PERSEUS

POLICY-ORIENTED MARINE ENVIRONMENTAL RESEARCH IN THE SOUTHERN EUROPEAN SEAS

Operation and data analysis from Argo and expendable systems at basin and sub-basin scale

D3.5

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EXECUTIVE SUMMARY/ABSTRACT

Considering the existing permanent routine observing systems and the scientific and society needs in the Southern European Seas (SES), as well as the gaps identified and reported in deliverable D3.1, specific upgrades of the observing components have been carried out as part of workpackage WP3 of the PERSEUS project. This report summarizes the upgraded observing components of the ARGO float network and the ship-of-opportunity program in the SES corresponding to subtask 3.2.2 of PERSEUS. It focuses on the operation and data processing of the upgraded observations for the period ranging from January 2012 to July 2015.

Twentyseven floats fully or partially funded by PERSEUS or provided as in-kind contribution to the project have been deployed in order to increase and broaden the ARGO network in most areas of the SES. They were mostly released during oceanographic cruises. Upgrades have also been made in terms of biogeochemical sensors to collect observations more related to the Marine Strategy Framework Directive (MSFD) descriptors for Good Environment Status (GES), including dissolved oxygen, chlorophyll, coloured dissolved organic matter, nitrate and hydrogen sulfide.

The ship-of-opportunity program in the SES was maintained with the release of Expendable Bathythermograph (XBT) probes along repeated lines in selected subbasins. A lidar fluorosensor was also operated to monitor the optical and biochemical characteristics of the surface water.

All data from SES existing systems, as well as data from the upgraded observing components, have been used in analyses performed in WP1 and WP2 of PERSEUS. The collected data have been made available through the PERSEUS Database (WP9).

SCOPE

The overall objective of WP3 is to upgrade and expand the present observing capacity in the SES towards fulfilment of the scientific and society needs addressed by PERSEUS with an emphasis on the characterization of the present state, increasing forecasting capabilities and the provision of solid grounds for the implementation of MSFD.

To this end, after the identification of gaps and needs of the existing observing capacities in the SES (see Task 3.1), specific upgrades of the SES observing components have been carried out, with particular focus on increasing the geographical sampling coverage and upgrading and expanding new sensors of existing multi-parametric platforms. The upgrade and expansion of the SES observing capacity using Argo floats and ships-of-opportunity during the PERSEUS project is summarised in this report.

1. UPGRADE OF THE ARGO FLOAT NETWORK IN THE SES

The SES have been sampled by Lagrangian instruments more or less uniformly over the last decades, providing data on surface temperature and currents (drifters) and temperature and salinity profiles, subsurface currents (floats) in most areas of these seas. Recently, floats have been fitted with new sensors to measure biogeochemical properties (dissolved oxygen, chlorophyll concentration, etc.) and with interactive satellite telemetry (Iridium and Argos 3) allowing the collection of multi-parametric data with optimized/adaptive sampling.

1.1 PERSEUS FLOAT DEPLOYMENTS IN THE SES (2012-2015)

The Argo fleet in the SES has been expanded and upgraded with the deployment of the following floats since the beginning of the project in 2012, some of them directly or partially funded by PERSEUS, other considered as in-kind contributions from other projects. The contribution of all the partners is reviewed hereafter.

1.1.1 IO-BAS

IO-BAS (Bulgaria) deployed two Provor floats with dissolved oxygen (DO) sensor in the western Black Sea on 2 June 2014 and 26 June 2015. The float tracks and profile positions are shown in Fig. 1 and information about the float operating lives is given in Table 1. The floats were programmed to perform 5-d cycles with a parking depth at 1000 m and maximal profiling depth at 2000 m.

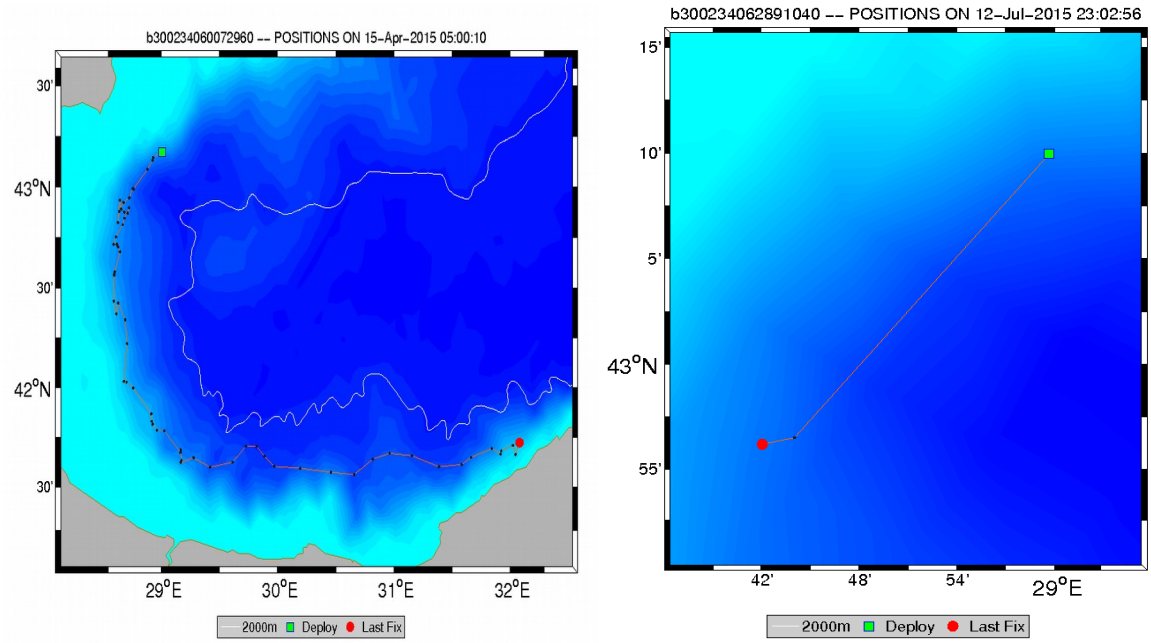


Figure 1. Trajectories and profile positions (black dots) of floats deployed by IO-BAS (WMO 7900593 – left & 7900594 - right) in the Black Sea.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
7900593	Provor DO	02-Jun-2014 05:18	43.17	29.00	15-Apr-2015 05:00	41.72	32.08	D
7900594	Provor DO	26-Jun-2015 12:55	43.17	28.99	17-Jul-2015 23:10	42.93	28.63	A

Table 1. Operating information for floats deployed by IO-BAS (WMO 7900593 & 7900594).

1.1.2 GeoECoMar

GeoECoMar (Romania) deployed one Provor float with sensors to measure DO, chlorophyll-a (CHL), colored dissolved organic matter (CDOM) and backscatter at 700 nm in the western Black Sea on 28 November 2014. The float track and profile positions are shown in Fig. 2 and information about the float operating life is given in Table 2. The float was programmed to perform 5-d cycles with a parking depth at 200 m and maximal profiling depth at 1000 m. Fig. 3 shows the float on the Romanian research vessel before deployment.

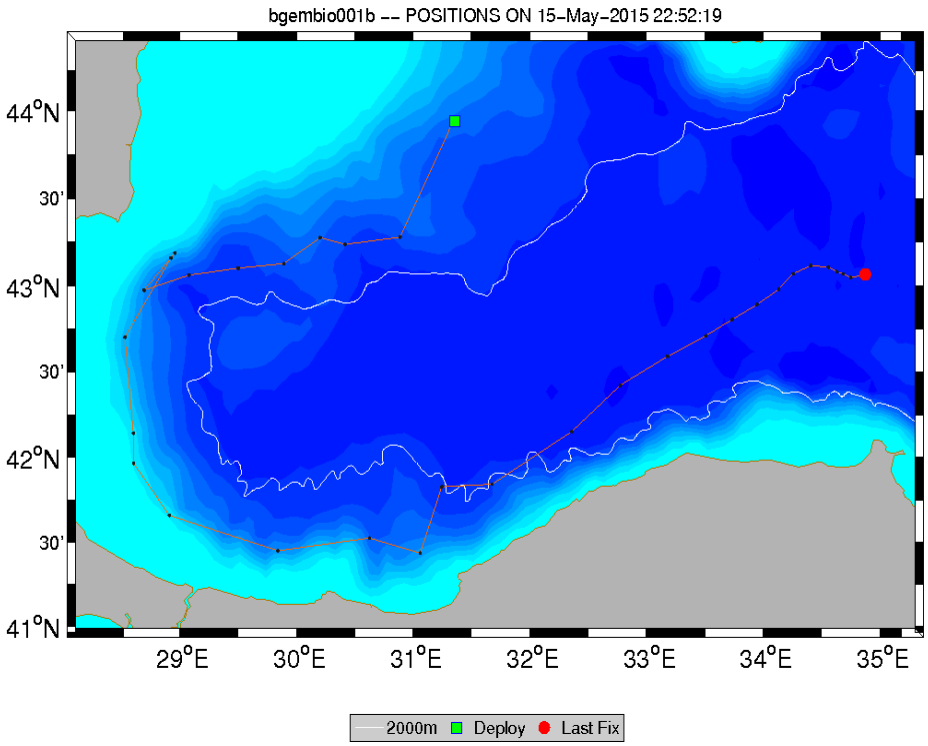


Figure 2. Trajectory and profile positions (black dots) of float deployed by GeoEcoMar (WMO 6900807) in the Black Sea.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
6900807	Provor BIO	28-Nov-2014 08:45	43.94	31.36	15-Jun-2015 22:58	43.5	34.9	A

Table 2. Operating information for float WMO 6900807.

As an example, profiles of the physical and biogeochemical variables measured by float WMO 6900807 on 15 June 2015 are plotted in Fig. 4. Note that the increase of CHL with depth down to 1000 m is an artefact and corresponds to fluorescence by another substance. This peculiar result is under investigation in collaboration with colleagues of the Laboratoire Océanographique de Villefranche-sur-Mer (LOV).

Figure 3. The Romanian Prov-BIO float is ready to be deployed from the R/V Mare Nigrum in the western Black Sea on 28 November 2015.

1.1.3 HCMR

HCMR (Greece) deployed one Provor float with DO sensor in the Aegean Sea on 30 October 2013. The float track and profile positions are shown in Fig. 5 and information about the float operating life is given in Table 3. The float was programmed to perform 5-d cycles with a parking depth at 350 m and maximal profiling depth at 1000 m. It was stranded or picked up near the Kasos Island on 14 June 2014. It was then recovered and transported to mainland Greece. This float was redeployed south of Crete in mid July 2015.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
6901881	Provor DO	30-Oct-2013 10:20	35.77	25.15	01-Sep-2014 07:27	37.73	23.9	D

Table 3. Operating information for float WMO 6901881.

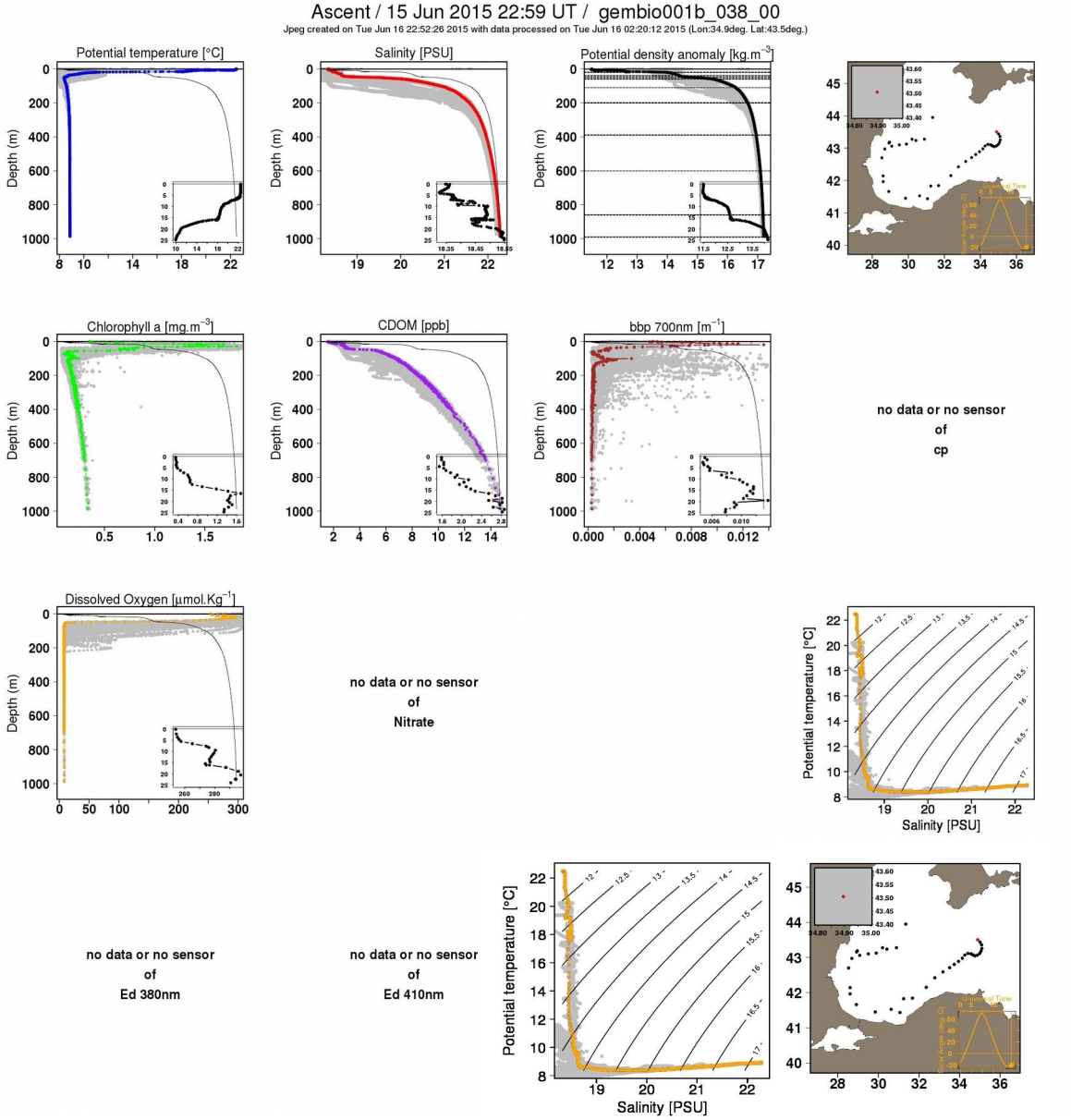


Figure 4. Physical and biogeochemical data on 15 June 2015 of the float deployed by GeoEcoMar (WMO 6900807) in the Black Sea.

1.1.6 OGS

OGS (Italy) deployed the following floats related to the PERSEUS project:

- Two Arvor-I floats , one Provor-BIO and one Provor-NUT in the northern Ionian Sea during the ADREX campaign in February 2014, in collaboration with CSIC.

- One Provor-BIO in the eastern Alboran Sea during the ALBOREX campaign in May 2014.
- A Provor-NUT modified to measure simultaneously nitrate and hydrogen sulfide with the SUNA sensor in the western Black Sea in spring 2015, in collaboration with IO-BAS.

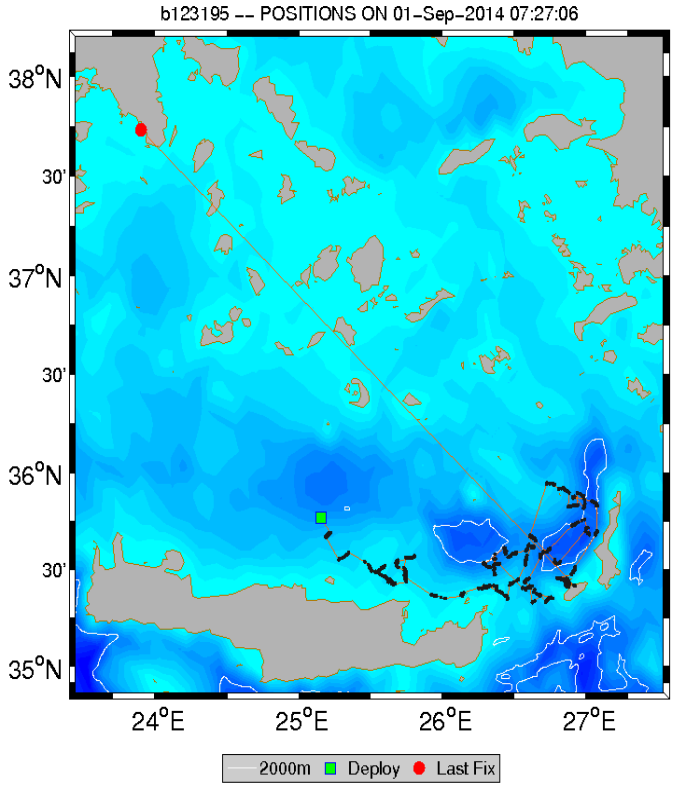


Figure 5. Trajectory and profile positions (black dots) of float deployed by HCMR (WMO 6901881) in the Aegean Sea.

The Arvor-I float was programmed to perform 5-d cycles with a parking depth at 350 m and maximal profiling depth at 1000 m. In addition to pressure, temperature and conductivity (salinity), the Provor-BIO measures also irradiance at three wavelengths (412 nm, 490 nm, 555 nm), fluorescence of coloured dissolved organic matter, fluorescence of chlorophyll-a, backscattering coefficient (530nm) and attenuation coefficient (660 nm). The Provor-NUT float is a Provor-Bio float with additional sensors: an Aanderaa optode oxygen sensor and a SUNA nitrate sensor. The floats were initially programmed to sample profiles from, and drift at, 1000 m near local noon time every day. After some time, the period was changed to 5 days and the parking depth was set to 350 m, using the Iridium downlink.

The OGS float tracks and profile positions are shown in Figs. 6 to 11, and information about the float operating lives is given in Table 4. Fig. 12 shows the Provor-NUT just before deployment in the southern Adriatic on 18 February 2014.

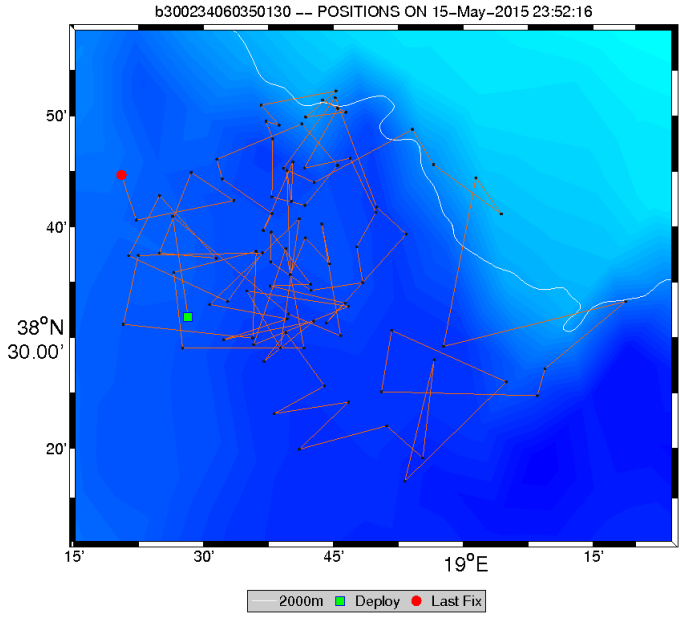


Figure 6. Trajectory and profile positions (black dots) of Arvor-I float (WMO 6901829) deployed by OGS in the northern Ionian Sea.

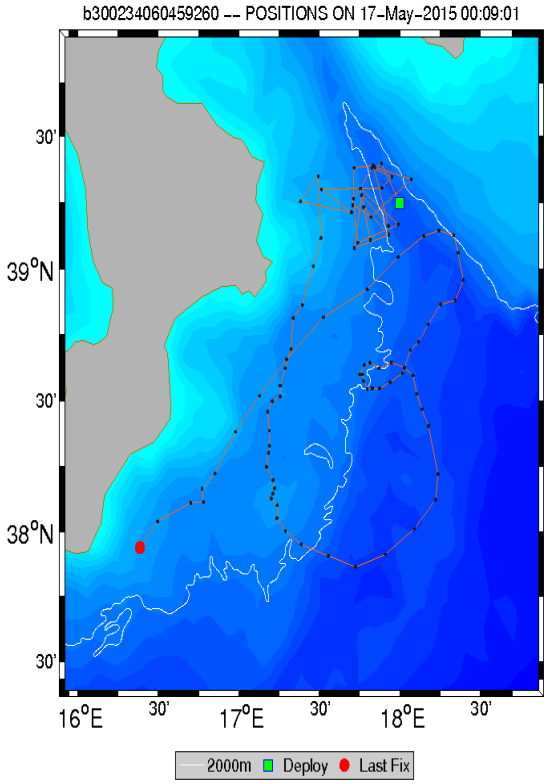


Figure 7. Trajectory and profile positions (black dots) of Arvor-I float (WMO 6901830) deployed by OGS in the northern Ionian Sea.

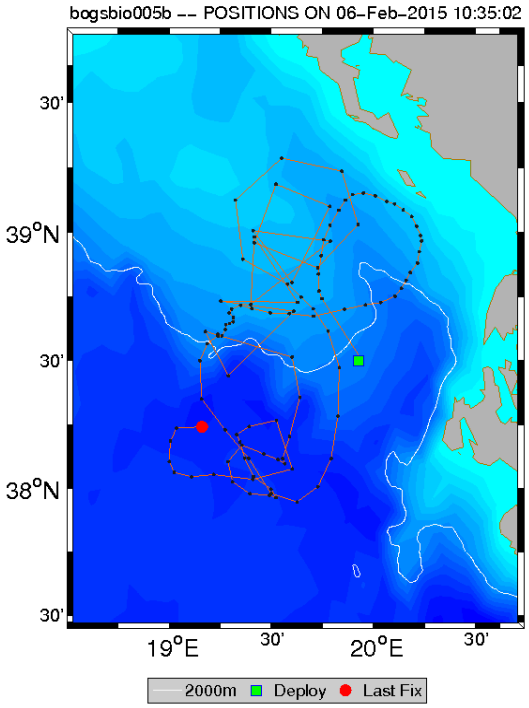


Figure 8. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901860) deployed by OGS in the northern Ionian Sea.

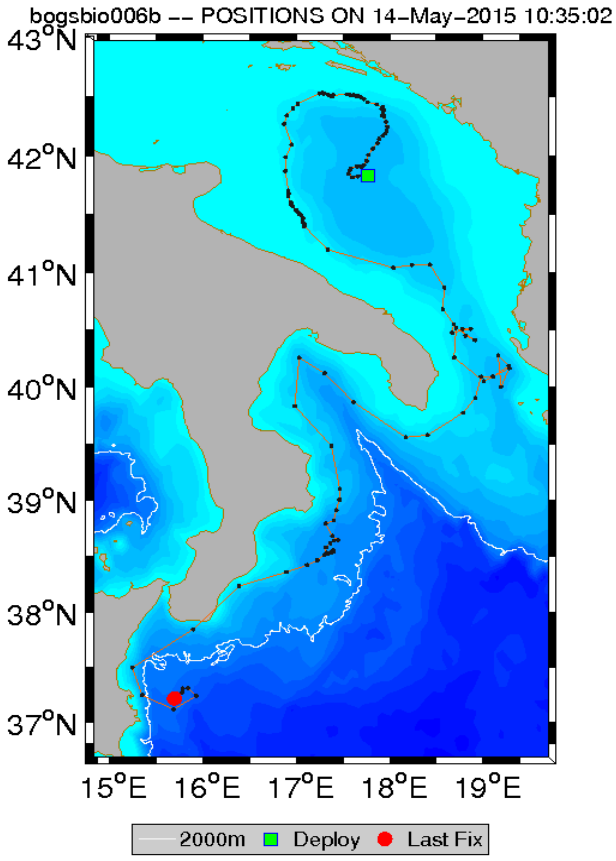


Figure 9. Trajectory and profile positions (black dots) of Provor-NUT (WMO 6901865) deployed by OGS in the southern Adriatic Sea.

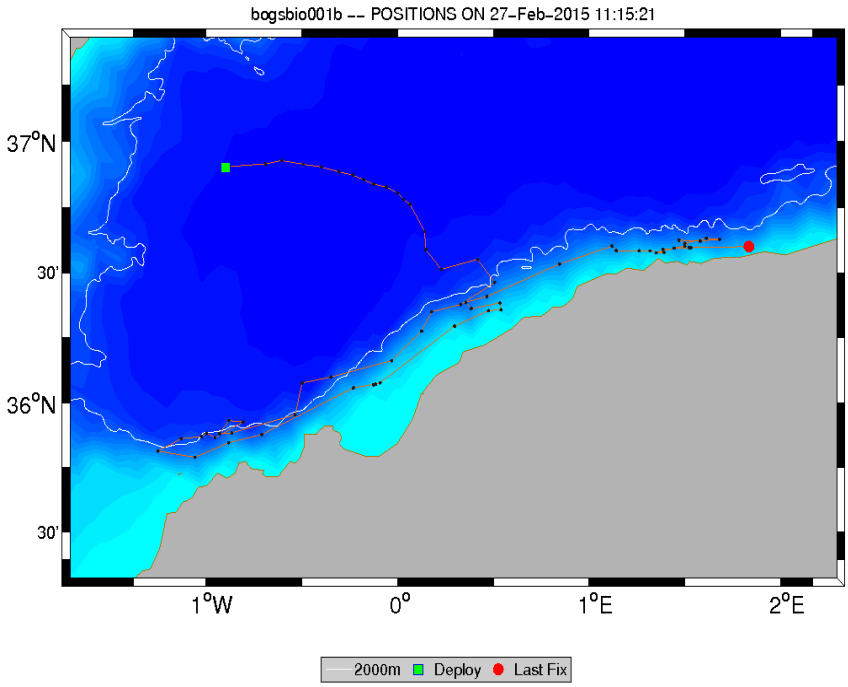


Figure 10. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901861) float deployed by OGS in the eastern Alboran Sea.

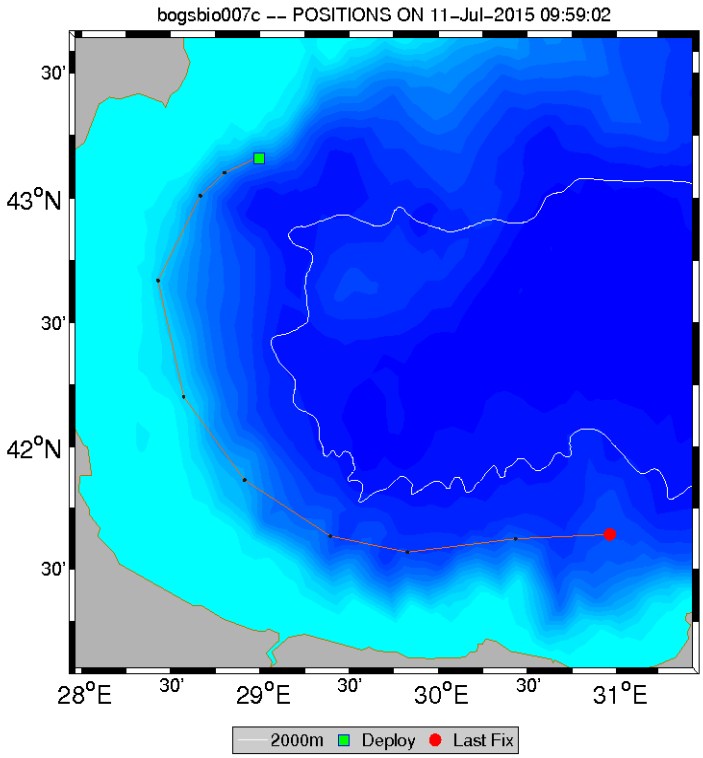


Figure 11. Trajectory and profile positions (black dots) of Provor-NUT (WMO 6901866) float deployed by OGS in the western Black Sea.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
6901829	Arvor I	13-Feb-2014 19:11	38.53	18.47	14-Jun-2015 23:58	38.71	18.21	A
6901830	Arvor I	14-Feb-2014 08:19	39.25	18.00	15-Jun-2015 23:59	37.37	15.67	A
6901860	Provor BIO	12-Feb-2014 13:47	38.5	19.93	06-Feb-2015 10:35	38.24	19.16	D
6901865	ProvorNUT	18-Feb-2014 17:28	41.83	17.76	14-May-201510:35	37.22	15.7	D
6901861	Provor BIO	25-May-201419:54	36.9	-0.9	27-Feb-2015 11:15	36.6	1.83	D
6901866	ProvorNUT	27-May-201515:12	43.16	29.00	21-Jun-2015 09:23	41.86	28.92	A

Table 4. Operating information for the floats deployed by OGS.

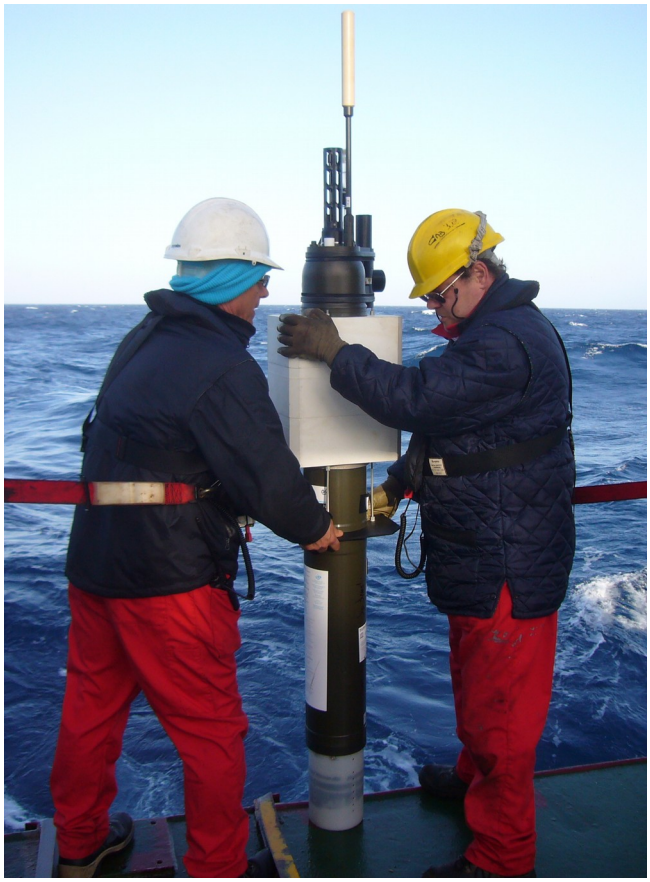


Figure 12. The Italian Provor-NUT float (WMO 6901865) is ready to be deployed from the R/V OGS Explora in the southern Adriatic Sea on 18 February 2014 during the ADREX campaign.

Figure 13. The Italian Provor-BIO float (WMO 6901861) is tested before deployment on the R/V SOCIB in the eastern Alboran Sea on 25 May 2014 during the ALBOREX campaign.

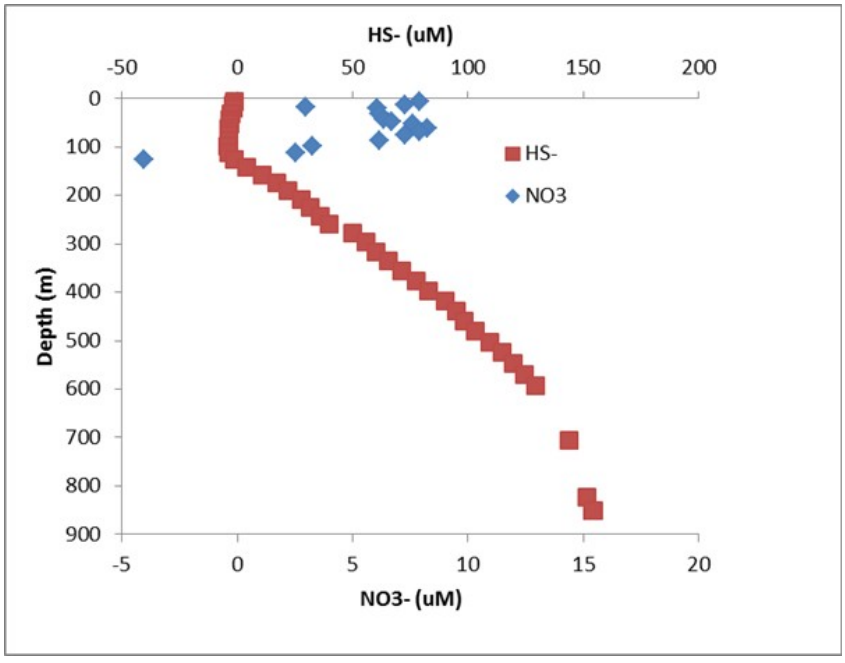


Figure 14. Example of profiles of nitrate and hydrogen sulfide measured by the Italian Provor-NUT float (WMO 6901866) in the western Black Sea.

1.1.7 CSIC/IEO

CSIC/IEO (Spain) deployed the following floats related to the PERSEUS project in the Western Mediterranean between June 2012 and November 2014:

- Six Apex floats,
- One Arvor-I float.

Trajectories and profile positions are shown in Figs. 15 to 21. Table 5 summarises details about the float operations.

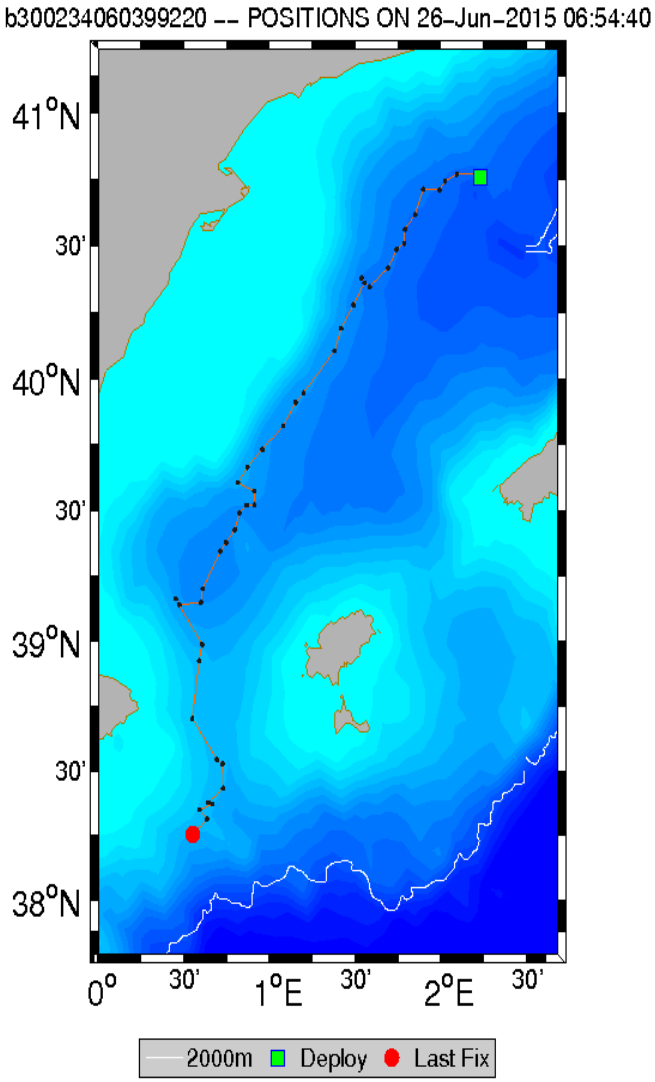


Figure 15. Trajectory and profile positions (black dots) of Arvor-I (WMO 6901245) float deployed by CSIC in the north western Mediterranean.

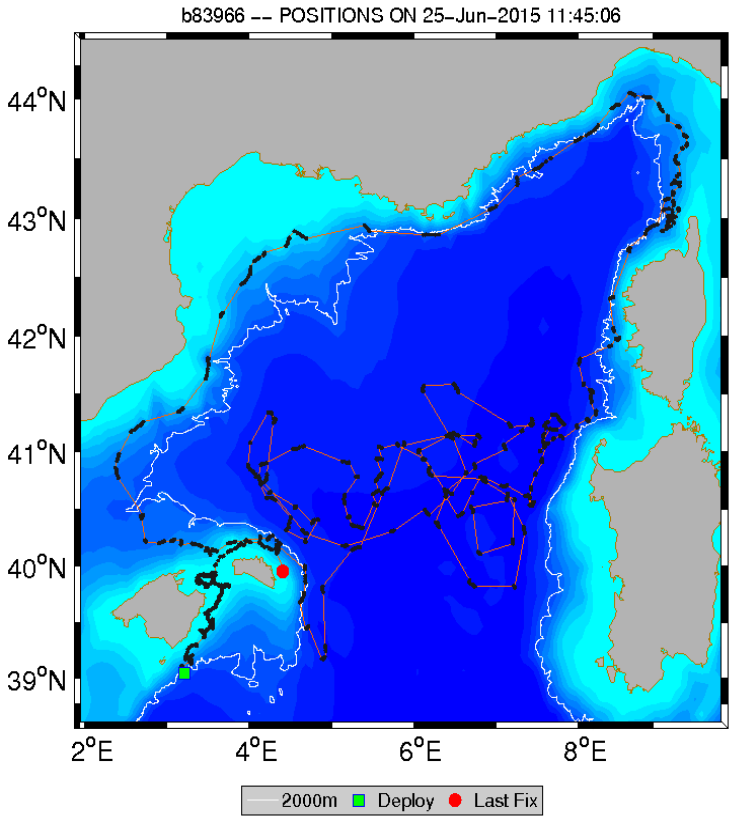


Figure 16. Trajectory and profile positions (black dots) of Apex (WMO 6900662) float deployed by CSIC in the Balearic Sea.

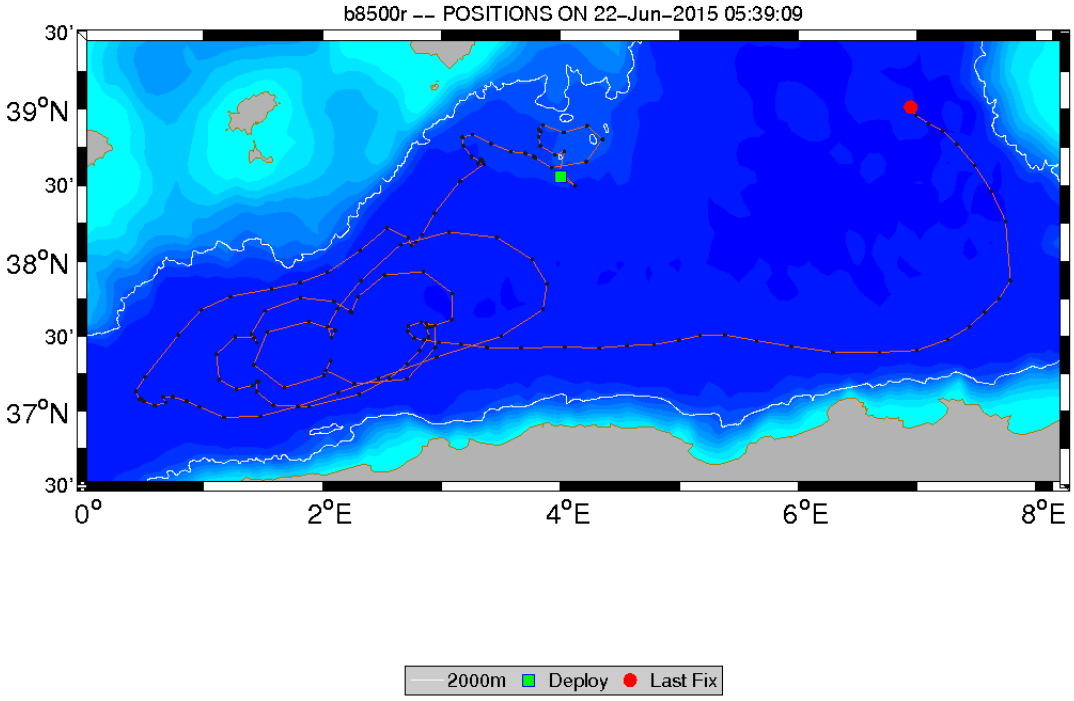


Figure 17. Trajectory and profile positions (black dots) of Apex (WMO 6900787) float deployed by CSIC in the Balearic Sea.

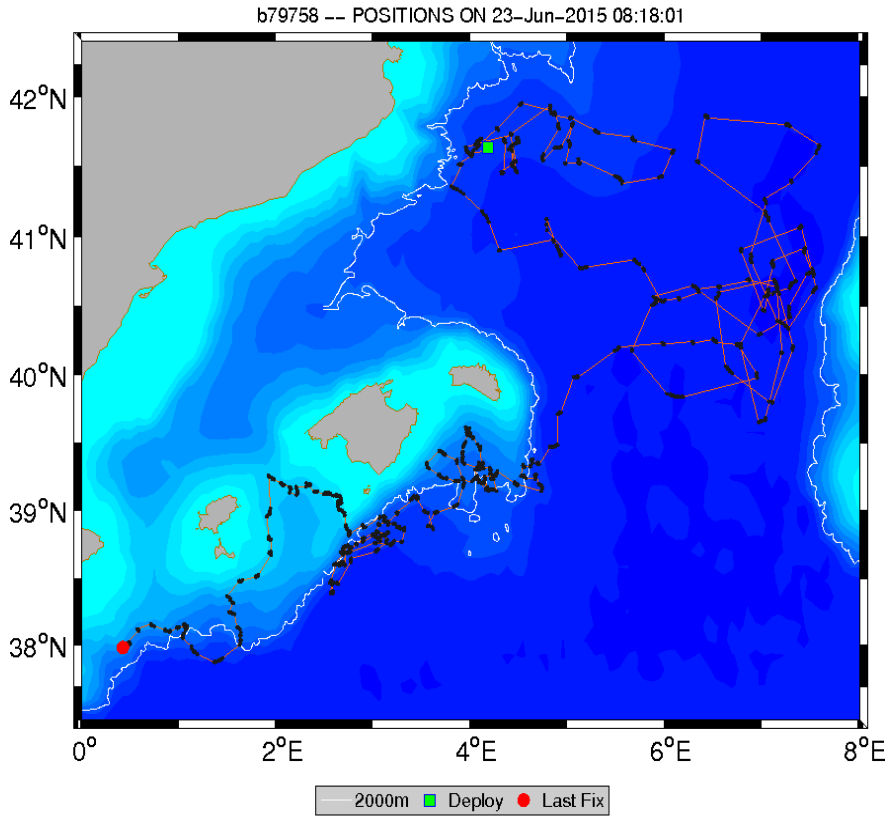


Figure 18. Trajectory and profile positions (black dots) of Apex (WMO 6900636) float deployed by CSIC in the Balearic Sea.

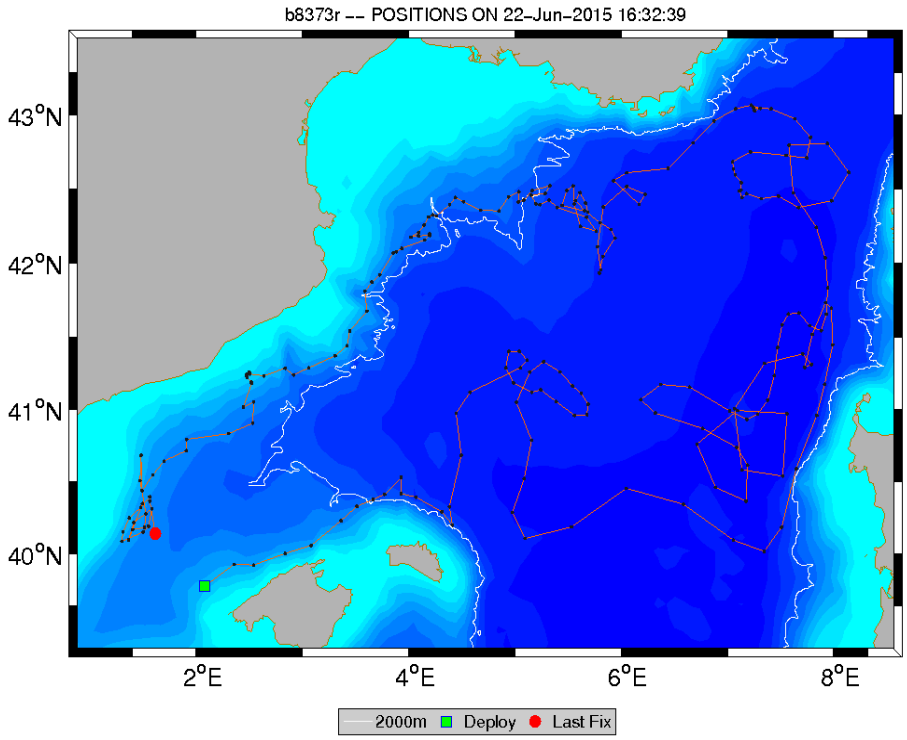


Figure 19. Trajectory and profile positions (black dots) of Apex (WMO 6900786) float deployed by CSIC in the Balearic Sea.

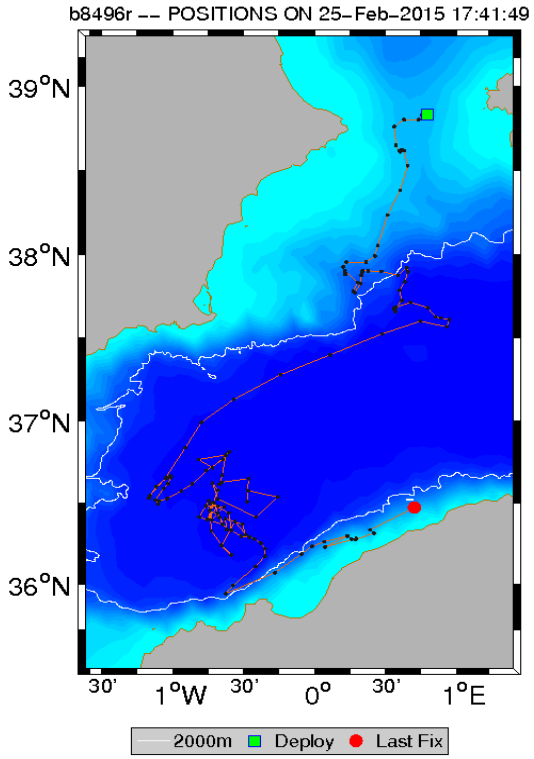


Figure 20. Trajectory and profile positions (black dots) of Apex (WMO 6900788) float deployed by CSIC in the Balearic Sea.

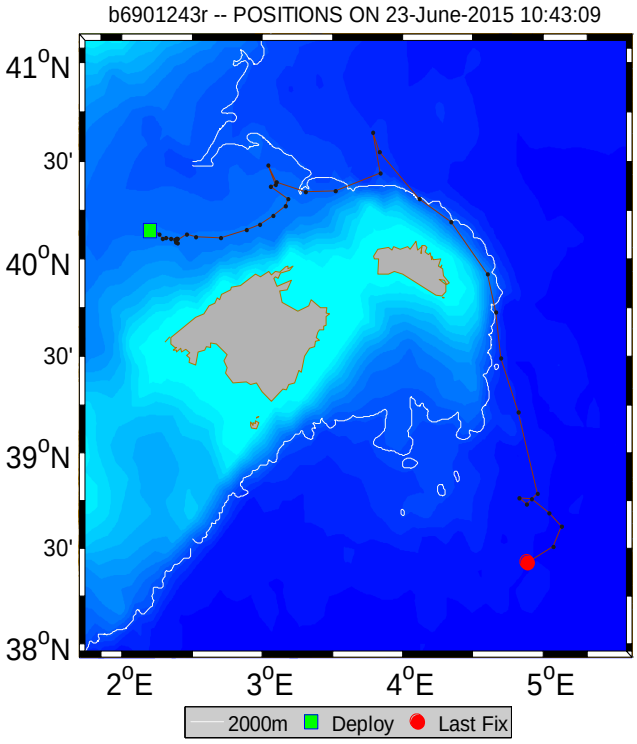


Figure 21. Trajectory and profile positions (black dots) of Apex (WMO 6901243) float deployed by CSIC in the Balearic Sea.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
6901245	Arvor I	21-Nov-2014 23:25	40.76	2.23	22-Jun-2015 05:33	38.31	0.64	A
6900662	Apex	10-Jun-2012 09:15	39.04	3.21	20-Jun-2015 12:05	40.11	4.33	A
6900787	Apex	15-Jul-2013 08:00	38.56	4	22-Jun-2015 05:39	39.02	6.95	A
6900636	Apex	28-Jul-2012 04:06	41.64	4.2	18-Jun-2015 07:18	38	0.49	A
6900786	Apex	02-Aug-2012 08:00	39.78	2.08	17-Jun-2015 23:51	40.37	1.57	A
6900788	Apex	15-Apr-2013 08:00	38.84	0.8	25-Feb-2015 17:12	36.47	0.71	D
6901243	Apex	22-Nov-2014 02:00	40.14	2.19	23-Jun-2015 10:43	38.43	4.89	A

Table 5. Operating information for the floats deployed by CSIC.

1.1.8 IFREMER/CNRS

IFREMER/CNRS (France) deployed the following floats related to the PERSEUS project throughout the Mediterranean Sea between April 2013 and February 2014, as part of the French NAOS project:

- Eight Provor-BIO,
- Two Provor-NUT.

Trajectories and profile positions are shown in Figs. 22-30. Details about the float operations are listed in Table 6.

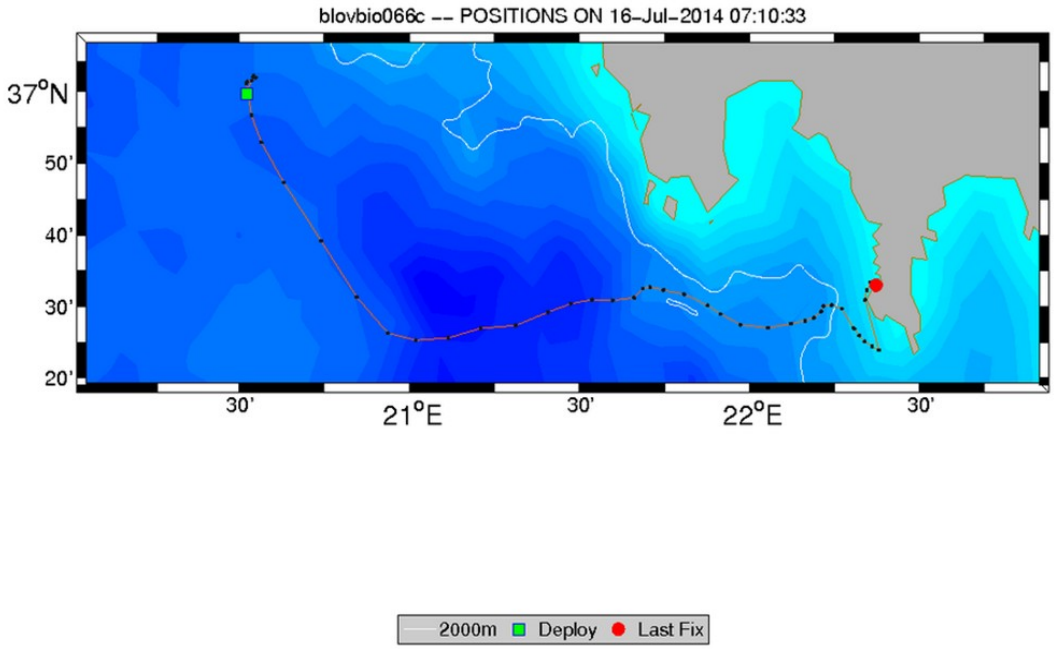


Figure 21. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901605) float deployed by LOV in the Ionian Sea.

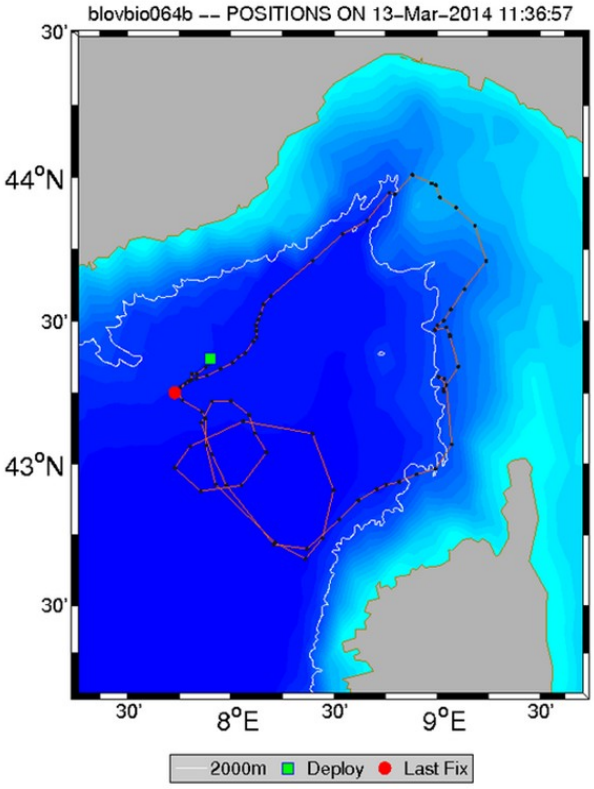


Figure 22. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901496) float deployed by LOV in the North Western Mediterranean Sea.

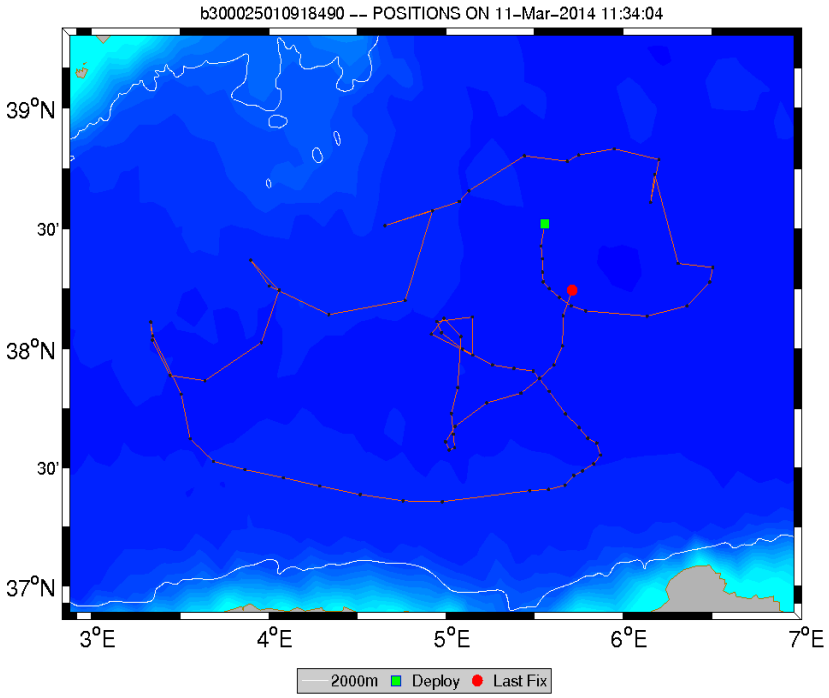


Figure 23. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901513) float deployed by LOV in the North Western Mediterranean Sea.

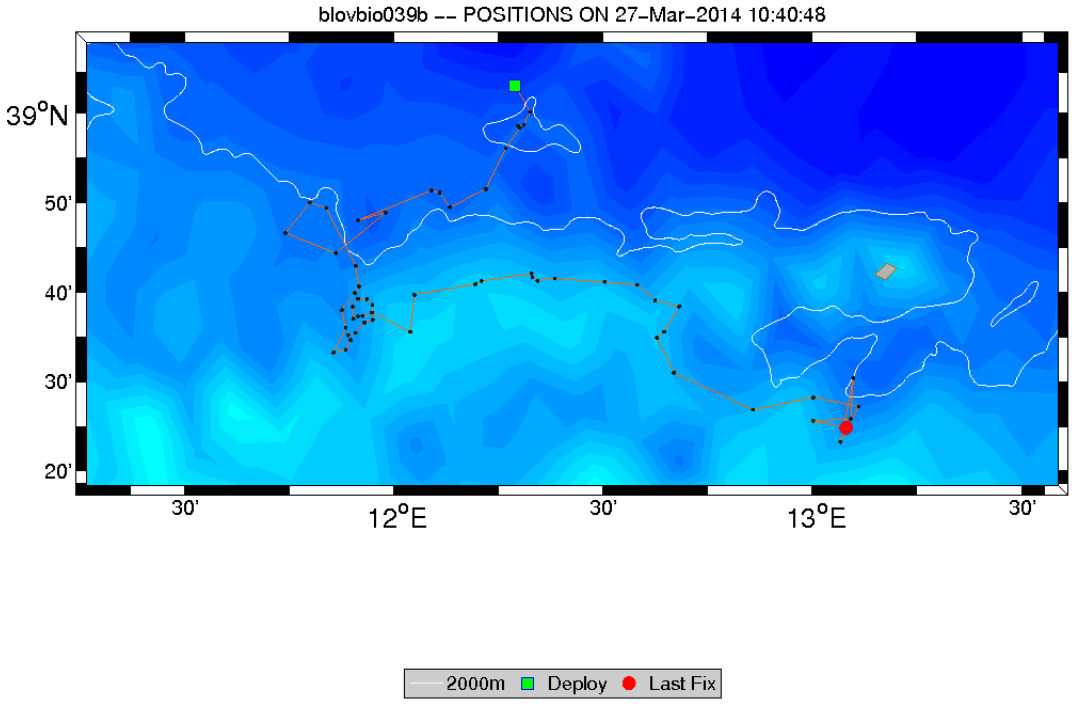


Figure 24. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901483) float deployed by LOV in the Thyrrenian Sea.

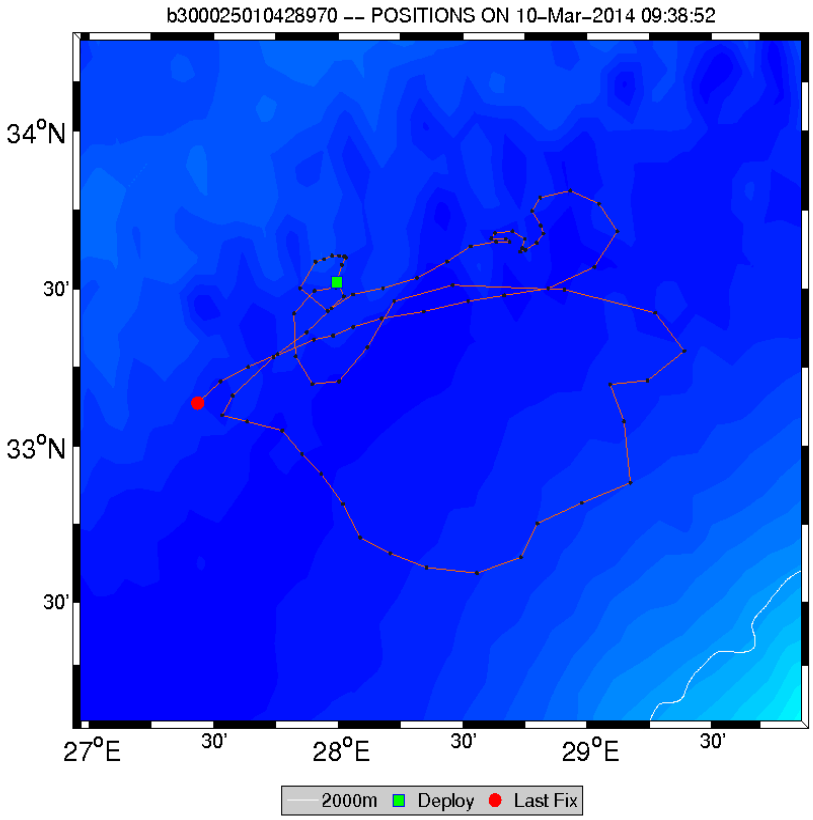


Figure 25. Trajectory and profile positions (black dots) of Provor-NUT (WMO 6901528) float deployed by LOV in the Eastern Mediterranean Sea

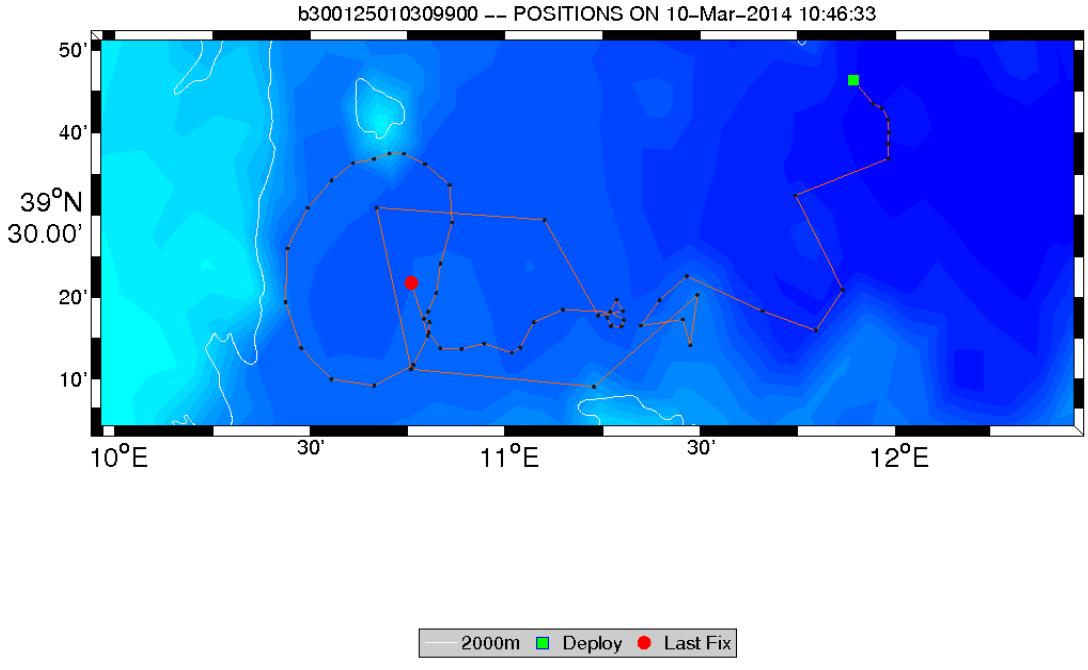


Figure 26. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901491) float deployed by LOV in the Thyrrenian Sea.

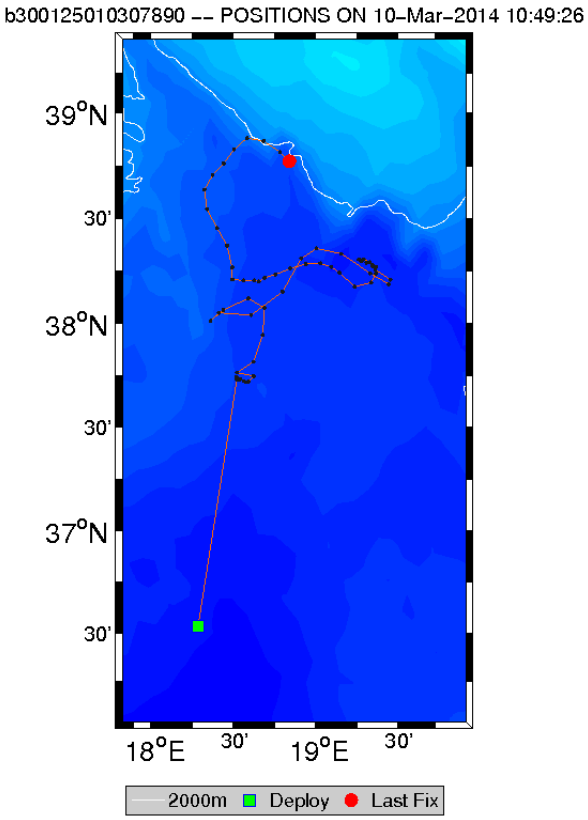


Figure 27. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901529) float deployed by LOV in the Ionian Sea.

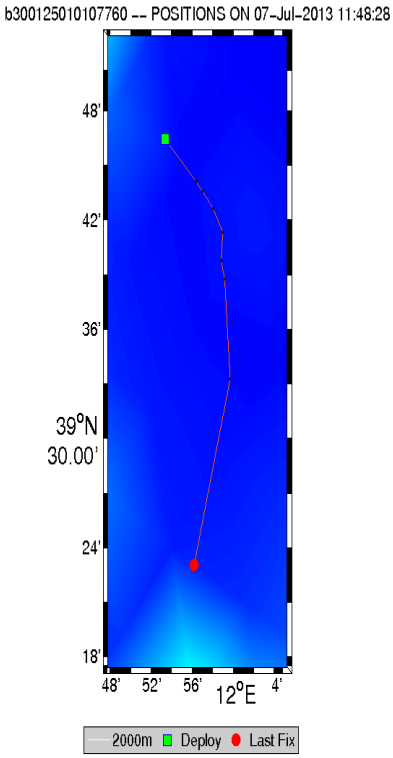


Figure 28. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901490) float deployed by LOV in the Thyrrenian Sea.

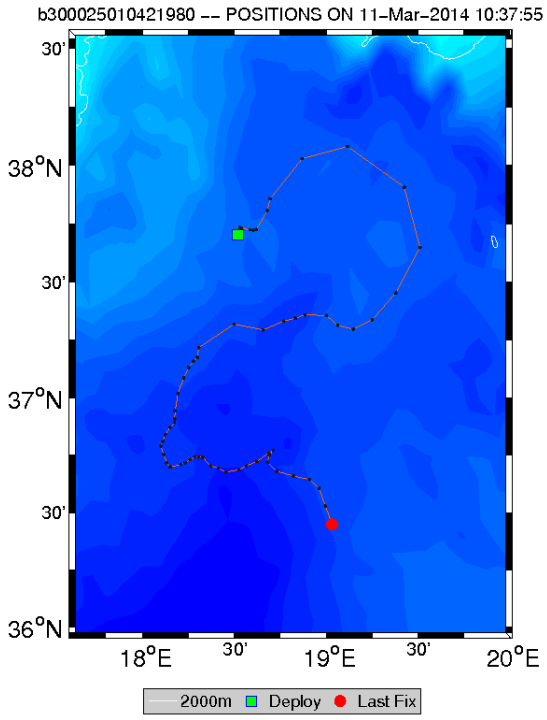


Figure 29. Trajectory and profile positions (black dots) of Provor-NUT (WMO 6901510) float deployed by LOV in the Ionian Sea.

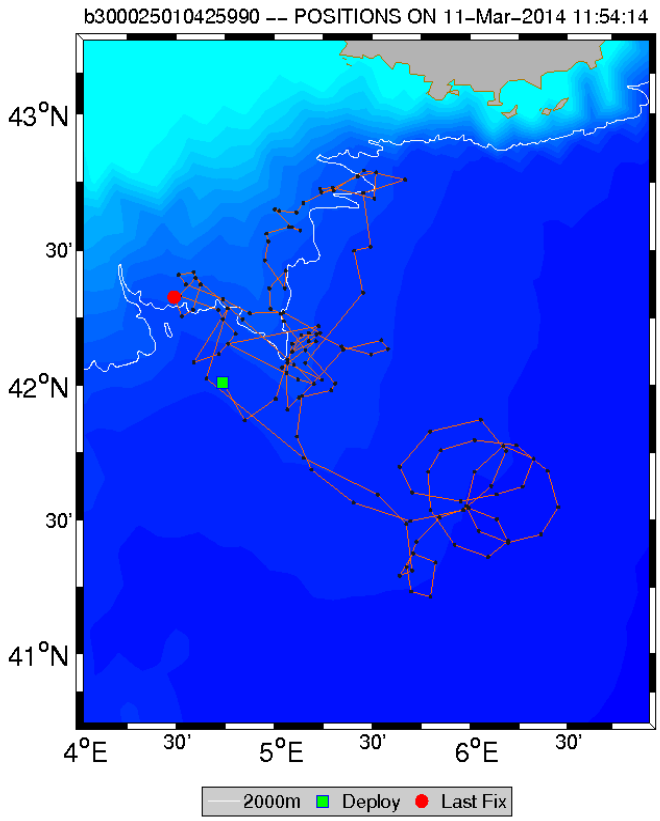


Figure 30. Trajectory and profile positions (black dots) of Provor-BIO (WMO 6901512) float deployed by LOV in the North Western Mediterranean.

WMO	TYPE	DEPLOY DATE	LAT	LON	LAST DATE	LAT	LON	STATUS
6901605	Provor BIO	11-Feb-2014 07:22	36.99	20.52	16-Jul-2014 07:10	36.55	22.37	D
6901496	Provor BIO	15-Jul-2013 00:00	43.37	7.9	13-Mar-2014 11:36	43.25	7.73	D
6901513	Provor BIO	09-May-2013 12:38	38.52	5.56	21-Jun-2015 11:39	39.89	6.26	A
6901483	Provor BIO	22-Jul-2013 00:00	39.05	12.29	27-Mar-2014 10:40	38.41	13.08	D
6901528	Provor NUT	16-May-2013 12:38	33.52	27.99	23-May-2015 09:50	32.35	31.4	D
6901491	Provor-BIO	16-Jun-2013 12:38	39.77	11.89	30-May-2015 10:55	39.19	10.84	D
6901529	Provor BIO	26-May-2013 12:56	36.53	18.29	10-Feb-2015 10:43	40.14	17.1	D
6901490	Provor-BIO	16-Jun-2013 12:47	39.77	11.89	07-Jul-2013 11:48	39.38	11.94	D
6901510	Provor NUT	26-May-2013 12:44	37.7	18.52	26-May-2015 10:37	36.7	20.12	D
6901512	Provor BIO	09-Apr-2013 12:28	42.01	4.74	04-May-2014 11:36	41.43	3.52	D

Table 6. Operating information for the floats deployed by IFREMER/CNRS.

1.2 The Argo network in the SES in 2015

Thanks to PERSEUS, the Argo fleet in the SES has been upgraded in terms of numbers of floats deployed (a total of 27) but also in terms of additional parameters been measured such as nitrate and hydrogen sulfide. The trajectories and last positions of all the PERSEUS-related floats are shown in Fig. 31. As of 24 July 2015, 11 floats were still active (green dots).

In late July 2015, there were 11 active PERSEUS floats, out of 101 floats, that is about 10% of the entire SES float network. Hence, PERSEUS had a significant impact to improve the Argo network in the SES.

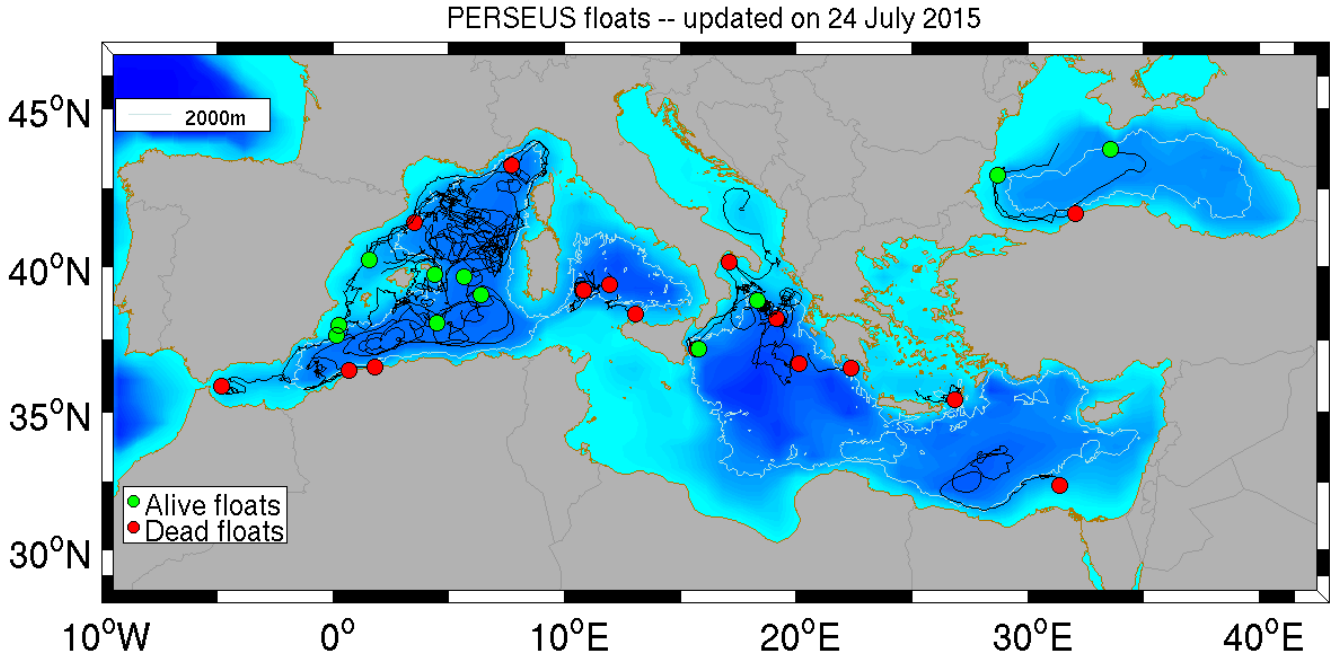


Figure 31. Trajectories and last profile positions (colored dots) of all the PERSEUS floats in the SES in late July 2015.

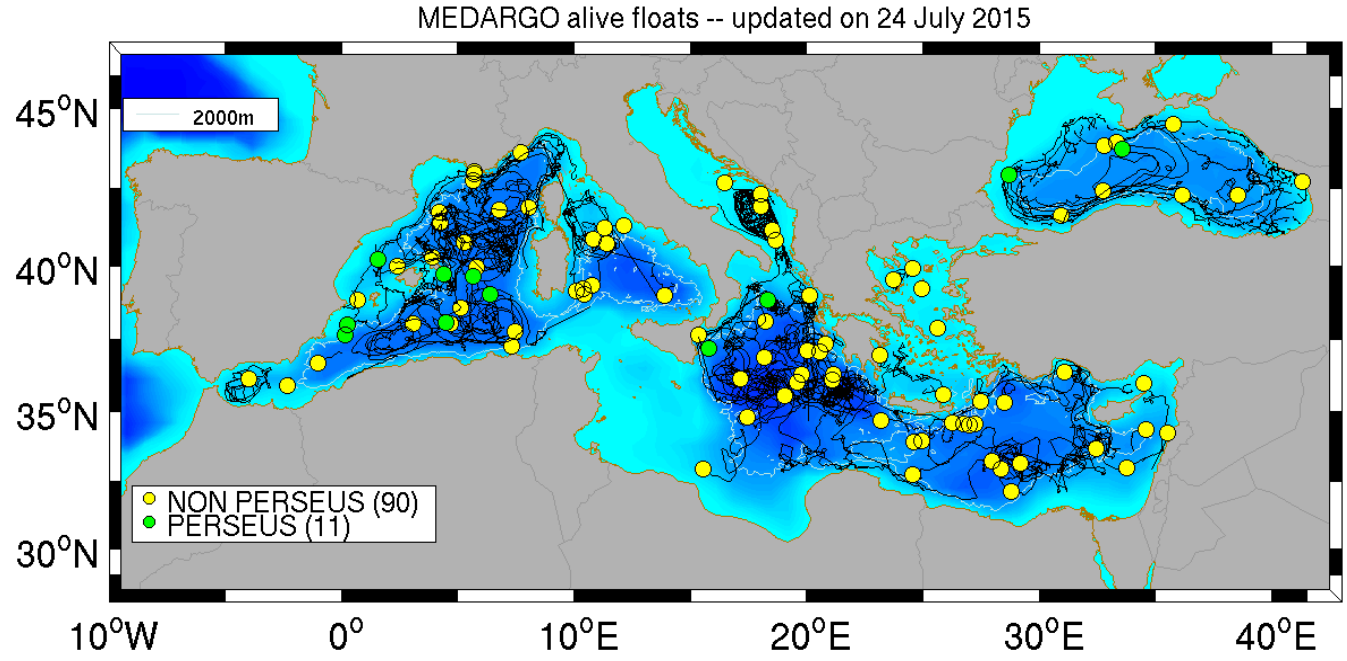


Figure 33. Trajectories and last profile positions (colored dots) of all the active PERSEUS (green dots) and non PERSEUS (yellow dots) floats in the SES in late July 2015.

During the PERSEUS project the following partners have not deployed any floats in the SES, although they were supposed to do so as written in the DOW: NE SIO-RAS (Russia), UHMI (Ukraine) and OC-UCY (Cyprus). Nevertheless, OC-UCY was of great help to deploy some Italian floats south of Cyprus. The funding dedicated to the Russian/Ukrainian float was transferred to IO-BAS in Bulgaria and was used to purchase a Provor-DO float which was successfully deployed in the Black Sea in June 2015 (see WMO 7900594 in section 1.1.1).

1.3 ARGO DATA ANALYSIS

All the Argo data in the SES are processed and analysed at the MedArgo, LOV and CORIOLIS centres.

MedArgo:

MedArgo is hosted by OGS in Trieste, Italy. MedArgo's main responsibility is the overall coordination of profiling float operations in the SES. As such, MedArgo serves as an Delayed Mode Operator (DMO) for the delayed-mode processing of the Argo data with specific quality control procedures tailored for the SES. In addition, MedArgo is a component of the North Atlantic Argo Regional Centre (ARC) and conducts the following activities:

1) the coordination of float deployments in the SES;

2) the preparation and distribution of SES Argo products and services;

3) the comparison of the SES Argo data with ancillary hydrographic data and model products.

The MedArgo web site address is: http://nettuno.ogs.trieste.it/sire/medargo

LOV:

The Laboratoire d'Océanographie de Villefranche-sur-mer (LOV) in France has taken the leadership to process the biogeochemical and optical data of the Argo floats. These data are processed in near-real time and can be visualised in dedicated web pages. The web address is: http://www.oao.obs-vlfr.fr

The LOV is also responsible for the delayed-mode quality control of some biological and optical parameters as part of other EU (Copernicus, AtlantOS) and national (NAOS) projects.

Some parameters such as the concentrations of nitrate and hydrogen sulfide are considered as "non operational variables" and their processing, calibration and validation are still in development phase.

CORIOLIS:

The Data Centre located at IFREMER in Brest, France is one of the Global Data Assembly Centre (GDAC) of Argo. CORIOLIS processes the Argo data in near-real time and makes them available freely through their web site. The web address is: http://www.argodatamgt.org

2. UPGRADE OF OTHER EXPANDABLE SYSTEMS IN THE SES

2.1 EXPANDABLE BATHYTHERMOGRAPH PROBES FROM SHIP-OF-OPPORTUNITY IN THE SES (2012-2015)

The Ship-of-Opportunity Programme (SOOP) makes use of volunteer merchant ships that routinely transit strategic shipping routes. Ship officers or dedicated technicians deploy XBTs at predetermined sampling intervals to acquire temperature profiles in the open ocean and marginal seas. In the SES, the collection of XBT data at seasonal scale in selected areas is maintained along specific transects based on existing facilities and with the support of other EU and national programs.

ENEA (Italy) has coordinated the collection of XBT data along three lines in the Western and Central Mediterranean Sea (see Fig. 32):

- MX01 between the Strait of Messina and the area south of the Peloponese;
- MX02 between Tangier, Barcelona and Genoa;
- MX04 between Palermo and Genoa.

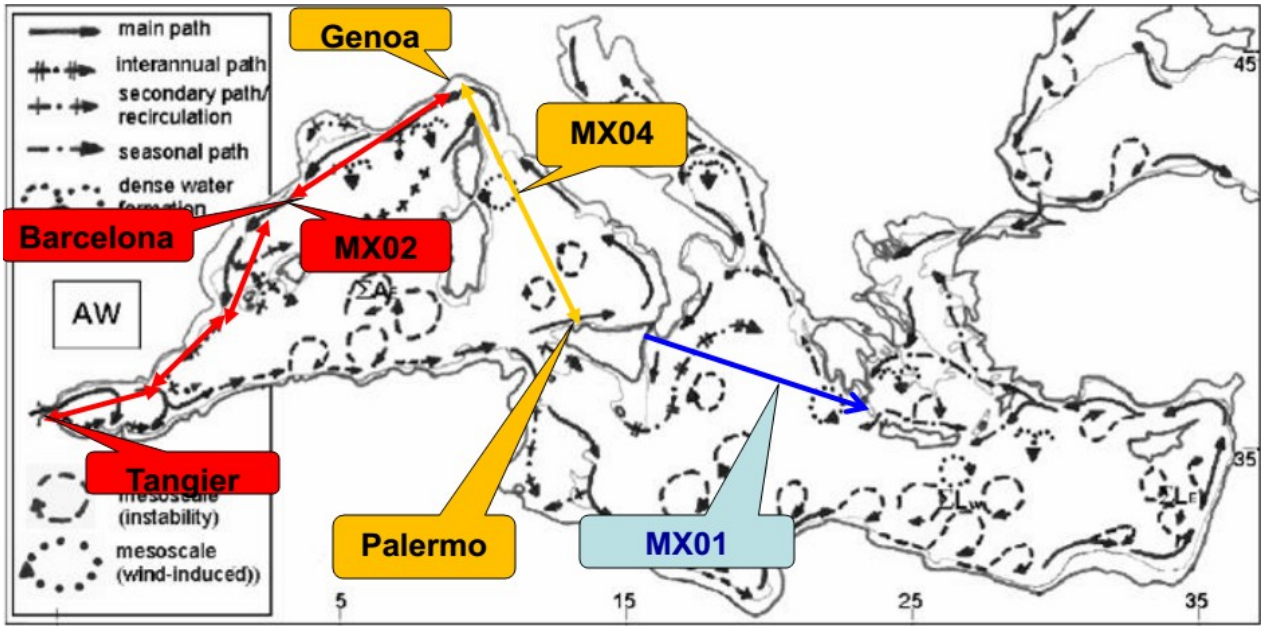


Figure 32. Lines along which XBT data were collected in the Western and Central Mediterranean Sea during the PERSEUS period (2012-2015).

During the PERSEUS period (2012-2015) a total of 31 campaigns were carried out. XBT data were obtained along the MX01 and MX02 transects at annual or semi-annual frequency in 2012-2014. More data were collected on the MX04 line with seasonal campaigns spanning the period March 2012 - March 2015. Details about the XBT data collected in the SES are listed in Table 7.

The XBT temperature profiles are illustrated for selected campaigns in Figs. 33-35 for the three transects.

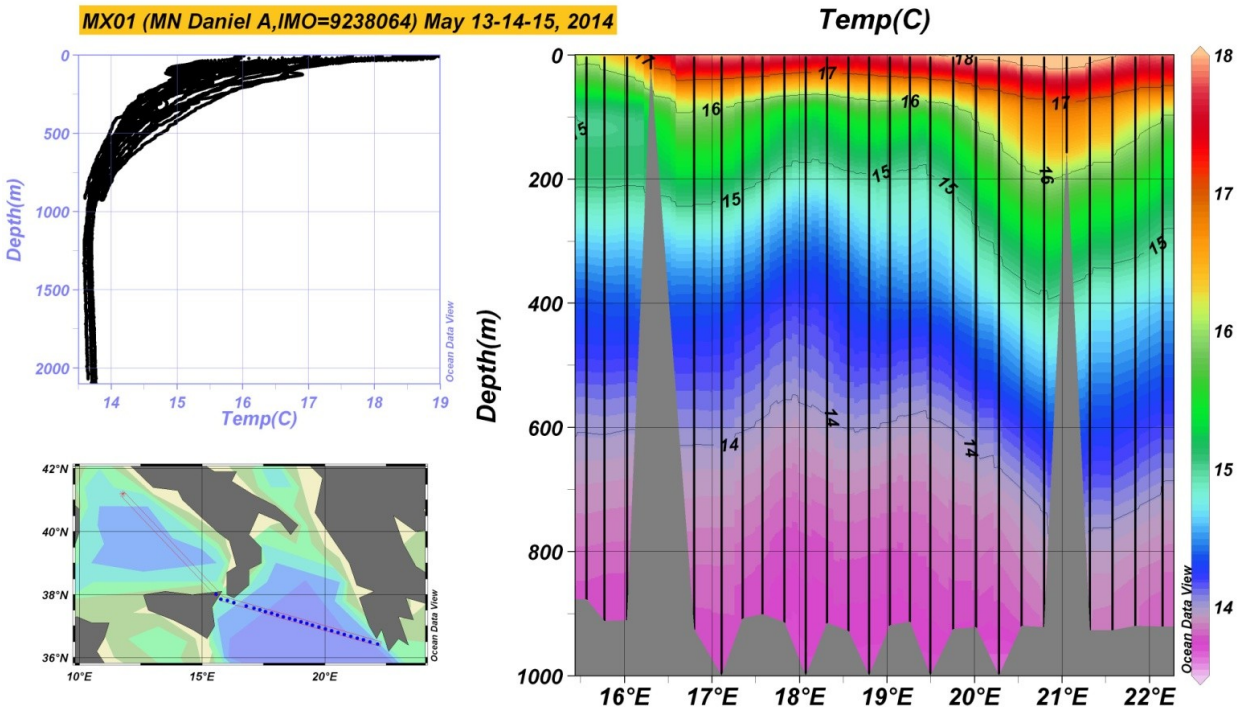


Figure 33. XBT data along MX01 on 13-15 March 2014: Temperature profiles and contour plots, positions of the XBT drops along the transect.

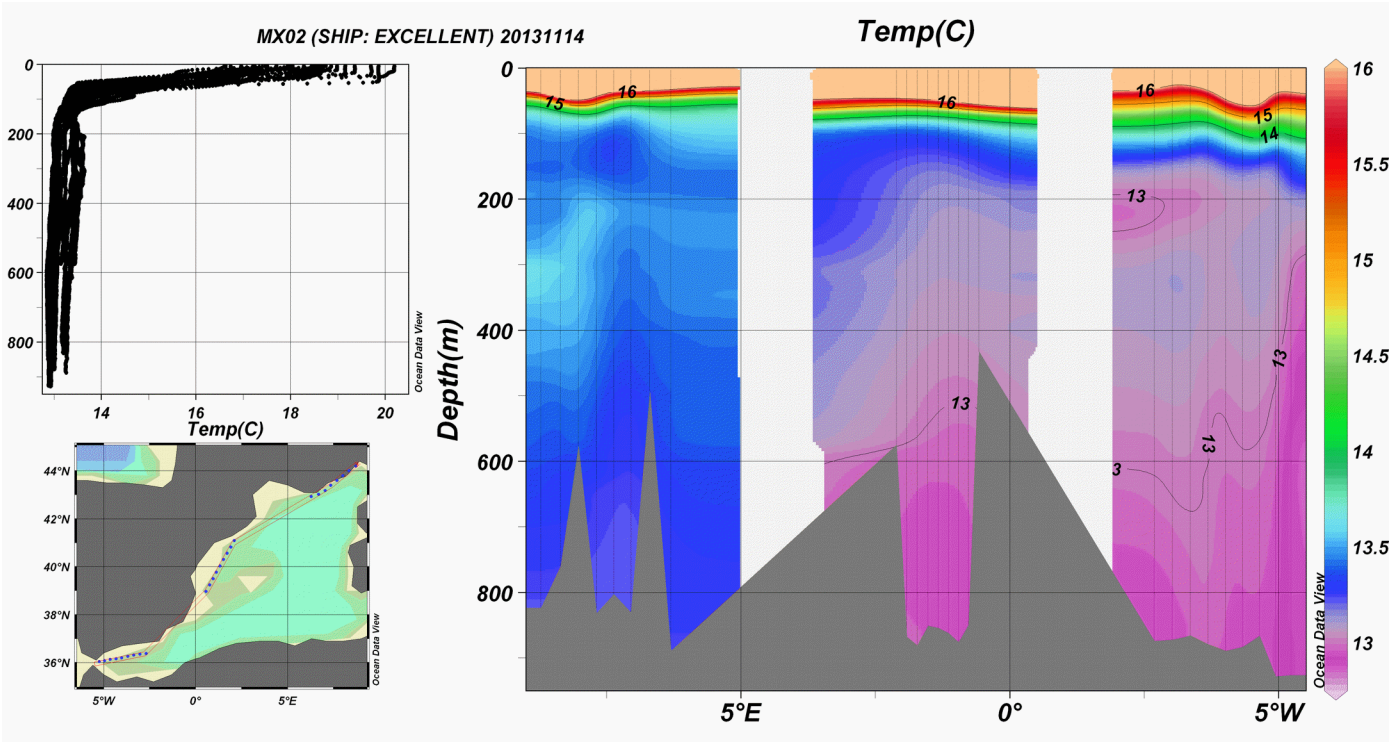


Figure 34. Same as in Fig. 33 but for XBT data along MX02 on 14 November 2013.

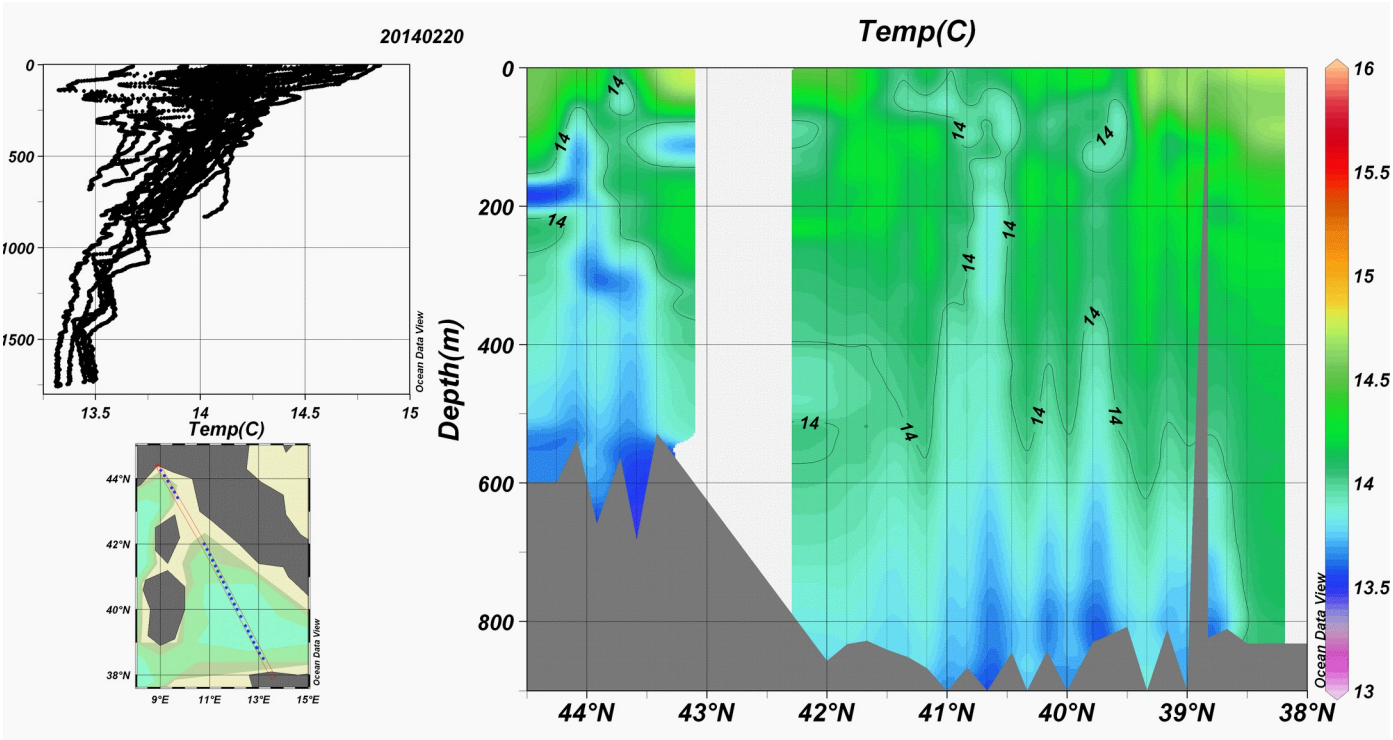


Figure 35. Same as in Fig. 33 but for XBT data along MX04 on 20 February 2014.

transect	STARTING date	XBT drops&type	Ship name	IMO number
MX01	2012.02.15	49 DB	Jolly Grigio	7616353
MX01	2013.03.09	26 DB&T5	Daniel A	9238064
MX01	2013.05.31	30 DB&T5	Daniel A	9238064
MX01	2013.09.27	26 DB&T5	Daniel A	9238064
MX01	2014.05.13	29 DB&T5	Daniel A	9238064
MX01	2014.08.05	25 DB,T5,XCTD1	Daniel A	9238064
MX01	2014.10.14	23 DB,T5,XCTD1	Daniel A	9238064
MX02	2012.05.31	36 DB	Excellent	9143441
MX02	2012.10.13	40 DB,T4	Excellent	9143441
MX02	2013.04.04	40 DB	Excellent	9143441
MX02	2013.11.14	26 DB	Excellent	9143441
MX02	2014.03.10	36 DB&T5	Excellent	9143441
MX04	2012.03.07	21 DB&T5	La Superba	9214276
MX04	2012.05.08	23 DB	La Superba	9214276
MX04	2012.07.22	18 DB&T4	Excelsior	9184419
MX04	2012.09.24	27 DB&T4	La Superba	9214276
MX04	2013.01.08	28 DB,T4,T5	La Superba	9214276
MX04	2013.03.19	30 DB,T4,T5	La Superba	9214276
MX04	2013.05.27	27 DB,T4,T5	La Superba	9214276
MX04	2013.09.20	30 DB,T4,T5	La Superba	9214276
MX04	2013.12.11	28 DB,T4,T5	La Superba	9214276
MX04	2014.02.20	29 DB,T4,T5	La Superba	9214276
MX04	2014.04.28	31 DB,T4,T5	La Superba	9214276
MX04	2014.06.04	28 DB,T4,T5	La Superba	9214276
MX04	2014.08.05	09 DB	Daniel A	9238064
MX04	2014.09.25	27 DB,T4,T5	La Superba	9214276
MX04	2014.10.13	10 DB	Daniel A	9238064
MX04	2014.12.18	30 DB,T4,T5,XCTD1	La Superba	9214276
MX04	2015.02.05	19 DB,T4,T5	La Superba	9214276
MX04	2015.03.10	30 DB,T4,T5,XCTD1	La Superba	9214276
MX04	2015.05.05	31 DB,T4,T5,XCTD1	La Superba	9214276

Table 7. Information about the XBT data collected during the SES period in the Western and Central Mediterranean Sea.

2.2 NEW MEASUREMENTS OF LIDAR FLUORESCENCE

The Lidar Fluorosensor is a radar laser based on laser induced fluorescence. The measurement is carried out continuously with high spatial and temporal resolution on a research vessels or ships-of-opportunity. The Lidar Fluorosensor relies on the observation of the Raman backscattering of water (at 404 nm) and the fluorescence of CHL (at 680 nm), both induced by a laser pulse (at 355 nm): the absolute concentration of that pigment is directly proportional to the fluorescence-to-Raman ratio (also known as concentration released in Raman units). Similar considerations apply for CDOM or other phytoplancton pigments.

Lidar measurements in the Mediterranean Sea started in 2010 during the TYR01 cruise in the Tyrrhenian Sea. During this cruise a first version of the Lidar prototype was used. In this case the excitation wavelength was 355 nm and data were recorded at 405, 450, 580, 630 and 680 nm.

The first PERSEUS Lidar experiment was conducted in April 2013 during the BIOOPT cruise in the Tyrrhenian and Ligurian seas. This experiment was mainly devoted to the determination of the optical properties of coastal, offshore and transitional surface waters in view of the adaptation of ocean colour algorithm for CHL determination in case I and II waters. Lidar measurements contributed to the calibration exercise extending point-wise measurements (at ship stations) to the entire ship course. Fig. 36 shows the calibration line of the Lidar during the cruise compared to the SeaTech fluorometer data, while Fig. 37 shows the variation of CHL and CDOM along the ship track during the whole BIOOPT 2013 cruise.

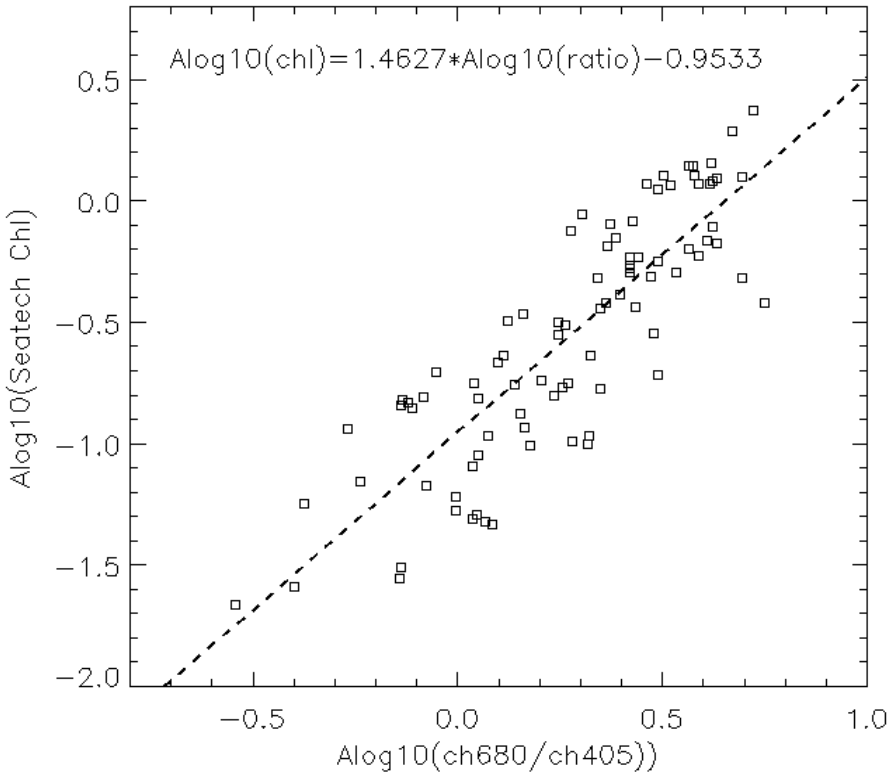


Figure 36. Calibration of the Lidar measurements during BIOOPT 2013 (April 2013).

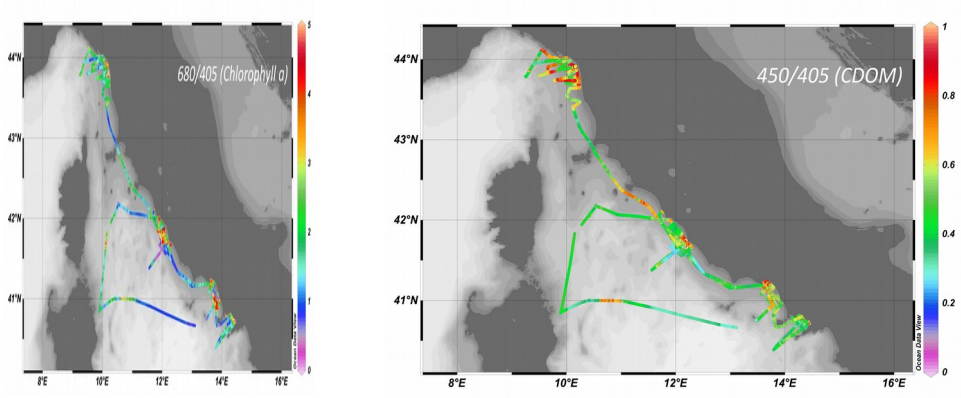


Figure 37. CHL and CDOM measurements during BIOOPT 2013 (April 2013).

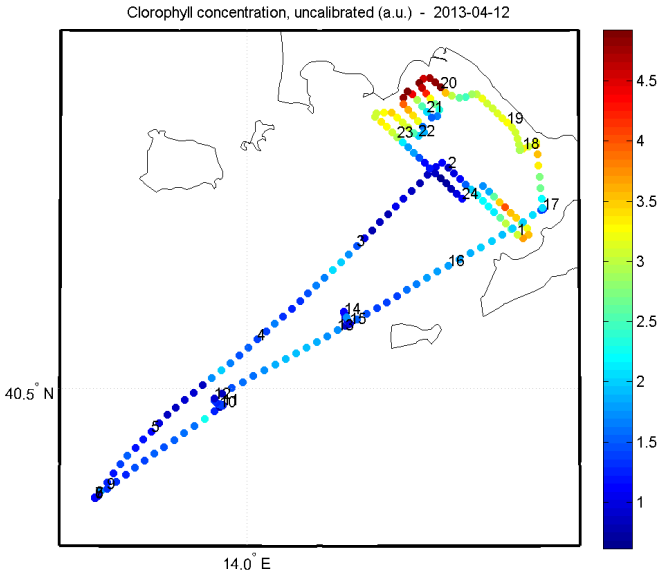


Figure 38. Zoom of the Lidar measurement in the Gulf of Naples on 12 April 2013.

The last version of the ENEA Lidar Fluorosensor was tested in April 2015 during the COSIMO cruise in the Adriatic Sea. In this case the instrument relies on the observation of the Raman backscattering of the water at 404 nm and the fluorescence at 450, 580, 650 and 680 nm, all induced by a laser pulse at 355 nm. Additional wavelengths will be included in the near future. In the new system the optics of detection (dichroic mirrors and interference filters) have been improved, and a new laser source (high peak power) has been implemented to allow measurement in strong solar conditions.

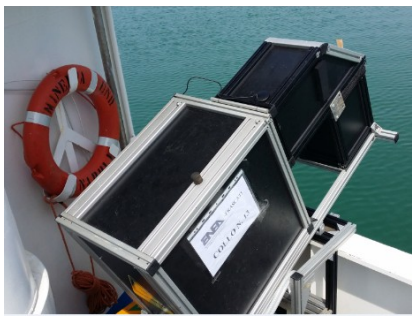
April 2015: the Lidar on board of Minerva UNO	CHL (680/404)	CDOM (450/404)
		

Figure 39. The ENEA Lidar Fluorosensor on board the Minerva Uno R/V (left panel), CHL and CDOM in Raman Units (central and left panels, respectively).

The Lidar measurements acquired during the COSIMO 2015 experiment are still preliminary and need further processing, including sensor temperature correction and calibration of Raman units data (ration between signals detected and Raman at 404 nm) using HPLC determination for CHL and samples for CDOM absorption analysis.

3. CONCLUSIONS

The activities planned in subtask 3.2.2 of PERSEUS have allowed to upgrade and improve significantly the observing capacity of the SES by means of Argo profiling floats and measurements on ship-of-opportunity. Improvements were twofold: the expansion of geographical coverage and the addition of biogeochemical sensors to measure parameters associated to the MSFD descriptors for Good Environment Status. It is hoped that these improvements will be sustained beyond the PERSEUS project as part of an integrated SES observing system.

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