or large nutrient inputs can mask the fine-scale coupled dynamics. During BIOSWOT-Med, an adaptive and Lagrangian sampling strategy was applied, combined with innovative methodologies that allowed to obtain high spatio-temporal resolution multidisciplinary measurements in the SWOT swaths.

Thanks to scientific complementarity, the SEASTARex airborne campaign in the Mediterranean Sea with the OSCAR (Ocean Surface Current Airborne Radar) instrument was conducted over the same region as sampled by BioSWOT-Med for the 5th, 7th and 8th of May. This instrument is a demonstrator for the ESA Earth Explorer 11 SeaSTAR satellite mission candidate, provide synoptic measurements of total ocean surface current (TSCV) and wind (OSVW) vectors at 200m resolution for tracks 5km wide and 40km long. In addition of these three airborne flights, standard satellite SAR images (e.g., RCM, Radarsat-2, NovaSAR-1, COSMO-SkyMed, …) have been acquired below SWOT pass #3 from May to July 2023 to provide a wider context for the BioSWOT-Med campaign and enable direct comparison with SWOT.

The BioSWOT-Med cruise aimed to improve our understanding of the coupling between physical and biological processes, from viruses to zooplankton. As the conditions of the Mediterranean Sea are representative of a large majority of the world's oceans, our research has a global significance. Moreover, our highly interdisciplinary research aimed to highlight the importance of the SWOT mission data for biogeochemical and ecological studies. Finally, our in situ experiment also helped to bridge a long-standing gap between modeling and global observations for assessing the role of the ocean fine scales on the Earth system.

4. Satellite Data Analysis and General Strategy

BIOSWOT-Med and the SWOT satellite mission. The strategy, region and timing of our cruise have been carefully chosen to benefit from the novel revolutionary fine-scale resolving satellite mission SWOT (Surface Water and Ocean Topography), in coordination with the SWOT Science Team, SWOT Project, and SWOT AdAC Consortium (http://www.swot-adac.org), that have supported our campaign in terms of funding, regionally-optimized satellite products, and early access to SWOT images. Successfully launched on 16 December 2022, SWOT sees the ocean circulation with a resolution about ten-fold better than traditional altimetry, hence resolving mesoscale cyclones, anticyclones, and possibly filaments as small as ~7 to 10 km. In some regions of the world dominated by small Rossby radii, this means that SWOT allows us to explore the full spectrum of the mesoscale circulation for the first time. This is the case of the Mediterranean Sea.

The SWOT mission divided into two phases. From April to June 2023 (the period chosen for the BioSWOT-Med campaign) SWOT satellite had high resolution both in space and time; to achieve this, its orbit was restricted to a few bands in the global ocean. After this short period, the SWOT coverage has become global, at a price of a much-reduced temporal resolution (repetition every about 21 days). In coordination with NASA and CNES, BioSWOT-Med has targeted one of the SWOT passes over the Mediterranean Sea during the 1-day-repeat phase. An example of a non-calibrated and preliminary map from SWOT (made available by the SWOT Project during our cruise) is shown in Figure 1. When compared to traditional altimetry, the quality of these SWOT images, although restricted to specific areas, is evident, and recalls the feeling of looking at a state-of-the-art high resolution model simulation compared to an old and obsolete one.
Land-based “SPASSO” near-real-time analysis in support of the BioSWOT-Med adaptive strategy.
SWOT Ka-band synthetic radar interferometer sensor is completely different from the standard sensors used until now in satellite altimetry, so that the post-processing of SWOT acquisitions was supposed to last several months and to be available to interpret in situ observations only after the cruise. In order to have some fine-scale resolving capabilities during the BioSWOT-Med cruise, in support for the sampling strategy, a critical contribution came from a specifically re-designed “SPASSO” toolbox (Rousselet et al, submitted).
Unexpected but very welcomed availability of near-real time SWOT images during our cruise. April and May images were expected only after the cruise. However, the first SWOT data in January 2023 revealed a performance of the SWOT sensor much higher than expected. In a rush against time, CNES and JPL SWOT Project decided to provide a preliminary beta-test product in near-real time for the in situ activities specifically organized over SWOT passes.

Selection of the study area and first survey. The first SWOT image of our operation zone was communicated to us the 14 April through the SWOT AdAC Consortium and showed the situation on the 6 April. In this image, a region 100km NE of Minorca that appeared relatively flat in traditional altimetry maps was instead strongly contrasted and energetic in the SWOT image, and showed cyclones and anticyclones few tens of km large. The SWOT Project Team also informed us that a special effort had been put in place to deliver one or more SWOT images per week along the period of our cruise.

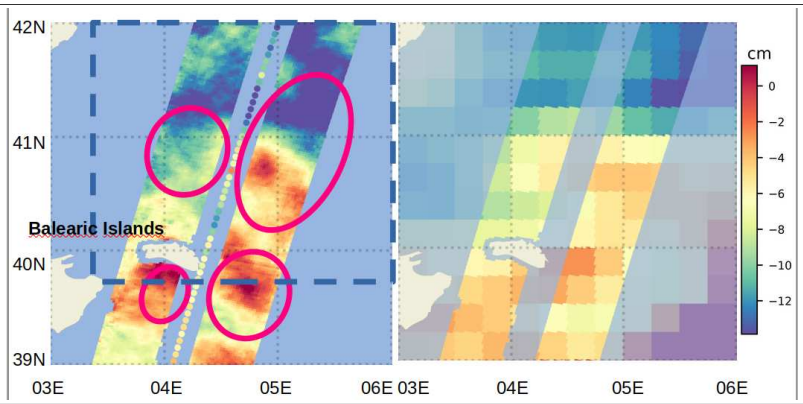


Figure 1. Comparison between the Sea Surface Height images from the new SWOT satellite (Left) and the images from conventional altimetry (Right) for the 30 April 2023 (beginning of the second week of our cruise). Although SWOT images were generated with non-validated beta-products, note the ten-fold increase in resolution and the fact that in this phase of the SWOT satellite mission the coverage is only on a band ~100km large. Our cruise has been specifically designed to explore an area of the Mediterranean Sea covered by SWOT. The purple ellipses indicate features surveyed by our cruise. The dotted box indicates the area of the Sentinel-3 image in Figure 2.

On the top of that, the low cloud coverage conditions typical of the Mediterranean (one of the characteristics for which we chose this region for our experiment) also played in our favor. A sequence of daily cloud-free high-resolution Sentinel-3 chlorophyll images allowed us to qualitatively validate SWOT data and co-locate SWOT-derived current features with gradients in chlorophyll concentration. As a potential candidate for our adaptive study, we thus selected a complex region structured by an anticyclone 70km x 30km well centered in the middle of the SWOT swath. The northern flank of the anticyclone was in excellent agreement with a strong front in surface chlorophyll concentration, suggesting the ideal conditions for studying the impact of fine-scale dynamics on phytoplankton community structure (Figure 2). We thus decided to head there for a survey.

This favorable situation and the presence of this front were particularly welcomed, because the extension of the study area we had preselected had been in the meanwhile strongly restricted by the lack of permission to access the large sector of the Spanish Exclusive Economic water recently claimed by Algeria.

Deployment of the BioSWOT-Med strategy. Our first survey of the anticyclone showed that this feature was possibly a meander of the so-called North Balearic Front (NBF). The northern rim of the anticyclone separated saltier and colder modified Atlantic waters in the north from younger Atlantic waters in the south. Underway systems (thermosalinograph, MVP, ADCP and flow cytometer) indicated that the contrast between the two water masses was extremely well marked in salinity, with a sharp transition of 0.4 - 0.5 over a few km and eastward current in excess of 30 cm/s. Chlorophyll concentration appeared also to react to the presence of the front, both at the surface and at the Deep Chlorophyll Maximum (DCM), and preliminary cytometric analysis suggested likely differences in the assemblages constituting the communities of the two sides of the front and even a third community specific of the front itself. The submesoscale eddies that were visible in Sentinel-3 satellite images detaching from the northern front and intruding the anticyclone appeared coherent with the underway signal of patches of anomalies in salinity and other biophysical parameters, few km wide, that we regularly crossed when approaching the frontal area.

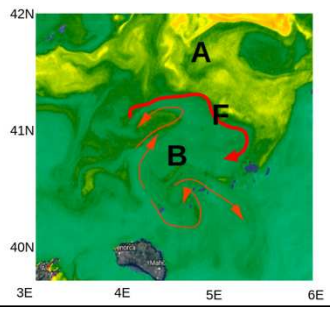


Figure 2. Sentinel-3 high resolution image of chlorophyll concentration (dark green: 0.1 µg/l, red: 1µg/l) depicting our study area on the first day of our cruise (21 April 2023). This biological activity takes place in what we called region “A” (modified Atlantic waters with higher salinity, lower temperature, and more productive), region “B” (more recent fresher, warmer, and less productive Atlantic water), and region “F” (frontal zone separating “A” from “B”). Note the submesoscale patches of probable “A” origin inside “B”.

Overall, these conditions fulfilled the criteria for our experiment, namely the presence of two highly contrasted water masses separated by a sharp front (respectively, “A”, “B”, and “F” in our notation: see Figure 2). Therefore, we started our biophysical sampling strategy by deploying three gliders in the area and starting a sequence of alternating 24h-long stations in the different water masses separated by underway surveys. The position of the stations as well as the underway transects have been adjusted day by day on the basis of the most recent SWOT and Sentinel-3 images, as well as of near-real analysis of ADCP, Moving Vessel Profiler sensors, surface drifters, and floats released during the cruise.

Operational Organization

The schematic view in Figure 3 shows the general planned organization that combined horizontal mapping with vertical Lagrangian stations. The sequence of operations was planned to be repeated for each of the three weeks. A typical week was organized in two parts: the first 3 days dedicated to transects across the front, then the following 3 days dedicated to vertical stations in three contrasted sites, typically a water mass A, a second water mass B and the front F separating them. The remaining 24 hours allowed displacements between stations, deployment/recovery of instruments, and, in general, some flexibility for the operation planning.

The horizontal sampling was planned to generate a mapping of the studied area with the towed fish and the automated measurements on the water intake. The choice of the 3-day sampling was done to adapt the temporal sampling in the different water masses to the biological time scales in order to reconstruct the phytoplankton diurnal cycle (Figure 4, Tzortis et al., 2021, 2023).

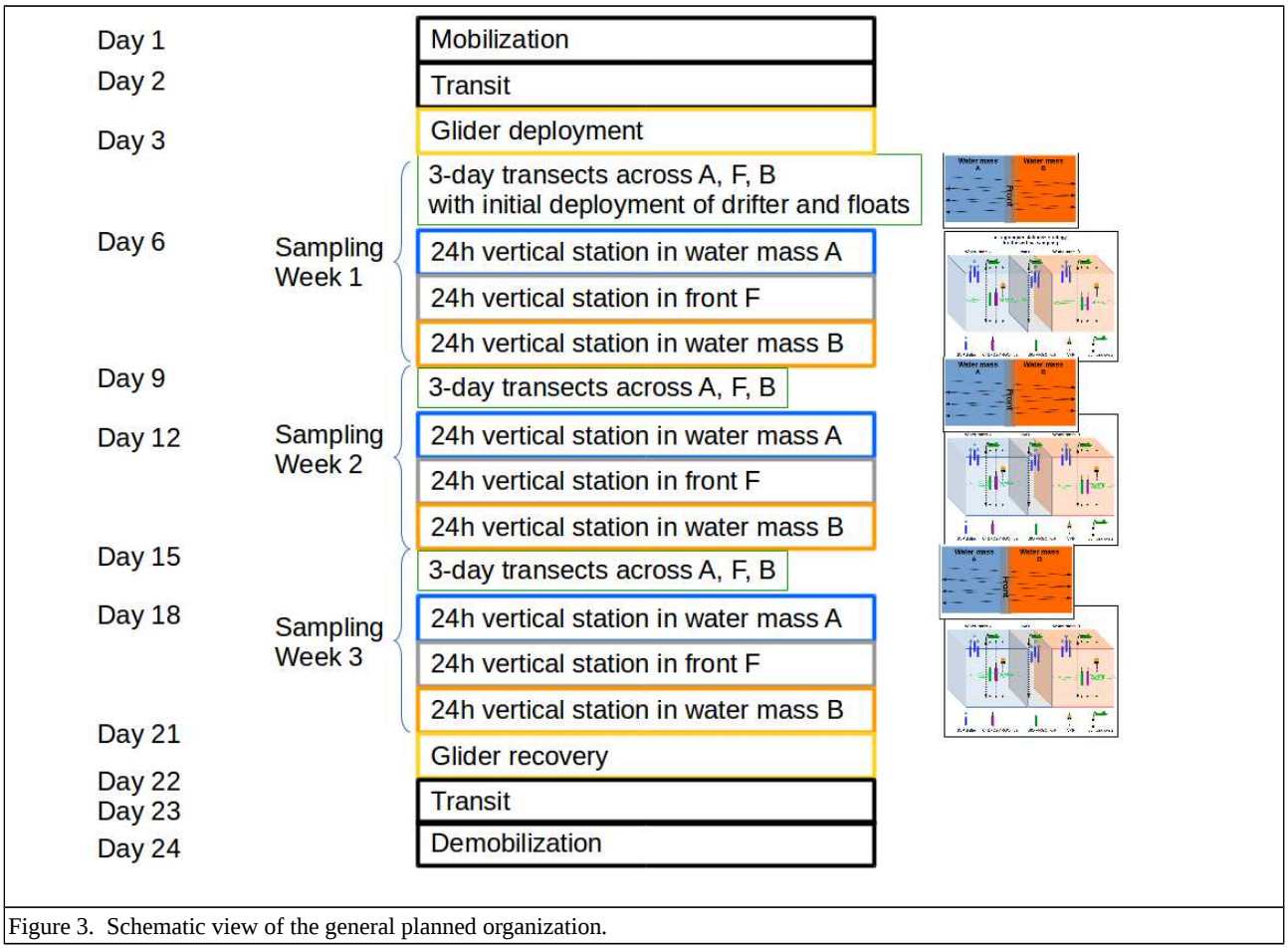


Figure 3. Schematic view of the general planned organization.

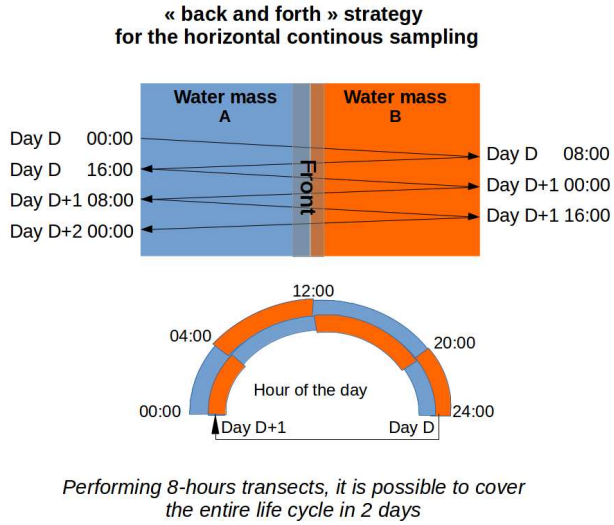


Figure 4. Scheme of the temporal sampling across a front based on transects of 8-hour duration, that allows to cover the entire diurnal life cycle in both the water masses separated by a front in two days. Based on Tzortis et al. (2021, 2023).

The vertical sampling was planned in the three contrasted sites (water masses A and B and in the front F), whose limits were identified during the horizontal sampling and marked with drifters and floats. 24 hours were planned for vertical sampling operations in each of the three sites (Figure 5).

At each of the vertical stations it was planned to deploy the VVP (Vertical Velocity Profiler) at the beginning of the station, then the water column was sampled at high resolution by both pumping seawater onboard and performing CTD carousel profiles. During the 24-hour stations, 4 deployments of the pumping system of 3 hours each were planned. Between these deployments, other casts of several instruments were also planned in order to measure vertical velocity with an Acoustic Doppler Current Profiler deployed in Free-Fall mode (FF-ADCP), vertical mixing by VMP (Vertical Microstructure Profiler) and zooplankton and microphytoplankton by cameras and nets. The VVP deployed at the beginning of the station was planned to be recovered before moving to the next station.

The detailed planning of the operations during the Lagrangian Stations adopted during the cruise is shown in Figure 6.

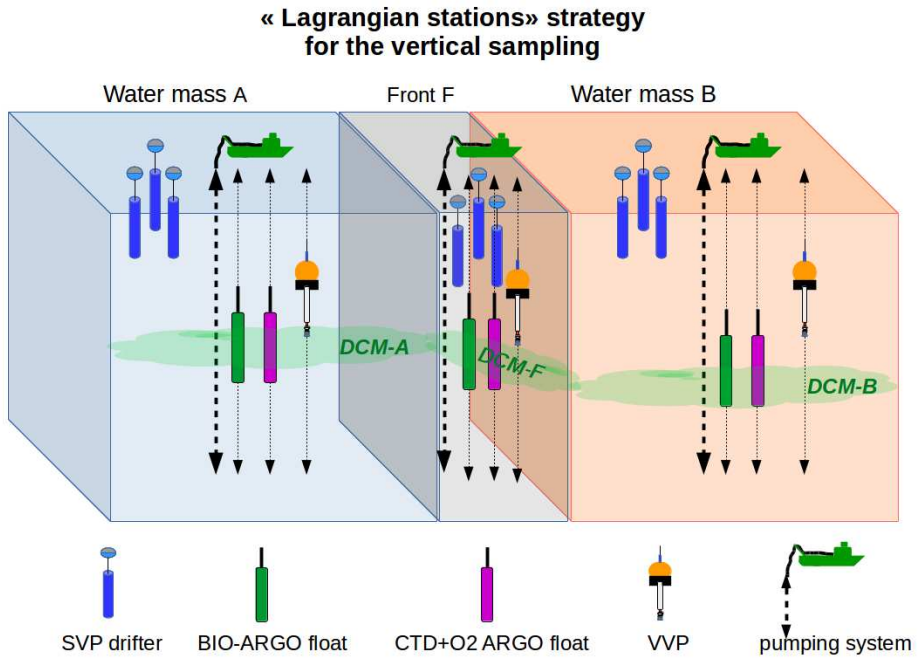


Figure 5. Schematics of the planned strategy to sample two different water masses separated by a front and mark them with drifters and floats. This allowed us to follow the water masses' displacements and to sample them in a Lagrangian reference framework. For the sake of clarity CARTHE and CODE drifters are not represented here, but each has been deployed paired with an SVP drifter. For the same reason, the series of profiles with the CTD-rosette, the plankton nets and the VMP are not represented here.

Stations

Hour (UTC)	Hour (local)	minutes	ACTIVITY	PEOPLE	Hour (UTC)	Hour (local)	minutes	ACTIVITY @ F1 B1 A2 B2 A3 F3	PEOPLE	ACTIVITY @ A1 F2 B3 (MESOCOSMS)	PEOPLE
22	00	00	Zooplankton nets NIGHT (triplenet vertical) 0-400	François (resp.)	10	12	00	Zooplankton nets DAY (triplenet vertical) 0-400	François (resp.)	Zooplankton nets DAY (triplenet vertical) 0-400	François (resp.)
		15		Loïc			15		Loïc		Loïc
		30	Zooplankton nets NIGHT (triplenet vertical) 0-200	Alice			30	Zooplankton nets DAY (triplenet vertical) 0-200	Marcella	Zooplankton nets DAY (triplenet vertical) 0-200	Marcella
		45		Mag			45		Véro		Véro
23	1	00	Zooplankton nets NIGHT (triplenet vertical) 0-100	Véro	11	13	00	Zooplankton nets DAY (triplenet vertical) 0-100		Zooplankton nets DAY (triplenet vertical) 0-100	
		15					15				
		30	Zooplankton nets NIGHT (triplenet vertical) 0-100				30	Zooplankton nets DAY (triplenet vertical) 0-100		Zooplankton nets DAY (triplenet vertical) 0-100	
		45					45				
00	2	00	VVPs1 deployment	Jean-Luc (resp)	12	14	00	VVPs2 deployment	Jean-Luc (resp)	VVPs2 deployment	Jean-Luc (resp)
		15	Carousel (22 bottles +LADCP+UVP+LISST) 0-500 m	Jean-Luc (resp)			15	Phytoplankton net 20µm 0-200 m	Véro (resp)	Phytoplankton net 20µm 0-200 m	Véro (resp)
		30		Steph (prep) Gerald (cyto)			30	Carousel (22 bottles +LADCP+UVP+LISST) 0-500 m	Jean-Luc (resp)	Carousel (22 bottles +LADCP+UVP+LISST) 0-500 m	Jean-Luc (resp)
		45		Laura (SeNut), Sven (chl)			45		Caroline (prep.)		Caroline (prep.)
1	3	00	VMP	Pascale (resp)	13	15	00		Gerald (cyto)		Gerald (cyto)
		15		Laurina (CTD)			15		Laura (SeNut)		Laura (SeNut)
		30		Cédric(à besoin)			30		Sandra Elvira Mag		Sandra Elvira Mag
		45	FF-ADCP	Stephane (resp)			45	VMP (in free fall, not on the CTD cable)	Pascale (resp)	VMP (in free fall, not on the CTD cable)	Pascale (resp)
2	4	00		Jean-Luc	14	16	00		Robin		Robin
		15		Cédric(largueur,si besoin)			15				
		30	pumping (selnut +cyto+omics) 0 - 50 m	Gérald (resp + cyto)			30	FF-ADCP	Caroline (resp)	FF-ADCP	Caroline (resp)
		45		Laurina (CTD)			45		Jean-Luc		Jean-Luc
3	5	00	at 2 m of resolution	Laura (SeNut)	15	17	00		Anne (largueur)		Anne (largueur)
		15		Stephanie (aide si besoin)			15				
		30					30	zooplankton net MESOCOSMS	Alice (resp)	zooplankton net MESOCOSMS	Alice (resp)
		45					45	pumping for MESOCOSM	Gérald (resp)	pumping for MESOCOSM	Gérald (resp)
4	6	00			16	18	00	pumping (selnut +cyto+omics) 0 - 50m	Gérald (resp + cyto)		Laurina (CTD)
		15					15		Laurina (CTD)	pumping (selnut +cyto+omics) 0 - 50m	Gérald (resp + cyto)
		30	at 2 m of resolution				30		Laura (SeNut)		Laurina (CTD)
		45					45		Robin (aide si besoin)	at 4 m of resolution	Laura (SeNut)
5	7	00	VVPs1 recovery ZODIAC	Steph (resp)	17	19	00				Robin (aide si besoin)
		15					15				
		30					30	VVPs2 recovery ZODIAC	Caroline (resp)	VVPs2 recovery ZODIAC	Caroline (resp)
		45					45				
6	8	00	Carousel (22bottles +LADCP+UVP+LISST) 0-500 m	Anthony	18	20	00				
		15		Léo (prep. + recup)			15				
		30		Elvira (SeNut)			30	Carousel (22 bottles +LADCP+UVP+LISST) 0-500 m	Anthony	Carousel (22 bottles +LADCP+UVP+LISST) 0-500 m	Anthony
		45		Morgane (cyto)			45		Léo (prep. + recup)		Léo (prep. + recup)
7	9	00	VMP (in free fall, not on the CTD cable)	Robin (resp.)	19	21	00		Elvira (SeNut)		Elvira (SeNut)
		15		Anthony			15		Morgane (cyto)		Morgane (cyto)
		30					30	VMP	Robin (resp.)	VMP	Robin (resp.)
		45	FF-ADCP (in free fall, not on the CTD cable)	Stephane (resp)			45		Anthony		Anthony
8	10	00		Leo	20	22	00				
		15		Anne (largueur)			15	FF-ADCP	Caroline (resp)	FF-ADCP	Caroline (resp)
		30	pumping (selnut +cyto+omics) 0 - 50 m	Elvira (resp + SeNut)			30		Leo		Leo
		45		Massimo (CTD)			45		Robin (largueur)		Robin (largueur)
9	11	00	at 3 m of resolution	Morgane (cyto)	21	23	00	pumping (selnut +cyto) 0 - 50m	Elvira (resp + SeNut)	zooplankton net MESOCOSMS	Alice (resp)
		15		Robin (aide si besoin)			15		Massimo (CTD)	pumping for MESOCOSM	Elvira (resp)
		30					30	at 4 m of resolution	Morgane (cyto)		Massimo (CTD
		45					45		Robin (aide si besoin)		Robin (aide si besoin)

Page 4

Figure 6. Organization of the operations during the Lagrangian stations. Note that the afternoon activities were not the same across the cruise, to allow measurements of high-resolution vertical profiles for nutrients and cytometry (in the following cited as the option “no mesocosms”) alternated with high volume pumping of water for the mesocosm experiments (in the following cited as option “mesocosms).

5. Cruise narrative

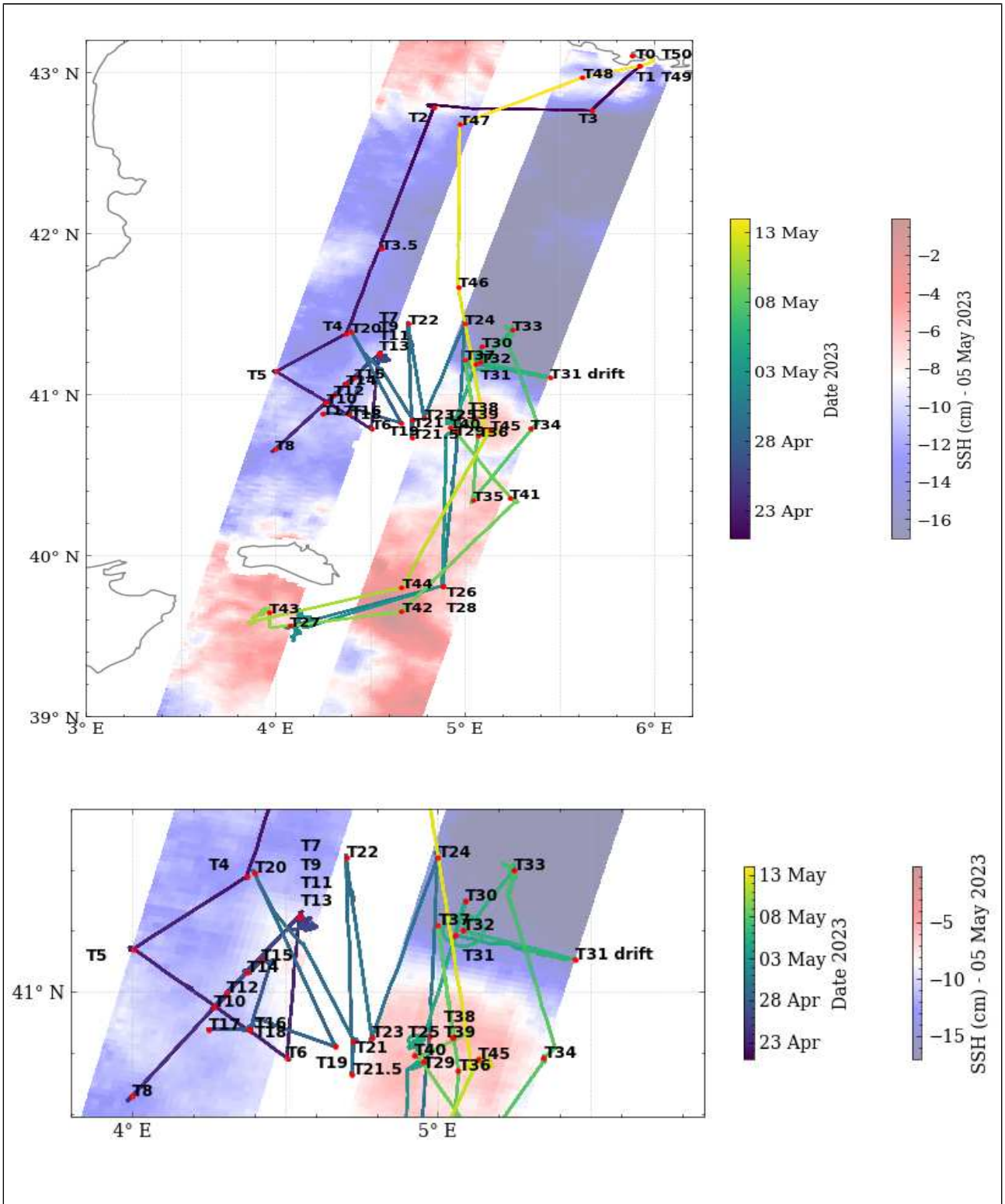


Figure 7. Map of the cruise route (Top) with a zoom of the North Balearic Front area (Bottom). The route line is colored as a function of the time and it is superposed to the SWOT pre-validated data. The schedule of the passages at the waypoints (red dots) is reported in Table 1.

Waypoint name	Latitude N (deg. min)	Longitude N (deg. min)	Latitude N (deg)	Longitude E (deg)	arrival time (UTC)	departure time (UTC)	note
T0	43º 06.360'	5º 53.075'	43.1060	5.8846	21/04/23 11:00:00	21/04/23 11:00:00	
T1	43º 02.284'	5º 55.206'	43.0381	5.9201	21/04/23 11:15:00	21/04/23 12:56:00	
T2	42º 45.811'	5º 40.122'	42.7635	5.6687	21/04/23 15:28:00	21/04/23 15:30:00	
T3	42º 46.742'	4º 50.160'	42.7790	4.8360	21/04/23 18:30:00	21/04/23 19:39:00	
T3.5	41º 54.240'	4º 33.600'	41.9040	4.5600	22/04/23 04:37:00	22/04/23 16:32:00	Emily-1
T4	41º 22.631'	4º 22.541'	41.3772	4.3757	22/04/23 22:12:00	22/04/23 22:42:00	
T5	41º 08.485'	4º 00.263'	41.1414	4.0044	23/04/23 02:30:00	23/04/23 03:00:00	
T6	40º 47.130'	4º 30.374'	40.7855	4.5062	23/04/23 08:55:00	23/04/23 09:19:00	
T7	41º 14.995'	4º 32.870'	41.2499	4.5478	23/04/23 14:05:00	23/04/23 16:58:00	
T8	40º 39.439'	3º 59.931'	40.6573	3.9988	24/04/23 00:26:00	24/04/23 00:53:00	
T9	41º 14.995'	4º 32.870'	41.2499	4.5478	24/04/23 08:57:00	24/04/23 09:15:00	
T10	40º 57.000'	4º 16.000'	40.9500	4.2667	24/04/23 13:33:00	24/04/23 17:26:00	Emily-2
T11	41º 14.995'	4º 32.870'	41.2499	4.5478	24/04/23 21:11:00	24/04/23 21:28:00	
T12	40º 59.820'	4º 18.480'	40.9970	4.3080	25/04/23 00:49:00	25/04/23 00:54:00	
T13	41º 14.995'	4º 32.870'	41.2499	4.5478	25/04/23 04:22:00	26/04/23 06:50:00	A1
T14	41º 03.891'	4º 22.513'	41.0648	4.3752	26/04/23 11:52:00	26/04/23 16:18:00	F1
T15	41º 06.085'	4º 25.254'	41.1014	4.4209	26/04/23 18:00:00	27/04/23 14:10:00	F1
T16	40º 52.703.	4º 23.191'	40.8784	4.3865	27/04/23 15:23:00	27/04/23 15:24:00	
T17	40º 52.703'	4º 15.000'	40.8784	4.2500	27/04/23 16:23:00	27/04/23 16:27:00	
T18	40º 52.703'	4º 23.191'	40.8784	4.3865	27/04/23 17:59:00	28/04/23 17:45:00	B1
T19	40º 49.234'	4º 39.864'	40.8206	4.6644	28/04/23 20:25:00	28/04/23 22:22:00	SUNA
T20	41º 23.400'	4º 24.000'	41.3900	4.4000	29/04/23 04:13:00	29/04/23 05:29:00	Emily-3
T21	40º 50.400'	4º 43.464'	40.8400	4.7244	29/04/23 11:00:00	29/04/23 12:22:00	
T21.5	40º 43.894'	4º 43.223'	40.7320	4.7203	29/04/23 13:28:00	29/04/23 13:34:00	
T22	41º 26.400'	4º 42.000'	41.4400	4.7000	29/04/23 20:18:00	29/04/23 20:38:00	
T23	40º 51.120'	4º 47.064'	40.8520	4.7844	30/04/23 03:50:00	30/04/23 05:17:00	Emily-4
T24	41º 26.430'	5º 00.000'	41.4405	5.0000	30/04/23 11:38:00	30/04/23 12:38:00	
T25	40º 51.368'	4º 58.348'	40.8561	4.9725	30/04/23 19:43:00	30/04/23 19:43:00	
T26	39º 48.590'	4º 52.949'	39.8098	4.8825	01/05/23 07:37:00	01/05/23 07:37:00	
T27	39º 33.603'	4º 04.515'	39.5600	4.0752	01/05/23 13:50:00	03/05/23 06:32:00	M1
T28	39º 48.590'	4º 52.949'	39.8098	4.8825	03/05/23 12:25:00	03/05/23 14:20:00	
T29	40º 46.260'	4º 57.120'	40.7710	4.9520	03/05/23 23:10:00	05/05/23 04:00:00	B2
T30	41º 17.775'	5º 05.302'	41.2963	5.0884	05/05/23 08:47:00	05/05/23 09:00:00	
T31	41º 11.220'	5º 03.420'	41.1870	5.0570	05/05/23 09:56:00	06/05/23 08:39:00	F2
T31drift	41º 06.360'	5º 27.060'	41.1060	5.4510	06/05/23 08:39:00	06/05/23 09:34:00	F2drift
T32	41º 12.000'	5º 05.000'	41.2000	5.0823	06/05/23 12:35:00	06/05/23 12:38:00	
T33	41º 24.000'	5º 15.000'	41.4000	5.2500	06/05/23 18:14:00	07/05/23 20:27:00	A2
T34	40º 47.160'	5º 20.790'	40.7860	5.3465	08/05/23 02:30:00	08/05/23 06:24:00	Zooglider
T35	40º 20.500'	5º 02.500'	40.3417	5.0417	08/05/23 11:26:00	08/05/23 11:52:00	
T36	40º 44.650'	5º 04.035'	40.7442	5.0672	08/05/23 15:56:00	08/05/23 15:57:00	
T37	41º 13.000'	5º 00.000'	41.2167	5.0000	08/05/23 21:41:00	08/05/23 21:48:00	
T38	40º 51.000'	5º 03.000'	40.8500	5.0500	09/05/23 04:28:00	09/05/23 05:13:00	Slocum
T39	40º 51.000'	5º 03.000'	40.8500	5.0500	09/05/23 05:13:00	09/05/23 05:31:00	SEA090
T40	40º 47.640'	4º 55.440'	40.7940	4.9240	09/05/23 06:36:00	09/05/23 06:47:00	SVP-BCG
T41	40º 21.298'	5º 14.110'	40.3550	5.2352	09/05/23 11:48:00	09/05/23 13:27:00	Spotter1
T42	39º 39.000'	4º 40.000'	39.6500	4.6667	09/05/23 21:54:00	10/05/23 00:09:00	Eddy_south
T43	39º 38.700'	3º 58.080'	39.6450	3.9680	10/05/23 06:55:00	11/05/23 17:30:00	M2
T44	39º 48.000'	4º 40.000'	39.8000	4.6667	11/05/23 21:46:00	11/05/23 21:46:00	
T45	40º 46.700'	5º 08.000'	40.7783	5.1333	12/05/23 09:56:00	13/05/23 09:56:00	B3
T46	41º 40.085'	4º 57.935'	41.6681	4.9656	13/05/23 18:58:00	13/05/23 18:58:00	
T47	42º 40.585'	4º 58.421'	42.6764	4.9737	14/05/23 05:04:00	14/05/23 05:04:00	
T48	42º 58.049'	5º 37.295'	42.9675	5.6216	14/05/23 10:28:00	14/05/23 10:28:00	
T49	43º 02.284'	5º 55.206'	43.0381	5.9201	14/05/23 12:28:00	14/05/23 12:28:00	
T50	43º 06.360'	5º 53.075'	43.1060	5.8846	14/05/23 14:30:00	14/05/23	

Table 1. List of the cruise waypoints (corresponding to the red dots in Figure7).

Thursday 20 April
Mobilization day. We loaded the ship with the scientific equipment and we installed the on-board laboratories.

Friday 21 April
After waiting for the delivery of the last equipment, we left the harbor at 12:54 (10:54 UTC); then we were further delayed for some vessel technical issues.
We performed a transect across the Norther Current moving parallel with the DriX autonomous platform for an opportunity cross-calibration (collaboration with A. Ponte, Ifremer).
Not having the authorization of the French Navy to perform vertical profiles in the French navy exercise area, we sailed westward to exit from it and to reach the middle of the SWOT western swath acquiring data only with hull-mounted Surface Acoustic Doppler Current Profiler (S-ADCP) and echosounder (EK60) and with the instruments installed on the surface water intake, the thermo-salinograph (TSG) and the automated cytometer (CytoBuoy).
We were authorized to deploy the MVP towed vehicle at 21:38 (19:38 UTC) at position 42°46.28'N, 04° 49.99'E.

Saturday 22 April
The MVP, equipped with the new multi-sensor towed vehicle (MSFFF), worked well during all night and the first sampling transect PL1 ended at 06:31 (04:31 UTC) at position 41°56.59'N,04°33.57'E.
We encounter the first whale and some basking sharks.
At 07:21 (05:21 UTC), position 41°54.52N',04°33.27'E, we deployed a glider (Seaglider SG508, CNRS-INSU) as a collaboration with the program MOOSE (PI A. Bosse). For intercalibration purposes, after the glider deployment we performed a first CTD cast (0-1500m) at 7:54 (05:54 UTC) and a second one (C02 “Emily-1”, 0-150) at 11:08 (09:08 UTC) for the first water sampling for polyPO4.
In the late morning we started to test the pumping system, an activity that was carried out until the evening.
The new MVP CTD (MVPX2) experienced a failure. After some trials and feedback from AML, we replaced it with a spare.
At 18:29 (16:29 UTC) we started the MVP sampling transect PL2, during which the Sound Velocity sensor (SV) did not give outputs.
At 21:00 (19:00 UTC) the scientific crew held the first science meeting to share information about the instrumentation tests and to organize the following operations.

Sunday 23 April
The MVP fish was recovered on board at 6:36 (04:36 UTC), checked and re-deployed at 7:46 (05:46 UTC) to perform the “butterfly” mapping. (PL3). The Sound Velocity sensor was now working.
At 08:29 (06:29 UTC) we launched the first EoDyn buoy (position 40°58.008'N, 04°15.16'E).
At 16:00 (14 UTC) the chief scientists gave a seminar to the vessel crew to illustrate the scientific research questions and the sampling methodology that would be applied during the campaign.
All along the day the pumping system was tested and improved successfully.
At 21:00 (19:00 UTC) the scientific crew had the second science meeting.
At 21:30 (19:30 UTC) the automatic cytometer was connected to the TSG water intake, since air bubbles were observed in the “clean water” intake.
At 22:10 (20:10 UTC) other Lagrangian drifters (CARTHE, EoDyn) were deployed, then launches continued during the night.

Monday 24 April
The MVP fish was recovered on board at 06:44 (04:44 UTC), checked and re-deployed at 07:39 (05:39 UTC). The tilt data was sent on land for analysis of the vehicle rotation.
At 09:59 (07:59 UTC) the automatic cytometer was re-connected to the “clean water” intake.
At 10:00 (08:00 UTC) the WP1 people meet to discuss the adaptive Lagrangian strategy.
At 10:30 (08:30 UTC) the WG “Pumping” discusses the planning of the operations during the vertical stations and the sample labeling
At 14:0 (12:00 UTC) the carousel cast C03 “Emily-2” (0-150) was performed.
At 15:16 (13:16 UTC) the MVP was recovered and between 16:00 (14:00 UTC) and 17:30 (15:30 UTC) we deployed 3 gliders (Seaexplorer SEA003 and SEA090 from MIO, and Odin glider from University of Bergen, a Slocum glider equipped with MicroRider) and 1 ARGO float.
At 17:59 (15:59 UTC) we deployed the VMP and then at 18:38 (16:38 UTC) the FF-ADCP.

At 19:08 (17:08 UTC) the first ArgoDO float (Arvor-I DO, WMO 2903795) was deployed.
At 19:35 (17:35 UTC) started the PL6 back-and-forth transect with the MVP.
At 21:00 (19:00 UTC) the scientific crew had the third science meeting.

Tuesday 25 April
At 06:22 (04:22 UTC) we arrived at T13 and the MVP fish was recovered few minutes before.
The first Lagrangian station A1 at T13 started at 7:09 following the planned sequence of operations (option "mesocosm", Figure 6).
At 16:12 (14:12 UTC) some issues with the pumping system impacted the planning of the operations. The mesocosms was not completely filled.
At 19:00 (17:00 UTC) the operations for recovery of the VVP started, but the instrument did not transmit its position and the research was unsuccessful. The vessel repositioned at T13 and the operation sequence restarted with a carousel cast. At 23:59 (21:59 UTC) the pumping for the mesocosms finished.

Wednesday 26 April
The operation sequence continued with some issues to the pumping system that had become clogged with gelatinous organisms, largely present in the area. The pumping ended at 06:00 (04:00 UTC).
At 6:06 (04:06 UTC) the research of the VVP restarted with a spiral route around the point estimated taking into account the potential drifting of the instrument due to the current measured by the S-ADCP. The research was again unsuccessful and ended at 08:00 (06:00 UTC).
During the route toward T14, there were drifter deployments (1 SVP, 1 Carthe, 1 EoDyn) and a second ArgoDO float deployment (Arvor-I DO, WMO 6903090).
Approaching T14, we deployed the SVP drifter named "Aurelia".
Then, at 14:06 (12:06 UTC) the sequence of operation of the Lagrangian station F1 (option "no mesocosm", Figure 6) started with a carousel cast.
During F1, we performed a repositioning at the new position T15 (the so-called "shame point") reached at 18:00 (16:00 UTC). Here the operation sequence of the F1 station continued.

Thursday 27 April
The operation sequence of the F1 station continued.
Before we left the F1 station we deployed the a BioArgo float (Provor CTS4, WMO 6990528).
At 14:10 (12:10 UTC) we left T15 to perform a back-and-forth route between the waypoints T16-T17-T18 across the estimated position of the front. In the absence of wind and with very calm sea, the crew confirmed the presence of a strong current, which forced the vessel to maneuver in order to perform the casts.
Approaching T18, we deployed the SVP drifter named "Amandine".
At 17:59 (15:59 UTC) we reached T18 where the sequence of operation of the Lagrangian station B1 started (option "no mesocosm, Figure 6).

Friday 28 April
The operations of station B1 continued during the day; both crew members and scientists remarked that the water seemed much poorer in life with respect to the previous two stations. We concluded the operation of B1 at 19:45 (17:45 UTC). At 21:00 (19:00 UTC), the scientists had a meeting.
We moved to T19 that was reached at 22:25 (20:25 UTC). There, we performed a carousel cast until 1'000 m depth with bottle sampling, we deployed the BioArgo float with SUNA (Provor CTS4, WMO 1902605) and the SVP drifter named "Amandine 2".
At 00:22 (22:22 UTC), we started the mapping in "star shape" (MVP transect PL07).
Saturday 29 April
During the night, the glider Seaexplorer SEA003 sent a leakage alert.
At 06:13 (04:13 UTC) we reached T20 where the MVP PL7 sampling ended and the "Emily-3" carousel cast was performed until 400 m.
At 07:29 (05:29 UTC) we start the research of the SEA003 glider and along the route we deployed one SVP. The glider was recovered on board at 09:25 (07:25 UTC).
Just before, at 09:14 (07:14 UTC) and at 09:18 (07:18 UTC) the configuration of ADCP OS150 and OS38 was changed from ES35 to ES37, respectively, to take into account the typical Mediterranean value of salinity.
At 09:37 (07:37 UTC) the MVP mapping restarted (PL8) toward T21 to follow the "star shape" route.
T21 was reached at 13:00 (11:00 UTC); here plankton net casts were performed.
Here plankton cast nets were performed before to leave the station at 14:20 (12:20 UTC), when the MVP

sampling restarted (PL9).
At 15:10 (13:10 UTC) the scientific team realized R/V L'Atalante was heading in the opposite direction to that planned: the bridge had transcribed the latitude of T22 as 40°N instead of 41°N. At T21.5, we reversed the ship's course Northward, toward the correct position of T22.
Along transect T20-T21 (from South to North) and transect T21-T22 (from North to South) we deployed EoDyn and CARTHE drifters in order to follow the different water masses.
At 18:00 (16:00 UTC) the scientific team had a meeting to share the information about the activities of the different groups.
At 23:52 (21:52 UTC) the MVP fish was recovered for periodical checking and redeployed at 00:44 (22:44 UTC) for the PL10 sampling.

Sunday 30 April
The MVP sampling PL10 ended at 05:45 (03:45 UTC)
T23 was reached at 05:50 (03:50 UTC). Here, at 06:16 (04:16 UTC) we performed the "Emily-4" carousel cast until 400 m.
The MVP sampling PL11 started at 07:12 (05:12 UTC) and ended at 13:30 (11:30 UTC) approaching the waypoint T24 that was reached few minutes later.
After the technical controls, the MVP sampling PL12 started from T24 at 14:35 (12:35 UTC)
At 18:00 (16:00 UTC) a science meeting was organized.
At 21:43 (19:43 UTC) we reached T25 concluding the mapping in a "star shape" and we continued the route southward. Indeed, due to the bad weather (strong Tramontane), we had to move to Minorca (waypoints T25 to T27).

Monday 1 May
The MVP sampling PL12 ended at 01:51 (23:51 UTC) for the technical control. At 02:58 (00:58 UTC) the MVP sampling restarted (PL13). The waypoint T26, touched at 09:37 (07:37 UTC), was chosen to cross an anticyclonic eddy.
At 11:27 (13:27 UTC) we crossed the 2000-m bathymetry and the ADCP configuration was changed.
In the early afternoon there was a short but intense downpour.
The MVP sampling PL13 ended at 13:53 (11:53 UTC) and then at 15:50 (13:50 UTC) we reached T27 where we started the sequence of operations of the Lagrangian station M1 deploying the VVP.
During the rest of the day, the sequence of operations of the station M1 continued regularly in the shelter of Minorca where we found very calm sea conditions.

Tuesday 2 May
The sequence of operations of the station M1 continued regularly during the day and ended at 17:37 (15:37 UTC) with the recovery of the VVP.
At 17:30 (15:30 UTC) the scientific teams had a meeting to organise a meeting to share information about the measures taken and the next operations.
Then, the scientific team and the crew meet for a social dinner.
During the night, we remained in stand-by before recovering the Zooglider.

Wednesday 3 May
Operations to recover the Zooglider began at 06:00 (04:00 UTC) and finished at 08:19 (06:19 UTC).
At 08:32 (06:32 UTC) we left T27 toward T28 and at 08:34 (06:34 UTC) we started the MVP transect PL14.
At 14:24 (12:25 UTC) we reached T28 where we performed a check on the MVP cable. At 16:20 (14:20 UTC) we moved toward T29 and at 15:29 (13:29 UTC) we re-deployed the MVP (PL15).
During the transect T28-T29 an unidentified floating object was observed.
For security the MVP fish was recovered and the route deviated to better observe the object, which was revealed to be the hull of an inflatable boat; in its proximity we observed a turtle. The observation was reported to the authorities and then the MVP fish was redeployed along the profile at 16:12 (14:12 UTC), position 39° 50.32'N, 4°E 52.88'E.
During our seventh Scientific Meeting we discussed the organization of the next Lagrangian stations, the new SWOT image and the glider sampling strategy.
The MVP sampling PL15 ended at 01:01 (23:01 UTC).

Thursday 4 May
At 01:10 (23:10 UTC) at the waypoint T29 (first-guess position: 40°46.26'N, 4° 54.16'E) a deep (0-2000)

CTD-carousel started, then the sequence of operations of the Lagrangian station B2 (option “no mesocosm”, Figure 6) started with a deployment of the VVP. At 06:38 (04:38 UTC), after an analysis of the S-ADCP data, we decided to move eastward the waypoint T29 (final position: 40°46.26'N, 4°57.15'E).
Then, the planned deployment of the drifter SVP^{BGC} and its companion drifters was delayed for technical problems with the data communication system.
Starting at 07:19 (05:19 UTC), the Zooglider was deployed with the tender, and the VVP recovered during the same expedition.
During the morning we observed at the sea surface numerous free-floating hydrozoan *Velella velella*.
All the planned operations of station B2 were successful concluded until the recovery of the VVP in the evening. The instrument did not transmit its position and the visual research in the area of potential drifting was unsuccessful. The sequence of operations of station B2 restarted. After sunset the VVP was tracked thanks to its flashlight and recovered on bord at 19:55 (17:55 UTC).
Then, the operations continued as planned following the sequence of a Lagrangian station with pumping and zooplankton net casts for the mesocosm experiments.

Friday 5 May

At 4:44 (02:44 UTC), after the end of the operations of the Lagrangian station B2, the buoy SVP^{BGC} was deployed together with a CARTHE, the Spotter #147 and an EoDyn (for cross-validation) encircled by 8 other SVPs and 8 CARTHEs. These deployments ended at 06:08 (04:08 UTC) with the launch of the last ArgoDO float (Arvor-I DO, WMO 3902500).
Then, the route restarted toward T30 and along the route the WP1 team analyzed in real time the TSG and ADCP data in order to identify the front position. After having reached the point T30 at 10:47 (08:47 UTC), the route reversed toward T31, considered as the best estimation of the positioning of the front, corresponding to the isohaline 38.15. During the route two whales were seen in the distance. At 11:56 (09:56 UTC) we reached T31; here a strong current of about 1 kn was observed and the Lagrangian station F2 started at 12:00 (10:00 UTC) by the zooplankton nets followed by the usual sequence of operations (option “mesocosm”, Figure 6), except for the deployment/recovery of the VVP. Indeed, being the reason for the leak in position transmitting during the previous deployment not yet clarified, the instrument was not deployed to be analyzed in more detail. The 2-hour slot dedicated to the VVP recuperation (19:30-20:30) had been used by the crew for a test of new navigation instrumentation.
The sequence of operations (option “mesocosm”) restarted at 20:30 (20:30 UTC).
All along the day the ship drifted eastward at about 1 kn, following the strong surface current measured by several instruments. The southeastern wind was weak and the sea calm.

The first OSCAR flight flew over Minorca for the calibration flight at 17:02 (15:02) and acquisitions over the ocean within the defined disk occurred between 17:30 and 21:10 (15:30 and 19:10 UTC.) SWOT swaths overflight was at 20:24 (18:24 UTC).

Saturday 6 May

During the night the sequence of operations of station F2 was perturbed by a connection problem with the CTD-carousel.
The weather conditions remained very good and the sea calm.
During the morning the vessel continued to drift east-south-eastward in the vein of the front current; in the late morning the drift was significatively reduced and the salinity increased slightly, suggesting that the vessel was exiting from the front on its northern part.
The sequence of the operations of the Lagrangian station F2 was concluded with the pumping.
At 11:34 (09:34 UTC) we left the waypoint reached by drifting and named $T31^{drift}$. We moved countercurrent toward T32 near the initial position of the Lagrangian station F2.
At 17:30 (15:30 UTC) the scientific team met to discuss the weather forecast that was announcing a second strong wind episode. We thus decided to move again on the Menorcan shelf. Scientists shared preliminary results and began to organize the dismantling of the scientific equipment.

Around waypoint T32, we performed a launch of a cluster of 14 buoys (5 SVPs and 9 CODEs) along a circle of 2 miles of radius from 14:35 and 18:10 (12:35 and 16:10 UTC).
Then, we moved NNEward toward T33; approaching the waypoint we deployed 4 buoys (EoDyn, Spotter 144, CODE and CARTHE) at 20:10 (18:10 UTC).
At 20:14 (18:14 UTC) we reached T33 and the sequence of operations of the Lagrangian station A2 (option "no mesocosm", Figure 6) started with the 0-500 m carousel.

Sunday 7 May
During the night and the morning, the sequence of operations of the Lagrangian station A2 continued until about 11:30 (09:30 UTC) when the vessel repositioned at the last position transmitted by the Spotter #147 buoy. There the VVP was deployed at 12:10 (10:10 UTC). Then the sequence of operations restarted with the cast of the zooplankton nets.
Two whales were seen at 11:25 (09:25 UTC) at about 1 nm from the vessel.
At 18:00 (16:00 UTC) some of the scientists met to organize the operations of recovery of the Spotter #147 buoy, of the VVP for day, and of the SVP^{BCG} and the gliders for the next day.
At 18:45 (16:45 UTC) we started the operation of recovery the VVP and the Spotter #147, moving toward the last position provided by the VVP; the VVP was recovered at 19:18 (17:18 UTC), then the Spotter #147, that had drifted about 2 nm southward, was recovered at 19:48 (17:48 UTC).
The vessel repositioned at the position were the VVP was recovered to perform a CTD-carousel cast ("Emily-6").
At 21:47 (19:47 UTC) we deployed the last BioArgo float (Provor CTS4, WMO 5906990), concluding the operations of the station A2.
At 22:01 (20:01 UTC) we started the MVP sampling PL16 toward T34, corresponding to the position of the last surfacing of the Zooglider.

This was also the second day of the OSCAR flight. The calibration flight over Minorca started at 16:26 (14:26 UTC). The acquisitions over the ocean within the defined disk occurred between 16:56 and 20:55 (14:56 and 18:55 UTC). SWOT overflight was at 16:05 (18:05 UTC).

Monday 8 May
The MVP sampling PL16 finished at 04:24 (02:24 UTC) and the waypoint T34 was reached at 04:30 (02:30 UTC). There, we were on stand-by until 06:00 (04:00 UTC) when we received the new surfacing position of the Zooglider. The end-of-profile signal was sent to the instrument that remained at the surface and sent its position each 10'. At 07:07 (05:07 UTC) the Zooglier was seen from the vessel and the recuperation operations started. The Zooglider was recovered by the tender at 07:33 (05:33 UTC) and then was taken onboard at 07:45 (05:45 UTC). Within rough sea conditions and strong wind, the operation was concluded successfully at 07:50 (05:50 UTC), thanks to the ability of the R/V L'Atalante's crew.
At 08:24 (06:24 UTC) the MVP started a sampling transect (PL17) along the route toward the waypoint T35, that ended at 13:21 (11:21 UTC). At 13:52 (11:52 UTC) we started the route toward T36 against the wind and in rough sea conditions, testing the feasibility of the MVP sampling. Few minutes after, at 13:57 (11:57 UTC), the MVP fish was recovered on-board for security, being the vessel pitch too high.
At 17:30 (15:30 UTC) the scientists had a meeting to discuss about internal waves, Zooglider measurements, and art inspired by oceanography.
At 21:00 (19:00 UTC), WP1 members had a meeting to decide the recovery operations for the next day.
During the evening the MVP was finally not deployed, since sea conditions remained too rough during the transect toward T37.
We left waypoint T37 at 23:48 (21:48 UTC) and we were finally able to deploy the MVP at 23:51 (21:51 UTC). Indeed, during the transect T37-T38 the change in direction, now southward, and the improvement of the sea conditions, allowed safe MVP sampling (PL18).

This day as also the third and last of OSCAR flight. The calibration flight over Minorca started at 16:26 (14:26 UTC). The acquisitions over the ocean within the defined disk occurred between 16:58 and 21:06 (14:58 and 19:06 UTC). SWOT overflight was at 19:56 (17:56 UTC).

Tuesday 9 May
The MVP sampling PL18 finished at 05:25 (03:25 UTC) and the waypoint T38 was reached few minutes after. There, the operations of the recovery of the glider Slocum "Odin" started.
The glider was rapidly seen thanks also to the good weather and sea conditions and rapidly the tender joined it. The glider was finally recovered on the vessel deck at 06:48 (04:48 UTC).
Then, the other glider, Seaexplorer 090, that was also piloted toward the same geographical position and surfaced at T39 was also rapidly seen, reached by the tender and recovered at 07:20 (05:20 UTC).
After these operations, we tracked the buoy SVP^{BCG} that was drifting at about 10 nm from the vessel where we fixed the next waypoint T40. After less than an hour of navigation the buoy was reached and the tender was again deployed to recover the buoy, that was retrieved on board at 08:45 (06:45 UTC).
The last buoy to be recovered, the Spotter #147, being not equipped with a floating anchor, was pushed by the strong wind of the previous days several miles southward.
Then, the MVP sampling transect PL19 was performed between T40 and the buoy position T41 between 09:15 and 13:51 (07:15 and 11:51 UTC).
The buoy Spotter #147 was seen at 14:10 (12:10 UTC) and reached by the tender and finally recovered onboard at 14:28 (12:28 UTC).
At 14:55 (12:55 UTC) the MVP was again deployed to perform the sampling transect PL20 between T41 and T42.
At 17:30 the scientists had a meeting with presentations of the first data of i) on-board analysis of nutrients, ii) FF-ADCP and iii) S-ADCP Nortek 500.
The MVP sampling PL20 ended at 23:46 (21:46 UTC), when the MVP towed vehicle was put onboard for cable inspection. The waypoint T42 was reached a few minutes after, at 23:54 (21:54 UTC).

Wednesday 10 May
At T42 we performed a deep CTD-carousel cast (0-1500) to sample the cyclonic structure identified southeast of Minorca. The planned cast started 30' late for a problem with a bottle, rapidly solved. At 02:11 (00:11 UTC) the MVP was again deployed for the sampling transect PL21 between T42 and T43.
At 07:25 (05:25) the MVP was recovered, but there the protection of Minorca Island was not sufficient and strong wind conditions (20kn, from North) were still present. Consequently, we decided to move northwestward for about 10 nm to find better conditions to perform the Lagrangian station M2.
At 08:55 (06:55 UTC) at the update position of the waypoint T43, we started the operations of the Lagrangian station M2 following the sequence of operations option "mesocosm" (Figure 6), except the pumping of 10:30 (08:30 UTC), that was canceled to make up for the delay in finding the station initial position. The sequence restarted with the zooplankton nets and concluded with the pumping to fill the night mesocosm.
During the morning, after analysis of the weather forecast, we decided to extend the sequence of operations of M2 until 20:30 (18:30 UTC) of the next day.

Thursday 11 May
The sequence of operations (option "mesocosm", Figure 6) continued as planned, except in two cases of small technical problems that suggested to reverse the sequence of the operations: the VMP planned at 09:00 (07:00 UTC) was performed after the FF-ADCP and the Phytonet cast planned at 14:15 (12:15 UTC) was performed after the CTD-carousel cast since the net had to be repaired.
In the afternoon there was some light rain.
During the last operation of the M2 station, the VVP was recovered rapidly by the tender and at 19:30 (17:30 UTC) and then we moved toward T44 at 10 kn. Outside the protection of Minorca Island, sea conditions were quite rough, but wave heights were decreasing.
At 23:46 (21:46 UTC) we reached T44 where an EoDyn float was deployed and, then, at 23:57 (21:57 UTC) the MVP was deployed to perform the sampling PL22 started along the route toward T45.

Friday 12 May
Four EoDym buoys were deployed along the route toward the waypoint T45. This latter was reached at 11:56 (09:56 UTC) and the operation of the Lagrangian Station B3 started as planned at 12:00 (10:00 UTC).
All along the day the operations followed the planned sequence with the vessel lightly drifting in the weak current and smooth swell.

Saturday 13 May
During the night and the morning, the operations at the Lagrangian station B3 followed the planned sequence (option “no mesocosm”, Figure 6), and ended at 11:45 (09:45 UTC).
At 11:56 (09:56 UTC) we left point T45 and the MVP sampling PL23 started at 11:58 (09:58 UTC).
During the route, the scientific teams started to unmount the laboratories and the scientific equipment.
At 16:15 (14:15 UTC), A. Doglioli, G. Grégori and F. d’Ovidio presented a first summary of the cruise activities at the crew members, then a picture of the crew and scientific team was taken.
After that, the science team met for an End-of-Mission General Meeting.
The MVP sampling PL23 ended at 23:44 (21:44 UTC). The towed vehicle and the cable were checked and then redeployed at 00:31 (22:31 UTC) for the PL24 sampling transect.

Sunday 14 May
The MVP sampling transect PL24 ended at 11:51 (09:51 UTC). The vessel continued the route across T48-T49-T50 and entered in the harbor of Toulon at 15:30 (13:30 UTC) and docked at 16:40 (13:30 UTC) at the Ifremer Center of La Seyne-sur-Mer.
During the route, the scientific teams concluded the packaging of the scientific equipment.
In the evening, scientists and crew celebrated the end of the mission together.

Monday 15 May
The day was dedicated to loading scientific equipment onto the dedicated vehicles, in particular, the main truck arrived at 13:55 (11:55 UTC). The operations concluded at about 18:00 (16:00 UTC).

6. In situ measurements and collected data

6.1 Positioning

During the mission, the ship's position was acquired with two differential GPS receivers. The scientific instruments received the position of the ship's reference point via the signal sent in the local network.

6.2 Meteorology

Meteorological data have been collected through an on-board Mercury weather station sending data in real time to operation weather forecast centers such as Météo France.
The station is equipped with the following instruments:
- thermometer/hygrometer Vaisala HMP35DE;
- barometer Vaisala PTB220;
- seawater thermometer PT100 (mounted on the hull);
- pyranometer Young 70721;
- ultra-sound anemometer Gill Windsonic.

6.3 Current (S-ADCPs)

The courantology work was carried out using three Ship hull-mounted Acoustic Doppler Current Profilers (S-ADCPs): RDI Ocean Surveyor (OS) 38kHz, RDI OS 150 kHz and Nortek Signature 500 kHz (Table 2). Most of the cruise data were collected with the deep-water configuration (apart for the os38 during the two periods close to Minorca Island). The OS data, acquired at 1/3 Hz frequency, were treated with CODAS (either short-time averaged over 2 minutes (sta) or long-time averaged over 10 minutes (lta)) and the Signature with the Nortek Review software. They were further analyzed with the software package LATEXTools (https://people.mio.osupytheas.fr/~doglioli/latextools.htm).

ADCP Name	**RDI Ocean Surveyor**	**RDI Ocean Surveyor**	**Nortek Signature**
Frequency (kHz)	**38**	**150**	**500**
Vertical resolution (m)	12	4	1
Depth range (m)	42-990	15-311	8-68
Number of bins	80	75	60

Table 2. Table of the frequency, vertical resolution, depth range and number of bins for the three ship-mounted ADCPs

The two RDI instruments provided horizontal and vertical velocities from the Ocean Survey configuration. Being a 5 beam ADCP, the Nortek Signature has been installed on R/V L'Atalante for navigation purposes using its 5th beam as altimeter and echo sounder. The Signature 500 measures at a frequency of 8 Hz. It has 8 slots available for each measurement: 1 slot is used for the bottom track, 1 other is used for the altimeter, 2 slots are reserved for the echo sounder and the last 4 are used for the current profile via the 4 inclined beams. The 4 measurements are then averaged to improve the data. Hence, they provide the classical horizontal velocities and vertical estimate using the pair beams (Beams 1 and 3 providing w1, beams 2 and 4 providing w2, and an average w being calculated as (w1+w2)/2, with an error estimate as (w1-w2). The 5th beam could be used to measure oceanic velocity directly as is done with the Sentinel ADCP deployed as FF-ADCP (Section 6.5).

As shown by preliminary on-board data analyses, ocean currents matched with the various oceanic structures observed in satellite data along the route (Figure 8). They were used in real-time in order to apply the Lagrangian sampling, plan the glider's navigation, and decide drifters' deployment location.

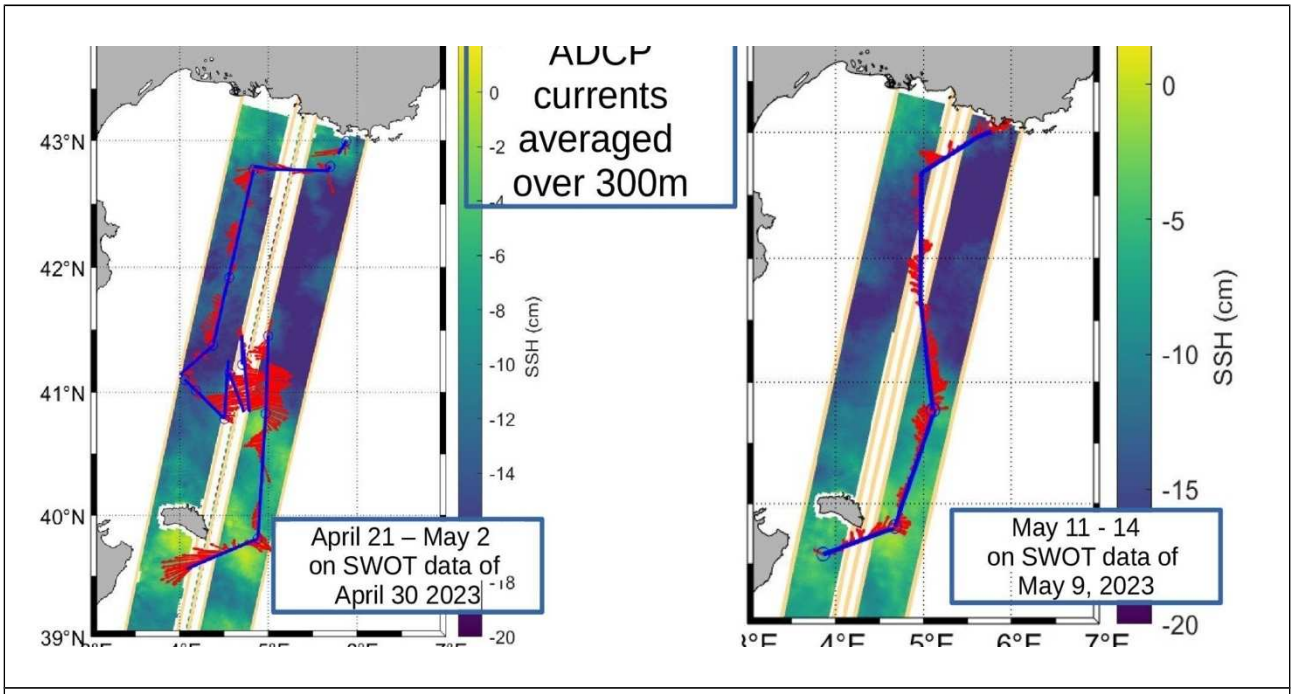


Figure 8. Horizontal current from the .sta files by the OS 150 kHz averaged over 300 m. Left. First part of the campaign (21 April - 2 May) on SWOT data of 30 April. Right. Final part of the campaign (11-14 May) on SWOT data of 9 May.

Currents were particularly strong in the North Balearic Front region (Figure 9) in the first 200 m of the water column. In this layer, they could be higher than 70 cm/s, with average currents around 50 cm/s over the first 300 m.

Otherwise, near inertial gravity waves could be observed especially after the two wind gust events (1 - 2 May and 10-11 May). A small anticyclonic eddy was crossed 4 times east of Minorca. Preliminary treatment of vertical velocities with the OS (especially the OS38) exhibited clear nychthemeral migrations.

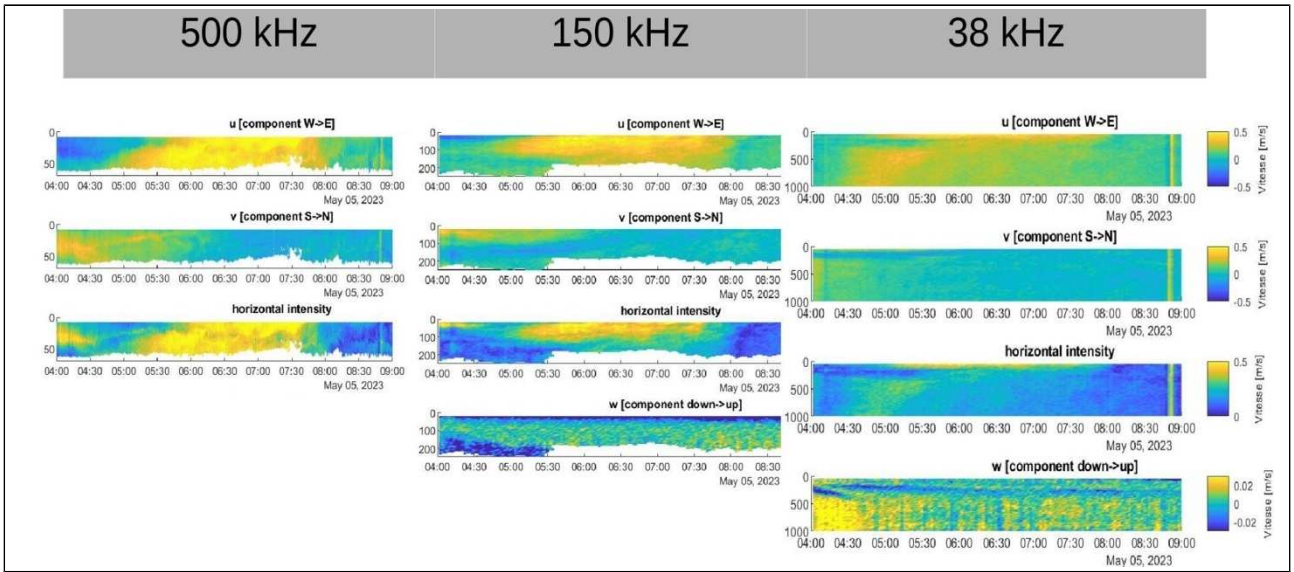


Figure 9. Vertical sections of the different components of the current velocity across the North Balearic Front region on 5 May 5. Left: Nortek 500 kHz data (the vertical velocity is not shown since the error was of the same order of magnitude as the signal itself). Middle. OS 150 kHz. sta data. Right: OS 38 kHz. sta data.

6.4 Echosounder (EK60)

Active acoustic (echosounder) data was recorded throughout the cruise for 24 hours each day.
Start: 21/04/2023 10:57 UTC
End: 14/05/2023 14:00 UTC
Number of files: 7472
Total Size: 73.4 GB

Equipment used:
Simrad EK60 operated at 12, 38 and 200 kHz in continuous wave mode (CW, discrete frequencies).

Channel	*Frequency (kHz)*	*3 dB Beam angle (°)*	*Mode*	*Pulse Duration (µs)*	*Power (W)*	*Recording Range (m)*
12-16	12	16	Active, CW	1024	2000	3500
ES38B	38	7	Active, CW	1024	2000	1500
ES200-7c	200	7	Active, CW	128	150	350

Table 3. Simrad EK60 Normal operation settings for the 3 channels at 12, 38 and 200 kHz, including the recording range in m.

All frequencies were calibrated shortly before the voyage by specialised personnel from IFREMER, following standard procedures described in Demer et al. (2015).

OSEA v2 was used to synchronize the Simrad echosounders with the vessel mounted 38 and 150 kHz ADCP. No synchronization with the 500 kHz Nortek Signature was possible, but no direct impact on the data quality was detected.
All three available frequencies were set to ping simultaneously with a ping interval of 4 seconds.

All data were recorded including Power / Angle Samples (Reduced File Size) using Simrad EK80 Software v21.15. Adjusting the ping rate on a regular basis to avoid the occurrence of ghost bottoms (second echoes from the seafloor) was not possible due to synchronization issued with the ADCP data. Second echoes from the seafloor need to be removed a posteriori. The 200 kHz echograms occasionally received a perceivable amount of electric noise from the MVP. The CTD and zooplankton nets were sometimes visible on the echograms. Other instruments occasionally created temporary noise patterns in the data.

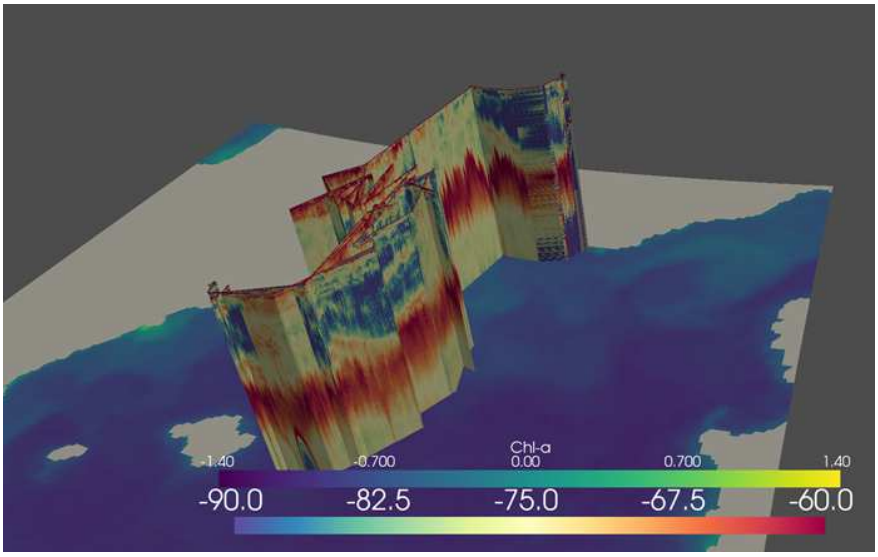


Figure 10. 3D view of the echosounder data at 38 kHz from the surface to 800 m and from 21 April to 12 May, overlayed on top of a Chl-a map of 21 May.

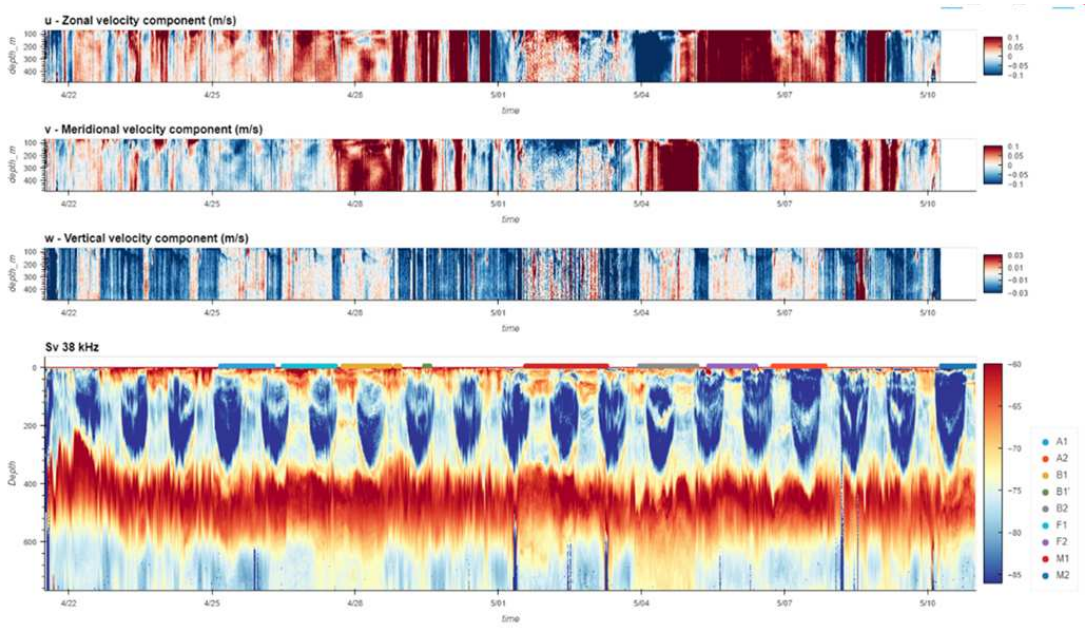


Figure 11. ADCP current recorded by the vessel mounted 38 kHz ADCP (u - eastward, v -westward, w-vertical velocity components in m/s) and the 38 kHz data sampled down to a resolution of 1 m of depth x 1 min time window. The line on top of the 38 kHz echogram indicates the location of the performed Lagrangian stations.

6.5 Vertical velocity direct measurements

6.5.1 Free Fall - Acoustic Doppler Current Profiler (FF-ADCP)

ADCPs are usually used for the horizontal components' measurements, but we were exploiting them for the vertical component. In particular, the new generation ADCPs can have an additional vertical beam dedicated to this component.
The idea of the FF-ADCP methodology is to decouple the ADCP from the vertical movement of the ship: attached to the ship by a loose rope, the FF-ADCP falls freely. Thanks to this decoupling, and using the vertical beam of the new generation ADCPs, the measurement of the vertical velocities can reach a precision of a few mm/s. For details see Comby et al. (2022).

During BioSWOT-Med cruise the FF-ADCP was composed of a cage containing an ADCP, a CTD and an acoustic release system with losable weights (Figure 12). Above the cage, 2 buoys insured a total weight in water of 5 kg (70 kg in air). A 200-m rope was attached to the FF-ADCP and deployed with the help of a winch LOIMEX with a rotation speed between 5 rpm and 40 rpm provided by Genavir.

Equipment used:
ADCP: RDI Sentinel V, 5 beams, 500 kHz, 5m bins, ~40m range, sampling frequency 1Hz
CTD: RBR Concerto
Release system: iXblue Oceano R1

The FF-ADCP analysis method is briefly described as follows:
- data selection: quality criteria of the ADCP 5th beam velocity (intensity and correlation),
- projection of the velocity components to the Earth reference frame (and removal of the u-, v- projections to the non-vertical 5th beam due to the tilt/roll of the instrument), projection of depths (expressed in the ADCP reference frame) to the gravimetric vertical axis,
- subtraction of the vehicle vertical velocity (from the pressure sensor of the ADCP Sentinel) to obtain the oceanic vertical velocity,
- temporal smoothing, removal of the upper and lower ends of profiles (small data occurrence).

Figure 12. Pictures of the FF-ADCP instrument, setting, and deployment.

An example of vertical velocity profiles for the deployment B1C13 is shown in Figure 13.

A total of 39 casts (+1 test cast) were performed, with 2 to 10 profiles each. The casts usually occurred 4 times per each 24h station, with night, morning, afternoon, and evening sessions, beginning usually around 3:45 am (or 6:00 am), 9:45 am, 16:45 pm and 22:15 pm (local time) for a duration of 45 min, 1h or 2h, see Table 5.

The FF-ADCP casts locations are shown in Figure 15.

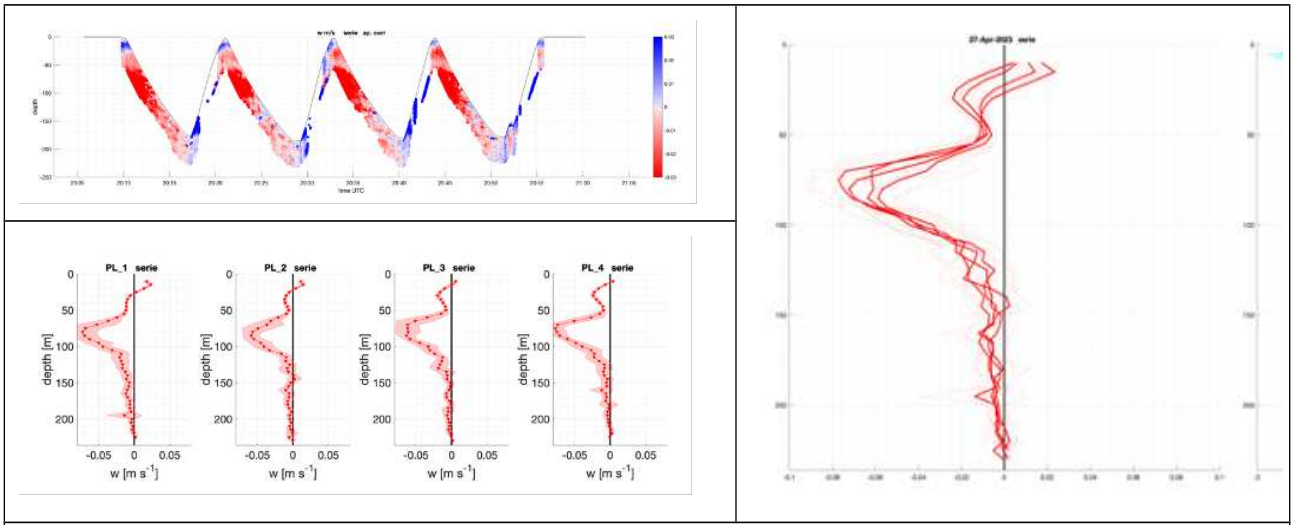


Figure 13. Top Left: Vertical velocities as a function of time and depth (4 dives). Bottom Left: Mean vertical velocities for each dive as a function of depth. Right: Mean vertical velocities for each dive as a function of depth, superimposed.

Deployment Identifier	Start time (UTC)	Initial Position (deg, min)	End Time (UTC)	End Position (deg, min)	Number of profiles
TestC02	24/04/23 16:38	40°56.770 N 4°15.786 E	24/04/23 16:52	40°56.838 N 4°15.770 E	1
A1C04	25/04/23 06:50	41°14.677 N 4°32.857 E	25/04/23 07:35	41°14.499 N 4°32.745 E	4
A1C05	25/04/23 13:58	41°14.260 N 4°33.825 E	25/04/23 14:13	41°14.216 N 4°34.080 E	2
A1C06	25/04/23 19:54	41°14.824 N 4°33.079 E	25/04/23 20:26	41°14.699 N 4°33.457 E	3
A1C07	26/04/23 01:42	41°12.880 N 4°32.749 E	26/04/23 02:32	41°12.877 N 4°32.807 E	4
F1C08	26/04/23 13:57	41°4.102 N 4°21.976 E	26/04/23 15:34	41°04.015 N 4°22.213 E	8
F1C09	26/04/23 20:18	41°6.189 N 4°25.342 E	26/04/23 20:59	41°6.205 N 4°25.230 E	4
F1C10	27/04/23 02:12	41°6.100 N 4°25.617 E	27/04/23 03:02	41°6.044 N 4°25.666 E	4
F1C11	27/04/23 07:48	41°5.660 N 4°26.967 E	27/04/23 08:28	41°5.786 N 4°26.716 E	4
B1C13	27/04/23 20:10	40°52.689 N 4°23.277 E	27/04/23 20:58	40°52.648 N 4°23.302 E	4
B1C14	28/04/23 01:54	40°52.330 N 4°23.178 E	28/04/23 02:44	40°52.454 N 4°23.205 E	4
B1C15	28/04/23 07:45	40°52.662 N 4°22.982 E	28/04/23 08:38	40°52.644 N 4°22.866 E	5
B1C16	28/04/23 14:50	40°53.273 N 4°23.629 E	28/04/23 15:47	40°53.414 N 4°23.860 E	4
M1C00	01/05/23 14:41	39°33.574 N 4°4.561 E	01/05/23 15:12	39°33.567 N 4°4.492 E	3
M1C20	01/05/23 20:09	39°33.625 N 4°4.429 E	01/05/23 20:53	39°33.961 N 4°4.898 E	4
M1C21	02/05/23 02:19	39°32.518 N 4°6.205 E	02/05/23 03:10	39°32.137 N 4°6.291 E	5
M1C22	02/05/23 07:41	39°30.770 N 4°7.279 E	02/05/23 08:27	39°30.762 N 4°7.069 E	5
M1C23	02/05/23 14:33	39°29.402 N 4°5.302 E	02/05/23 15:29	39°29.298 N 4°5.442 E	6
B2C25	04/05/23 07:59	40°46.045 N 4°56.849 E	04/05/23 08:45	40°46.910 N 4°56.353 E	5
B2C26	04/05/23 14:19	40°48.045 N 4°55.887 E	04/05/23 15:15	40°48.182 N 4°56.004 E	6
B2C27	04/05/23 20:36	40°50.384 N 4°55.698 E	04/05/23 20:58	40°50.451 N 4°55.787 E	2
B2C28	05/05/23 01:48	40°50.454 N 4°55.756 E	05/05/23 02:30	40°50.494 N 4°55.594 E	4
F2C29	05/05/23 14:06	41°9.538 N 5°9.993 E	05/05/23 15:10	41°9.538 N 5°11.129 E	6
F2C30	05/05/23 20:12	41°8.748 N 5°15.187 E	05/05/23 20:59	41°8.818 N 5°14.853 E	5
F2C31	06/05/23 04:15	41°7.215 N 5°21.557 E	06/05/23 05:52	41°6.848 N 5°23.285 E	10
F2C32	06/05/23 07:56	41°6.380 N 5°25.604 E	06/05/23 08:28	41°6.515 N 5°26.732 E	3
A2C33	06/05/23 20:04	41°24.622 N 5°15.073 E	06/05/23 21:00	41°24.947 N 5°15.065 E	5
A2C34	07/05/23 04:09	41°24.864 N 5°13.388 E	07/05/23 05:50	41°25.234 N 5°12.817 E	10
A2C35	07/05/23 07:55	41°24.764 N 5°13.073 E	07/05/23 08:35	41°24.609 N 5°13.970 E	4
A2C36	07/05/23 14:29	41°22.501 N 5°15.000 E	07/05/23 15:42	41°22.471 N 5°14.880 E	7
M2C39	10/05/23 08:58	39°39.521 N 3°57.328 E	10/05/23 09:28	39°39.776 N 3°57.649 E	3
M2C40	10/05/23 13:48	39°40.235 N 3°56.626 E	10/05/23 15:12	39°39.925 N 3°56.566 E	8
M2C41	10/05/23 20:13	39°37.766 N 3°55.389 E	10/05/23 20:55	39°37.878 N 3°55.490 E	4
M2C42	11/05/23 04:00	39°36.996 N 3°53.624 E	11/05/23 05:48	39°36.765 N 3°53.381 E	10
M2C43	11/05/23 07:05	39°36.532 N 3°53.227 E	11/05/23 07:46	39°36.667 N 3°53.118 E	4
M2C44	11/05/23 14:38	39°35.060 N 3°53.447 E	11/05/23 15:40	39°34.927 N 3°53.307 E	6
B3C45	12/05/23 14:39	40°46.779 N 5°9.899 E	12/05/23 15:45	40°46.494 N 5°10.218 E	7
B3C46	12/05/23 20:12	40°45.867 N 5°8.299 E	12/05/23 20:57	40°46.107 N 5°7.510 E	5
B3C47	13/05/23 03:55	40°45.025 N 5°5.716 E	13/05/23 04:28	40°45.195 N 5°5.767 E	3
B3C48	13/05/23 08:02	40°45.575 N 5°6.084 E	13/05/23 08:40	40°45.847 N 5°6.387 E	3

Table 5. FF-ADCP casts. The initial and final positions are extracted from VM-ADCP and initial and final times of the casts.

6.5.2 Vertical Velocity profiler (VVP)

The VVP was inspired by several published works exploiting the difference between the true vertical speed W W^{true} of a submarine glider that can be estimated as $W^{true} \sim dP/dt$ from the onboard pressure sensor and its theoretical vertical speed W^{th} extracted from a flight model. The oceanic vertical speed W^{oc} is thus expressed by the simple difference $W^{oc} = W^{true} - W^{th}$ at any point in the water column.

The VVP uses an electric thruster that drives it down to a predefined setpoint depth. Once the depth is reached, the thruster is stopped and the profiler then rises slowly (~0.1 m/s) to the surface under the sole effect of its slightly positive buoyancy. The mechanical balance between buoyancy and hydrodynamic drag results in a constant vertical speed of ascent in water at rest. Any deviation from this theoretical speed is then interpreted as an oceanic vertical velocity signal (see Figure 14). This design allowed to collect several consecutive profiles, the number of descent-ascent cycles and the setpoint depth being programmed and controlled using an ARDUINO microcontroller board. The selected Li-Io battery allowed for several hours of continuous profiling. When on surface, the profiler was located by a commercial SPOT GPS tracker integrated into the electronic case.

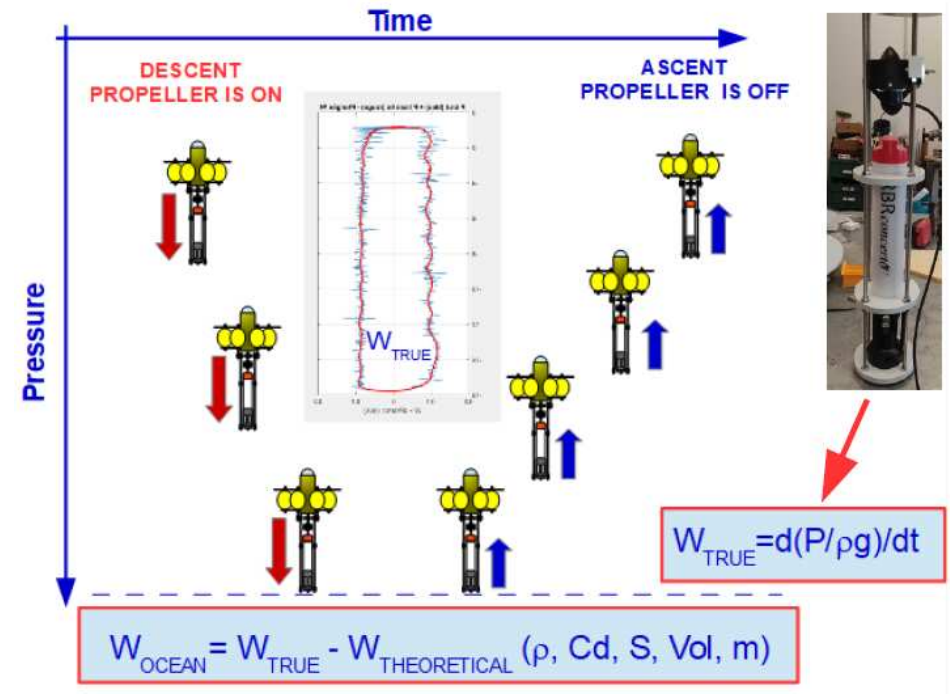


Figure 14. VVP Methodology.

The vertical velocity of the profiler is accurately measured at high frequency (2 Hz) thanks to the fast-response pressure sensor of the onboard RBR-CONCERTO autonomous CTD, which also measures sea water density involved in drag and buoyancy. For details see Fuda et al. (2023).

Two clones VVPs (VVP1 and VVP2) were constructed at MIO, specifically for the BioSWOT-Med cruise, with identical electronics, mechanics and ballasting.
Unfortunately, VVP1 was lost after its first deployment on 25 April. Its last known position (41°14.4198'N, 4°32.8512'E) was sent at 11:45 by the SPOT GPS tracker, just before its first dive. No more positions were received since that time, and VVP1 was considered as definitely lost. The reason of that loss remains currently not well understood.

In the following of the cruise, we deployed VVP2, that performed a large number of profiles between 0 and 200 m (Table 6). The FF-ADCP and VVP casts locations are shown in Figure 15.

Deployment Identifier	Start time (UTC)	Start Position	End Time (end of mission)	Number of profiles
F1C10	27/04/23 00:10	41°05.970 N 04°25.378 E	27/04/23 04:58	3 (without RBR)
B1C14	27/04/23 23:57	40°52.559 N 04°23.330 E	28/04/23 04:48	4
B1C16	28/04/23 11:46	40°52.987 N 04°23.297 E	28/04/23 16:40	4
M1C00	01/05/23 14:03	39°33.585 N 04°04.490 E	01/05/23 17:27	2
M1C21	02/05/23 00:16	39°33.308 N 04°06.171 E	02/05/23 05:10	3
M1C23	02/05/23 11:43	39°29.783 N 04°05.599 E	02/05/23 15:37	3
B2C24	03/05/23 23:28	40°46.387 N 04°57.620 E	04/05/23 04:49	4
B2C26	04/05/23 11:47	40°47.682 N 04°55.983 E	04/05/23 17:10	4
A2C36	07/05/23 10:10	41°22.402 N 05°15.330 E	07/05/23 17:03	4
M2C40	10/05/23 09:39	39°39.907 N 03°57.715 E	10/05/23 16:47	5
M2C44	11/05/23 10:04	39°36.710 N 03°53.110 E	11/05/23 16:58	4
B3C45	12/05/23 10:15	40°46.897 N 05°08.183 E	12/05/23 16:55	4

Table 6. VVP casts.

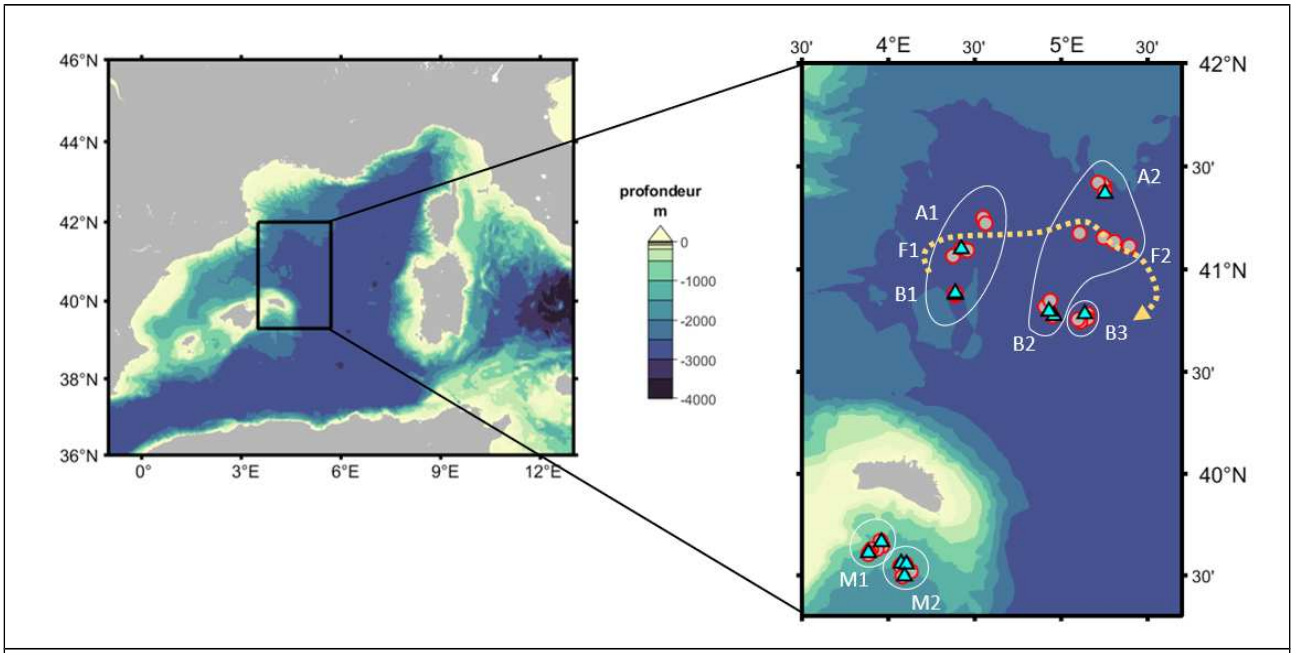
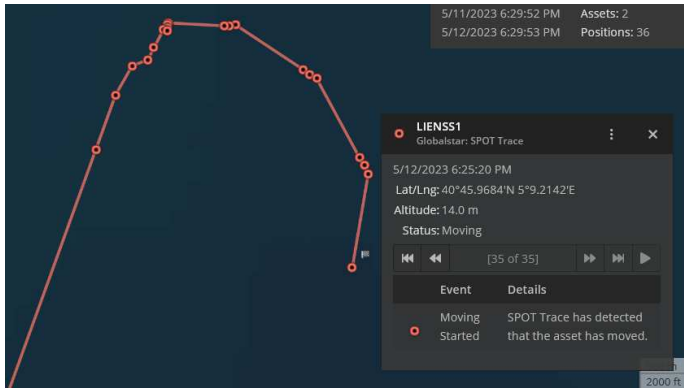


Figure 15. FF-ADCP (red circles) and VVP (blue triangles) deployments. The yellow dots represent the estimated position of the front.

Figure 16. The VVP positioning provides the trajectory of the VVP from which an estimation of the vertically-integrated horizontal current can be obtained. Here, as an example the data of the deployment A3C45.



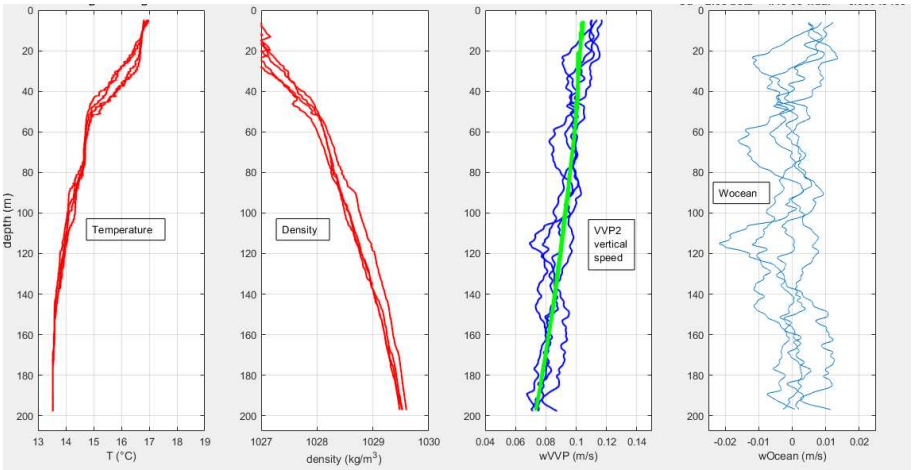


Figure 17. Example of VVP measurements and data processing for the deployment B2C26. The green lines represent the modeled vertical velocity of the VVP in motionless water, superimposed on measured vertical velocities, for all 4 successive profiles. The difference between respective modeled and measured VVP velocities represents the ocean velocity (right panel).

6.6 Microstructure and Mixing (VMP)

The aim of the Vertical Mixing Profiler (VMP) measurements was to quantify turbulence across submesoscale fronts in various dynamical conditions and water masses, and to quantify turbulent diffusive fluxes of nutrients.
We used a VMP250 (Rockland Scientific) with 1000dbars maximum pressure and equipped with two shear probes (512 Hz), a high-frequency temperature probe (512 Hz) and a lower-frequency CTD (64 Hz).
During each of the 24-hour Lagrangian Stations, four series of casts each 6-hours were performed in order to characterize the inertial signal.
In general, VMP casts were performed with good weather conditions with wind speed always below 15 kn during profiles.

Time schedule of operations:
20 April: Arrival on board. Check the connection with the instrument.
23 April: check of the marks on the VMP cable.
24 April: first test profile just after the rosette.
24-28 April: first set Lagrangian stations: A1, F1 and B1.
1-2 May: first Minorca Lagrangian station M1.
4-7 May: second set of Lagrangian stations: B2, F2 and A2.
10-11 May: second Minorca Lagrangian station M2.
12-13 May: third Lagragian station B3.

A total of 40 VMP casts were collected during the cruise (Table 7), with yoyo for most of them leading to a total number of 121 profiles.
Most of the profiles exhibited low averaged dissipation rates during the first Lagrangian station. A few peaks of dissipation rates were observed mostly in the first 200 m, with some correlation with shear. The comparison between the first and second Lagrangian series revealed the striking effect of the storm with intensified turbulence down to 250 m in the B2 anticyclone where the propagation of near-inertial waves was triggered by the background vorticity field (Figure 18). The last Lagrangian station in the B3 anticyclone after the second storm showed the strengthening of the waves and the turbulence.
Most of the profiles rely on the two shear sensors with a few exceptions mostly for shear sensor #1 because of medusa filaments stuck on the probe.

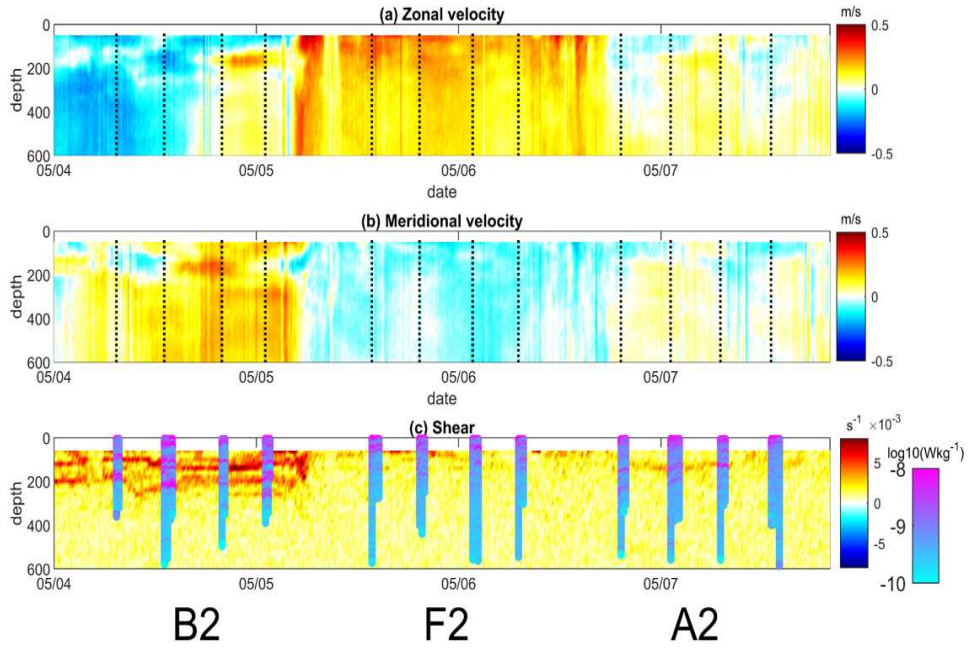


Figure 18: Time-depth sections of zonal (top) and meridional (middle) velocities and shear with dissipation rates superimposed on vertical shear (bottom) during stations the second set of Lagrangian stations. The enhanced dissipation rate observed in the anticyclonic structure (station B2) is co-located with shear layers associated with near-inertial waves whose vertical propagation is triggered by the anticyclonic background vorticity. Outside this structure the dissipation rate is small consistently with the weak shear and currents measured.

VPM sta. #	VMP sta. # position	CTD sta. #	Deployment Date Time (TU)	File	Lagrangian station
1	40°56.62'N - 04°15.87'E	C03	24/04/2023 15:59	BSW_002.p	Test
2	41°14.79'N - 04°32.99'E	C04	25/04/2023 6:15	BSW_003.p	A1
3	41°14.3'N - 04°33.5'E	C05	25/04/2023 13:33	BSW_004.p	A1
4	41°14.98'N - 04°32.87'E	C06	25/04/2023 19:20	BSW_005.p	A1
5	41°13.4'N - 04°33.2'E	C07	26/04/2023 1:03	BSW_006.p	A1
6	41°04.04'N - 04°22.64'E	C08	26/04/2023 13:05	BSW_008.p	F1
7	41°06.07'N - 04°25.45'E	C09	26/04/2023 19:15	BSW_009.p	F1
8	41°06.06'N - 04°25.46'E	C10	27/04/2023 1:27	BSW_010.p	F1
9	41°05.65'N - 04°27.14'E	C11	27/04/2023 7:23	BSW_011.p	F1
10	40°52.72'N - 04°23.21'E	C13	27/04/2023 19:30	BSW_012.p	B1
11	40°52.34'N - 04°23.24'E	C14	28/04/2023 1:11	BSW_013.p	B1
12	40°52.69'N - 04°23.07'E	C15	28/04/2023 7:08	BSW_014.p	B1
13	40°55.07'N - 04°23.4'E	C16	28/04/2023 13:22	BSW_015.p	B1
14	39°33.60'N - 04°4.51'E	C20	01/05/2023 14:08	BSW_016.p	M1
15	39°33.3'N - 04°4.1'E	C21	01/05/2023 19:13	BSW_018.p	M1
16	39°32.90'N - 04°6.1'E	C22	02/05/2023 1:30	BSW_019.p	M1
17	39°30.71'N - 04°7.68'E	C23	02/05/2023 6:58	BSW_020.p	M1
18	39°29.55'N - 04°5.06'E	No CTD cast	02/05/2023 13:15	BSW_021.p	M1
19	40°46.3'N - 04°56.9'E	C25	04/05/2023 7:24	BSW_022.p	B2
20	40°47.82'N - 04°55.99'E	C26	04/05/2023 13:04	BSW_024.p	B2
21	40°50.3'N - 04°55.5'E	C27	04/05/2023 19:55	BSW_025.p	B2
22	40°50.58'N - 04°56.05'E	C28	05/05/2023 1:04	BSW_026.p	B2
23	41°10.28'N - 04°7.70'E	C29	05/05/2023 12:42	BSW_027.p	F2
24	41°8.75'N - 05°15.56'E	C30	05/05/2023 19:21	BSW_028.p	F2
25	41°7.84'N - 05°19.42'E	C31	06/05/2023 1:40	BSW_029.p	F2
26	41°6.42'N - 05°24.49'E	C32	06/05/2023 7:05	BSW_030.p	F2
27	41°24.3'N - 05°15'E	C33	06/05/2023 19:15	BSW_033.p	A2
28	41°24.7'N - 05°14.5'E	C34	07/05/2023 1:09	BSW_034.p	A2
29	41°25.2'N - 05°12.9'E	C35	07/05/2023 7:03	BSW_035.p	A2
30	41°22.4'N - 05°15.3'E	C36	07/05/2023 13:04	BSW_037.p	A2
31	39°39.1'N - 03°57.0'E	C39	10/05/2023 8:11	BSW_039.p	M2
32	39°40.17'N - 03°56.86'E	C40	10/05/2023 12:22	BSW_040.p	M2
33	39°37.7'N - 03°55.5'E	C41	10/05/2023 19:08	BSW_041.p	M2
34	39°37.52'N - 03°53.85'E	C42	11/05/2023 1:51	BSW_042.p	M2
35	39°36.7'N - 03°53.1'E	C43	11/05/2023 7:48	BSW_045.p	M2
36	39°35.55'N - 03°53.25'E	C44	11/05/2023 13:09	BSW_046.p	M2
37	40°47.0'N - 05°09.5'E	C45	12/05/2023 13:04	BSW_047.p	B3
38	40°45.5'N - 05°08.9'E	C46	12/05/2023 19:15	BSW_048.p	B3
39	40°44.8'N - 05°06.7'E	C47	13/05/2023 0:49	BSW_049.p	B3
40	40°45.3'N - 05°06.0'E	C48	13/05/2023 7:00	BSW_050.p	B3

Table 7. VMP casts.

6.7 Radiation (AutoPAR)

R/V L'Atalante was fitted on deck with an automated PAR (Photosynthetically Available Radiation) instrument (QCR-S/N 10637 Biospherical Instruments Inc.). The instrument was installed far enough away from the ship's shadow (see Fig.19). Acquisition was made on a scientific PC programmed in local time (CEST summer time, i.e., UTC-2h). The acquisition frequency was 1 min.

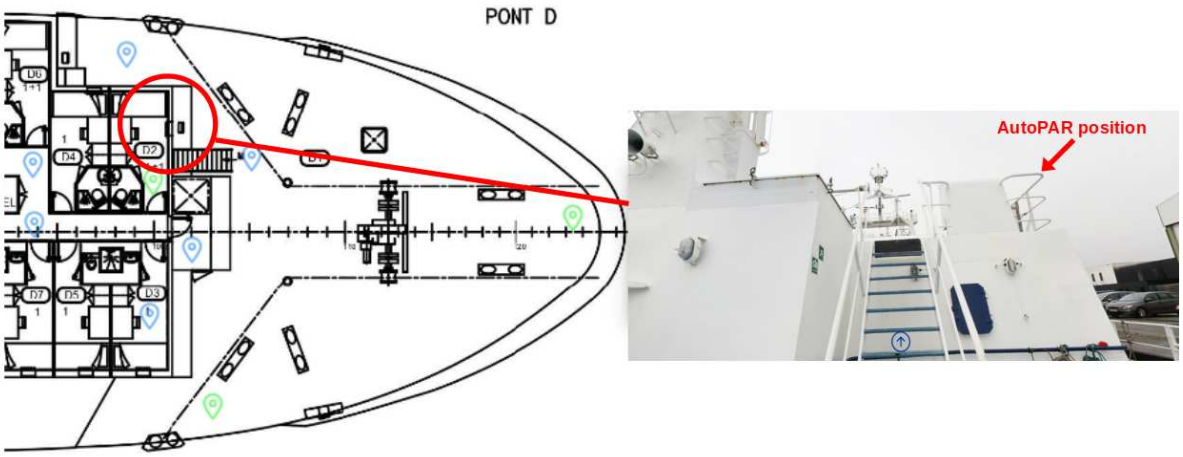


Figure 19: Position of the AutoPAR sensor.

6.8 Multiparametric Moving Vessel Profiler (MVP)

We used a MVP200 equipped with a MSFFF I (MultiSensor Free Fall Fish type I) containing a microCTD MVPx2 with a sound velocity sensor by AML Oceanographic, a fluorimeter, a Dissolved Oxygen sensor and a Turbidity sensor by Wetlabs.

Figure 19. MVP200 (winch and container) installation on the deck.

A total of 1414 casts were performed (196 hours of effective work) and the performed sampling transects are summarized in Table 8. Additional details about the MVP deployments can be found in the technical documents (in French) available at the following links:
https://people.mio.osupytheas.fr/~doglioli/BioSWOT/BioSWOT-Med_2023/Cahier-de-quart-MVP_BioSWOT-Med.pdf
https://people.mio.osupytheas.fr/~doglioli/BioSWOT/BioSWOT-Med_2023/Rapports-Plongees-MVP_BioSWOT-Med.zip

The large majority of the MVP sampling was in the swaths of SWOT as shown by Figure 20.

Transect name	start time (UTC)	end time (UTC)
PL1	21-Apr-2023 19:38:47	22-Apr-2023 04:31:14
PL2	22-Apr-2023 16:29:56	23-Apr-2023 04:36:16
PL3	23-Apr-2023 05:46:19	23-Apr-2023 14:09:20
PL4	23-Apr-2023 16:57:40	24-Apr-2023 04:44:04
PL5	24-Apr-2023 05:39:31	24-Apr-2023 13:16:51
PL6	24-Apr-2023 17:35:09	25-Apr-2023 04:13:49
PL7	29-Apr-2023 00:01:42	29-Apr-2023 04:11:31
PL8	29-Apr-2023 07:37:56	29-Apr-2023 10:50:45
PL9	29-Apr-2023 12:20:20	29-Apr-2023 21:52:06
PL10	29-Apr-2023 22:44:10	30-Apr-2023 03:45:24
PL11	30-Apr-2023 05:12:02	30-Apr-2023 11:30:15
PL12	30-Apr-2023 12:35:54	30-Apr-2023 23:51:54
PL13	01-May-2023 00:58:53	01-May-2023 11:53:35
PL14	03-May-2023 06:34:12	03-May-2023 12:21:56
PL15	03-May-2023 13:29:27	03-May-2023 23:01:16
PL16	07-May-2023 20:00:56	08-May-2023 02:24:43
PL17	08-May-2023 06:24:41	08-May-2023 11:21:57
PL18	08-May-2023 21:51:16	09-May-2023 03:25:58
PL19	09-May-2023 07:15:41	09-May-2023 11:51:23
PL20	09-May-2023 12:55:11	09-May-2023 21:46:35
PL21	10-May-2023 00:11:42	10-May-2023 05:25:14
PL22	11-May-2023 21:57:51	12-May-2023 09:47:53
PL23	13-May-2023 09:58:06	13-May-2023 21:44:21
PL24	13-May-2023 22:31:57	14-May-2023 09:51:19

Table 8. Summary of the MVP sampling transects.

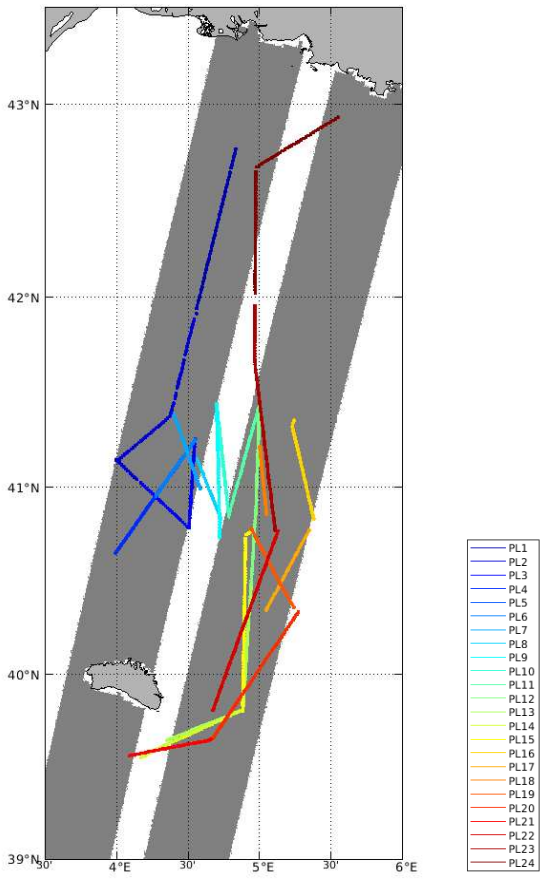


Figure 20. Position of the MVP sampling transects. The colors indicate the dives PL1 to PL24. In grey the SWOT swaths.

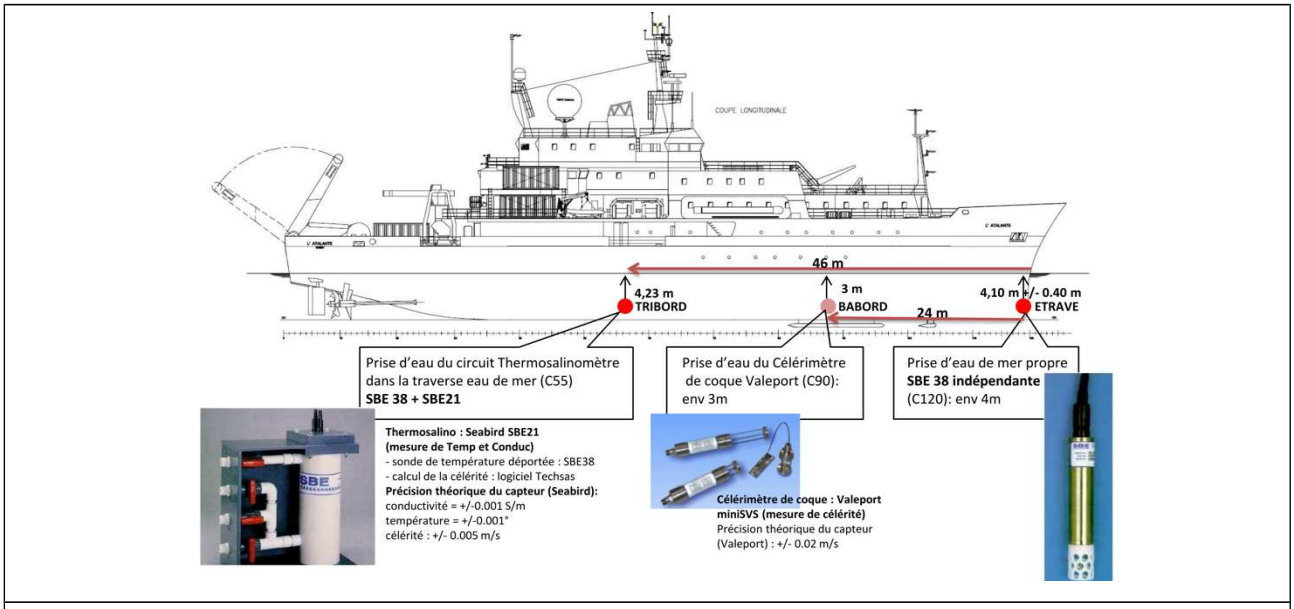


Figure 21. Positioning of the sea water intakes.

6.9 Underway surface water intake and associated biogeochemical analyses

6.9.1 Thermo-salinometer

The R/V L'Atalante was equipped with SeaBird SBE21 sensors positioned in a tank of the clean seawater circuit fed by a centrifugal pump sampling water at 4,23 m below the waterline. A second temperature sensor SBE38 is installed at the bow at 4,10 m below the waterline to correct temperature inaccuracies linked to the heating of the water in the pipework of the first sensor. Both sensors are calibrated every year.
The surface-water intake system has a flow rate of about 1 L/s and the characteristics reported in Table 9.
The draught of the ship at the beginning and at the end of the cruise are reported in Table 10.

	Conductivity:	**Temperature:**
Range:	0 - 70 mmho/cm	5 to +35 °C
Accuracy:	+0.01 mmho/cm	+0.01°C
Resolution:	+0.001 mmho/cm	+0.001°C

Table 9. Characteristics of the Thermo-Salinometer mounted on R/V L'Atalante

	21 April 2023	**14 May 2023**
Bow	4.70 m	4.50 m
Stern	4.90 m	4.80 m

Table 10. Values of the draught of the ship at the beginning and at the end of the cruise.

6.9.2 Chemical analyses

Nutrients
Sampling goal: to measure horizontal distribution of surface nutrient (phosphate, nitrate) concentration across the frontal region.
Between waypoints T22 and T24, samples were collected in 20-mL HDPE bottles and stored at 4°C until analysis within 1-2 days.

Nanomolar phosphate
Sampling goal: to measure horizontal distribution of surface phosphate concentration at nanomolar levels across the frontal region.

Between waypoints T22 and T24, samples were collected in 20-mL HDPE bottles after inline filtration through 0.2 µM using Sterivex cartridge. Samples are stored at -20°C and will be analyzed in the lab through the CFA-LWCC.

Polyphosphate

Sampling goal: measure polyphosphate distribution in the major microbial groups (synechococcus, prochlorococcus, picoeukaryotes, and heterotrophic bacteria) and the subsequent allocation of poly-P to biomolecules within each group.
Sampling collection: Seawater was collected from the underway system (1 to 8 L for each sample). For each sample, seawater was pre-filtered with a 250µm nitex mesh and filtered on a 20µm polycarbonate filter to collect the first fraction. The same seawater was then passed through a cell trap, concentrating the 20µm to 0.2µm fraction. The cells were eluted from the cell trap and resuspended in filtered seawater. Four sets of samples were collected at each station to include poly-P allocation to lipids, nucleic acids and lipids. Ancillary data was collected and included bulk poly-P, POP, TDP and DIP, APA, and samples for flow cytometry (see below).

Net community production (NCP)

Underway measurements were collected onboard the RV L'Atalante. O_2/Ar measurements were taken using equilibrator inlet mass spectrometry (EIMS) in which seawater from the ship´s underway flow-through system is pumped through a gas–permeable membrane contactor cartridge (MicroModule® 0.75×1) allowing gases in the headspace of the cartridge to equilibrate with gases in seawater, and the air is sent via a fused silica capillary to a quadrupole mass spectrometer (Pfeiffer Prisma model QMG 220 M1) to measure the ratio of O_2 to Ar and other dissolved gases. The system calibrates by sampling the atmosphere for 20 min every 4 h. Atmospheric O_2/Ar was very stable and there is no observable instrument drift; the average difference between consecutive air calibrations was 0.2%. The instrument precision is ±0.3% or better and the EIMS e-folding response time is 7.75±0.25 min (Cassar et al., 2009).

6.9.3 Automatic flow cytometry

We sampled the sea water intake at high frequency to study the spatio-temporal dynamics of phytoplankton communities along the ship's track and during stations.
An automated CytoSense flow cytometer (CytoBuoy b.v.) was connected to the seawater circuit of the thermo-salinometer (TSG) to perform scheduled automated sampling and analysis of phytoplankton at high frequency (up to every 15 min).
Three distinct protocols have been run sequentially every 30 min and then during the cruise every 15 min. The first protocol (FLR8) had a trigger threshold fixed at 8 mV on the red fluorescence signal (FLR8) and analyzed a volume of 0.5 cm^3. It was dedicated to the analysis of the smaller phytoplankton (picoplankton). The second protocol (FLR25) had a trigger threshold fixed at 25 mV on the red fluorescence signal. It was set up to target the nano- and microphytoplankton and to analyze a bigger volume (5 cm^3). A last protocol (IIF) was used to take pictures of the biggest cells.
The data were acquired thanks to the USB software (Cytobuoy b.v.) and were analyzed with the CytoClus 4 software (Cytobuoy b.v.).

Figure 22. The shipboard setup of the automated flow cytometry platform.

The sampling time intervals between 21 and 28 April were as follows:
1/ FLR8 (6min)
2/ FLR25 (10min)
3/ IIF (10min)
A second strategy was adopted between 29 April and the end of the cruise because the analysis did not show large cells (like MICRO). We therefore deleted the IIF protocol and created two FLR8 protocols that provide very good analysis resolution for all phytoplankton groups:
1/ FLR8 (6min)
2/ FLR8 (6min)
3/ FLR25 (10min)

The FLR25 protocol was retained in case larger cells were present. However, the analyses were mainly performed with the FLR8 protocol.
The first analyses determined 7 groups of phytoplankton, following the standardized vocabulary (Thyssen et al, 2022): OraPicoProk (Synechococcus), RedPico, RedRedPico, RedNano, RedRedNano, HsNano, HfNano.
Preliminary and general results for spatial distribution showed higher abundances of all groups at the stations A1 and A2 than at stations B1, B2 and B3. At stations F1 and F2, abundances were intermediate. The observed variability throughout the cruise was clearly correlated with the variability of the salinity.
Figure 23 shows the very close link between hydrodynamics and phytoplankton. The Lagrangian mapping shows a gradient of abundance from north to south according to the salinity gradient (Figure 24).

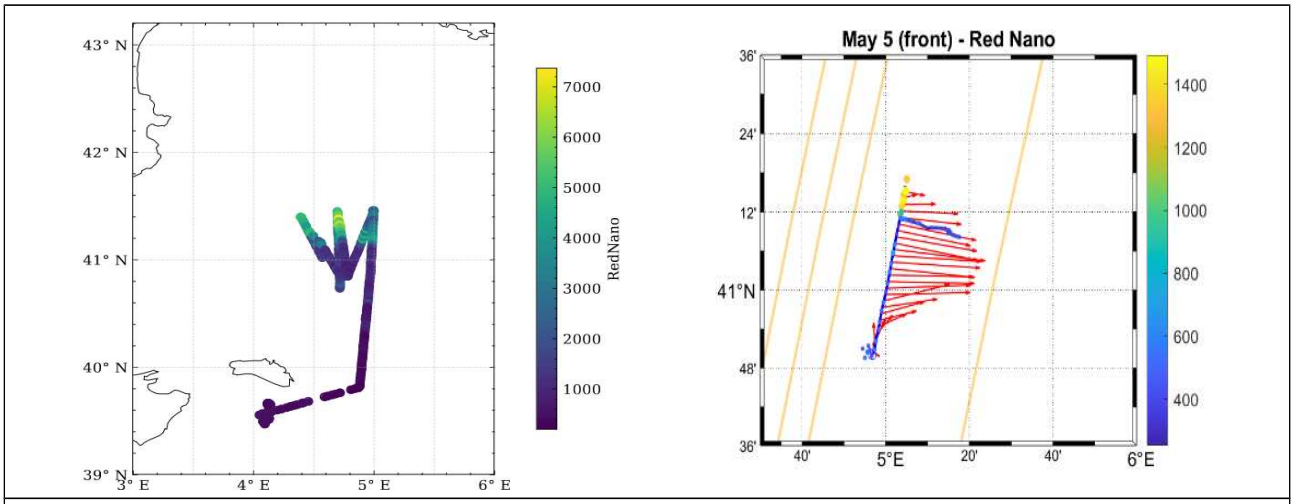


Figure 23. Left: Cytometry mapping from 29 April to 1 May of the "RedNano" abundances [cell/cm3]. Right: Cytometry mapping from 5 May (frontal area) of the "RedNano" abundances [cell/cm3] superposed with the ADCP horizontal current.

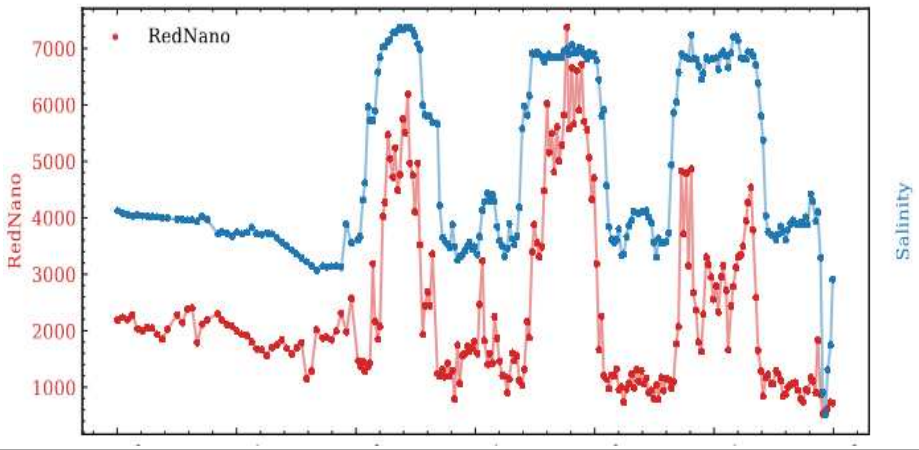


Figure 24. Temporal variability of the abundance of the "RedNano" [cell/cm3] and salinity for the 29 to 30 April.

6.10 Drifters (EoDyn, Spotter, CARTHE, CODE, SVP)

The BioSWOT-Med observational strategy included the Lagrangian component, constituted by drifters, that are gps-tracked buoys moving passively with currents at different depths. Some drifters were equipped with additional sensors to measure specific seawater properties along their path.
The deployment of drifters aimed, first of all, to provide guidance on the circulation features to be targeted with in situ measurements. Moreover, the analysis of drifters' data provided a reference for SWOT sea surface currents cal/val purposes and contributed to the estimate of sea surface convergence/divergence and vertical velocity in the upper 15m depth.
Different types of drifters were deployed (Figure 25); they are listed below from the one closest to the surface to the deepest ones:
- EoDyns: 14 prototype surface drifters measuring wave properties along their track;
- Spotters: 2 very surface drifters measuring wave properties along their track;
- CARTHEs: 20 drifters following currents within the first 60 cm depth;
- CODEs: 10 drifters following currents within the first 1 m depth;
- SVPs: 18 drifters following currents at 15 m depth and measuring sea surface temperature along their track;
- BGC-SVP:1 prototypal SVP drifter, following currents at 15 m depth, equipped with additional sensors such as a CTD (for temperature and salinity) and an optical triplet measuring biochemical properties of sea water.

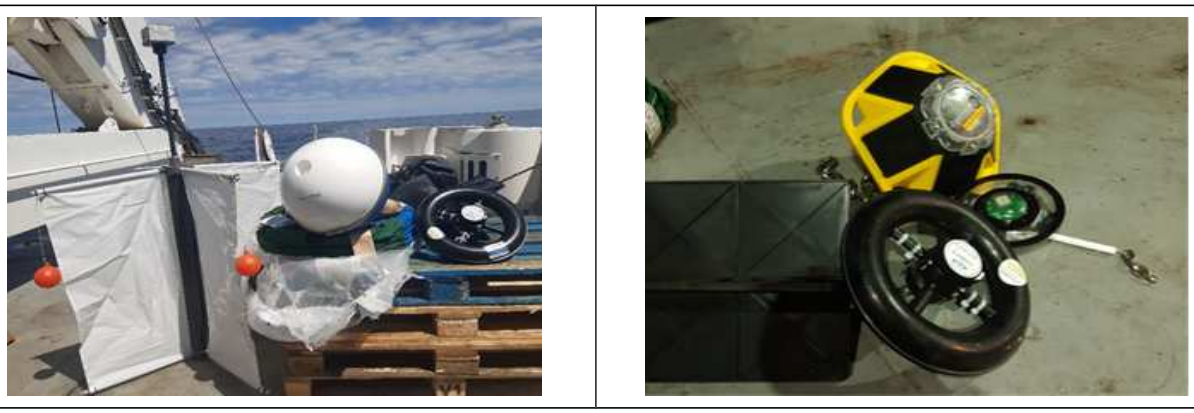


Figure 25. Left: from left to right, CODE, SVP and CARTHE drifter. Right: from top to bottom, SPOTTER, EoDyn, and CARTHE drifter.

The deployment strategies adopted in BioSWOT-Med reflect the coordination among the "Strategy" and the "Physical processes" groups.
Three types of deployment strategy were finally applied during the cruise:
i) an initial survey deployment with a cluster of EoDyn and CARTHE drifters to outline the background circulation in the area of interest, identified through SWOT images, and to provide guidance for the other scientific activities. The deployment targeted a frontal area and aimed at identifying the general dynamics of the two water masses interacting at the front interface (Figure 26);
ii) deployment of SVP drifters during the Lagrangian stations to be able to track the evolution of the water mass dynamics during and after sampling;
iii) deployment of clusters of drifters at different depths (CARTHE, CODE, SVP) with specific geometrical patterns in order to combine the sea current information at different sea layers, estimate convergence and divergence of water masses and vertical velocity in the upper layer. In particular, we targeted first an anticyclonic eddy which drove drifters in a clockwise rotation. Afterwards we targeted the North Balearic Front, characterized by strong shear and convergence among trajectories (Figure 26).

A specific strategy was adopted for drifters to be recovered (the BGC-SVP and the Spotters). The prototype BGC-SVP drifter was deployed inside the anticyclone surrounded by other drifters and recovered 4 days later, after the drifter had almost completed a complete loop around the anticyclone. The two Spotters were released respectively in the anticyclone and north of the North Balearic Front. Co-located with each Spotter, one EoDyn buoy was released for inter-comparison purposes. Spotters showed high sensitivity to wind episodes during the cruise, compared to the SVP drifters anchored at 15m depth.

Table 11 summarizes the drifter deployments during the cruise.

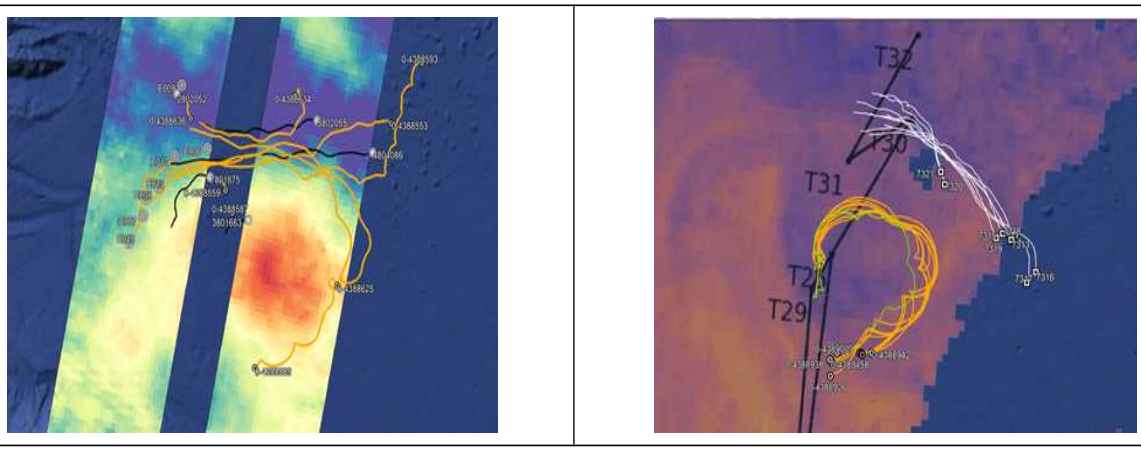


Figure 26. Left: Map of trajectories on April 29: CARTHE (orange), SVP (black), EoDyn deployment location (target symbol). The background is the SSH map from SWOT passage on 24 April. Right: Map of trajectories on 10 May: CARTHE (orange), BGC-SVP (green), CODE (white). The background is the SST map 5 May with some waypoints and ship track (black).

EXPERIMENT: BioSWOT-Med R/V: Atalante SHEET N.: 1/7							
Lagr. device type and ID	**Deploy / Recover (D/R)**	**Date and time (UTC)**	**Lat (DDM)**	**Lon (DDM)**	**Garmin waypoint nr. (WP)**	**Target**	**Notes**
EODYN 008	D	23/04/2023 - 06:29	40° 58.008'N	04° 15.163'E	195	Along transect T5-T6 (NW-SE), targeting the core of the cyclone visible from SWOT	Buoy nr. 11 in the data file (check)
CARTHE 8593	D	23/04/2023 -17:51	41° 10.682'N	04° 28.892'E	196	Along transect T7-T8, crossing the front following the butterfly sampling pattern	First drifter of a sequence of deployment at approx. 10km separation, or finer (5 km). adaptive strategy along the transect crossing the front.
EODYN 012	D	23/04/2023 -18:51	41° 05.721'N	04° 24.345'E	197	Transect from T7 to T8. NE-SW transect.	We alternate CARTHE and EODYN depl. Along the transect.
CARTHE 8589	D	23/04/2023 - 19:26	41° 02.781'N	04° 21.460'E	198	Transect T7-T8	We adapt depl. every approx. 5km given the frontal crossing (evident form TSG)
EODYN 013	D	23/04/2023 - 20:00	41° 00.109'N	04° 19.099'E	199	Transect T7-T8	Deployment at 5km separation according to TSG salinity front signal
CARTHE 8625	D	23/04/2023 - 20:34	40° 57.575'N	04° 16.667'E	200	Transect T7-T8	Crossing point of butterfly pattern, supposedly inside recirculation structure (from SWOT)
EODYN 007	D	23/04/2023 - 21:09	40° 54.842'N	04° 14.152'E	202	Transect T7-T8	Another salinity minimum in TSG
CARTHE 8553	D	23/04/2023 - 21:44	40° 52.069'N	04° 11.659'E	203	Transect T7-T8	We decide to keep all subsequent deployment along T7-T8 every 5km, given the variability in TS signal.
EODYN 015	D	23/04/2023 - 22:12	40° 50.001'N	04° 09.687'E	204	Transect T7-T8	This is the last deployment of the T7-T8 transect, we consider we want to focus on the front that has just been crossed. Lots of jellyfish in the RV wake.
ARVOR-OGS 18EU024 WMO 2903795	D	24/04/2023 - 17:08	40° 56.714'N	04° 15.624'E	205	Water mass B (southern end of T7-T8)	Condition at deployment: sea state smooth, wind at 140°, speed 9 kn, bottom depth 2613m. Set up first cycle down to approx. 1000m, then surfacing every 6h, vertical res. 2m. Params: T, S, DO. Correspondent CTD station C03 (1000m) at 40°56.674'N 04°15.857'E, 12:00UTC.
EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 2/7							
Lagr. device type and ID	**Deploy / Recover (D/R)**	**Date and time (UTC)**	**Lat (DDM)**	**Lon (DDM)**	**Garmin waypoint nr. (WP)**	**Target**	**Notes**
SVP-OGS 64107880	D	26/04/2023 - 06:41	41° 12.244'N	04° 32.490'E	206	Water mass A (northern end of T7-T8)	Co-located release of SVP, CARTHE and EODYN at the end of Lagrangian station in water mass A
CARTHE 8634	D	26/04/2023 - 06:41	41° 12.244'N	04° 32.490'E	206	Water mass A	Co-located release of SVP, CARTHE and EODYN at the end of Lagrangian station in water mass A
EODYN 014	D	26/04/2023 - 06:41	41° 12.244'N	04° 32.490'E	206	Water mass A	Co-located release of SVP, CARTHE and EODYN at the end of Lagrangian station in water mass A
ARVOR-FR 22FR002 WMO 6903090	D	26/04/2023 - 06:45	41° 12.277'N	04° 32.528'E	207	Water mass A (together with drifters above)	Condition at deployment: sea state smooth, wind at 10°, speed 13 kn, bottom depth 2600m. Set up first cycle down to approx. 1000m, then surfacing every 6h, vertical res. 2m. Params: T, S, DO. No dedicated CTD station. Closest CTD in mass A is C07 (500m) at 41°13.172'N 04°33.252'E, 00:00UTC.
SVP-OGS 64107900	D	26/04/2023 - 11:43	41° 04.344'N	04° 22.871'E	208	In between water mass A and F (front)	The aim is for the R/V to sample F, the SVP track together with TSG helps staying in F during the Lagrangian station. SVP called Aurélia.

PROVOR-FR 19FR007 WMO 6990528	D	27/04/2023 - 12:44	41° 06.115'N	04°27.399'E	209	Before leaving water mass F (actually we spent the second half of the Lagrangian station in mass A for overestimated R/V repositioning)	Condition at deployment: sea state smooth, wind at 230°, speed 5 kn, bottom depth 2621m. All cycles to approx. 380m, surfacing every 6h, vertical res. 2m. Params: T, S, DO+BGC. Correspondent CTD station C12 (500m) at 41°6.139'N 04°27.412'E, 12:00UTC.
SVP-OGS 9890	D	27/04/2023 - 17:41	40° 52.727'N	04° 23.105'E	211	Water mass B	The aim is for the R/V to sample B, the SVP track together with TSG will help to stay in B during the Lagrangian station. SVP called Amandine.

EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 3/7

Lagr. device type and ID	Deploy / Recover (D/R)	Date and time (UTC)	Lat (DDM)	Lon (DDM)	Garmin waypoint nr. (WP)	Target	Notes
PROVOR-SUNA 22EU004 WMO 1902605	D	28/04/2023 - 22:04	40° 49.267'N	04° 39.976'E	212	Water mass B (poorer than mass A), as close as possible to the AC core. Measure nutrients before/during/after the Mistral event (forecasted starting on April 30).	Condition at deployment: sea state: slight (1m), wind speed 10 kn, bottom depth 2697m. Set up first cycle down to approx. 1000m, then surfacing every 6h, vertical res. 2m. Params: T, S, DO+BGC+nutrients. Correspondent CTD station C17 (1000m) at 40°49.481'N 04°40.115'E, 20:45UTC.
SVP-OGS 9870	D	28/04/2023 - 22:08	40° 49.212'N	04° 39.930'E	213	Water mass B, as close as possible to the AC core	To give a reference of water mass advection for the following 3-day MVP radiator pattern across the front
EODYN 009	D	29/04/2023 - 05:56	41° 18.703'N	04° 26.353'E	214	Water mass A, northern of the front. Along T20-T21.	Approx. time and location (fix taken right after actual deployment)
SVP-OGS 8950	D	29/04/2023 - 06:02	41° 17.803'N	04° 26.812'E	215	Water mass A, northern of the front. Along T20-T21.	See TSG signal and MVP
CARTHE 8636	D	29/04/2023 - 06:17	41° 15.104'N	04° 28.416'E	216	Water mass A, northern of the front. Along T20-T21.	See TSG signal and MVP. Possible to build chance triplets for div/conv estimate and combined with SVP (larger scale) triplets, also vertical velocity along the front.
EODYN 006	D	29/04/2023 - 08:54	41° 07.148'N	04° 34.776'E	NA	Along T20-T21	Fix not marked. Approx. location from ship navigation system. Possible submesoscale eddy signature.
CARTHE 8559	D	29/04/2023 - 09:01	41° 01.290'N	04°37.835'E	217	Water mass B, southern of the front. Along T20-T21	See TSG signal and MVP. Possible to build chance triplets for div/conv estimate, see also following CARTHE deployment in/04/29.
CARTHE 8587	D	29/04/2023 - 15:20	40° 55.584'N	04°42.963'E	218	Water mass B, southern of the front. Along T21-T22	See TSG signal and MVP
CARTHE 8632	D	29/04/2023 - 17:20	41° 08.197'N	04° 42.732'E	219	Front. Along T21-T22	See TSG signal and MVP
CARTHE 8640	D	29/04/2023 - 18:27	41° 15.044'N	04° 42.224'E	220	Water mass A, southern of the front. Along T21-T22	See TSG signal and MVP

EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 4/7

Lagr. device type and ID	Deploy / Recover (D/R)	Date and time (UTC)	Lat (DDM)	Lon (DDM)	Garmin waypoint nr. (WP)	Target	Notes
BGC-SVP	D	05/05/2023 - 02:44	40° 50.495'N	04° 55.605'E	221	Center of the circle (radius 1nm, approx. 1.8km) in water mass B2	Circular deployment in the anticyclone to have controlled drift of BGC-SVP (to be recovered). Co-located deployment of the following drifters below.
CARTHE 8923	D	05/05/2023 - 02:44	40° 50.495'N	04° 55.605'E	221	Center of the circular depl.	Co-located with BGC-SVP
EODYN 010	D	05/05/2023 - 02:44	40° 50.495'N	04° 55.605'E	221	Center of the circular depl.	To be compared with SPOTTER. Co-located with BGC-SVP.
SPOTTER 147	D	05/05/2023 - 02:44	40° 50.495'N	04° 55.605'E	221	Center of the circular depl.	To be recovered as well. End of co-located depl.
SVP-SIO 8370	D	05/05/2023 - 03:04	40° 50.579'N	04° 56.906'E	222	First point of the circle	
CARTHE 9009	D	05/05/2023 - 03:04	40° 50.579'N	04° 56.906'E	222	First point of the circle	Co-located with SVP-SIO 8370 (above)
SVP-SIO 8320	D	05/05/2023 - 03:12	40° 51.233'N	04° 56.418'E	223	Second point along the circle. Approx. distance between depl. is 1km.	
CARTHE 8938	D	05/05/2023 - 03:12	40° 51.233'N	04° 56.418'E	223	Second point of the circle.	Co-located with SVP-SIO 8320 (above)
SVP-SIO 8910	D	05/05/2023 - 03:20	40° 51.452'N	04° 55.444'E	224	3rd point of the circle.	
CARTHE 8926	D	05/05/2023 - 03:20	40° 51.452'N	04° 55.444'E	224	3rd point of the circle.	Co-located with SVP-SIO 8910 (above)
SVP-SIO 5970	D	05/05/2023 - 03:28	40° 51.042'N	04° 54.533'E	225	4th point of the circle.	
CARTHE 9467	D	05/05/2023 - 03:28	40° 51.042'N	04° 54.533'E	225	4th point of the circle.	Co-located with SVP-SIO 5970 (above)
SVP-SIO 0460	D	05/05/2023 - 03:37	40° 50.266'N	04° 54.318'E	226	5th point of the circle.	
CARTHE 9458	D	05/05/2023 - 03:37	40° 50.266'N	04° 54.318'E	226	5th point of the circle.	Co-located with SVP-SIO 0460 (above)
SVP-SIO 5960	D	05/05/2023 - 03:45	40° 49.627'N	04° 54.908'E	227	6th point of the circle.	
CARTHE 9089	D	05/05/2023 - 03:45	40° 49.627'N	04° 54.908'E	227	6th point of the circle.	Co-located with SVP-SIO 5960 (above)

EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 5/7

Lagr. device type and ID	Deploy / Recover (D/R)	Date and time (UTC)	Lat (DDM)	Lon (DDM)	Garmin waypoint nr. (WP)	Target	Notes
SVP-SIO 0510	D	05/05/2023 - 03:53	40° 49.490'N	04° 55.919'E	228	7th point of the circle.	
CARTHE 8942	D	05/05/2023 - 03:53	40° 49.490'N	04° 55.919'E	228	7th point of the circle.	Co-located with SVP-SIO 0510 (above)
SVP-SIO 5980	D	05/05/2023 - 04:01	40° 49.956'N	04° 56.348'E	229	8th point of the circle.	
CARTHE 8943	D	05/05/2023 - 04:01	40° 49.956'N	04° 56.348'E	229	8th (last) point of circle.	Co-located with SVP-SIO 5980 (above). One-hour depl tot.

ARVOR-OGS 21EU034 WMO 3902500	D	05/05/2023 - 04:07	40° 50.319'N	04° 57.064'E	230	Before leaving water mass B2.	Condition at deployment: sea state: calm, wind speed 6 kn, dir: 112°. bottom depth 2655m. Set up first cycle down to approx. 1000m, then approx. 300m depth, surfacing every 6h, vertical res. 2m. Params: T, S, DO. Correspondent CTD station C28 (500m) at 40° 50.922'N 4° 56.165'E, 04:00.
CODE 64	D	06/05/2023 - 12:35	41° 12.003'N	05° 05.011'E	231	Center of the circle (radius approx. 3nm) in the front (revisiting water mass F2)	Circular deployment in the front to track conv/div. Co-located deployment of the following SVP below.
SVP-OGS 3920	D	06/05/2023 - 12:35	41° 12.003'N	05° 05.011'E	231	Center of the circle	Co-located with CODE 64 above.
SVP-OGS 3890	D	06/05/2023 - 13:15	41° 13.641'N	05° 08.304'E	232	First point of the circle	Beginning of circle
CODE 65	D	06/05/2023 - 13:32	41° 12.086'N	05° 08.971'E	233	Second point along the circle. Approx. distance between depl. is 2.8 km.	
CODE 66	D	06/05/2023 - 13:47	41° 10.679'N	05° 08.558'E	234	3rd point of the circle.	
SVP-OGS 4890	D	06/05/2023 - 14:03	41° 09.458'N	05° 07.080'E	235	4th point of the circle.	
CODE 67	D	06/05/2023 - 14:19	41° 09.005'N	05° 05.080'E	236	5th point of the circle.	
CODE 68	D	06/05/2023 - 14:35	41° 09.376'N	05° 03.093'E	237	6th point of the circle.	
SVP-OGS 4920	D	06/05/2023 - 14:51	41° 10.487'N	05° 01.574'E	238	7th point of the circle.	

EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 6/7

Lagr. device type and ID	Deploy / Recover (D/R)	Date and time (UTC)	Lat (DDM)	Lon (DDM)	Garmin waypoint nr. (WP)	Target	Notes
CODE 69	D	06/05/2023 - 15:07	41° 11.989'N	05° 01.024'E	239	8th point of the circle.	
CODE 70	D	06/05/2023 - 15:23	41° 13.517'N	05° 01.545'E	240	9th point of the circle.	
SVP-OGS 6800	D	06/05/2023 - 15:39	41° 14.640'N	05° 03.061'E	241	10th point of the circle.	
CODE 71	D	06/05/2023 - 15:55	41° 15.012'N	05° 05.097'E	242	11th point of the circle	Look at TSG signal during circle depl., salinity gradient.
CODE 72	D	06/05/2023 - 16:10	41° 14.606'N	05° 07.017'E	243	12th (last) point of circle	End of the circle on the front (3h depl. in total)
EODYN 017	D	06/05/2023 - 18:10	41° 23.868'N	05° 14.923'E	244	Beginning of water mass A2	Co-located depl. of the drifters below
SPOTTER 144	D	06/05/2023 - 18:10	41° 23.868'N	05° 14.923'E	244	Beginning of water mass A2	Co-located depl. for comparison with Eodyn
CODE 73	D	06/05/2023 - 18:10	41° 23.868'N	05° 14.923'E	244	Beginning of water mass A2	Co-located depl.
CARTHE 9439	D	06/05/2023 - 18:10	41° 23.868'N	05° 14.923'E	244	Beginning of water mass A2	End of co-located depl.
SPOTTER 144	**R**	07/05/2023 - 17:48	41° 19.582'N	05° 14.151'E	N/A	Before leaving water mass A2	Recovered with zodiac. Approx. nearby vessel pos.
PROVOR-FR 19FR004 WMO 5906990	D	07/05/2023 - 19:47	41° 21.693'N	05° 14.769'E	245	Before leaving water mass A2	Condition at deployment: sea state: smooth, wind speed 7.5 kn, dir: 278°. bottom depth 2524m. Set up all cycles approx. 300m depth, surfacing every 6h, vertical res. 2m. Params: T, S, DO, BGC. Correspondent CTD station C37 (500m) at 41° 21.727'N 5° 14.688'E, 18:59.
BGC-SVP	**R**	09/05/2023 - 06:45	40° 47.740'N	04° 55.515'E	N/A	Transiting water mass B2	Recovered with zodiac. Approx. nearby vessel pos.
SPOTTER 147	**R**	09/05/2023 - 12:28	40° 19.594'N	05° 16.100'E	246	Running after it at the SWOT edge	Recovered with zodiac (Garmin fix marked).

EXPERIMENT: BIOSWOT-Med R/V: Atalante SHEET N.: 7/7

Lagr. device type and ID	Deploy / Recover (D/R)	Date and time (UTC)	Lat (DDM)	Lon (DDM)	Garmin waypoint nr. (WP)	Target	Notes
EODYN 018	D	11/05/2023 - 21:57	39° 48.388'N	04° 40.354'E	247	In transit from T44 to T45	Regular deployment of the last 4 Eodyn going from Minorca to water mass B3. One deployment every 2-4 hours (nominally).
EODYN 005	D	12/05/2023 - 01:00	40° 03.390'N	04° 47.319'E	248	In transit from T44 to T45	Deployed to unravel current dynamics in area with unclear SWOT signal (see May 9 map)
EODYN 004	D	12/05/2023 - 05:49	40° 26.479'N	04° 48.382'E	249	In transit from T44 to T45	Regular deployment (as planned)
EODYN 011	D	12/05/2023 - 09:56	40° 46.737'N	05° 07.996'E	250	Arrived in T45	Beginning of station B3

Table 11. Drifter deployments during the cruise.

6.11 Floats (ArgoDO and BIOARGO)

The floats employed in this campaign were three ArgoDO (Arvor-I with Dissolved Oxygen probe) and three BioArgo (Provor CTS4 with radiometer, PAR SATLANTIC_OCR504_ICSW), fluorometer WETLABS with chlorophyll, CDOM and backscattering at 700 nm, the AANDERAA_OPTODE_4330 for dissolved oxygen). One of the BioArgo was equipped with SUNA sensor for nitrates. All floats were set at six hours high resolution cycling period immediately after their deployment and this configuration was switched to the standard Argo one at the end of the experiment. In this case the parking depth was disregarded because the float must respect the imposed cycling period that allows it to reach a maximal depth around 300-400 m.
The floats were deployed according to Table 12 and here below are reported the data collected during the cruise for each float.

WMO	Type	Lat	Lon	Date	Associated Station
2903795	Arvor-I DO	40° 56.714' N	004° 15.624' E	24/04/2023 - 17:08:00	A1
6903090	Arvor-I DO	41° 12.277' N	004° 32.528' E	26/04/2023 - 06:45:00	F1
6990528	Provor CTS4	41° 06.115' N	004° 27.399' E	27/04/2023 - 12:44:00	F1
1902605	Provor CTS4 SUNA	40° 49.267' N	004° 39.976' E	28/04/2023 - 22:04:00	B1
3902500	Arvor-I DO	40° 50.329' N	004° 57.058' E	05/05/2023 - 04:08:00	B2
5906990	Provor CTS4	41° 21.693' N	005° 14.769' E	07/05/2023 - 19:47:00	A2

Table 12. Deployments of the Argo floats during the BioSWOT-Med campaign.

Arvor-I WMO 2903795 (ArgoDO float provided by OGS, Trieste, Italy)
The float was deployed on 24 April before the station A1. It was equipped with CTD and the oxygen probe. Temperature, salinity and dissolved oxygen interpolated in time and depth are shown in Figure 27.

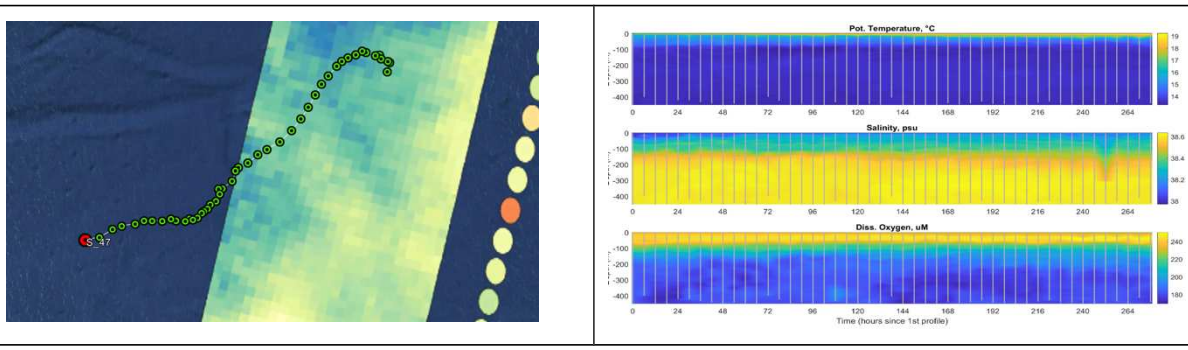


Figure 27. Left: Trajectory of the float from deployment to 5 May superposed to the SWOT altimetry data. Right: Temperature, salinity and oxygen interpolation in time and depth.

Arvor-I WMO 6903090 (ArgoDO float provided by LEFE-GMMC, France)
The float was deployed on 26 April before the station F1. It was equipped with CTD and the oxygen probe. The GPS positioning was sometimes not available and an interpolated position provided by the Coriolis center. Temperature, salinity and dissolved oxygen interpolated in time and depth are shown in Figure 26.

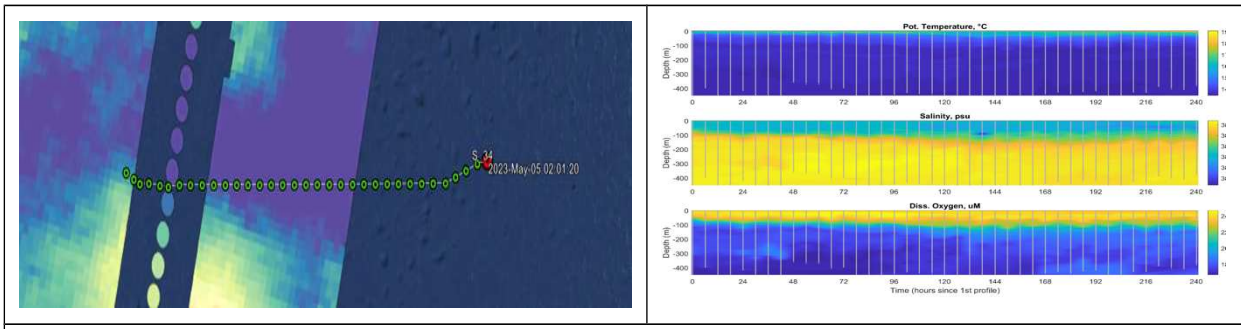


Figure 28. Left: Trajectory of the float from deployment to 5 May. Right: Temperature, salinity and oxygen interpolation.

PROVOR CTS4 WMO 6990528 (BioArgo float provided by LEFE-GMMC, France)
The float was deployed on 27 April after the station F1. It was equipped with CTD, oxygen probe, radiometer and fluorimeter. The measured parameters interpolated in time and depth are shown in Figure 29.

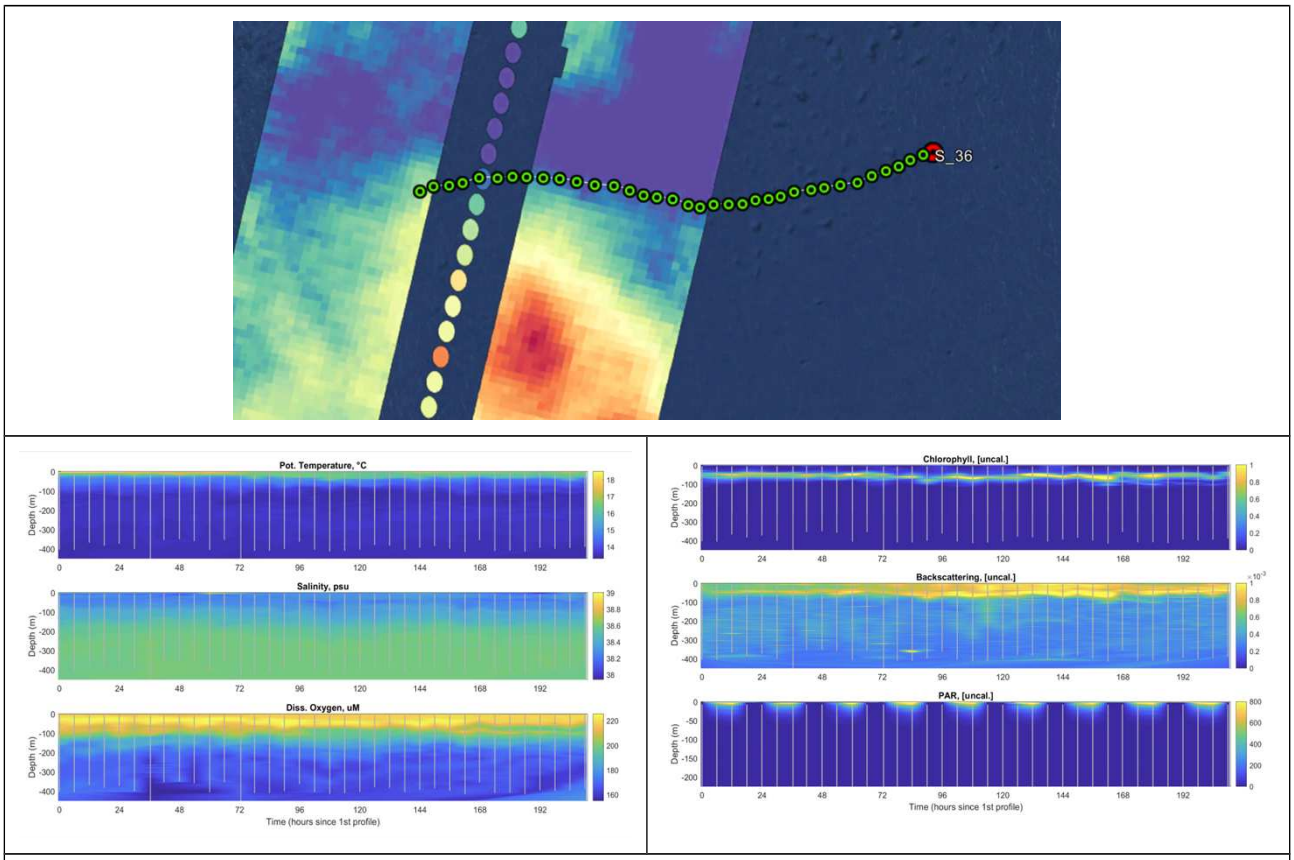


Figure 29. Top: Trajectory of the float from deployment to 6 May. Left: Temperature, salinity and oxygen interpolation in time and depth. Right: Chlorophyll, backscattering at 700 nm and PAR interpolation in time and depth.

PROVOR CTS4 SUNA WMO 1902606 (BioArgo float with SUNA provided by OGS, Trieste, Italy)
The float was deployed on 28 April after the station B1 and was captured by the eddy structure (Figure 30). It was equipped with CTD, oxygen probe, radiometer, fluorometer and SUNA for nitrates. The measured parameters interpolated in time and depth are shown in Figures 31 and 32.

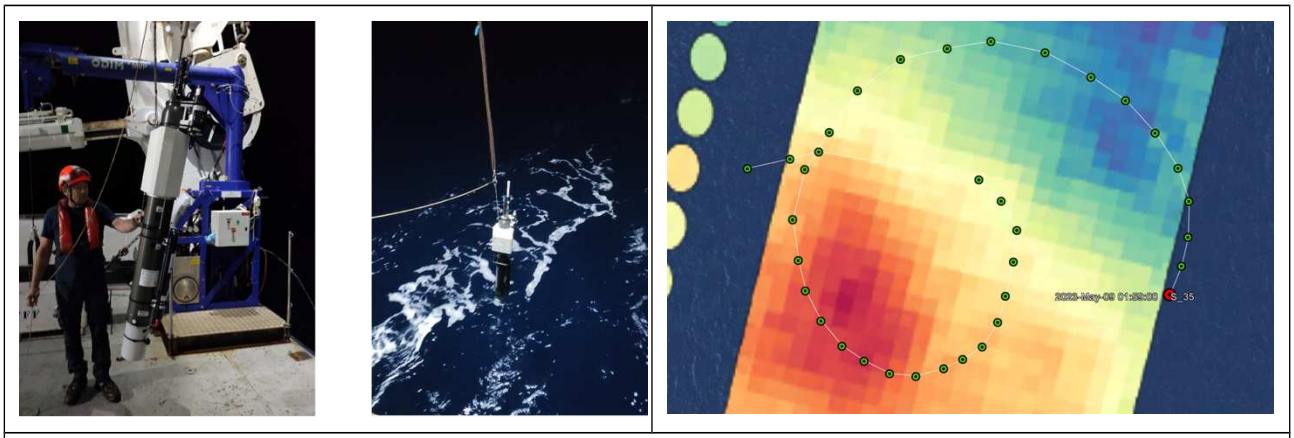


Figure 30. Deployment and trajectory of the float from deployment to 9 May.

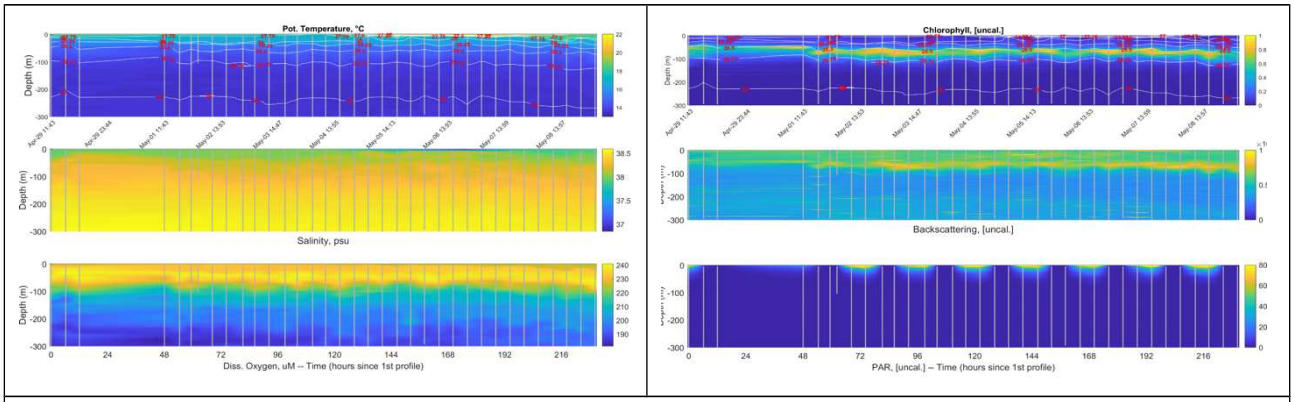


Figure 31. Left: Temperature, salinity and oxygen interpolation in time and depth. Right: Chlorophyll, backscattering at 700 nm and PAR interpolation in time and depth.

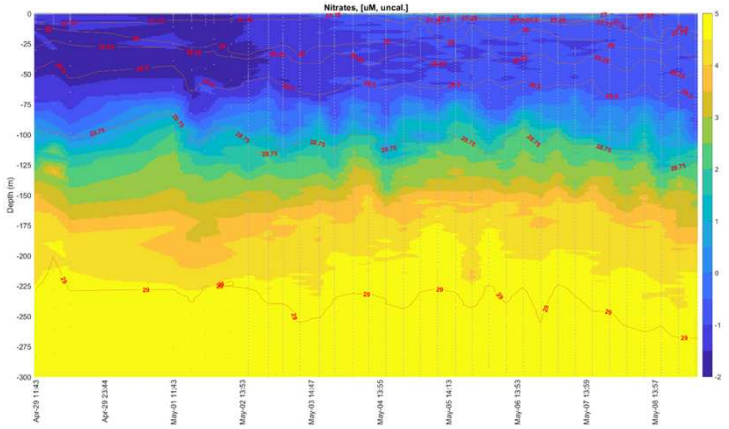


Figure 32. Nitrates uncalibrated concentration interpolated in time and depth.

On 10 May, the SUNA probe showed difficulty in sampling the entire water column, and only few measurements starting from the bottom were acquired. The vertical resolution was modified to sample every 10 meters, in order to save battery energy. On 11 May new mission commands were sent to sample at 5 m from 10 to 200 m.

Arvor-I WMO 3902500 (ArgoDO float provided by OGS, Trieste, Italy)

The float was deployed on 5 May after the station B2. It was equipped with CTD and the oxygen probe. The measured parameters interpolated in time and depth are shown in Figure 33.

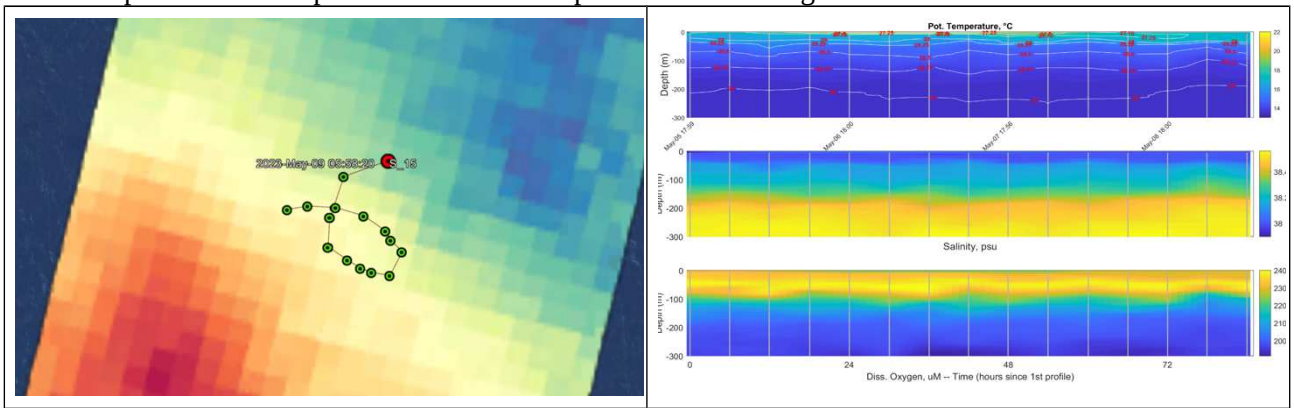


Figure 33. Left: Trajectory of the float from deployment to 9 May. Right: Temperature, salinity and oxygen interpolation in time and depth.

PROVOR CTS4 WMO 5906990 (ArgoDO float provided by LEFE-GMMC, France)
The float was deployed on 7 May after station A2. It was equipped with CTD, oxygen probe, radiometer and fluorometer. The measured parameters interpolated in time and depth are shown in Figure 34.

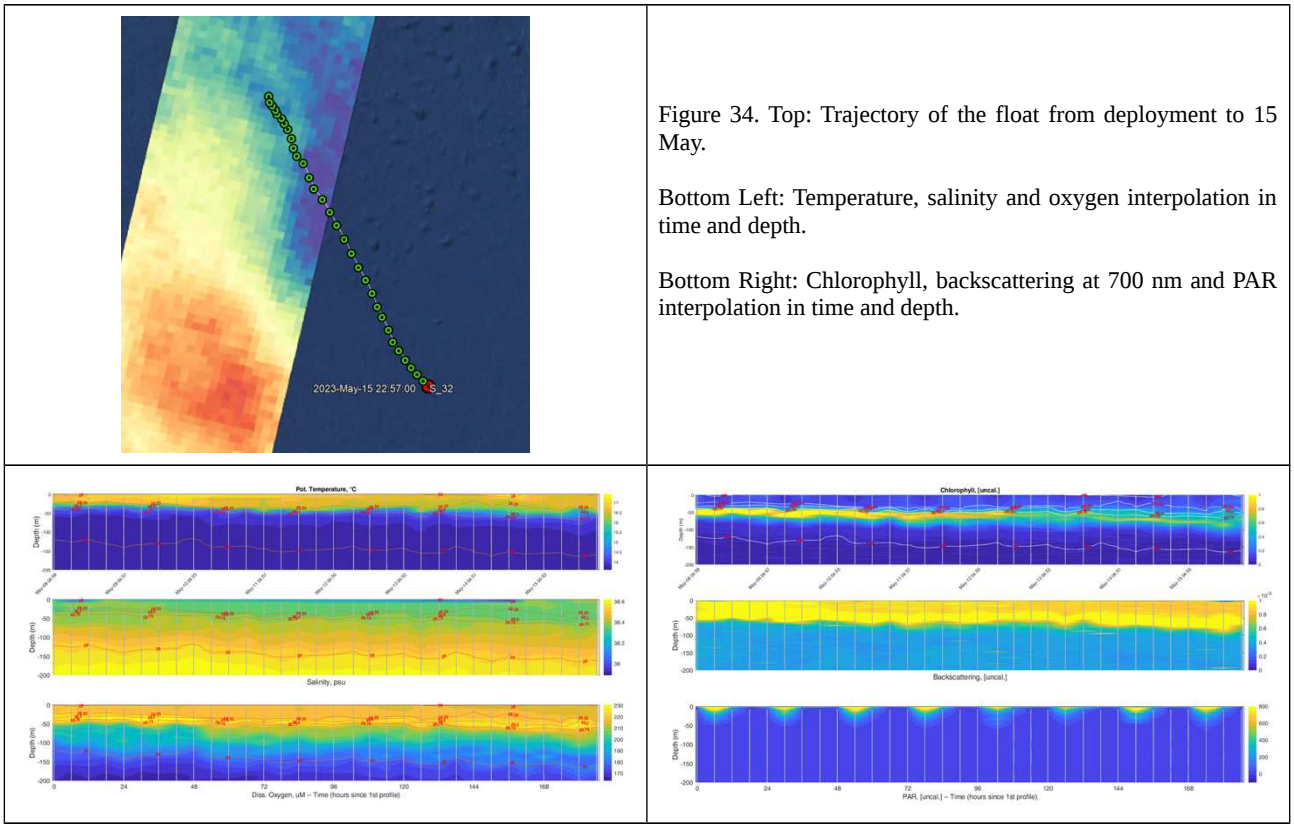


Figure 34. Top: Trajectory of the float from deployment to 15 May.

Bottom Left: Temperature, salinity and oxygen interpolation in time and depth.

Bottom Right: Chlorophyll, backscattering at 700 nm and PAR interpolation in time and depth.

Float data are also available on the web page:
http://www.oao.obs-vlfr.fr/bioargo/PHP/lovbio120c/lovbio120c.html

6.12 Gliders (Seaexplorers, Slocum-UIB, Zooglider-SCRIPPS)

During the cruise, four gliders were deployed and/or recovered (Figure 35):
- two Alseamar's Seaexplorer ("SEA003" and "SEA090", from MIO, France)
- one Teledyne Webb Research's Slocum G3 glider ("Odin" from University of Bergen, Norway)
- one Spray glider (SN0051, "Zooglider" from SCRIPPS, La Jolla, USA)

Figure 35. Left: Zooglider. Right: SEA090 and Odin.

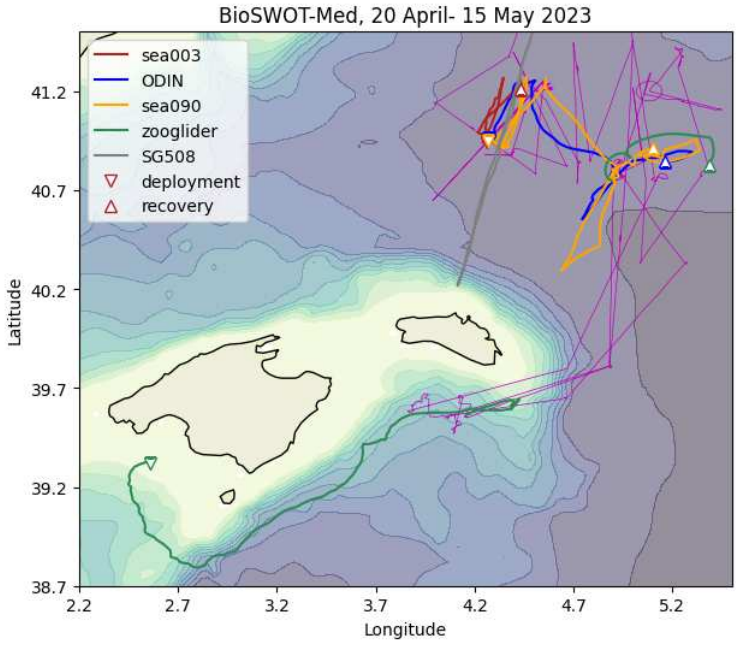


Figure 36. Map of the gliders trajectories performed during the BioSWOT-Med cruise with the ship track (magenta).

Note that another glider (Huttington Ingalls's Seaglider, SG508 from CNRS-INSU and managed at MIO, France) was deployed at the start of the cruise (22 April 2023, 05:36 at 41°54.52'N, 004°33.27'E) for the MOOSE program (https://www.moose-network.fr/) along the MOOSE T02 (Marseille-Minorca) endurance line. This glider was equipped with a Seabird's unpumped CTD sail, an Aanderaa optode (switch off after sensor failure) and an Wetlab's FLBBCD (BB2FL). It sampled along its fixed North-South line during the cruise in the area directly West of the operation, therefore complementing important information to the cruise data in order to document the general context. This glider was recovered in August 2023 during the MOOSE-GE cruise.

All gliders generally performed well during the BioSWOT-Med experiment (Figure 36). SEA003, SEA090 and Odin were all deployed at the outskirts of an anticyclonic eddy. Spray zooglider was deployed by Spanish colleagues from IMEDEA/SOCIB on 30 March 2023, off Majorca (Balearic Islands). Depth-average currents over 1000m reached 30 cm/s and were a challenge for gliders piloting. SEA003 and SEA090 were fast enough to keep their trajectory more or less straight, performing about 20 km/day. Odin was more affected by currents but could still cross the strong currents. Zooglider was too slow to be able to maneuver against the currents and got stuck on some occasion by the currents or deviated from its path. The initial plan to meet Zooglider in the study area had to be modified. Zooglider was thus recovered East of Minorca and redeployed in the eddy for its end of mission.

SEA003 had to be recovered anticipatively on 29 April 2023 after it gave an alert for water leakage during the night of between 2 and 3 May. By chance, the R/V L'Atalante was at about 10 nm far when the alert was transmitted and the glider was recovered the next morning.

Zooglider was recovered on 8 May with 2 m waves and 25 kt wind. The rough sea state made the recovery with the tender challenging, but R/V L'Atalante's crew managed to bring it successfully onboard without damage.

Odin and SEA090 were recovered without difficulties with the tender on 9 May in better conditions and a calm sea.

Gliders' data were sent in real-time to the Global Data Assembly Center Coriolis for Operational Oceanography which provides free access to the netcdf files following EGO/OceanGliders format on its ftp server.

Table 11 summarizes the characteristics of the sensors mounted on the different gliders.

Glider	sensors	Serial Number
SEA003 (Seaexplorer)	Seabird's GPCTD	0068
	Seabird's SBE43F (O2)	0249
	Wetlab's ECOpuck (FLBBCD)	4299
	MiniFluo-UV1 and UV-2 (#13 and 14)	
SEA090 (Seaexplorer)	RBR Legato CTD	214178
	JFE Rinko optode	0075
	Wetlab's ECOpuck (FLNTU)	7983
Odin (Slocum G3)	Seabird's SBE41CP	4595
	RSI's Microrider	SN324
Zooglider (Spray)	Seabird's SBE41CP	
	Seapoint mini-scf fluorometer	
	Zoocam	
	Echosounder (200kHz and 1000kHz)	
	Acousonde	

Table 11. Characteristics of the sensors mounted on the gliders deployed during the cruise.

Odin (Slocum G3) specifications

The Slocum G3 glider from the University of Bergen (Norway) was equipped with a turbulence sensor. The MicroRider is a self-contained turbulence instrument package, fitted with two velocity shear probes (SPM-38), two fast response thermistors (FP07) and high-resolution pressure, acceleration and tilt sensors. The following sensors were installed: SH1: M2033, SH2: M2034, T1: T2060, T2: T1107. The two shear sensors were installed perpendicularly from each other (horizontally and vertically in the axis of the instrument).
Sampling rate for the turbulence sensors is 512 Hz, while the slow-response sensors sample at 64 Hz. Sensors were protected by a probe guard designed not to disturb turbulence measurements (see picture), but greatly reducing the risk of breaking sensors during recovery. The MicroRider was powered by the glider's battery, but stored data separately on a flash card. For details, see Fer et al. (2014).

Zooglider (Spray) specifications

Zooglider is a glider specifically designed for ecological sensing of zooplankton. It was equipped with active acoustics (echosounder at 200 and 1000 kHz), passive acoustics (acousonde), as well as imagery thanks to a Zoocam shadowgraph for plankton identification. It also measures environmental conditions with a CTD sensor and Chlorophyll-a fluorescence. For details see Ohman et al. (2019).
Real-time data of the mission were accessible via https://zooglider.ucsd.edu .
Note that during the BioSWOT-Med cruise, Zooglider had a fatal error with the acousonde, but the other sensors performed normally.

Table 12 reports dates and positions of deployment and recovery of the different gliders.

Glider	Date and time (UTC)		position	travelled distance
SEA003, deployment	24 April 23	14:00	40°56.68'N; 4°15.80'E	122km
SEA003, recovery	29 April 23	07:52	41°08.87'N; 5°15.40'E	
SEA090, deployment	24 April 23	14:30	40°56.68'N; 4°15.83'E	440km
SEA090, recovery	09 May 23	05:20	40°52.82'N; 5°05.85'E	
Odin, deployment	24 April 23	15:30	40°58.00'N; 4°15.92'E	228km
Odin, recovery	09 May 23	04:48	40°51.82'N; 5°05.33'E	
Zooglider, deployment #1	30 March 23	08:53	39°19.15'N; 2°33.73'E	384km
Zooglider, recovery #1	03 May 23	06:19	39°33.60'N; 4°09,26'E	
Zooglider, deployment #2	04 May 23	05:19	40°45.00'N; 4°53.52'E	
Zooglider, recovery #2	08 May 23	05:45	40°46.25'N; 5°21.00'E	

Table 12. Dates and positions of deployment and recovery of the different gliders.

6.13 Multiparametric carousel (CTD, UVP, LISST, PAR, FLUORIMETER, TURBIDIMETER)

The hydrographic work was carried out using a CTD-water sampling package from SeaBird Inc., acquiring data during both down and upcast. The package consisted of a SBE 911plus CTD with a pair of sensors for temperature, conductivity and oxygen (see list in Table 13). The CTD was equipped with a 24 position SBE 32 Carousel, fitted with 22 12-L sampling bottles for discrete sampling (see Figure 37). In total 48 CTD casts were performed during the mission (Table 14 and Figure 38). During all the stations, once per day, samples were taken at all depths for Winkler analysis in order to calibrate the two SBE43 sensors (see Oxygen section).
No salinity samples were taken for Autosal analysis, but the pair of temperature and conductivity sensors showed a very good agreement with differences lower than manufacturer's precision (0.001° for T and 0.003 for salinity, Figure 39). They were both calibrated by the manufacturer in the past 10 months.

Sensor	SN	Calibration/Service date
Temperature	2112	26-Jan-23
Conductivity	3178	26-Jan-23
Pressure	0268	25-Jan-23
Temperature, 2	4775	05-Jul-22
Conductivity, 2	3341	05-Jul-22
Oxygen, SBE 43	3307	04-Nov-22
Oxygen, SBE 43, 2	0514	25-May-22
Fluorometer, Chelsea Aqua 3	088-057	12-Aug-19
Transmissometer, Chelsea/Seatech/Wetlab CStar	1658	11-Oct-22
PAR/Irradiance, Biospherical/Licor	70499	10-Dec-21
Altimeter	63697	May-13
UVP5	005	2022
RDI WH300 L-ADCP, downlooker	10307	07-Nov-2022
RDI WH300 L-ADCP, uplooker	5354	07-Nov-2022

Table 13. Characteristics of the sensors installed on the CTD carousel.

Figure 37. The CTD rosette (left) together with the CTD sensors (right): 22 12-L Niskin bottles, CTD SBE unit with a pair of CT and O2 sensors, UVP, LISST, down and up looking ADCPs. The transducers of both ADCPs and the altimeter have a non-obstructed path. The position of the lead weights and the ADCPs are adjusted to have a negligible tilt of the entire system.

Cast	Date	Time (UTC)	Longitude ^{O}N	Latitude ^{O}E	Waypoint	Station	Notes
C01	Sat 22 Apr	05:54:13	41.9041	4.5572	T3.5	Test	
C02	Sat 22 Apr	09:08:38	41.9040	4.5600	T3.5	Emily-1	
C03	Mon 24 Apr	14:25:13	40.9445	4.2642	T10	Emily-2	
C04	Tue 25 Apr	04:58:00	41.2499	4.5478	T13	A1	
C05	Tue 25 Apr	12:40:54	41.2499	4.5478	T13	A1	
C06	Tue 25 Apr	18:17:44	41.2499	4.5478	T13	A1	
C07	Wed 26 Apr	23:59:00	41.2499	4.5478	T13	A1	Manual entry of the date and time; same entry for start and end.
C08	Wed 26 Apr	12:14:40	41.0648	4.3752	T14	F1	
C09	Wed 26 Apr	18:15:35	41.1014	4.4209	T15	F1	
C10	Thu 27 Apr	00:35:00	41.1014	4.4209	T15	F1	
C11	Thu 27 Apr	06:21:42	41.1014	4.4209	T15	F1	UVP started only at 90-m depth, maybe a problem of connectors; F recovery and redeployment, now the UVP started correctly. Automatic entry of the date/time again not working: T manual entry of the end date/time.
C12	Thu 27 Apr	11:54:00	41.1014	4.4209	T15	F1-end	CTD cast without water samples. Manual entry of the start and end date/time.
C13	Thu 27 Apr	18:54:55	40.8784	4.3865	T18	B1	
C14	Fri 28 Apr	00:14:58	40.8206	4.6644	T19	B1	Manual entry of the end position.
C15	Fri 28 Apr	06:13:22	40.8206	4.6644	T19	B1	
C16	Fri 28 Apr	12:27:40	40.8206	4.6644	T19	B1	
C17	Fri 28 Apr	20:42:12	40.8211	4.6636	T19	SUNA	Cast with water sampling for intercalibration [NO3-] with SUNA and with MVP CTD.
C18	Sat 29 Apr	04:43:49	41.3895	4.3974	T20	Emily-3	
C19	Sun 30 Apr	04:25:29	40.8518	4.7841	T23	Emily-4	
C20	Mon 1 May	18:11:02	39.5600	4.0752	T27	M	
C21	Mon 1 May	00:27:37	39.5600	4.0752	T27	M	
C22	Tue 2 May	06:04:00	39.5600	4.0752	T27	M	
C23	Tue 2 May	12:23:47	39.5600	4.0752	T27	M	
C24	Wed 3 May	23:51:08	40.7711	4.9604	T29	Emily-5	CTD 2000m in the center of an eddy
C25	Thu 4 May	06:33:21	40.7710	4.9520	T29	B2	
C26	Thu 4 May	12:01:51	40.7710	4.9520	T29	B2	
C27	Thu 4 May	18:38:00	40.7710	4.9520	T29	B2	
C28	05/05 et 04/05	00:04:18	40.7710	4.9520	T29	B2	
C29	05/05/23	11:51:28	41.1870	5.0570	T31	F2	
C30	05/05/23	18:33:03	41.1870	5.0570	T31	F2	Sampling for mesocosms
C31	05/06/23	00:42:46	41.1870	5.0570	T31	F2	
C32	05/06/23	06:17:34	41.1870	5.0570	T31	F2	
C33	05/06/23	18:29:06	41.4000	5.2500	T33	A2	
C34	05/07/23	00:16:09			T33	A2	
C35	05/07/23	06:13:58	41.4000	5.2500	T33	A2	
C36	05/07/23	12:05:29	41.4000	5.2500	T33	A2	
C37	05/07/23	18:57:01	41.4000	5.2500	T33	A2	
C38	05/09/23	22:01:16	39.6470	4.6642	T41	Eddy south	
C39	05/10/23	07:00:48	39.6448	3.9663	T44	M2	
C40	05/10/23	11:24:49	39.8000	4.6667	T44	M2	
C41	05/10/23	19:12:36	39.8000	4.6667	T44	M2	sampling for mesocosms
C42	05/11/23	00:08:12	39.8000	4.6667	T44	M2	
C43	05/11/23	06:40:21	39.8000	4.6667	T44	M2	
C44	05/11/23	13:49:48	39.8000	4.6667	T44	M2	
C45	05/12/23	13:53:06	40.7783	5.1333	T45	B3	
C46	05/12/23	19:04:30	40.7783	5.1333	T45	B3	
C47	05/13/23	00:13:01	41.6681	4.9656	T46	B3	
C48	05/13/23	06:43:51	41.6681	4.9656	T46	B3	

Table 14. Report of the Carousel-CTD casts

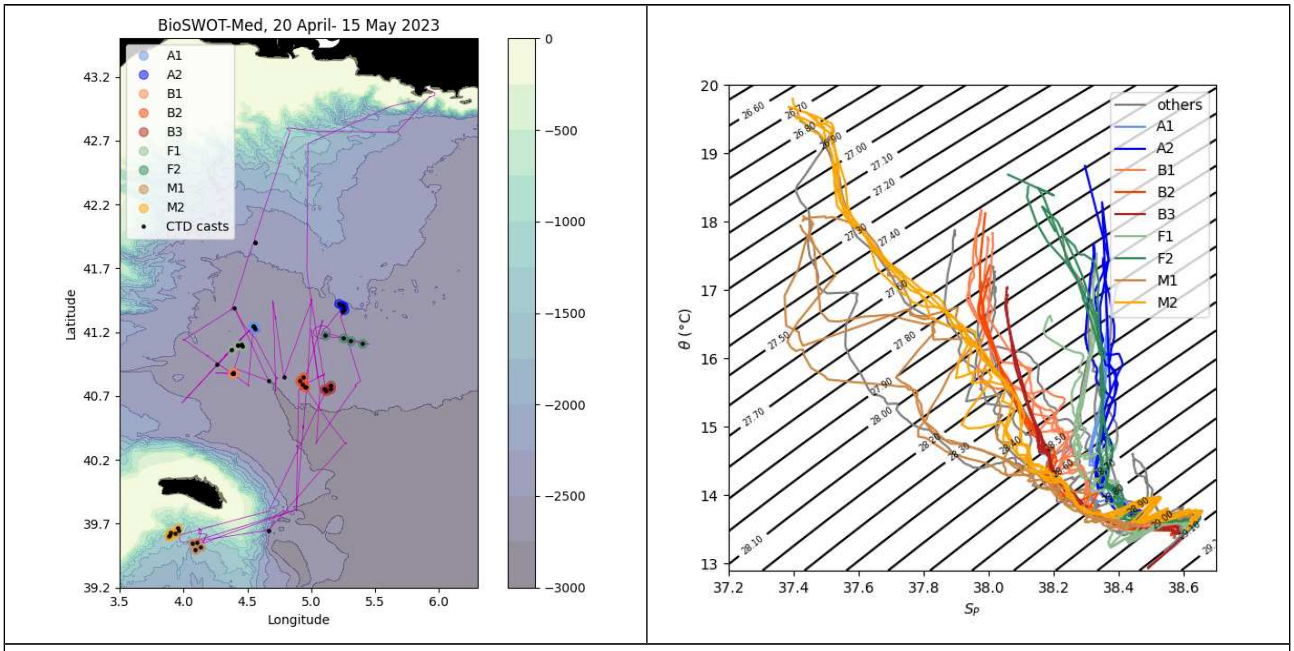


Figure 38. Left: Map of the CTD casts and stations performed during the BioSWOT-Med cruise with the ship track (magenta). Right: Temperature-Salinity diagram of all CTD casts performed during the cruise. The colors aim at grouping CTD cast of the same set of Lagrangian stations.

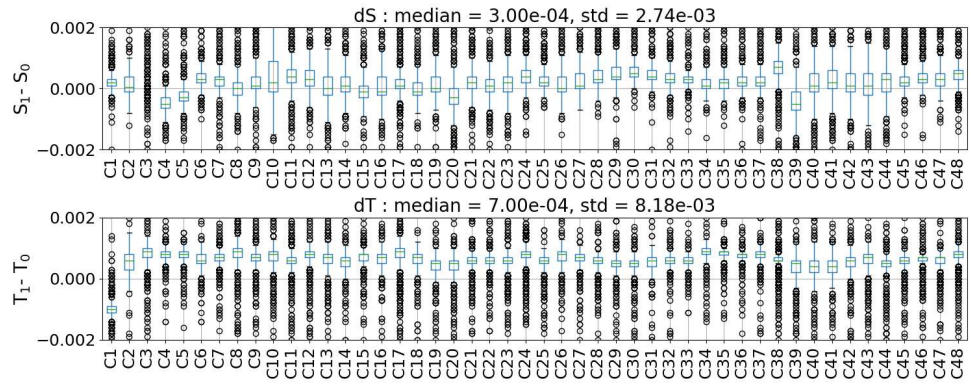


Figure 39. Boxplot of the differences in salinity and temperature for each cast between the pair of CT sensors.

The Underwater Vision Profiler 5 (UVP5) sampling was achieved along with each CTD cast, totaling 48 profiles. Total abundance of particles was rather stable along the cruise, while total biovolume strongly decreased after the first wind event (cast 20, station M1 in figure 40).

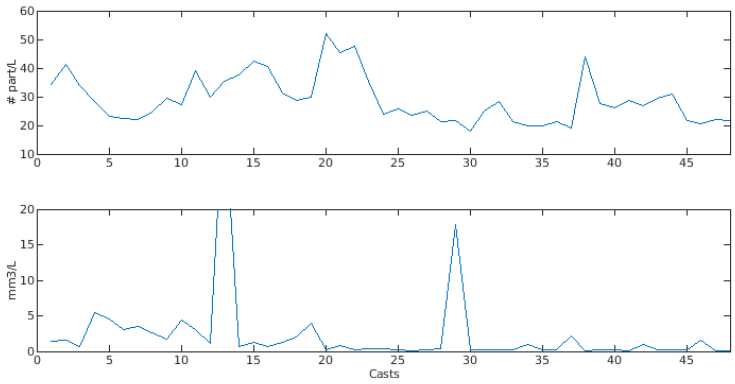


Figure 40. UVP particle abundance (average) and biovolume (average), over 0-500m.

6.14 Water sampling by carousel and associated biogeochemical analyses

At each of the 9 Lagrangian stations (A1, B1, F1, A2, B2, F2, M1, M2, B3), 4 carousel casts were deployed down to 500 m with water sampling for biogeochemical parameters.
All carousel casts were systematically sampled for nutrients (16 depths between 0 and 500 m), nanomolar phosphate (12 depths between 0 and 150 m) and cytometry (16 depths between 0 and 500 m). One cast per station (the one planned at 02:15 UTC, Figure 6) was also sampled for chlorophyll-a and net community production (NCP). One cast per station (the one planned at 14:30 UTC, Figure 6) was also sampled for ammonium (NH4), nanomolar nitrate (nanoN), dissolved organic carbon (DOC), chromophoric and fluorescent dissolved organic matter (CDOM and FDOM), dissolved organic phosphorus and nitrogen (DON and DOP), particulate organic phosphorus and nitrogen (POP and PON), alkaline phosphatase activity (APA) and organophosphate-esters (OPE). One cast per day (the one planned at 20:30 UTC, Figure 6) was sampled for oxygen analysis for calibration of the SBE sensors.
The sampling and analysis methods for the above cited parameters are described below.

Cytometry
Sampling: Samples were directly collected from the Niskin bottles into 15ml Falcon tubes, and then fixed into 2 ml cryotubes. Samples were collected in triplicates (for the analysis of phytoplankton, heterotrophic nanoflagellates, bacterias + viruses). All samples were fixed to preserve the cell integrity according to this protocol: 20 µl glutaraldehyde-pluronic + 1980 µl of sample. They were left for 30 min in the dark at room temperature to optimize the fixation of the cells. Then samples were flash frozen in liquid nitrogen prior to being stored at -80°C until analysis in the on-land laboratory (at the flow cytometry platform of the MIO PRECYM (https://precym.mio.osupytheas.fr/)).
Overall, 39 CTD casts were sampled to address the structure of the microbial communities by conventional (i.e., not automated) flow cytometry during the cruise, at 16 depths for each cast, which makes up to 635 samples in total, dispatched into 1905 tubes to analyze.
Acquisition: Samples for phytoplankton analysis were acquired on board, using the Cytoflex flow cytometer. Samples were thawed, then dispatched on 96-well plates (mixed with a solution of 2µm and TruCount counting beads) and analyzed according to two different protocols: one dedicated to small cyanobacteria and picoplankton and another one dedicated to the larger nano- and microplankton (5 min per protocol).
Samples for bacterioplankton, heterotrophic nanoflagellates, and virus analyses will be acquired at the laboratory on land after the cruise.
Analysis: Analysis of flow cytometry data will be done on land, using dedicated software (FCS Express; Cytexpert).

Nutrients
Samples were collected from Niskin bottles (16 depths between 0 and 500 m) in 20-mL HDPE bottles and stored at 4°C until analysis within 1-2 days. Analysis for nitrite, nitrate, phosphate and silicate were performed on board using an automated colorimetric procedure (Aminot and Kerouel, 2007).

Nanomolar phosphate:
Samples were collected from the Niskin bottles (12 depths between 0 and 150 m), filtered inline through 0.2 µm using a Sterivex cartridge and collected in 20-mL HDPE bottles previously cleaned with HCl. Due to a technical problem with the analytical instrument on board, samples were stored at -20°C and will be analyzed back in the laboratory at MIO. The analysis will be performed using an auto-analyzer system (SFA, segmented flow analyzer) coupled to a 2.5 m length LWCC (long waveguide capillary cell) and connected to a USB-Flame spectrophotometer. The protocol is based on Zhang and Chi (2002) and Patey et al. (2008).

NH4
Samples were collected from Niskin bottles (12 depths between 0 and 500 m) into PC 60ml Nalgene Oak Ridge bottles. The orthophtaldialdehyde (OPA) reagent was then added and samples were incubated for 4 hours in the dark before fluorescence measurements using a Fluorimeter TD-700 Turner Designs after Holmes et al. (1999)'s method based on the reaction of ammonia with orthophtaldialdehyde and sulfite.

Nanomolar nitrate
Samples were collected from Niskin bottles (6 depths from 0 to 150 m) and filtered immediately after sampling through 0.2 µm using a Sterivex cartridge under a laminar flow hood. Samples were stored in 30-

mL HDPE bottles at -20°C. The analysis will be performed back in the laboratory at MIO or PML through SFA (segmented flow analyzer) coupled to a 1-m LWCC (long waveguide capillary cell) based on Patey et al. (2008).

DOC
Samples were collected from Niskin bottles (13 depths from 0 to 500 m) and filtered immediately after sampling through 0.2 µm using a Sterivex cartridge under a laminar flow hood. Samples were acidified with 20 µL of H2SO4 and stored in pre-combusted 20-mL glass vials at 4°C until analysis. Analysis will be performed in the laboratory at MIO. Samples are bubbled with CO2-free air for 2 min to purge inorganic carbon followed by a high-temperature catalytic oxidation using TOC-V csh analyzer (Shimadzu, Japan). DOC concentrations (µM) are validated using certified reference material (low carbon water and deep-sea water references) purchased from Hansell Laboratories (Miami, USA). The protocol is adapted from Sohrin and Sempéré (2005) and Fourrier et al. (2022).

CDOM-FDOM
Samples were collected from Niskin bottles (13 depths from 0 to 500 m) and filtered immediately after sampling through 0.2 µm using a Sterivex cartridge under a laminar flow hood. Samples were stored at -20°C in pre-combusted 60-mL glass vials. Back in the laboratory at MIO, measurements of absorption spectra for CDOM will be performed with a 10-cm long cell on a UV–Vis 2450 spectrophotometer (Shimadzu, Japan). Measurements for FDOM will be performed on a F-7000 spectrofluorometer (Hitachi, Japan) for which excitation-emission matrices (EEMs) will be combined with PARAFAC treatment (Ferretto et al., 2017; Tedetti et al., 2020).

DOP-DON
Samples were collected from Niskin bottles (10 depths between 0 and 200 m) and filtered immediately after sampling through 0.2 µm using a Sterivex cartridge under a laminar flow hood. Samples were acidified with 100 µL of H2SO4 immediately after filtration and stored in Teflon flasks at room temperature. Back in the laboratory at MIO, total dissolved nitrogen and total dissolved phosphorus have been measured using the wet-oxidation procedure described by Raimbault et al. (1999). Dissolved organic nitrogen (DON) and dissolved organic phosphorus (DOP) are calculated as total dissolved nitrogen and total dissolved phosphorus minus dissolved inorganic nitrogen (nitrate + nitrite + ammonium) or phosphate respectively measured in the same samples. Analyses were performed using an automated colorimetric procedure (Aminot and Kerouel, 2007).

POP-PON
Samples were collected from Niskin bottles (6 depths between 0 and 150 m). 1.2 L samples were filtered immediately after sampling onto a precombusted (450°C, 4h) glass fiber filter (Whatman 47 mm GF/F). Filters were stored at -20°C. Back in the lab at MIO, particulate organic nitrogen (PON) and particulate organic phosphorus (POP) were converted in nitrate and phosphate respectively using the wet oxidation method based on a persulfate digestion at 120°C according to Raimbault et al. (1999). The nitrogen and phosphate formed by this oxidation were then determined with a SFA nutrient auto-analyzer (SEAL AA3).

APA
Samples were collected from Niskin bottles (6 depths between 0 and 150 m) and distributed in 24-well multiplates. Samples were spiked with increasing concentrations (0.025 to 1 µM) of a fluorogenic substrate (Methylumbelliferyl phosphate disodium salt, MUF-P) immediately after sampling. Samples were incubated in the dark at in situ temperature for ca. 6 hours. Fluorescence measurements were conducted at selected intervals during the incubations by spectrofluorimetry using a Varioskan multi-plate reader (Hoppe, 1993).

OPE
Seawater samples were collected from the CTD carousel (4 depths between 0 and 150 m) using glass bottles (pre-combusted, acetone rinsed). Each seawater sample was passed through a pre-combusted GF/F Whatman 47mm filter (to collect the particulate fraction), and the filtrate was then mounted on a solid phase extraction manifold and passed through a glass cartridge (5cc, 200mg HLB sorbent, Waters corp). The glass cartridges were wrapped in pre-combusted aluminum and stored in the freezer. Filters were flash frozen in liquid nitrogen and stored in the -80°C freezer for transport.

Poly-P

Seawater samples for this parameter were collected during the extra casts listed in timeline as “Emily-X” casts), in order to measure particulate polyphosphate in the water column, the contribution of polyphosphate to the major biomolecules at each depth, and polyphosphate distribution across the major microbial groups (*Synechococcus*, *Prochlorococcus*, picoeukaryotes, and heterotrophic bacteria). Seawater samples were collected from the CTD carousel (3 depths between 0 and 150 m). At each depth, the collected seawater was split into measuring the following parameters: 1) bulk poly-P measured by DAPI and MS, 2) poly-P in lipids and 3) nucleic acids, 4) poly-P in the major microbial groups, and 5) TDP, DIP, POP, APA and cell counts as ancillary data. For the parameters listed in 1–3, as well as POP and APA, seawater (1–4 L) was filtered on a range of 0.2 µm filters (pre combusted Whatman GF/F, polycarbonate, and durapore). Filters were flash frozen in liquid nitrogen and stored in the -80°C freezer until transport. The filtrate was collected for inorganic phosphate and total dissolved phosphate measurements. To quantify poly-P in specific microbial groups, cells were collected in two fractions, 200µm to 25µm (polycarbonate filter) and 25µm to 0.2µm (cell trap) which will be analyzed for poly-P and cell sorted to identify specific community members.

Chl-a

Seawater samples were collected from the CTD carousel (6 depths between 5 and 150 m) using 0.5 L dark plastic bottles (Nalgen bottles with a volume calibrated). Each seawater sample was passed through a GF/F Whatman 25mm filter (to collect the phytoplankton).

Vacuum filtration was carried out as soon as possible after sampling (no later than 2 hours). The filtration manifold was connected to a vacuum pump fitted with a pressure gauge. Vacuum should not exceed 0.2 bar vacuum (or 150 mm Hg). The filters were then placed in a storage tube (glass) identified with the number of the sample kept in the freezer onboard. Samples were then kept frozen until analysis in the onshore laboratory at the PACEM Chemistry platform of the MIO according to the protocol defined by Raimbault et al. (2004).

Production versus irradiance

Samples were taken for CTD cast within the euphotic layer and from the underway for the surface samples in 1 dm^3 borosilicate bottle. Bottles were fitted with Aanderaa® oxygen optodes. Samples were incubated in a 30 dm^3 water tank regulated to a fixed temperature corresponding to the mixed layer. Experiments were run for 23 hours using a light system from the alpheus Radiometrix IV. This model of module was equipped with Amber (590nm), NWhite (4500kK), Rblue (450nm) and Green (525nm) LEDs. This range was chosen for its modularity. This assembly of LEDs was established with the manufacturer to match the natural solar spectrum received on the surface in a natural environment. Light steps range for 0% to 100% of natural light with 11 steps after 1 hour of sample acclimatation for temperature equilibrium. Jassby and Platt (1976) PvsE model is applied to each sample to derive the photosynthetic parameters.

Determination of dissolved O2 concentrations in water samples using the Winkler method (O2W)

Samples were collected from Niskin bottles (12 dm^3) into 125 cm^3 borosilicate glass vials using VERSILIC® tubing. The flasks were filled by overfilling by the equivalent of 3 times the volume, and the sample temperature was taken during filling to correct for variations in volume due to thermal changes in relation to the calibration of the flasks carried out at 20°C and the calculation of the density of the sample. Dissolved oxygen in the sample was immediately fixed using the Carpenter (1965) protocol of the Winkler (1888) method. The samples were kept in the dark in water at laboratory temperature until they were analyzed.

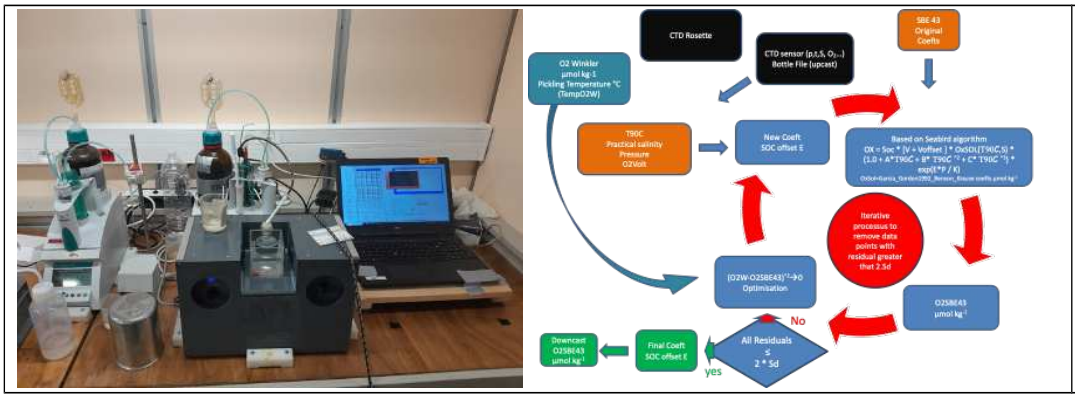


Figure 41.

Left: Winkler analysis setup on board.

Right: Discrete O2 data processing algorithm for SBE43 sensor data calibration.

For the measurement of dissolved oxygen, chemical determinations were carried out using the Winkler method according to the protocol described in Culberson (1991) and Dickson (1996). Oxygen concentrations were determined partly using the photometric method (Williams, Jenkinson 1982). Thiosulphate was calibrated daily using a solution of KIO3 prepared as 713.41 mg diluted in 2 L of deionized water. The title of this solution was compared with the standard for validation of title: 0.01N (CSK Standard Solution Potassium Iodate Wako).
The Winkler O2 data were converted from µM to µmol kg^{-1} by normalizing by the density calculated from the practical salinity and the sample fixation temperature (cf Dickson 1991).

Data processing of O2 data acquired by the SBE43 carousel probe (O2SBE43) was carried out using the Seabird note 64-2 application procedure shown in Figure 41.
In the procedure, it is important to note that the 3 parameters SOC, OffSet and E were adjusted by the optimization procedure between the Winkler data (O2W) and the O2SBE43-1 data in the bottle file from the upward profile.
The O2-SBE43 data are expressed in µmol kg^{-1} using the solubility from Garcia and Gordon (1992) and Benson and Krause (1984) coefficients.
The values of the calibration coefficients of the SBE43 sensor before and after the optimization process using Winkler discrete samples are presented in Table 15.

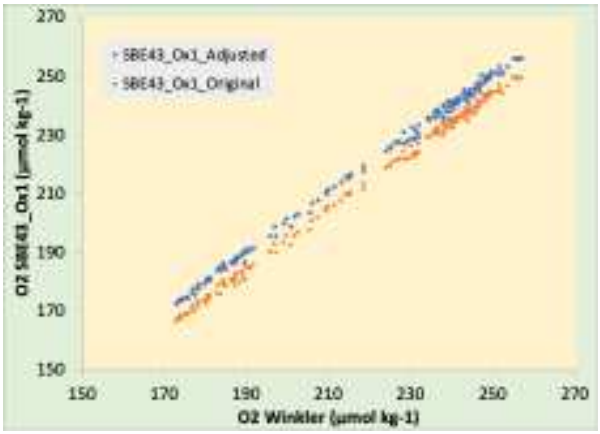
	New	Original
Soc	**4.7262E-01**	4.64E-01
Offset	**-4.8334E-01**	-0.5025
A	-4.5229E-03	-4.52E-03
B	2.1038E-04	2.10E-04
C	-3.1362E-06	-3.14E-06
D0	2.5826E+00	2.58E+00
D1	1.9263E-04	1.93E-04
D2	-4.6480E-02	-4.65E-02
E	**3.7676E-02**	3.60E-02
Tau20	1.5400E+00	1.54
H1	-3.3000E-02	-3.30E-02
H2	5.0000E+03	5.00E+03
H3	1.4500E+03	1.4500E+03

Table 15: Calibration coefficients for the oxygen carousel probe SBE 43 SN#8.

Figures 42 shows, respectively, the relationship between the SBE 43 sensor and the O2 Winkler data before and after calibration and the associated residuals.

Figure 43 shows the distribution of the oxygen concentration as both O2 Winkler and SBE43 sensor values over all the samples taken during the upward profiles and the residuals (O2SBE43 minus O2W) as a function of pressure.

Microzooplankton
Samples were collected from four Niskin bottles per station between the surface and the DCM. 10 L of water were filtered with a 10 µm plankton net with non-filtering cod-end whose content was transferred to a vial. Acidified lugol was added and the samples were stored in the fridge in the dark.



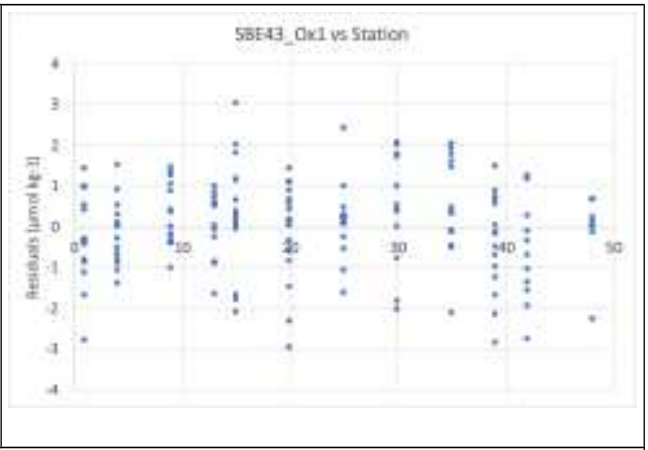
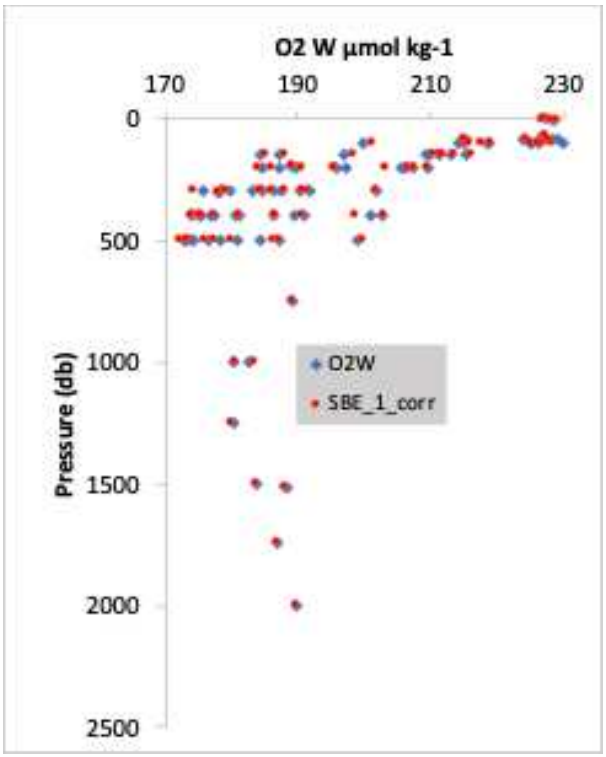


Figure 42. Left: Relationship between the O2 values of the SBE43 sensor before and after correction as a function of the oxygen measured by the Winkler method (µmol O2 kg^{-1}). Right: Distribution of residuals (O2SBE43 minus O2W) as a function of station number.



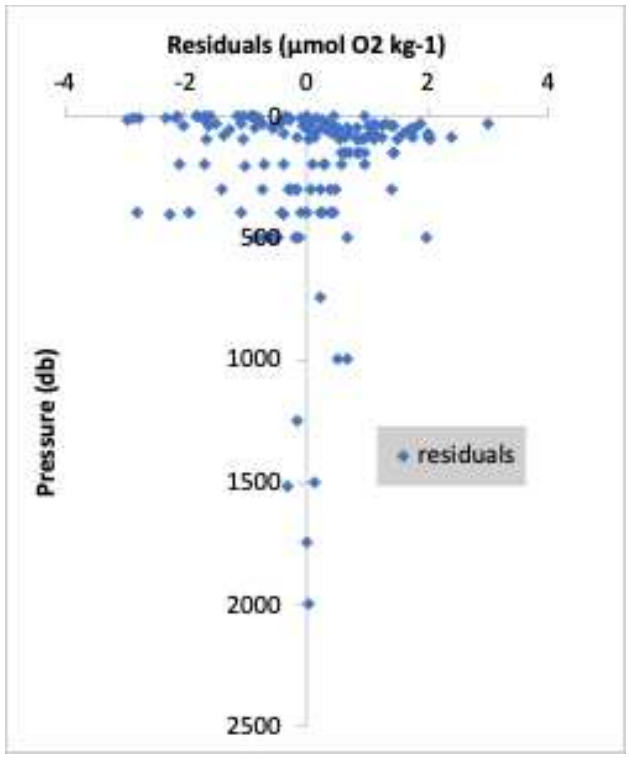


Figure 43. Left: O2Winkler and O2SBE43 (µmol O2 kg^{-1}) adjusted as a function of pressure (db). Right: Residuals as a function of pressure (O2SBE43 minus O2, Wµmol O2 kg^{-1}).

6.15 Pumping system and associated biogeochemical analyses

A system for seawater sampling down to 50 m with a vertical resolution of 2, 3 and 4 m (depending on the sea state) was developed, tested and used.
Seawater was collected by two *Teflon* pumps (*AstiPure™ II High Purity Bellows Pumps* with a flow rate of 30 L min^{-1}) connected to two polyethylene (PE) tube (diameter =19 mm, length = 50 and 25 m, volume= 19 L) (Figure 44). The entries of the PE tubes were fixed to the cable (shallower entry) and to the frame (deepest entry) of a *Seabird SBE19+ CTD* (Figure 44, picture top left), a *WetLab WETstar WS3S* fluorimeter and a *Sea Point* turbiditymeter. All sensors were used with real time acquisition at 4 Hz.

Figure 44. Pumping system deployed during the BioSWOT-Med cruise composed of two AstiPure pumps, two PE tubes (50 and 26 m long in the water) and a Seabird SBE19+ CTD.

The CTD frame was deployed at starboard with the winch normally used for the hydrological sampling. The PE tubes and the electrical cables of the CTD were deployed manually along the steel wire.
At each sampling depth, seawater was pumped during at least 1' in order to flush at least twice the entire volume of the tube. Seawater was then collected through a split on the main seawater circulation with a flow rate of 2 L min^{-1}. Time at the beginning and at the end of the sampling was recorded. Seawater temperature, salinity and depth for the collected sample was estimated from the average values of the parameters recorded by the SBE19+ CTD during the time of sampling. The vertical resolution of the sampling can be estimated from the difference between the highest and lower pressure recorded during sampling.

The system was used in 37 casts in order to collect samples for nutrients, nanomolar phosphate, conventional flow cytometry analyses back to the laboratory and diversity measurements. Samples were collected on the 11 stations every 2, 3 or 4 meters (depending on the sea conditions) down to 50 m. Main information on these pumping system deployments is resumed in Table 16.

Cytometry
In order to complete the automated flow cytometry analyses performed on the samples from the surface water intake (section 6.9), discrete samples were collected on the 11 stations every 2, 3 or 4 meters (depending on the sea conditions) down to 50 m. The structure of the microbial planktonic community has been investigated back in the laboratory with conventional flow cytometry. The analyses were run on a Cytoflex flow cytometer equipped, among others, with a blue laser beam (488nm), providing the same wavelength excitation than the one on the Cytosense automated flow cytometer. Several fluorescences have been collected, as well as two light scatter signals to discriminate the different clusters of cells defined by their optical properties. These data are consistent with the ones collected by the automated flow cytometer for phytoplankton and make it possible to collect the same kind of information, providing the same flow cytometry clusters, when compared to the Cytosense used on the sea surface water intake.

Cast	Date	Start UTC	Longitude °N	Latitude °E	Waypoint	Station name	Notes
tests	22/04		41.9040	4.5600	T3.5	Emily-1	
P01	25/04	07:44	41.2499	4.5478	T13	A1	vertical resolution 3m
P02	25/04	14:57	41.2499	4.5478	T13	A1	vertical resolution 2m
P03	25/04	21:00	41.2499	4.5478	T13	A1	only for filling mesocosms (no profile)
P04	26/04	02:30	41.2499	4.5478	T13	A1	vertical resolution 4m
P05	26/04	15:41	41.0648	4.3752	T14	F1	vertical resolution 2m
P06	26/04	21:18	41.1014	4.4209	T15	F1	vertical resolution 4m
P07	27/04	03:08	41.1014	4.4209	T15	F1	vertical resolution 2m
P08	27/04	08:35	41.1014	4.4209	T15	F1	vertical resolution 3m
P09	27/04	21:15	40.8784	4.3865	T18	B1	vertical resolution 3m
P10	28/04	02:48	40.8206	4.6644	T19	B1	vertical resolution 2m
P11	28/04	08:46	40.8206	4.6644	T19	B1	vertical resolution 3m – CTD acquisition stopped at 26 m
P12	28/04	15:53	40.8206	4.6644	T19	B1	vertical resolution 2m
P13	01/05	17:00	39.5600	4.0752	T27	M	vertical resolution 4m
P14	01/05	21:15	39.5600	4.0752	T27	M	only for filling mesocosms (no profile)
P15	02/05	03:16	39.5600	4.0752	T27	M	vertical resolution 2m
P16	02/05	08:34	39.5600	4.0752	T27	M	vertical resolution 3m
P17	04/05	02:13	40.7710	4.9520	T29	B2	vertical resolution 2m
P18	04/05	08:57	40.7710	4.9520	T29	B2	vertical resolution 3m
P19	04/05	16:26	40.7710	4.9520	T29	B2	vertical resolution 4m
P20	04/05	21:30	40.7710	4.9520	T29	B2	only for filling mesocosms (no profile)
P21	05/05	15:33	41.1870	5.0570	T31	F2	vertical resolution 4m
P22	05/05	21:33	41.1870	5.0570	T31	F2	only for filling mesocosms (no profile)
P23	05/06	02:48	41.1870	5.0570	T31	F2	vertical resolution 2m
P24	06/05	08:35	41.1870	5.0570	T31	F2	vertical resolution 3m
P25	05/06	21:12	41.4000	5.2500	T33	A2	vertical resolution 4m
P26	07/05	02:38	41.4000	5.2500	T33	A2	vertical resolution 2m
P27	07/05	08:41	41.4000	5.2500	T33	A2	vertical resolution 3m
P28	07/05	15:51	41.4000	5.2500	T33	A2	vertical resolution 2m
P29	10/05	13:32	39.8000	4.6667	T44	M2	vertical resolution 3m
P30	10/05	19:12	39.8000	4.6667	T44	M2	only for filling mesocosms (no profile)
P31	11/05	00:08	39.8000	4.6667	T44	M2	vertical resolution 2m
P32	11/05	06:40	39.8000	4.6667	T44	M2	vertical resolution 3m
P33	11/05	13:49	39.8000	4.6667	T44	M2	vertical resolution 3m
P34	12/05	13:53	40.7783	5.1333	T45	B3	vertical resolution 3m
P35	12/05	19:04	40.7783	5.1333	T45	B3	vertical resolution 4m
P36	13/05	00:13	41.6681	4.9656	T45	B3	vertical resolution 2m – CTD acquisition stopped
P37	13/05	06:43	41.6681	4.9656	T45	B3	vertical resolution 3m – CTD out of service

Table 16. Summary of the pumping system casts.

The optical resolution of picoeukaryotes, nanoeukaryotes, *Synechococcus*, *Prochlorococcus*, and *Cryptophycea* allowed us to complement the data obtained at the surface during the cruise and expand the characterization of the phytoplankton down to 50 m.

In addition, thanks to the analysis in the laboratory, it was possible to use a fluorescent dye such as SYBER Green (Sigma) in order to detect heterotrophic micro-organisms by flow cytometry. Heterotrophic bacteria and nanoflagellates (HNF) have thus also be addressed for the 11 stations, along the 50 m of the investigated water column. That was technically not possible with the automated flow cytometry installed on board during the cruise.

As flow cytometry remains a blind method, it is important to observe at least some samples by microscopy. This is why samples have also been collected and fixed in lugol, and preserved in the dark at ambient temperature, to perform some diversity analysis that have been carried out back in the laboratory. After the flow cytometry analyses have been performed and the most relevant samples were identified, biodiversity analyses have been run for these samples first. This helped us to better characterize the phytoplankton community in the various conditions met during the cruise.
Samples were directly collected onboard into 15ml Falcon tubes, rinsed 3 times with the pumped seawater, and then fixed into 2 ml cryotubes. Samples were collected in triplicates (for the analysis of phytoplankton, heterotrophic nanoflagellates, bacterias and viruses). All samples were fixed with a mixture of glutaraldehyde and poloxamer to preserve the cell integrity according to this protocol (the reference for the French network of marine stations): 20µl glutaraldehyde-pluronic + 1 980µl of sample. They were left for 30 min in the dark at room temperature to optimize the fixation of the cells. Then samples were flash frozen in liquid nitrogen prior to be stored at -80°C until analysis in the laboratory (at the flow cytometry platform of the MIO PRECYM (https://precym.mio.osupytheas.fr/)).

Up to 37 pumpings were performed for conventional cytometry during the cruise, which makes 566 samplings in total, dispatched into 1698 tubes to analyze.

Acquisition: Samples for phytoplankton analysis were acquired on board, using the Cytoflex flow cytometer of PRECYM. Samples were thawed, then dispatched on 96-well plates (mixed with a solution of 2µm and TruCount counting beads) and analyzed according to two different protocols: one dedicated to small cyanobacteria and picoplankton and another one dedicated to the larger nano- and microplankton (5 min per protocol).
Samples for bacterioplankton, heterotrophic nanoflagellates, and viruses' analyses have been acquired at the laboratory, after the cruise.
Analysis: Analysis of flow cytometry data will be done in the laboratory, using dedicated softwares (FCS Express and Cytexpert softwares).

Nutrients
Samples were collected in HDPE 20-mL bottles and stored at 4°C until analysis within 1-2 days.

Nanomolar phosphate
Samples were filtered inline through 0.2 µm using a Sartobran-P cartridge (Sartorius) and stored in 20-mL HDPE bottles at -20°C.

NH4
Samples were collected into PC 60ml Nalgene Oak Ridge bottles from the following pumping casts: P03, P06, P09, P13, P19, P25, P28 and P35.

6.16 Zooplankton nets and associate analyses

Objectives: (i) to characterize horizontal and vertical distributions of metazooplankton (60 µm to few mm, metazoan zooplankton) at the different stations, ii) to observe and quantify structural and functional changes of zooplanktonic communities between and within the different identified meso- and fine- scales physical structures, (iii) to infer the trophic role of zooplankton on primary production and its ability to transfer matter to higher trophic levels

Sampling procedure: The methodology combined results from an in situ camera mounted on a glider mapping zooplankton distribution at horizontal and vertical fine scales with camera and acoustics (Zooglider, see section 6.12), a UVP camera mounted on a CTD rosette (see section 6.13), the onboard EK60 acoustic signals at 12, 38 and 200 kHz (see section 6.4), and different zooplankton net tows (Triple Net with 3 mesh sizes deployed vertically at 3 depths). The deployed in situ Zoocam mounted on Zooglider allowed us to image and quantify zooplankton fine vertical structure and marine snow every 5 cm from around 400 m depth to the sea surface, as well as to resolve cross frontal changes in zooplankton communities along the transects. Additionally, a dual frequency (200 and 1000 kHz) Sonar also mounted on the Zooglider allowed to differentiate small (copepods) and large (fish) sources of acoustic backscatter across the sampled features. An Underwater Video Profiler (UVP) associated with a Laser In Situ Scattering and Transmissometry (LISST) mounted on the CTD-rosette was deployed to document the vertical distribution of plankton and particles in each station before net sampling. The echosounder Simrad EK60 on board R/V L'Atalante was operated at 12, 38 and 200 kHz in continuous wave mode (discrete frequencies).

Zooplankton samples were collected using Triple net (Triple-WP2 type, Figure 45) equipped with 3 different mesh size nets (500 µm, 200 µm, 64 µm) and deployed vertically for three integrated vertical layers (400-0 m; 200-0 m; 100-0 m).
Four successive net tows were realized at each station, day and night.
The two tows at -400m and -200m deep followed the same protocols for conditioning samples. A part was used for further omics analyses.
Two successive net tows at -100 m were realized to analyze the zooplankton in the productive layer. A first tow was dedicated to get abundances and biomasses, and a second tow was realized to get fractionated biomass samples for stable C and N isotopes and biochemical contents, and for gut pigment contents.

Table 17 summarizes the net sampling and reports an example of all samples collected during one sampling session.

Figure 45. The triple net deployed during the BioSWOT-Med cruise.

Net number	Station name	Day/ Night	Date	Start time (local time)	Latitude	Longitude	Nearest CTD #	Type of net	Depth range (m)
ZN1	A1 -ZOO1	Day	25/04/23	11:30	41º 14.384' N	4º 36.226'E	before #C5	TPN	400-0
ZN2	A1 -ZOO1	Day	25/04/23	12:20	41º 14.384' N	4º 36.226'E	before #C5	TPN	200-0
ZN3	A1 -ZOO1	Day	25/04/23	12:55	41º 14.384' N	4º 36.226'E	before #C5	TPN	100-0
ZN4	A1 -ZOO1	Day	25/04/23	13:16	41º 14.384' N	4º 36.226'E	before #C5	TPN	100-0
PN01	A1 -ZOO1	Day	25/04/23	14:07	41º 14.384' N	4º 36.226'E	before #C5	PN	150-0
Meso1	A1 -ZOO1	Day	25/04/23	16:00	41º 14.384' N	4º 36.226'E	before #C5	R	40-0
ZN5	A1 -ZOO2	Night	26/04/23	00:13	41º 14.384' N	4º 34.398'E	before #C7	TPN	400-0
ZN6	A1 -ZOO2	Night	26/04/23	00:54	41º 14.384' N	4º 34.398'E	before #C7	TPN	200-0
ZN7	A1 -ZOO2	Night	26/04/23	01:15	41º 14.384' N	4º 34.398'E	before #C7	TPN	100-0
ZN8	A1 -ZOO2	Night	26/04/23	01:29	41º 14.384' N	4º 34.398'E	before #C7	TPN	100-0
ZN9	F1 -ZOO1	Night	27/04/23	00:16	41°06.060'N	4°25.405E	before #C10	TPN	400-0
ZN10	F1 -ZOO1	Night	27/04/23	00:44	41°06.060'N	4°25.405E	before #C10	TPN	200-0
ZN11	F1 -ZOO1	Night	27/04/23	01:04	41°06.060'N	4°25.405E	before #C10	TPN	100-0
ZN12	F1 -ZOO1	Night	27/04/23	01:23	41°06.060'N	4°25.405E	before #C10	TPN	100-0
ZN13	F1 -ZOO2	Day	27/04/23	12:08	41°06.047'N	4°26.822E	before #C12	TPN	400-0
ZN14	F1 -ZOO2	Day	27/04/23	12:38	41°06.047'N	4°26.822E	before #C12	TPN	200-0
ZN15	F1 -ZOO2	Day	27/04/23	12:58	41°06.047'N	4°26.822E	before #C12	TPN	100-0
ZN16	F1 -ZOO2	Day	27/04/23	13:15	41°06.047'N	4°26.822E	before #C12	TPN	100-0
PN02	F1 -ZOO2	Day	27/04/23	13:30	41°06.047'N	4°26.822E	before #C12	PN	150-0
ZN17	B1 -ZOO1	Night	28/04/23	00:11	40°52.639 N	4°23.398E	before #C14	TPN	400-0
ZN18	B1 -ZOO1	Night	28/04/23	00:38	40°52.639 N	4°23.398E	before #C14	TPN	200-0
ZN19	B1 -ZOO1	Night	28/04/23	00:58	40°52.639 N	4°23.398E	before #C14	TPN	100-0
ZN20	B1 -ZOO1	Night	28/04/23	01:16	40°52.639 N	4°23.398E	before #C14	TPN	100-0
ZN21	B1 -ZOO2	Day	28/04/23	12:09	40°52:796'N	4°23:749'E	before #16	TPN	400-0
ZN22	B1 -ZOO2	Day	28/04/23	N/A	40°52:796'N	4°23:749'E	before #16	TPN	200-0
ZN23	B1 -ZOO2	Day	28/04/23	12:50	40°52:796'N	4°23:749'E	before #16	TPN	100-0
ZN24	B1 -ZOO2	Day	28/04/23	13:05	40°52:796'N	4°23:749'E	before #16	TPN	100-0
PN03	B1 -ZOO2	Day	28/04/23	14:03	40°52:796'N	4°23:749'E	before #16	PN	150-0
ZN25	B1BIS-ZOO1	Day	29/04/23	13:17	40°50.381 N	4°43.969 E	before #16	TPN	400-0
ZN26	B1BIS-ZOO1	Day	29/04/23	13:44	40°50.381 N	4°43.969 E	before #16	TPN	200-0
Meso2	B1BIS-ZOO1	Day	01/05/23	17:22	39°33.542'N	4°04.401'E	N/A	R	N/A
ZN27	M -ZOO1	Night	02/05/23	01:48	39°33.498'N	4°06.067'E	before #C21	TPN	400-0
ZN28	M -ZOO1	Night	02/05/23	01:05	39°33.498'N	4°06.067'E	before #C21	TPN	200-0
ZN29	M -ZOO1	Night	02/05/23	01:23	39°33.498'N	4°06.067'E	before #C21	TPN	100-0
ZN30	M -ZOO1	Night	02/05/23	01:33	39°33.498'N	4°06.067'E	before #C21	TPN	100-0
Meso3	M -ZOO1	Night	02/05/23	N/A	39°33.498'N	4°06.067'E	before #C21	R	50-0
ZN31	M -ZOO2	Day	02/05/23	12:16	39°30.207'N	4°06.228'E	before #C23	TPN	200-0
ZN32	M -ZOO2	Day	02/05/23	12:29	39°30.207'N	4°06.228'E	before #C23	TPN	100-0
ZN33	M -ZOO2	Day	02/05/23	12:42	39°30.207'N	4°06.228'E	before #C23	TPN	400-0
ZN34	M -ZOO2	Day	02/05/23	13:12	39°30.207'N	4°06.228'E	before #C23	TPN	100-0
PN04	M -ZOO2	Day	02/05/23	13:59	39°30.207'N	4°06.228'E	before #C23	PN	150-0
ZN35	B2 -ZOO1	Day	04/05/23	12:07	40º 47.303' N	4º 56.319'E	before #C26	TPN	400-0
ZN36	B2 -ZOO1	Day	04/05/23	N/A	40º 50.867' N	4º 56.096'E	before #C26	TPN	200-0
ZN37	B2 -ZOO1	Day	04/05/23	12:50	40º 50.871' N	4º 56.096'E	before #C26	TPN	100-0
ZN38	B2 -ZOO1	Day	04/05/23	13:07	40º 50.918' N	4º 56.100'E	before #C26	TPN	100-0
PN05	B2 -ZOO1	Day	04/05/23	13:22	40º 50.918' N	4º 56.100'E	before #C26	PN	150-0
Meso3	B2 -ZOO1	Day	04/05/23	N/A	40º 50.918' N	4º 56.100'E	before #C26	R	58-0
ZN39	B2 -ZOO2	Night	05/05/23	00:36	40º 50.746' N	4º 55.931'E	before #C28	TPN	400-0
ZN40	B2 -ZOO2	Night	05/05/23	01:05	40º 50.746' N	4º 55.931'E	before #C28	TPN	200-0
ZN41	B2 -ZOO2	Night	05/05/23	01:25	40º 50.746' N	4º 55.931'E	before #C28	TPN	100-0
ZN42	B2 -ZOO2	Night	05/05/23	01:40	40º 50.746' N	4º 55.931'E	before #C28	TPN	100-0
ZN43	F2 -ZOO1	Day	05/05/23	12:09	41º 10.955' N	5º 03.733'E	before #C29	TPN	400-0
ZN44	F2 -ZOO1	Day	05/05/23	12:32	41º 10.955' N	5º 03.733'E	before #C29	TPN	200-0
ZN45	F2 -ZOO1	Day	05/05/23	12:50	41º 10.955' N	5º 03.733'E	before #C29	TPN	100-0
ZN46	F2 -ZOO1	Day	05/05/23	13:08	41º 10.955' N	5º 03.733'E	before #C29	TPN	100-0
PN06	F2 -ZOO1	Day	05/05/23	13:26	41º 10.955' N	5º 03.733'E	before #C29	PN	150-0
Meso4	F2 -ZOO1	Day	05/05/23	N/A	41º 10.955' N	5º 03.733'E	before #C29	R	58-0
ZN47	F2 -ZOO2	Night	06/05/23	00:30	41º 08.463' N	5º 16.205'E	before #C31	TPN	400-0
ZN48	F2 -ZOO2	Night	06/05/23	00:55	41º 08.463' N	5º 16.205'E	before #C31	TPN	200-0
ZN49	F2 -ZOO2	Night	06/05/23	01:13	41º 08.463' N	5º 16.205'E	before #C31	TPN	100-0
ZN50	F2 -ZOO2	Night	06/05/23	01:30	41º 08.463' N	5º 16.205'E	before #C31	TPN	100-0
ZN51	A2 -ZOO1	Night	07/05/23	00:00	41º 24.816' N	5º 15.019'E	before #C34	TPN	400-0
ZN52	A2 -ZOO1	Night	07/05/23	00:27	41º 24.816' N	5º 15.019'E	before #C34	TPN	200-0
ZN53	A2 -ZOO1	Night	07/05/23	00:43	41º 24.816' N	5º 15.019'E	before #C34	TPN	100-0
ZN54	A2 -ZOO1	Night	07/05/23	00:56	41º 24.816' N	5º 15.019'E	before #C34	TPN	100-0
ZN52bis	A2 -ZOO1	Night	07/05/23	01:27	41º 24.816' N	5º 15.019'E	before #C34	TPN	200-0
ZN55	A2 -ZOO2	Day	07/05/23	12:35	41º 22.483' N	5º 15.398'E	before #C36	TPN	400-0
ZN56	A2 -ZOO2	Day	07/05/23	12:59	41º 22.483' N	5º 15.398'E	before #C36	TPN	200-0
ZN57	A2 -ZOO2	Day	07/05/23	13:15	41º 22.483' N	5º 15.398'E	before #C36	TPN	100-0
ZN58	A2 -ZOO2	Day	07/05/23	13:29	41º 22.483' N	5º 15.398'E	before #C36	TPN	100-0
PN07	A2 -ZOO2	Day	07/05/23	13:50	41º 22.483' N	5º 15.398'E	before #C36	PN	150-0
ZN59	M2 -ZOO1	Day	10/05/23	12:06	39º 40.027' N	3º 58.005'E	before #C40	TPN	400-0
ZN60	M2 -ZOO1	Day	10/05/23	12:29	39º 40.150' N	3º 57.837'E	before #C40	TPN	200-0
ZN61	M2 -ZOO1	Day	10/05/23	12:45	39º 40.191' N	3º 57.711'E	before #C40	TPN	100-0
ZN62	M2 -ZOO1	Day	10/05/23	12:58	39º 40.231' N	3º 57.621'E	before #C40	TPN	100-0
PN08	M2 -ZOO1	Day	10/05/23	13:13	39º 40.231' N	3º 57.621'E	before #C40	PN	150-0
Meso5	M2 -ZOO1	Day	10/05/23	N/A	39º 40.231' N	3º 57.621'E	before #C40	R	55-0
ZN63	M2 -ZOO2	Night	11/05/23	00:12	39º 38.047' N	3º 54.905'E	before #C42	TPN	400-0
ZN64	M2 -ZOO2	Night	11/05/23	00:35	39º 37.989' N	3º 54.539'E	before #C42	TPN	200-0
ZN65	M2 -ZOO2	Night	11/05/23	00:53	39º 37.959' N	3º 54.905'E	before #C42	TPN	100-0
ZN66	M2 -ZOO2	Night	11/05/23	01:05	39º 37.916' N	3º 54.4335'E	before #C42	TPN	100-0
ZN67	M2 -ZOO3	Day	11/05/23	12:18	39º 36.775' N	3º24.976'E	before #C44	TPN	400-0
ZN68	M2 -ZOO3	Day	11/05/23	12:42	39º 36.775' N	3º24.976'E	before #C44	TPN	200-0
ZN69	M2 -ZOO3	Day	11/05/23	13:00	39º 36.775' N	3º24.976'E	before #C44	TPN	100-0
ZN70	M2 -ZOO3	Day	11/05/23	13:12	39º 36.775' N	3º24.976'E	before #C44	TPN	100-0
PN09	M2 -ZOO3	Day	11/05/23	14:44	39º 36.775' N	3º24.976'E	before #C44	PN	150-0
ZN71	B3 -ZOO1	Day	12/05/23	12:32	40º 47.063' N	5º 08.326'E	before #C45	TPN	400-0
ZN72	B3 -ZOO1	Day	12/05/23	12:58	40º 47.124' N	5º 08.855'E	before #C45	TPN	200-0
ZN73	B3 -ZOO1	Day	12/05/23	13:17	40º 47.714' N	5º 08.612'E	before #C45	TPN	100-0
ZN74	B3 -ZOO1	Day	12/05/23	13:34	40º 47.055' N	5º 08.766'E	before #C45	TPN	100-0
PN10	B3 -ZOO1	Day	12/05/23	13:50	40º 47.055' N	5º 08.766'E	before #C45	PN	150-0
ZN75	B3 -ZOO2	Night	13/05/23	00:00	40º 45.444' N	5º 07.269'E	before #C47	TPN	400-0
ZN76	B3 -ZOO2	Night	13/05/23	00:24	40º 45.240' N	5º 07.190'E	before #C47	TPN	200-0
ZN77	B3 -ZOO2	Night	13/05/23	00:43	40º 45.081' N	5º 07.131'E	before #C47	TPN	100-0
ZN78	B3 -ZOO2	Night	13/05/23	00:57	40º 44.962' N	5º 07.079'E	before #C47	TPN	100-0

Pot Formol	Pot Formol	Pot Formol	Pot Formol	Pot Formol	Pot Formol	Pot Formol	Pot Formol	Pot Formol
BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-400 m / #500 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-400 m / #200 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-400 m / # 60 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-200 m / # 500 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-200 m / # 200 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-200 m / # 60 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-100 m / # 500 µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-100 m / # 200µm	BIOSWOT -MED Station B3 -ZOO2 13/05/2023 Night 0-100 m / # 60 µm

BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-400 m / # 500 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-400 m / # 200 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-400 m / # 60 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-200 m / # 500 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-200 m / # 200 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-200 m / # 60 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-100 m / # 500 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-100 m / # 200 µm	BIOSWOT -MED Station B3 -ZOO2 Biomass 13/05/2023 Night 0-100 m / # 60 µm
220.3	214.8	215.9	219.5	217.5	223.7	214.5	216.0	214.5

Isotopic analysis Petri dish	Isotopic analysis Petri dish	Isotopic analysis Petri dish	Isotopic analysis Petri dish	Isotopic analysis Petri dish	Isotopic analysis Petri dish
BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / 60-200 µm	BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / 200-500 µm	BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / 500-1000 µm	BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / 1000-2000 µm	BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / 2000-5000 µm	BIOSWOT -MED Station B3 -ZOO2 Isotopic analysis-Bioch 13/05/2023 Night 0-100 m / > 5000 µm
223.7	219.2	219.5	220.0	220.9	216.0

Gut content Petri dish	Gut content Petri dish	Gut content Petri dish	Gut content Petri dish	Gut content Petri dish	Gut content Petri dish
BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / 60-200 µm	BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / 200-500 µm	BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / 500-1000 µm	BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / 1000-2000 µm	BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / 2000-5000 µm	BIOSWOT -MED Station B3 -ZOO2 Gut Content 13/05/2023 Night 0-100 m / > 5000 µm

Table 17. Top (previous page). Summary of net sampling (R: Regent net, TPN: Triplenet, PN:Phytonet). Bottom (this page). Details of the zooplankton sampling at the station B3 ZOO2 Night 13/05/2023.

Further laboratory analyses.

Zooplankton structure and functioning (species abundances, taxonomic diversity, biovolume and biomass, size spectrum, C and N stable isotope contents, carbohydrates, lipids and proteins contents, and gut pigment contents) have been investigated through laboratory analyses. Comparative day and night profiles will allow us to identify the changes in community in the different vertical layers and to identify migrant organisms.

Image analysis and binocular treatment

Zooplankton samples will be treated by imagery using a combination of Flowcam (fraction < 300 µm) and Zooscan (fraction < 300 µm) (see Figure). Additionally, dedicated samples will be then observed under dissecting microscope allowing a more detailed estimation of the taxonomic composition to be further compared with genomics data in comparable size-fractions.

Normalized biovolume and biomass size spectra have been derived from imagery biometric measurements with contributions of the different major taxa. Size-spectra data analysis (> 500 µm) have been analyzed in conjunction with observations from UVP casts and echosounder signals.

Additionally, triple net tows within the productive layer (100 to surface) with three different mesh sizes (60, 200 and 500 µm) were used to collect plankton biomass for various isotopic and biochemical measurements, and for collecting alive zooplankton (for mesocosm experiments) and for freezing in situ organisms (for size-fractionated gut contents measurements.

Expected results are biomass and abundance spatial distributions, with a fine description of their size-spectra and the taxonomy, at different spatial scales and day-night comparisons. Ingestion and metabolic rates will be derived from the biomass size spectra, and the zooplankton production will be estimated. Comparison with metabolic rates directly measured in mesocosms and ingestion derived from in situ samples for pigment gut content measurements (Landry et al., 2010).

Drying, and isotopic and biochemical measurements

A half of the cod-end content of the second net tow 100m-surface was fractionated on a sieve column in 5 fractions: >2000 µm, 1000-2000 µm, 500-1000 µm, 200-500 µm and 60-200 µm. The material on each sieve class was dried during 48h at 60°C on pre-combusted and pre-weighed Whatman GF/D. Stable isotopes ratio and biochemical analyses will be performed on these samples.

These samples have been complemented with samples collected daily at the DCM layer with a Niskin bottle and at surface from pumping for the fractions 0,2 µm-2 µm (using GF/F); 2 µm-20 µm (GF/D) and 20-60 µm (Nytex).

Elemental and stable isotopes ratio analyses

Samples for δ13C analysis were acidified in HCl 1% solution. The acidification aimed at avoiding the possible bias influenced by inorganic carbonates (Pinnegar & Polunin, 1999). From acidified samples,

carbon and nitrogen concentrations (expressed as % of DW), and δ15N have been measured. The dried matter collected on filters, will be placed in aluminum cups and weighted with a precision balance (d = 0.00001 g). The stable isotope ratios (of C and N), the percentages of carbon and nitrogen component (%C and %N) and the C/N ratio will be determined using an elemental analyzer and a mass spectrometer. The deviations in isotope composition were expressed from standard reference materials (N2 in air and Vienna Pee Dee Belemnite for δ15N and δ13C) as follows:
δX sample = [((R sample)/(R standard))-1]x 1000
where X is 13C or 15N, R is the isotope ratio between heavy and light isotopes (13C:12C or 15 N:14 N).

Biochemical quality
Proteins, carbohydrates and lipids have been extracted following adapted protocols, respectively Lowry et al. (1951), Dubois et al. (1956) and Bligh & Dyer (1959). The concentrations of the components have been determined in spectrophotometry (wavelengths l=700 nm, l=490 nm, and l=360 nm for respectively proteins, carbohydrates and lipids). The concentrations of the biochemical compounds in µg.mg-1 of DW have been converted into energetic metric using conversion constants (21.4 kJg^{-1} for proteins, 17.2 kJg^{-1} for carbohydrates and 35.6 kJg^{-1} for lipids) (Postel et al., 2000). The energetic concentration content of the sample per unit of DW (Econ, in kJg^{-1} of DW) have been calculated by summing the energetic value of the three biochemical components.

6.17 Genomics and Phytoplankton diversity

Objective: Coupled ecological and physical models consistently suggest that in the open ocean, the role of the fine-scale physics appears to organize phytoplankton community structure, shaping diversity and biogeochemical patterns in space and time.
Genetic analyses will start in 2024 under the ANR BioSWOT project (PI F. d'Ovidio). In order to explore this connection between small scale physics of the ocean and biological features of plankton organisms, the sequencing data will allow us to explore changes in community over time and space, using standard taxonomic marker genes (16S and 18S). Qualitative and semi-quantitative variations indicating the level of flexibility of plankton communities at short spatio-temporal distances. Metagenomic and metatranscriptomic data from the same samples, ranging from viruses to small multicellular eukaryotes, will describe the functional response of community members to these environmental changes.
Short scale population dynamics will also be explored through identification and quantification of genome structural features (SNP and SNV) that will provide insights into evolutionary forces shaping the communities at that scale. We expect to elucidate taxonomic as well as metabolic differences between the three water masses and to relate them to their physicochemical properties. Marine viruses together with their interactions with picophytoplankton (eukaryotes) and viruses will also be studied by DNA sequencing.
The microbial community has been sampled repeatedly (once per day) inside and outside the fine-scale features tracked in the region both underway and at 2 depths following the *Tara* Oceans and EMBRC protocols. In order to achieve this and in addition to WP3 (Automated cytometry) metabarcoding (Genoscope, SZN, and MIO) will evaluate the "patchiness" of phytoplankton functional types and taxa created by the fine scale physics with a wider qualitative spectrum of diversity. Metagenomics and metatranscriptomics (Genoscope) will monitor the short term biogeochemical functional responses of the microbiome to the highly dynamic physical environment.

6.17.1 Genomics

Metagenomics and Metatranscriptomics samples from the surface to 150 m depth.
For each Rosette Cast, 4 Niskin bottles were sampled with 2 at DCM and 2 at 150m. At the same time that the Rosette Cast, surface water was collected from to the seawater circuit of the thermosalinometer (THS or TSG). Samples are collected directly from the Niskin bottle with a 200 µm mesh into a 25L carboy. A peristaltic pump is passing the seawater through the system. Seawater is first passing through a 142 mm filtration tripode equipped with a 3 µm PC filter and subsequently through another 142 mm filtration unit equipped with a 0.2 µm PC filter (see BIOSWOT_MetaBGTomics_S320_S023.pdf, protocol modified with a mesh of 200µm instead of 20µm and emo-bon-handbook).

A first filtration taking no longer the 15 min allows to make metaT samples. Then a second filtration with the rest of seawater, taking no longer than one hour, allows to make the metaG samples. Once the samples are done, they are flash frozen in liquid nitrogen and stored onboard in a -80°C freezer. The seawater resulting of the 2 filtrations, inferior of 0.2 µm, is treated by Iron Chloride (2.82 g FeCL3 in 50 mL ultrapure water) for virus precipitation and after one hour at room temperature the seawater is filtered on a 0.8 µm PC filters and should not take more than one hour. These virus samples are stored at +4°C (see BIOSWOT_MetaBGTomics_S02.pdf from Sullivan and Casotti).

Samples from the net tows.

At each station at 12:00, we deployed a WP2 net with a 20 microns mesh at 150 m (speed 0.5 m/s) and 2 triple net with 3 different meshes (64, 200 and 500 microns) at 400 and 200 m (speed 1 m/s). One fourth of each cod-end was given for genomics and immediately sieved to 2 mm.
For the live fraction 20_2000, half of it was sieved to a 300 microns mesh.
The live fraction was then used for DNA/RNA filtration and ethanol fixation for single cell morpho molecular identification.
- *Filtration DNA/RNA:* Two thirds of each size fraction are filtered in less than 15 min on a 10 µm PC filter using a 47 mm filtration unit and a peristaltic pump. Once the samples were gathered, they were flash frozen in liquid nitrogen and stored onboard in a -80°C freezer. See protocol BIOSWOT_MetaBGTomics_net.pdf .
- *Ethanol fixation for single cell morpho molecular identification:* One third of each size fraction (PVC sieve) was sieved through a sieve as the net mesh. The biological material retained on the sieve was rinsed using 99% molecular grade EtOH and recovered from the sieve into a 50ml falcon tube, using EtOH and a funnel. The tube was filled up to 40 mL and stored at -20°C.

Sample labeling

All samples were labeled with appropriate barcodes and printed labels. All information about volume and time of the sampling were mentioned in the logsheet file.
The sample nomenclature is the following:
BSM: BioSWOT-Med
Station: A1, A2, F1, F2, B1, B2, B3, M1, M2
Event: C for Rosette CAST, ZN for ZooNet (or TripleNet) and PN for PhytoNet
Depth: SRF, DCM or EPI (150m) for underway surface water and Rosette cast. Not mentioned for net.
Size fraction: inf0.2, 0.3-3,3-200, 20-300, 20-2000, 64-2000, 200-2000 and 500-2000
Sample replicate: MetaT (MT), MetaG (MG) and R(1 or 2) for net DNA samples
Examples:
BSM_A1_C01_SRF_3-200_MT
BSM_B3_C05_DCM_inf02
BSM_M1_PN04_20_2000_DNA1
BSM_F1_ZN44_64_2000_EtOH
Details of data collection can be found in the BIOSWOT_Med_Samples.xls file which was regularly updated.

The information about the number of the different samples collected is summarized in Table 18.

Figure 46. Genomics platform on board R/V L'Atalante. Top: The tripods installation for Niskin and underway water filtration. Bottom: the filtration ramp for the net tows' samples.

Figure 47. Logsheet and sample labeling.

Rosette cast samples	THS	DCM	EPI (150m)	Nb	Total	Storage
MT	36	36	36	108	270	-80°C
MG	36	36	36	108		-80°C
Virus	18	18	18	54		+4°C
Taxonomy	18 (x2)	18 (x2)	18 (x2)		108	Room temp.

Net tows samples	TripleNet 400m	TripleNet 200m	PhytoNet 150m	Total	Storage
DNA/RNA	51 (x2)	54 (x2)	20 (x2)	250	-80°C
EtOH	60	-	11	71	-20°C
Taxonomy	WP4	WP4	20 (x2)	40	Room temp.

Table 18. Summary of the collected samples for genomics.

Sequencing analysis and data treatment

All the samples will be used for DNA and RNA extraction and sent for sequencing to Genoscope once the financing will be obtained.

Access to genes and genome contents will be provided by both de-novo assembly of metagenomic reads into MAGs, by comparison with available datasets (*Tara* Ocean gene catalogs: TOV, OM-RGC and MATOU as well as *Tara* and MGnify MAGs collections) as well as by reads recruitments by these resources, to quantify functional modifications of communities.

The bioinformatics analysis will be done at MIO and Genoscope. All the sequence datasets will be put on our web services (Ocean Gene Atlas and Ocean Barcode Atlas at https://tara-oceans.mio.osupytheas.fr) to allow users to explore the biodiversity and biogeography of plankton sequences and taxa.

6.17.2 Phytoplankton diversity

Sampling methods

For each station at about 12:00, we deployed a WP2 net with a mesh of 20 microns at 150 m (speed 0,5 m/s). The content of the collector is immediately sieved to 2 mm.

Two subsamples of 30 ml are taken in amber glass bottle; one is fixed with acidified Lugol's iodine solution and one with neutral formalin solution and stored on board in the cold lab in the dark

1/4 of the live fraction 20-2000 will be used for OMICS filtration.

About 1/2 of the live fraction 20-2000 sieved to 300 microns.

Two subsamples of 60 ml are taken in amber glass bottle; one is fixed with acidified lugol's iodine solution and one with neutral formalin solution and stored on board in the cold lab in the dark

1 at 5 ml of this fraction 20-300 filtered on Polycarbonate filter 0.2 microns for observation by SEM. These filters are dried in an oven at 60°C for 24 h, then stored at room temperature.

Analysis methods

Live samples were observed on board by optical microscopy and images were taken, for an approch of the live community (interactions between organisms, for example).

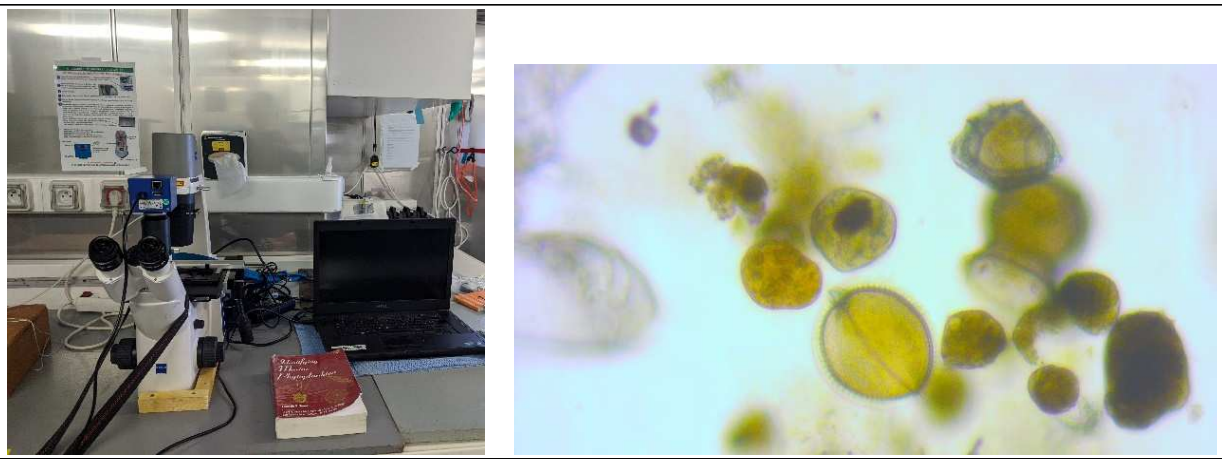


Figure 48. Microscope Zeiss Primovert equipped with camera.

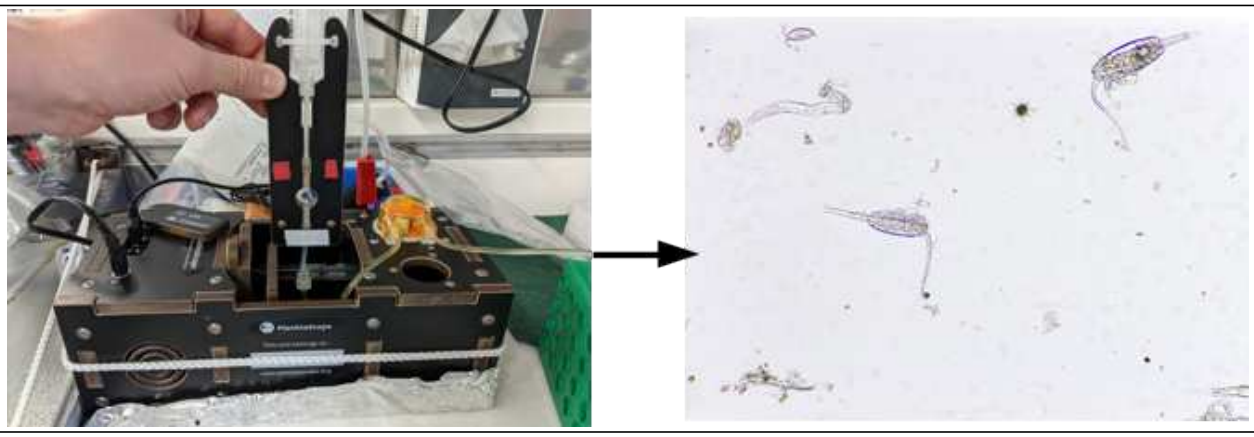


Figure 49. Planktoscope and an example of image obtained.

The live samples fraction 20-300 microns were analyzed on board with Planktoscope to obtain the diversity of the microplankton.
For each sample, about 600 images were acquired, that is 20.10^6 objects after segmentation. The sorting and recognition of the objects is done using automatic image recognition tools.
At the MIO the fixed samples are analyzed by optical microscopy to address the diversity and abundances of the community of micro-phytoplankton in the different stations.
The 0.2 microns PC filters PC 0.2. microns will be observed by SEM at MIO or at another laboratory.

Appendices
1. MetaBGTomics – S320 - targeting unicellular eukaryotes - Patrick Wincker, CEA Genoscope France (pwinker@genoscope.cnrs.fr)
2. MetaBGTomics – S023 - targeting prokaryotes - Patrick Wincker, CEA Genoscope France (pwinker@genoscope.cnrs.fr)
3. MetaBGTomics – S<02 – targeting viruses - Matthew Sullivan, Ohio State University, USA (mbsulli@gmail.com) -https://www.protocols.io/view/Iron-Chloride-Precipitation-of-Viruses-from-Seawat-x54v981pl3eq/v1?step=4 and modified by Estelle Bigeard, Anne-Claire Baudoux and Magali Lescot.
4. Raffaella Casotti- NEREA – SOP: Viruses - https://www.nerea-observatory.org/_files/ugd/044fbd_743e50d7e3d54584a5bb6ede605a76f7.pdf

6.18 Mesocosm experiment

Goal: Estimate the impact of vertically migrating zooplankton on the near-surface planktonic community.
Key idea: This is an exclusion experiment that aims at comparing a mesocosm where the vertically migrating community of zooplankton is present with one where it is absent. In ideal conditions this allows to separate the differences between day and night within the near-surface planktonic community from the impact of daily migrating grazers and predators. The exclusion experiment is carried out by filling a tank with near-surface waters immediately before sunset (the *day tank*, that hosts only the near-surface community) and another just after sunset (the *night tank*, that hosts both the near-surface community and vertically migrating animals; Figure 50).

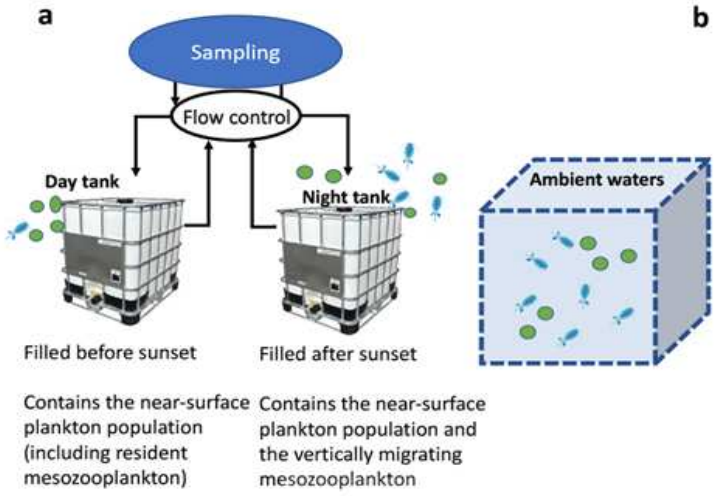


Figure 50. Schematic of the key concept behind the mesocosm experiment.

Timeline of the experiment: The experiment run between a few hours before sunset and the following morning. The following description summarizes the main actions involved. The times are indicative.

17:00 local time	Regent's net to collect zooplankton for the day tank. The Regent's net (750 um) has a non-filtering cod-end to protect zooplankton, especially gelatinous organisms. The targeted depth is that of the DCM and the speed 0.3-0.4 m/s. The sample is transferred to a container that is kept in the cold room in the dark.
17:20 local time	Pumping of water from the depth of the DCM (when possible, or 58 m, the deepest we could reach) into the day tank. This takes approximately 40 m. We generally filled ~ 450 L out.
18:00 local time (T1)	The day tank is full and we add an aliquot of organisms (decided for each experiment, aiming for 5-20 times the natural concentrations of grazers) from the Regent's net sample into the day tank. Another aliquot of zooplankton is preserved in formalin (typically ~ 1L) and another one is processed for gut content (typically ~ 2 L), i.e., added to soda water, filtered and flash frozen to -80 C. Samples for nutrients, chlorophyll, *Planktoscope*, and flow-cytometry analysis are collected. Mixing system for the day tank is started.
23:00 local time	Regent's net to collect zooplankton for the night tank. The Regent's net (750 um) has a non-filtering cod-end to protect zooplankton, especially gelatinous organisms. The targeted depth is that of the DCM and the speed 0.3-0.4 m/s. The sample is transferred to a container that is kept in the cold room in the dark.
23:20 local time	Pumping of water from the depth of the DCM (when possible, or 58 m, the deepest we could reach) into the night tank. This takes approximately 40 m. We generally filled ~ 450 L out.
00:00 local time (T2)	The night tank is full and we add an aliquot of organisms (decided for each experiment, aiming for 5-20 times the natural concentrations of grazers) from the Regent's net sample into the day tank. Another aliquot of zooplankton is preserved in formalin (typically ~ 1L) and another one is processed for gut content (typically ~ 2 L), i.e., added to soda water, filtered and flash frozen to -80 C. Samples for nutrients, chlorophyll, *Planktoscope*, and flow-cytometry analysis are collected. Chlorophyll and flow-cytometry samples are collected also from the day tank for comparison. Mixing system for the night tank is started.
02:00 local time (T3)	Collection of samples for flow-cytometry
04:00 local time (T4)	Collection of samples for flow-cytometry
06:00 local time (T5)	Collection of samples for flow-cytometry, chlorophyll, nutrients, and *Planktoscope*.
07:00 local time (end of experiment)	Emptying of the tanks. Collection and fixing of zooplankton samples for taxonomy.

This process resulted in the set of samples for further analysis summarized in Table 19.

Experiment run	Station and date	Depth of the Regent's net and pumping	Zooplankton samples	Gut content samples	*Planktoscope* samples	Flow-cytometry samples	Chl	Nutrients
Meso1	A1 25-04-2023	40 m (DCM)	Start day Start night End day End night	Start day Start night	Start day Start night End day End night	Triplicates for day at T1-5 Triplicates for night T2-5	3 Start day 3 Start night 3 End day 3 End night	NA
Meso2	M 02-05-2023	50 m (DCM)	Start day Start night End day End night	Start day Start night	Start day Start night End day End night	Triplicates for day at T1-5 Triplicates for night T2-5	3 Start day 3 Start night 3 End day 3 End night	3 Start day 3 Start night 2 End day 2 End night
Meso3	B2 04-05-2023	58 m (DCM)	Start day Start night End day End night	Start day Start night	3 Start day 3 Start night 3 End day 3 End night	Triplicates for day at T1-5 Triplicates for night T2-5	3 Start day 3 Start night 3 End day 3 End night	3 Start day 3 Start night 2 End day 2 End night
Meso4	F2 05-05-2023	58 m (DCM)	Start day Start night End day End night	Start day Start night	3 Start day 3 Start night 3 End day 3 End night	Triplicates for day at T1-5 Triplicates for night T2-5	3 Start day 3 Start night 3 End day 3 End night	3 Start day 3 Start night 2 End day 2 End night
Meso5	M2 10-05-2023	55 m	Start day Start night End day End night	Start day Start night	3 Start day 3 Start night 3 End day 3 End night	Triplicates for day at T1-5 Triplicates for night T2-5	3 Start day 3 Start night 3 End day 3 End night	3 Start day 3 Start night 2 End day 2 End night

Table 19. Summary of the mesocosm experiments.

6.19 Megafauna observations

Visual observations were performed from naked eyes and binoculars during the 10 first minutes of each hour during transit time. Here below are reported the forms completed during the cruise.

al Observations during the BIOSWOT cruise

Observator : Cédric Cotté

Protocol : 10 first minutes of each h during transits

te/Hour		Positions		Observations				Conditions of Observations										N° of Obs	Remarks
lour TU		Latitude	Longitude	Species	Estimated distance (?/3)	Number	Behaviour	Visibility (?/4)	Cloud (?/8)	Sea state	Wind Direction	Wind (knots)	Sea Temp.	Air Temp.	Atm. Pressure	Bottom speed (GPS)	Wave		
23	13:00																		
23	14:00																		
23	15:00																		
23	16:00																		
23	17:00																		
23	18:00																		
23	05:00	41°53.3	04°33.7	P	1/2	5		4	4	2	145	14	14,6	15	1011,8	0	0,5		Obs during station (glider deployemer
23	07:00	41°53.3	04°33.7	Mm	1	1		4	4	2	145	14	14,6	15	1011,8	0	0,5		
23	15:45	41°55.2	04°33.7	Bp	3	2	Tran	4	6	2	140	15	14,8	15,7	1010,9	0	0,5		
23	19:00																		
23	20:00																		
23	06:00																		
23	07:00																		
23	08:00																		
23	09:00																		
23	10:00																		
23	11:00																		
23	12:00																		
23	13:00																		
23	14:00																		few jellies (boussoles)
23	17:00																		
23	18:00																		
23	05:00																		
23	06:00																		few jellies (velleles)
23	07:00																		
23	08:00																		
23	09:00																		
23	10:00																		
23	11:00																		few jellies (velleles) + Balearic shearw
23	12:00																		
23	13:00																		Shearwaters
23	17:00																		Seagull

DISTANCE: 1 = close (0-300m), 2 = medium (300-1000m), 3 = far (>1000m)

BEHAVIOUR: Forag = foraging, Tran = transit, Soc = socialized behaviour

SPECIES: **Bp** = Fin whale, **Pm** = Sperm whale,

Zc = Ziphius, **Gm** = Pilot whale, **Gg** = Risso's dolphin,

Tt = Bottlenose , **Sc** = Striped dolphin, **Dd** = Common dolphin,

Cc = Loggerhead turtle, **Cm** = Green turtle, **Dc** = Leatherback turtle,

S = Tunas, **P** = Basking shark, **Mm** = Sunfish

VISIBILITY: 0 = foggy, 1 = <1mn, 2 = 1-4mn, 3 = 4-7mn, 4 > 7mn

SEA STATE: 0 (V=0, flat sea), 1 (V=1-3, rippled), 2 (V=4-6, small wavelets), 3 (V=7-10, large wavelets and few whitecaps), 4(V=11-16, small waves and many whitecaps), 5(V=17-21, medium waves and numerous whitecaps), 6 (V=22-27, large waves and spray)

Observator : Cédric Cotté

Protocol : 10 first minutes of each during transits

Date/Hour		Positions		Observations				Conditions of Observations										N° of Obs	Remarks
Hour TU		Latitude	Longitude	Species	Estimated distance (?/3)	Number	Behaviour	Visibility (?/4)	Cloud (?/8)	Sea state	Wind Direction	Wind (knots)	Sea Temp.	Air Temp.	Atm. Pressure	Bottom speed (GPS)	Wave		
04/23	18:00																		
04/23																			
04/23	08:00																		
04/23	09:00																		
04/23	10:00																		
04/23	11:00	41°05.13	04°23.59	Bp	2	1	Tran	4	3	4	12	10	16,7	16,3	1015,7	6	0,8		
04/23	13:00	41°04.69	04°26.88	Cc	1	1		2	6	1	220	3	17,3	18,6	1016,2	6	0,3		
04/23	14:00	40°57.89	04°24.78	Bp	1	1	Tran	4	2	2	157	9	17,6	18,9	1015,3	3	0,3		Jellies + seagulls
04/23	14:10	40°57.89	04°24.78	Cc	1	1		4	2	2	157	9	17,6	18,9	1015,3	3	0,3		
04/23	19:00																		
04/23	07:00																		
04/23	08:00																		
04/23	09:00																		
04/23	10:00																		
04/23	12:00																		
04/23	13:00																		
04/23	15:00																		
04/23	16:00																		
04/23	17:00																		
04/23	05:00																		
04/23	06:00																		
04/23	07:00																		
04/23	08:00																		
04/23	09:00																		
04/23	10:00																		
04/23	11:00																		
04/23	16:00	41°07.8	04°59.16	Bp	2	1	Tran	4	3	4	340	13	17,1	17,1	1013	5	1,5		
04/23	17:00																		
04/23	18:00																		
05/23	05:00																		
05/23	06:00																		
05/23	07:00																		

DISTANCE: 1 = close (0-300m), 2 = medium (300-1000m), 3 = far (>1000m)

BEHAVIOUR: Forag = foraging, Tran = transit, Soc = socialized behaviour

SPECIES: **Bp** = Fin whale, **Pm** = Sperm whale,

Zc = Ziphius, **Gm** = Pilot whale, **Gg** = Risso's dolphin,

Tt = Bottlenose , **Sc** = Striped dolphin, **Dd** = Common dolphin,

Cc = Loggerhead turtle, **Cm** = Green turtle, **Dc** = Leatherback turtle,

S = Tunas, **P** = Basking shark, **Mm** = Sunfish

VISIBILITY: 0 = foggy, 1 = <1mn, 2 = 1-4mn, 3 = 4-7mn, 4 > 7mn

SEA STATE: 0 (V=0, flat sea), 1 (V=1-3, rippled), 2 (V=4-6, small wavelets), 3 (V=7-10, large wavelets and few whitecaps), 4(V=11-16, small waves and many whitecaps), 5(V=17-21, medium waves and numerous whitecaps), 6 (V=22-27, large waves and spray)

ual Observations during the BIOSWOT cruise

Observator : Cédric Cotté

Protocol : 10 first minutes of each hour during transits

Date/Hour		Positions		Observations				Conditions of Observations										N° of Obs	Remarks
	Hour TU	Latitude	Longitude	Species	Estimated distance (?/3)	Number	Behaviour	Visibility (?/4)	Cloud (?/8)	Sea state	Wind Direction	Wind (knots)	Sea Temp.	Air Temp.	Atm. Pressure	Bottom speed (GPS)	Wave		
05/23	08:00																		
05/23	09:00																		
05/23	10:00																		
05/23	11:00																		
05/23	12:00																		
05/23	13:00																		
05/23	08:00																		
05/23	09:00																		
05/23	10:00																		
05/23	14:00	39°50.26	04°53.05	Cc	1	2		3	0	3	355	8	18,2	17,8	1017,5	6	0,8		
05/23	15:00																		
05/23	18:00																		
05/23	05:00																		
05/23	06:00																		
05/23	07:00																		
05/23	08:00	41°14.39	05°04.46	Bp	3	2	Tran	3	2	3	355	9	16,6	17,6	1019,4	6	0,5		
05/23	10:00																		
05/23	11:00	41°11.35	05°07.38	Bp	3	1	Tran	3	3	2	120	6	17,8	18,9	1015,6	6	0,5		
05/23	12:00																		
05/23	06:00																		
05/23	07:00																		
05/23	08:00																		
05/23	09:00																		
05/23	10:00																		
05/23	11:00																		
05/23	12:00																		
05/23	13:00																		
05/23	14:00																		
05/23	15:00																		
05/23	18:00	40°08.03	05°01.00	Cc	1	1		4	2	2	240	4	18,6	19,4	1015,6	6	0,5		
05/23	19:00																		
05/23	20:00																		

DISTANCE: 1 = close (0-300m), 2 = medium (300-1000m), 3 = far (>1000m)

BEHAVIOUR: Forag = foraging, Tran = transit, Soc = socialized behaviour

SPECIES: **Bp** = Fin whale, **Pm** = Sperm whale,

Zc = Ziphius, **Gm** = Pilot whale, **Gg** = Risso's dolphin,

Tt = Bottlenose , **Sc** = Striped dolphin, **Dd** = Common dolphin,

Cc = Loggerhead turtle, **Cm** = Green turtle, **Dc** = Leatherback turtle,

S = Tunas, **P** = Basking shark, **Mm** = Sunfish

VISIBILITY: 0 = foggy, 1 = <1mn, 2 = 1-4mn, 3 = 4-7mn, 4 > 7mn

SEA STATE: 0 (V=0, flat sea), 1 (V=1-3, rippled), 2 (V=4-6, small wavelets), 3 (V=7-10, large wavelets and few whitecaps), 4(V=11-16, small waves and many whitecaps), 5(V=17-21, medium waves and numerous whitecaps), 6 (V=22-27, large waves and spray)

BIOSWOT cruise

Observator : Cédric Cotté

during transits

Date/Hour		Positions		Observations				Conditions of Observations										N° of Obs	Remarks
	Hour TU	Latitude	Longitude	Species	Estimated distance (?/3)	Number	Behaviour	Visibility (?/4)	Cloud (?/8)	Sea state	Wind Direction	Wind (knots)	Sea Temp.	Air Temp.	Atm. Pressure	Bottom speed (GPS)	Wave		
05/23	06:00																		
05/23	05:00																		
05/23	06:00																		
05/23	07:00																		
05/23	08:00																		
05/23	09:00																		

DISTANCE: 1 = close (0-300m), 2 = medium (300-1000m), 3 = far (>1000m)

BEHAVIOUR: Forag = foraging, Tran = transit, Soc = socialized behaviour

SPECIES: **Bp** = Fin whale, **Pm** = Sperm whale,

Zc = Ziphius, **Gm** = Pilot whale, **Gg** = Risso's dolphin,

Tt = Bottlenose , **Sc** = Striped dolphin, **Dd** = Common dolphin,

VISIBILITY: 0 = foggy, 1 = <1mn, 2 = 1-4mn, 3 = 4-7mn, 4 > 7mn

SEA STATE: 0 (V=0, flat sea), 1 (V=1-3, rippled), 2 (V=4-6, small wavelets), 3 (V=7-10, large wavelets and few whitecaps), 4(V=11-16, small waves and many whitecaps), 5(V=17-21, medium waves and numerous whitecaps), 6 (V=22-27, large waves and spray)

6.20 SEASTARex-Med campaign: OSCAR airborne measurements of ocean surface wind and current and ordered satellite SAR images

The main objective of SEASTARex-Med was to acquire OSCAR airborne data under the SWOT fast-repeat ground tracks in the N.W. Mediterranean Sea. OSCAR acquisitions coincided with SWOT overflights and in situ oceanographic observations taken under the framework of the SWOT fast-repeat Cal/Val phase.

OSCAR (Ocean Surface Current Airborne Radar) is a new instrument developed by MetaSensing under ESA contract 4000116410/16/NL/BJ, to measure ocean surface current and wind vectors over a swath of 5 km at 200 m resolution. There is no limitation in term of track length. They are typically about 10-100 km long. The table below gives the main characteristics of the aircraft and instrument. The two figures below show the boom system, which is attached to a gimbal, with antennas looking in three different directions. The boom systems is protected by a certified Ku-band radome when the aircraft is flying. A first successful campaign happened in Iroise Sea in May 2022.

Parameter	Value
Aircraft	LN-PNB Piper PA-31-310 Navajo
Height	3000m amsl (FL095 acceptable)
Ground speed (goal, wind dependent)	150 kt (75 m/s, 270 km/h)
Central Frequency	Ku-band
Polarization	V in all beams (squinted and 0-Doppler)
System preset	3-view V
RF peak TX power	50 dBm
IF attenuation	5 dB
PRF	8 kHz
Duty cycle	25%
ATI baseline	17 cm

Table 20: Aircraft and radar settings common to all the acquisitions (land and sea).

Figure 51. Antennas and instrument fixed on the aircraft.

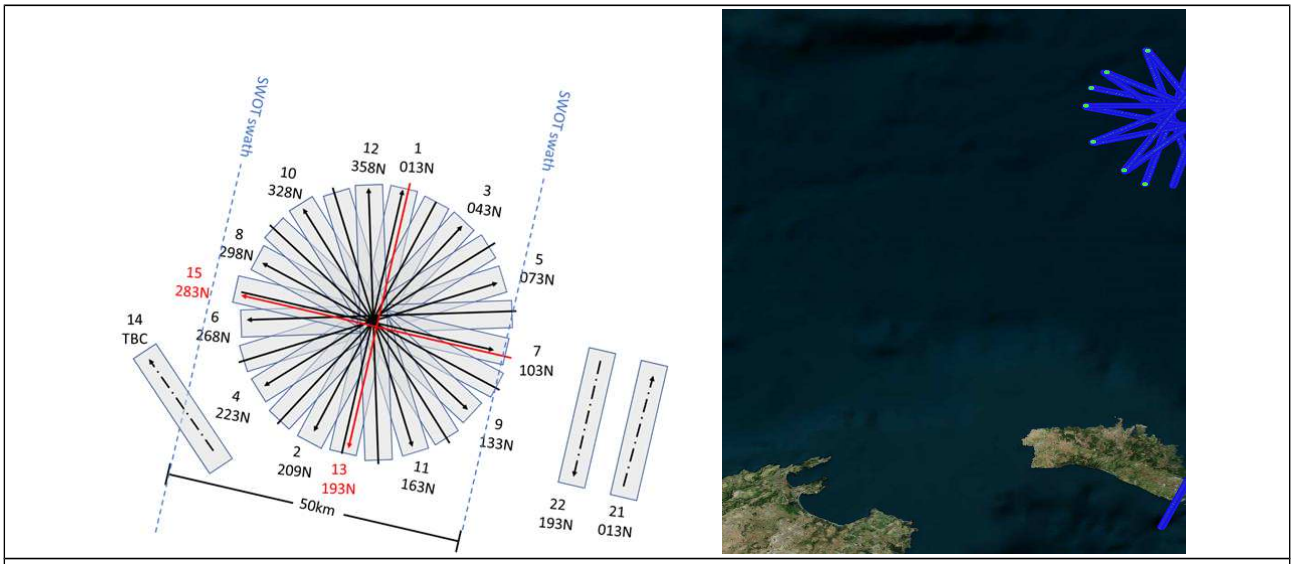


Figure 52. Antennas and instrument fixed on the aircraft.

For this campaign we proceeded with 3 flights on the 5, 7 and 8 May when wind conditions were strong enough for the radar to get enough backscattered signal. The same acquisition pattern was proceeded for the three days with a rose pattern within a disk of about 50km in diameter centered at 41.09°N, 4.29°E (see Figure 52). A calibration track over the East part of Minorca was proceeded at the beginning of each flight.

In addition of these three airborne flights, a wide range a standard satellite SAR images have been ordered and acquired below SWOT pass #3 on the North-East part of the Balearic Islands from May to July 2023. We have nearly daily acquisition of RCM. We have 10 or slightly more acquisitions for each of the following satellites: NovaSAR-1, PAZ, COSMO-SkyMed, Radarsat-2, TerraSAR-X. In addition to these specific acquisitions there is the standard acquisition by Sentinel-1 with about 20 acquisitions.

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