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High-Resolution Observations in the Western Mediterranean Sea: The REP14-MED Experiment

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Abstract. The observational part of the REP14-MED experiment was conducted in June 2014 in the Sardo-Balearic Sea west of Sardinia Island (Western Mediterranean Sea). Two research vessels collected high-resolution oceanographic data by means of hydrographic casts, towed systems, and underway measurements. In addition, a vast amount of data was provided by a fleet of 11 gliders, time series were available from moored instruments, and information on Lagrangian flow patterns were obtained from surface drifters and one profiling float. The spatial resolution of the observations encompasses a spectrum over four orders of magnitude from $\mathcal{O}(10^1\text{ m})$ to $\mathcal{O}(10^5\text{ m})$, and the time series from the moored instruments cover a spectral range of five orders from $\mathcal{O}(10^1\text{ s})$ to $\mathcal{O}(10^6\text{ s})$. The objective of this article is to provide an overview of the huge data set which is utilized by various ongoing studies, focusing on (i) sub-mesoscale and mesoscale pattern analyses, (ii) operational forecasting in terms of the development and assessment of sampling strategies, assimilation methods, and model validation, (iii) modeling the variability of the ocean, and (iv) testing of new payloads for gliders.

1 Introduction

The REP14-MED experiment was conducted in the framework of the *Environmental Knowledge and Operational Effectiveness* research program of CMRE. REP14-MED was part of a series of experiments denoted by the acronym REP (*Recognized Environmental Picture*). The suffix 'MED' stands for *Mediterranean*, in order to distinguish these experiments from another REP series conducted by the Portuguese Navy. Usually, those experiments take place in the Atlantic and are attributed by the suffix "Atlantic". REP14-MED was led by CMRE, and the experiment was supported by 20 partners from six different

NATO nations (Table 1). The activities at sea were conducted in June 2014 by the NATO Research Vessel *Alliance* and the Research Vessel *Planet* of the German Federal Ministry of Defence (Fig. 1), and comprised both oceanographic and acoustic observations. This article, however, describes only the oceanographic measurements which are the basis of several research papers to be published in this Special Issue of *Ocean Science*. In addition, standard names are introduced which may be referred to by other papers related to REP14-MED, e.g. for sections, tracks, and moorings. The objectives of the oceanographic surveys were to

- Collect data for operational ocean forecasting, model validation, and the evaluation of forecast skill;
- Provide a data set for the development and comparison of different methods for data assimilation;
- Find the best sampling strategy for ocean forecasting;
- Utilize data from a fleet of gliders for a cost/benefit analysis;
- Conduct a generic experiment for the exploration of the variability of the ocean;
- Analyse mesoscale and sub-mesoscale features;
- Test new payloads for gliders.

The selection of the experimental site was driven by the requirements of the acoustic experiments and the objectives defined above: the acoustic experiments required a wide shelf area, and the operations of the glider fleet should take place in an area with little ship traffic and without strong boundary currents. Therefore, the waters off the west coast of Sardinia (Western Mediterranean) were selected (Fig. 2). From a morphological point of view, this area is characterized by a wide continental shelf area, the width of which varies between about 40 km and 80 km. The shelf ends at water depths between 150 m and 200 m, followed by the continental slope which features several canyons. The deep-sea area belongs to the Sardo-Balearic Basin and exhibits water depths of up to 2800 m. The surface circulation is mainly related to the inflow of Atlantic Water from the south by means of the Algerian Current (Ribotti et al., 2004), and it is known to be impacted by the transit and formation of anticyclonic eddies of different origins (Ribotti et al., 2004; Testor and Gascard, 2005). Ribotti et al. (2004) found a significant mesoscale activity generated by anticyclones originating from the Algerian Current. The Provençal Basin to the north is mainly characterized by a surface intensified cyclonic gyre which contributes to the formation of the North Balearic Front (Testor and Gascard, 2003). This front represents the separation between the Atlantic Water and the saltier and denser waters of the Provençal Basin; according to Millot (1999), Fuda et al. (2000), and Olita et al. (2013), it is located between about 40° N and 41° N.

The activities of both vessels took place within the red box indicated in Fig. 2 which is the so-called *observational domain*. In the west, it is bounded by the 7° 15′ E meridian, and in the east by the Sardinian coast. The southern and northern boundaries are at 39° 12′ N and 40° 12′ N, and the area size is approximately 60 nmi (nautical miles) x 60 nmi or 111 km x 111 km, respectively.

2 Measuring systems

Shipborne systems

Both *Alliance* and *Planet* are survey ships equipped with the standard oceanographic measuring systems. Only those systems which were used for the oceanographic experiments will be described (for more details, see Onken et al. (2014)). On *Alliance*, there were

- 2× *SBE* CTD (*Conductivity-Temperature-Depth*) probes with Rosette sampler (for more details, see http://www.seabird.com)
- 1× *SBE* CTD probe with Rosette sampler and optical sensors
- 1× *SATLANTIC* HyperPro optical profiler (http://satlantic.com)
- 2× towed ScanFish with dual CTD (http://www.eiva.com)
- 2× *RDI* ADCPs (*Acoustic Doppler Current Profiler*, http://www.rdinstruments.com), 300 kHz and 75 kHz
- 1× thermosalinograph (http://www.seabird.com)
- ship meteorological sensor systems

and on *Planet*

- 2× *SBE* CTD probe with Rosette sampler
- 1× *OceanScience* underway CTD probe (*uCTD*, http://www.oceanscience.com)
- 1× towed CTD chain with 91 sensors 3.5 m apart (Sellschopp, 1997)
- 1× ADCP, 150 kHz
- ship meteorological sensor systems

Gliders

16 gliders from different manufacturers were provided for launch during the experiment, of which 11 were used for the tasks described in this article. Another three were utilized for the acoustic experiments, and the remaining two served as backup:

- 9× *Slocum* (CMRE, http://www.webbresearch.com)
- 1× *Slocum* (PSU)
- 1× *Slocum* (WTD71)
- 3× *Seaglider* (UEA, http://www.km.kongsberg.com)
- 2× *SeaExplorer* (ACSA, http://www.acsa-alcen.com)

For further details and the technical specifications, see Table 2.

Surface drifters and profiling floats

In total, 17 surface drifters and 2 profiling floats were available:

- 9× *Albatros* (http://www.albatrosmt.com) MD03i surface drifters (CMRE)
- 3× *Albatros* ODi-Solar surface drifters (CMRE)
- 5× SVP (Lumpkin, 2005) surface drifters (OGS)
- 2× ARVOR-I profiling floats (OGS, http://www.euro-argo.eu/Activities/Floats-Developments-Deployments/Existing-Floats).

Moored instruments

Finally, CMRE provided in total six moorings, named W1, M1, M2, M3, M4, M5:

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- W1 is a *Datawell* Waverider buoy (http://www.datawell.nl)
- M1 consisted of the central mooring M1$_{CTR}$ and a sideways extending appendix M1$_{APP}$ floating at the sea surface (Fig. 3). M1$_{CTR}$ was equipped with an upward-looking 300-kHz ADCP mounted at a nominal depth of 100 m below the sea surface, a CTD probe at 1 m depth, and with a meteorological buoy at the surface (Table 3). M1$_{APP}$ was connected by a 50 m long rope to M1$_{CTR}$ and extended to about 40 m depth in the vertical direction. 41 Starmon mini temperature recorders (http://www.star-oddi.com) were densely spaced along the vertical cable in order to record temperature with high vertical resolution. In addition, four RBR data loggers (https://rbr-global.com) were mounted on the cable for determining the actual depth of the Starmons.
- M2, M3, M4, and M5 were "traditional" oceanographic sub-surface moorings equipped with CTD probes and current meters. A diagram of the general design of such a mooring, in this case M3, is displayed in Fig. 4, and the vertical arrangement of measuring devices for all moorings (M1, M2, M3, M4, M5) is shown in Table 3.

3 Schedule

The experiments at sea were separated into three legs (Table 4). Leg 1 started on 6 June with the departure of *Alliance* and *Planet* from La Spezia and Toulon, respectively (see Fig. 2), and was solely dedicated to oceanography. Both vessels conducted a so-called CTD *initialisation survey* which covered the entire observational domain at 10 km horizontal resolution. In addition, 11 gliders, six moorings, 17 surface drifters, and one sub-surface float were deployed by *Alliance*. Leg 1 was finished at 00:00 UTC (*Universal Coordinated Time*) on 12 June and *Alliance* called port in Porto Torres for the exchange of personnel.

During Leg 2 (12–20 June), all activities on *Alliance* were related to acoustic experiments which will not be discussed in this article. However during this period of time, some limited data sets from short-term glider missions (not included in Table 4), CTD casts, and underway measurements are available for oceanographic analyses. At the same time, *Planet* continued with casts by lowered CTD (lCTD) and uCTD and measurements by the CTD chain.

After a short port call in Oristano, Italy (*Alliance*, only), for another exchange of personnel, both vessels had a rendezvouz for the inter-calibration of their CTD probes on 21 June. Afterwards, so-called *validation surveys* were conducted for about 40 h until 23 June, using the ScanFish (*Alliance*) and the CTD chain (*Planet*) simultaneously on parallel tracks. Thereafter, *Planet* finished her field work and headed towards Palma de Mallorca. *Alliance* remained another day in the area for the recovery of all gliders and moorings, concluding the experiment on 25 June in La Spezia.

4 Observations

CTD casts

In total, 315 CTD casts were taken by both vessels (Fig. 5). Additionally, 23 CTD profiles down to 350 m were recorded by *Planet* for the calibration of the CTD chain. The scheduled vertical extent of all casts was 1000 dbar or bottom depth (whatever was shallower) but a few casts especially at the western boundary of the obserational domain reached greater depths in order to characterise the deep water masses. Casts taken during the deployment and recovery of moorings always reached the bottom, whereas those taken during the deployment and recovery of gliders were limited to 1000 dbar as the gliders could not measure deeper than this.

For the calibration of the CTD probes, water samples were taken with the Rosette on *Planet* on 57 stations during Leg 1 and on the inter-calibration station on 21 June. On the same station, samples were taken by *Alliance* as well, while no samples were taken on any other station. This was not considered necessary because the CTD probes were equipped with a double line of sensors for temperature and salinity.

A comparison of the casts taken during Leg 1 revealed slight differences of 0.001 S m^{-1} between the conductivities measured on both vessels, where the conductivity recorded by *Alliance* is the lower value. This leads to differences of salinity and potential density of 0.010 and 0.008 kg m^{-3}, respectively. Although this shift is fairly small it is above the expected level of accuracy. Hereupon, Knoll et al. (2015b) investigated this issue in greater detail but it could not be clarified which sensor caused the observed shift. Therefore, the authors recommended to add 0.001 S m^{-1} to all CTD profiles recorded by *Alliance*, or to subtract the same value from the conductivities measured by *Planet* . The result of this procedure is illustrated in Fig. 6. Here are shown maps of potential density at 990 m depth before and after the applied correction.

Glider missions

11 gliders were deployed on 8 and 9 June in two batches es of six and five respectively, at the positions marked by the green circles in Fig. 7a, and afterwards were directed to their nominal tracks G01, . . . , G10. The distribution of the gliders on their assigned tracks was arranged in a way that at least every other track was occupied by a "deep" glider (pressure rating >650 dbar). Track G08 was occupied by two gliders (*Dora* and *Minke*) because *Dora* was a brand new glider equipped with a propeller drive and its performance should be compared with that of a conventional glider. All gliders except for *Clyde* and *Fin*, accomplished their tasks satisfactorily until recovery on 23 June (Fig. 7b) while commuting up to five times between the eastern and western end of their tracks. *Clyde* had to be recovered earlier than planned on 12 June because of a hardware malfunction and was never redeployed, and *Fin* had to be recovered on 10 June because of a software problem. However, *Fin* was redeployed successfully the following day. After recovery, no apparent biofouling was observed on any glider.

CTD chain and ScanFish

The CTD chain towed by *Planet* came into operation twice, 12–14 June (Fig. 8a), and 21–23 June in sync with the ScanFish towed by *Alliance* as shown in Fig. 8b. The meridional distance between the zonal tracks in Fig. 8b is 10 km, and the zonal tracks are aligned with the zonal CTD sections (Fig. 5).

Optical stations

Optical measurements were carried out daily around local noon on 7–11 June. Each station consisted of an ensemble of vertical profiles with the free-falling HyperPro and one cast down to about 150 m depth using the CTD probe equipped with optical sensors. For the position of the casts, see Fig. 9. Additional optical data are available from some gliders equipped with optical sensors and from the ScanFish.

Drifters and floats

During transit from La Spezia to the survey area, one ARVOR-I float was launched on 6 June near the eastern mouth of the Bonifacio Strait in the Tyrrhenian Sea in support of the Argo programme and without any direct relevance to REP14-MED. A further 17 surface drifters and one more ARVOR-I float were deployed 8–11 June in the observational domain. The deployment positions are shown in Fig. 9.

Moorings

Six moorings were deployed 8–11 June at the positions shown in Fig. 9. W1 and M1 were recovered on 20 June, and M2, M3, M4, M5 on 23 June.

Underway measurements

On *Alliance*, temperature and salinity at 2.5 m depth were recorded continuously by a thermosalinograph during the entire survey. At the same time, the 75-kHz ADCP acquired the three-dimensional velocity field under the vessel down to a depth of 653 m with a vertical resolution of 16 m. Usable data of the vessel-mounted 150-kHz ADCP on *Planet* were obtained 10–23 June only at depths below 80 m. The profiling depth varied between about 180 m during daylight and 280 m during the night (Knoll et al., 2015a). For the tracks of the vessels see Fig. 10.

Continuous shipborne observations of meteorological parameters were recorded on both vessels. On *Alliance*, records of wind speed, wind direction, air temperature, air pressure, relative humidity, and wind gusts were made at three locations on the foredeck (starboard and port) and at the stern, whilst on *Planet*, wind speed and direction at different positions on the vessel, relative humidity, air temperature, air pressure, visibility, altitude of clouds, and rain were recorded with sensors at nine different locations within a height of 10–26 m. The seawater temperature was measured at 6 m depth. Additional records of various meteorological parameters are available from the meteorological buoy on top of mooring M1.

Statistics of the observations

Table 5 provides a statistics of most of the observations.

5 Complementary data

Weather and wave prediction models

For the entire experiment, weather analyses and forecasts of the COSMO (*Consortium for Small-Scale Modeling*) atmospheric model were made available by the Italian Weather Service *Centro Nazionale di Meteorologia e Climatologia Aeronautica* (CNMCA) in two different setups, COSMO-ME and COSMO-IT. COSMO-ME covers the entire Mediterranean Sea with a horizontal resolution of 7 km and provided 72-h forecasts. COSMO-IT encompasses Italy and the adjacent waters at a high

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resolution of 2.2 km but the forecast range was only 24 h. In addition, CNMCA also provided forecasts of the NETTUNO wave model for the entire Mediterranean.

Ocean circulation models

In order to assess the environmental conditions in the survey area and to support the efforts of the REP14-MED modeling community, the outputs of five ocean circulation models were downloaded routinely from the respective servers. Products of the *Mediterranean Forecasting System* (MFS) and the MERCATOR global model were provided via CMEMS (*COPERNICUS Marine Environment Monitoring Service*), WMED – a high-resolution model of the waters around Sardinia – was obtained from IAMC, WMOP (*Western Mediterranean Operational Forecasting System*) was produced by SOCIB, and finally the Extended Range Prediction System was provided by NRL.

Remote sensing

Derived sea surface temperature was collected during the experiment by the CMRE *TeraScan* satellite system from the polar orbiting satellites POES and METOP.

Historical data

Historical data include temperature and salinity profiles extracted from the *World Ocean Database 2013* (Boyer et al., 2013) in a wider area surrounding the REP14-MED observational domain, and four CTD cruises conducted by IAMC 2001–2003 (Ribotti et al., 2004).

6 Discussion

This article describes the oceanographic surveys of the REP14-MED experiment. The description is restricted to the geographic and oceanographic settings of the survey area, the schedule, the employed measuring systems, the timing and the positioning of all observations, and the availability of complementary data. No observations are shown; this is to avoid the anticipation of potential results of forthcoming publications.

The surveys undertaken at sea provided a huge dataset, the properties of which satisfies all requirements to tackle the tasks as specified in the objectives:

- The CTD initialization survey (Fig. 5) was carried out on a regular 10 km × 10 km grid and thus resolved the internal Rossby radius of deformation which is 10–14 km in the Mediterranean Sea (Robinson et al., 2001). Hence, it is well suited for any task related to ocean forecasting, data assimilation, and feature analyses, as long as it is restricted to mesoscale and larger-scale processes. However, if CTD measurements of both vessels are combined for deep-water studies, the observed systematic difference of about 0.010 in salinity between the CTD probes of *Alliance* and *Planet* must be taken into account (Knoll et al., 2015b).

- The nominal tracks of the gliders (Fig. 7a) were arranged halfway between the zonal CTD sections of the initialization survey (Fig. 5). This improved the meridional resolution by a factor 2. The "wavelength" of the sawtooth-like glider path is between $\mathcal{O}(100\,\text{m})$ and $\mathcal{O}(1\,\text{km})$ depending on the water depth. Hence, the along-path resolution is on the same order of magnitude as that of sub-mesoscale features. The records of an individual glider also allow analyses of the temporal variability along its path as the same path is repeatedly sampled during the experiment. However, the spectral cut-off period of the variability lies between $\mathcal{O}$(days) in the central parts of the track and is close to zero at the return points. Moreover, the alternating occupation of the tracks by deep and shallow gliders enabled model studies which assess the dynamical impact of the sub-thermocline flow on the overall circulation pattern. For instance, the data of all available gliders may be assimilated in a control run, while in another run the glider data below approximately 200 m depth are ignored. The huge amount of glider data also advances assimilation experiments aimed to test the efficiency of different sampling patterns (Oke et al., 2015) in terms of sub-sampling or "super observations" (Lorenc, 1981).
- The intention of the the ScanFish surveys (Fig. 8) was to provide a quasi-synoptic validation data set for model forecasts. Synopticity is almost satisfied because the duration of the entire survey was a little less than 60 h. As the wavelength of the undulating device is around one kilometre (in deep water), the data are also suitable to validate the forecasts of high-resolution numerical models with a comparable grid size. Depending on the tow speed, the vertical extent of the measurements comprise the depth range between the surface and about 250 m depth. This enables studies on the circulation of the surface and intermediate waters.
- The duration of the CTD chain surveys (Fig. 8) during Legs 2 and 3 was about 51 h and 41 h, respectively. Hence, the time frames may also be considered quasi-synoptic. The Leg 3 survey was carried out synchronously with the ScanFish. Therefore, as the meridional distance between the ScanFish tracks and the tracks of the CTD chain was 20 km in each case, the combined data sets provide a meridional resolution of 10 km. Informative comparisons between the towed systems may be deduced from tracks P01b, ..., P03b (CTD chain) and from the aligned ScanFish tracks A01, ..., A03 (cf. Fig. 8b). While tracks no. 1 and 2 were carried out in "follow mode" where *Planet* was in the lead and *Alliance* was in pursuit at a distance of 1 nmi, the mode was switched to "parallel mode" during track 3 where *Alliance* was 1 nmi north of *Planet*. The maximum vertical extent of the CTD chain measurements depended on the towing speed and was usually about 190 m during Leg 2 and 140 m during Leg 3, i.e. somewhat less than the ScanFish. However, this potential deficit is compensated by the extremely high temporal resolution of 3 s and, therefore, depending on the towing speed of 4–5 kn, a horizontal resolution of less than 10 m allowed very detailed studies of sub-mesoscale features.
- The sub-surface moorings M2, M3, M4, and M5 were equipped with CT probes and current meters (partly upward looking ADCPs) at standard depths. Hence, time series of scalar parameters and velocities are available for the upper ocean, the diurnal and seasonal thermocline, and for the levels of the intermediate and deep water masses. They may be used for model validation and would allow a deeper insight into the meridional exchange of water masses across the 40° N latitude circle.
- The special design of the M1 mooring was intended to provide detailed information on the variability of the upper ocean: the temperature between the surface and 40 m depth was recorded with high vertical resolution for about 12

days, an upward-looking ADCP was mounted at 100 m depth, and various atmospheric parameters were recorded by a meteorological buoy on top of the mooring. Therefore, M1 – together with the waverider W1 – was an ideal test case for the development and validation of models focusing on the temporal variability. Moreover, the recordings of the meteorological buoy in conjunction with the observations on the survey vessels, may serve as a ground truth for the analyses and forecasts of atmospheric prediction models.

- The surface drifters and the float (Fig. 9) together with the underway measurements (Fig. 10) by thermosalinograph and ADCP, provide additional information on the general circulation in the survey area, and the data could serve to validate forecast models.
- The measurements on the optical stations together with optical data from the gliders and the ScanFish, contributed to an international project, the objective of which is to extend information from satellite remote sensing from the surface to the sub-surface.

Altogether, the surveys undertaken at sea provided an extremely rich dataset that can be used for multiple studies on different topics. The major advantage of the data set is its consistency, which was not affected by the handful of glitches experienced:

- Glider *Clyde* failed completely after 12 June. However, *Clyde* was fortunately positioned on track G01 and the malfunction did not impact the regularity of the entire glider track pattern.
- Glider *Fin* dropped out for about one day.
- On 23 June, *Planet* had to circumvent a fishing area while towing the CTD chain. This explains the northward excursion from track P09b in Fig. 8.
- Originally on mooring M1, a CTD probe was mounted directly at the sea surface but the recording of conductivity failed shortly after the deployment of the mooring.
- Two out of 40 thermistors in mooring M1 failed.

7 Conclusions

In June 2014, a huge dataset was collected by two research vessels, 11 gliders, and other measuring systems in the waters west of Sardinia. The large volume of the dataset, its consistency and the quality, were the stimulus for various scientific studies which will be published in a Special Issue of this journal. The present article provides an overview of the observations at sea. The objective is to acquaint all authors and readers of ongoing studies in the Special Issue with the background of the observations and the logistics, and to prevent the scientific articles from repeating the same information.

Data availability. All data of the REP14-MED experiment are available on the CMRE data server at http://geos3.cmre.nato.int. The data are NATO UNCLASSIFIED and available only for the partners of the experiment (cf. Table 1). However, interested institutions can sign up for partnership at any time. Requests may be directed to the first author or to <geos-webmaster@nurc.nato.int>.

Author contributions. Reiner Onken was the coordinator of the experiment and Chief Scientist on NRV *Alliance*, Heinz-Volker Fiekas was Chief Scientist on RV *Planet*, Laurent Beguery was the Principal Investigator from ACSA and provided the SeaExplorers, Ines Borrione and Aniello Russo were responsible for the collection and processing of CTD and ADCP data on NRV *Alliance*, Karen Heywood and Jan Kaiser were the Principal Investigators from UEA and provided the SeaGliders, Pierre-Marie Poulain provided the SVP drifters and the ARVOR-I floats, Michaela Knoll and Andreas Funk collected and processed all data on RV *Planet* and the data from the WTD71 glider, Bastien Queste and Michael Hemming processed the SeaGlider data, Kiminori Shitashima was in charge of the new pH/pCO_2 sensor on glider *Fin*, and Martin Siderius was the Principal Investigator from PSU; he provided the Slocum glider *Clyde* which was piloted by Elizabeth Thorp Küsel.

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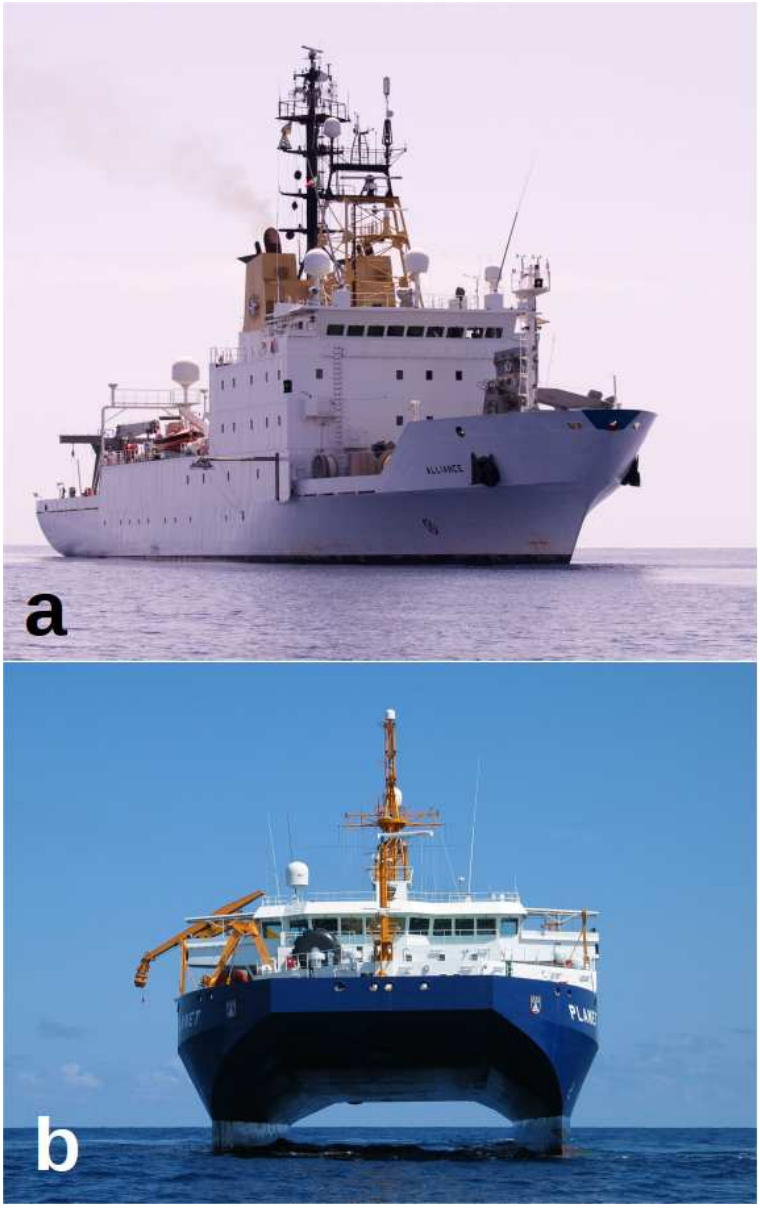

Figure 1. NRV *Alliance* (a) and RV *Planet (b)*

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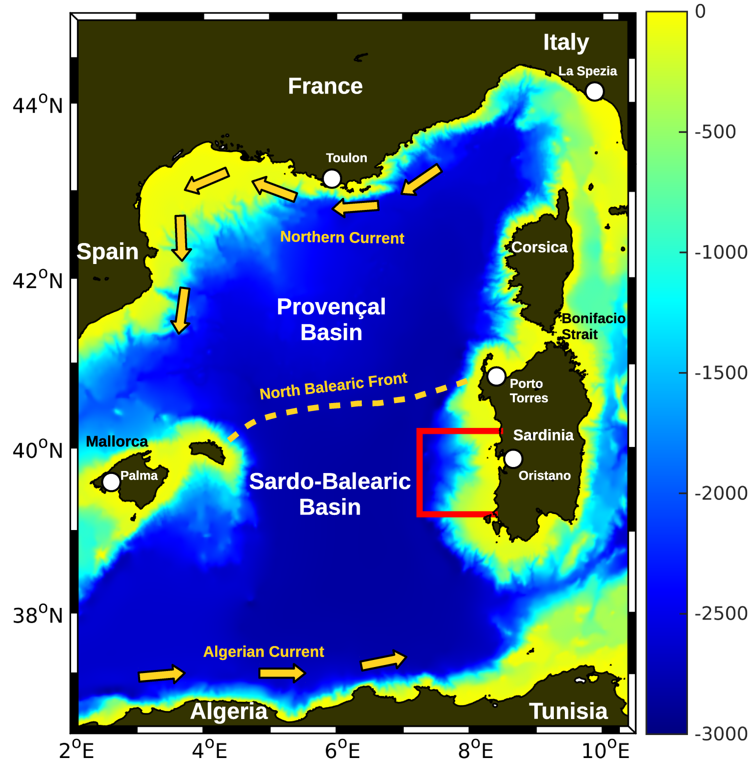

Figure 2. The survey area west of Sardinia. Observational data were collected within the red box. The colour code refers to the water depth [m]. Large-scale circulation patterns were sketched after Olita et al. (2013)

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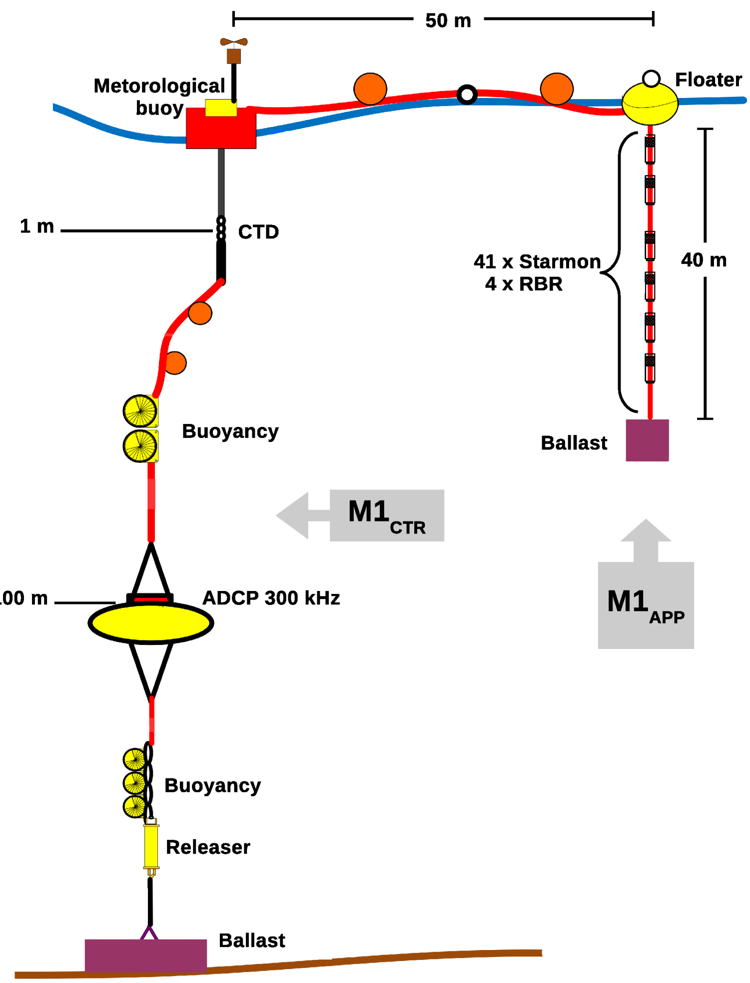

Figure 3. Design drawing of mooring M1. For explanations see text.

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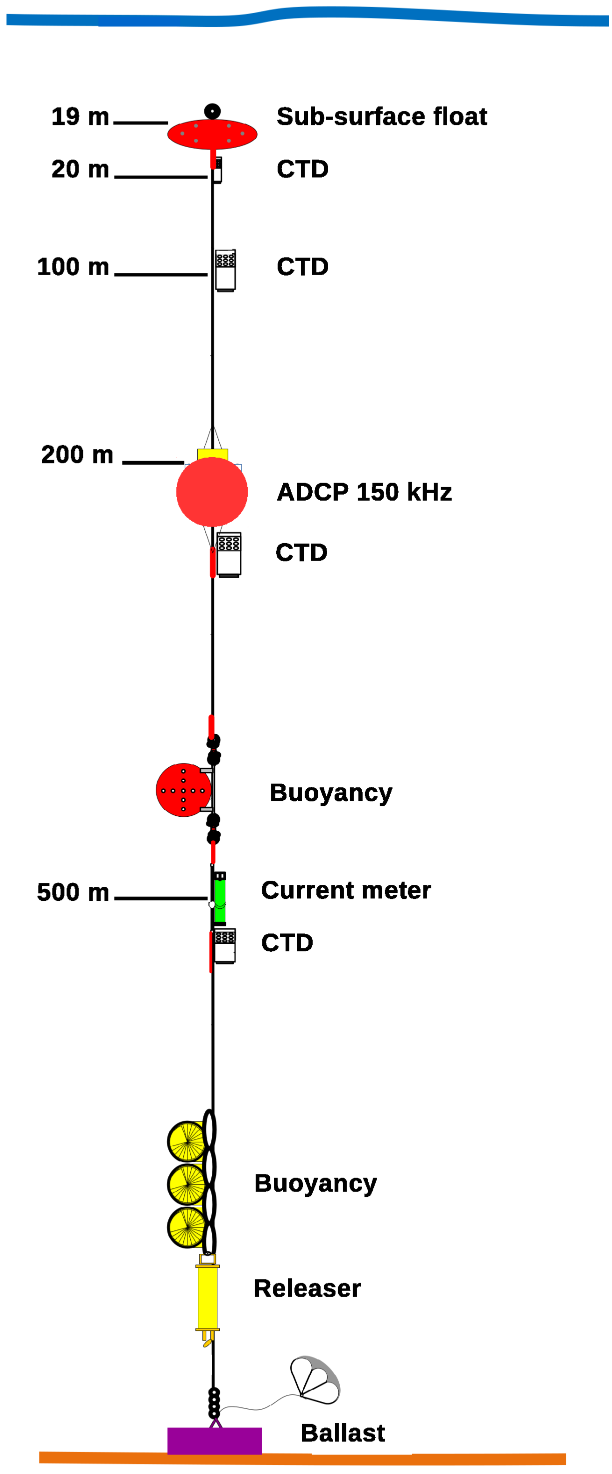

Figure 4. Design drawing of mooring M3. For explanations see text.

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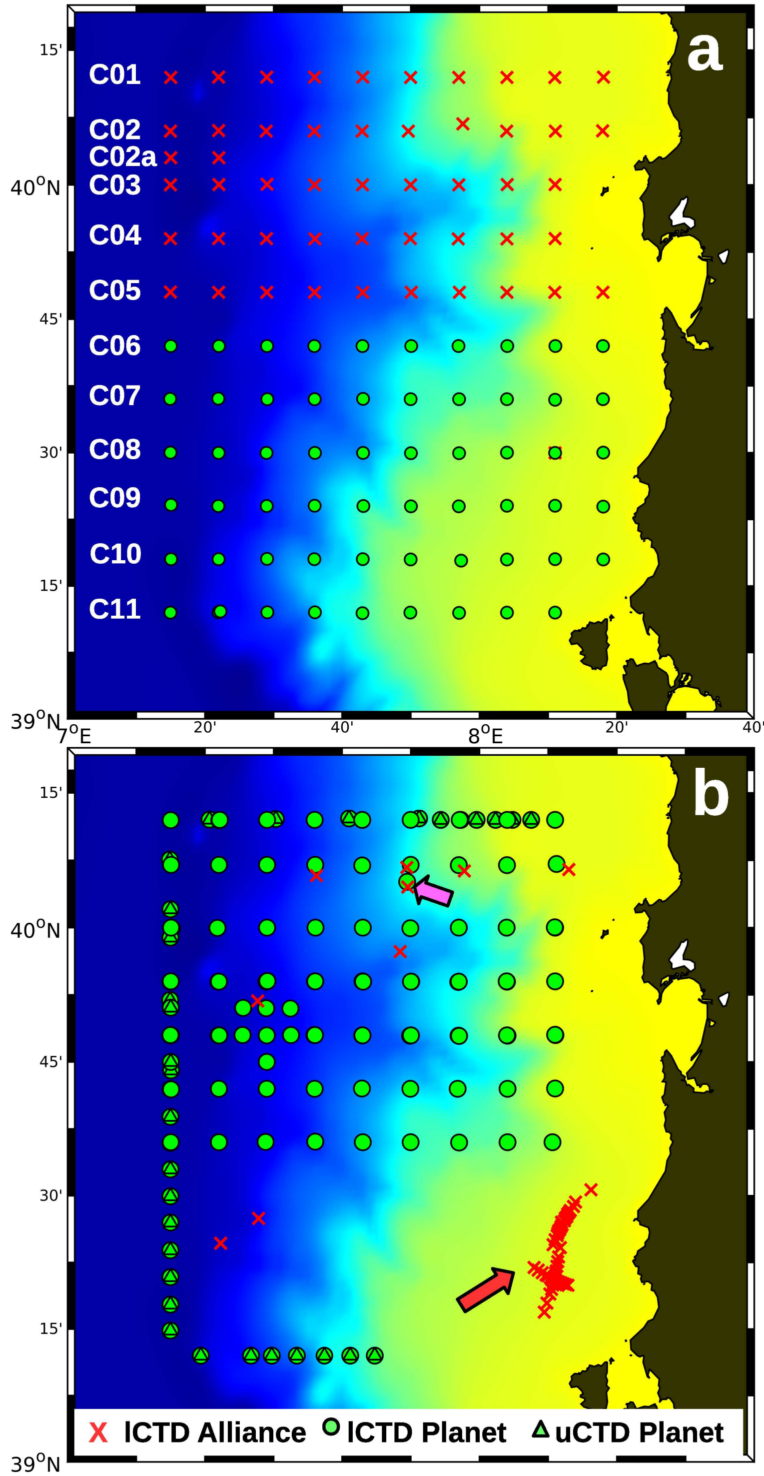

Figure 5. CTD casts taken during (a) Leg 1 and (b) Legs 2 and 3. Zonal sections in (a) are numbered C01, . . ., C11. The 46 CTD casts taken by *Alliance* in the framework of the acoustic experiments during Leg 2 are highlighted by the red arrow, the magenta arrow points to the position of the CTD inter-calibration. Extra casts taken by *Planet* for the calibration of the CTD chain are not shown. The colour code for the water depth is the same as in Fig. 2.

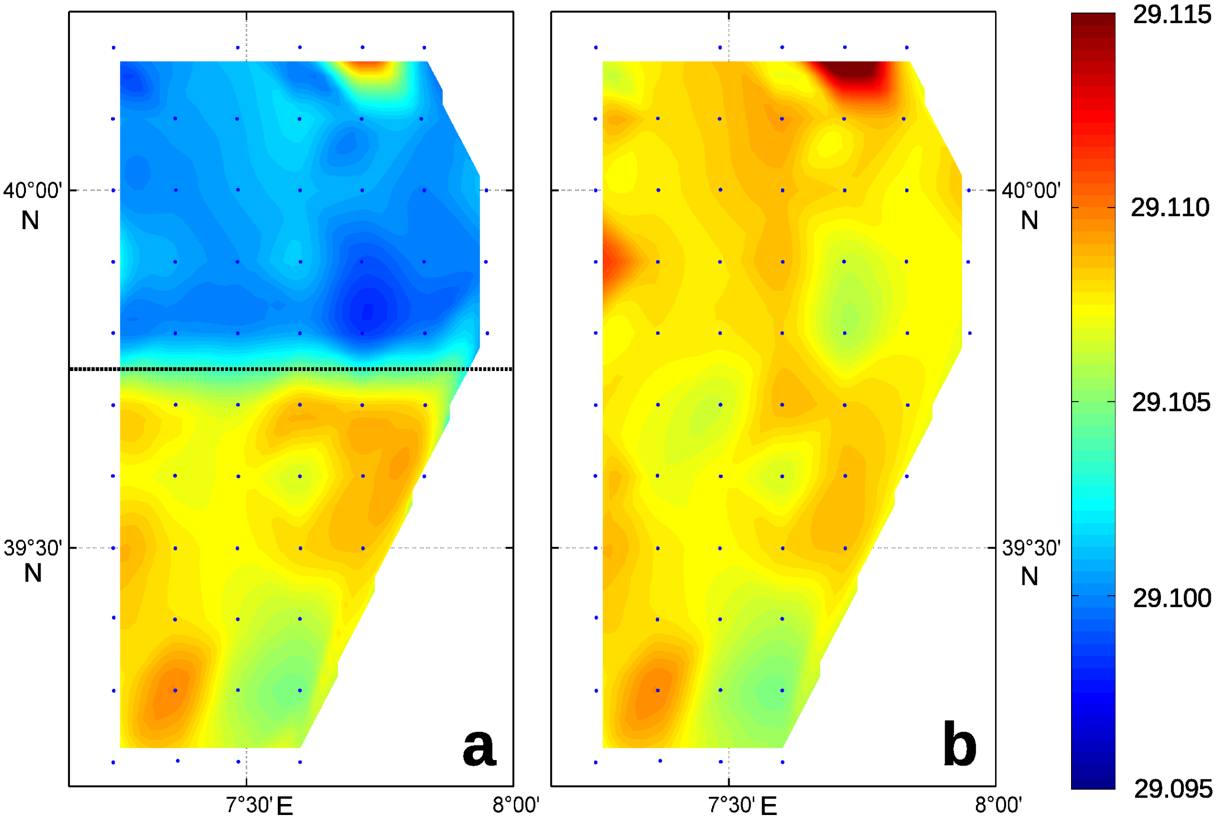

Figure 6. Potential density [kg m^{-3}] at 990 m depth (a) before and (b) after applying the salinity correction to the CTD casts taken during Leg 1. The positions of all casts are indicated by blue dots. All casts north of the dotted line were taken by *Alliance*, all casts south of that line were from *Planet*.

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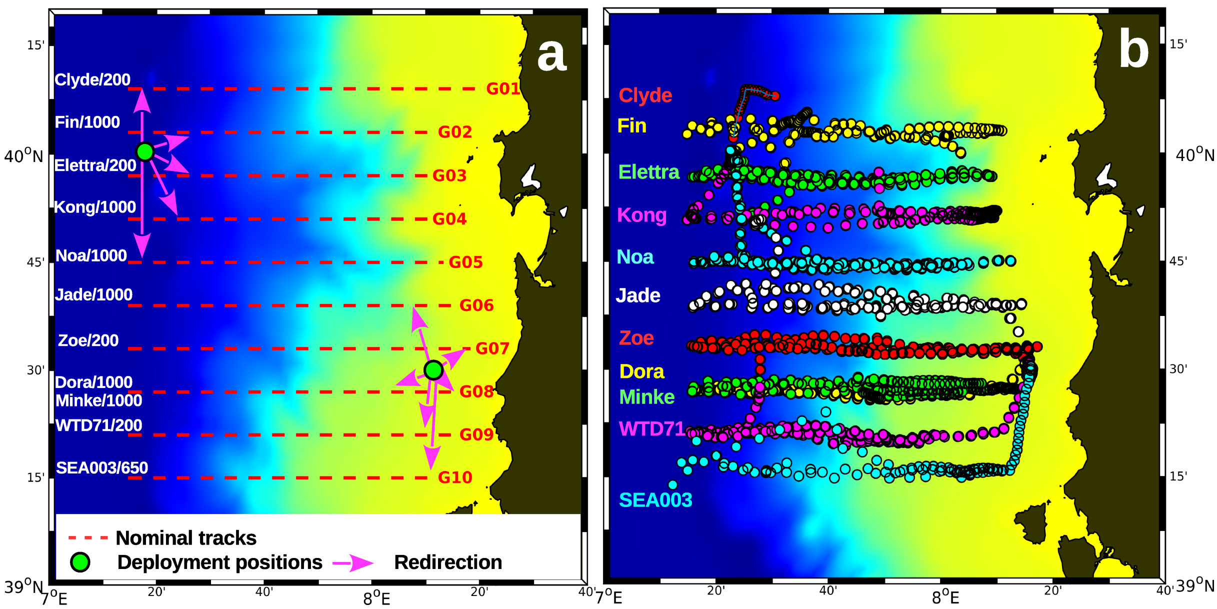

Figure 7. (a) Nominal tracks and deployment positions of all gliders launched during Leg 1. The names of the gliders are written at the western end of their respective tracks, and the number behind the name stands for the pressure rating in dbar. The gliders are redirected from the deployment positions to their nominal tracks. (b) Real tracks of all gliders 8–23 June. The circles indicate the surfacing positions. The colour code for the water depth is the same as in Fig. 2.

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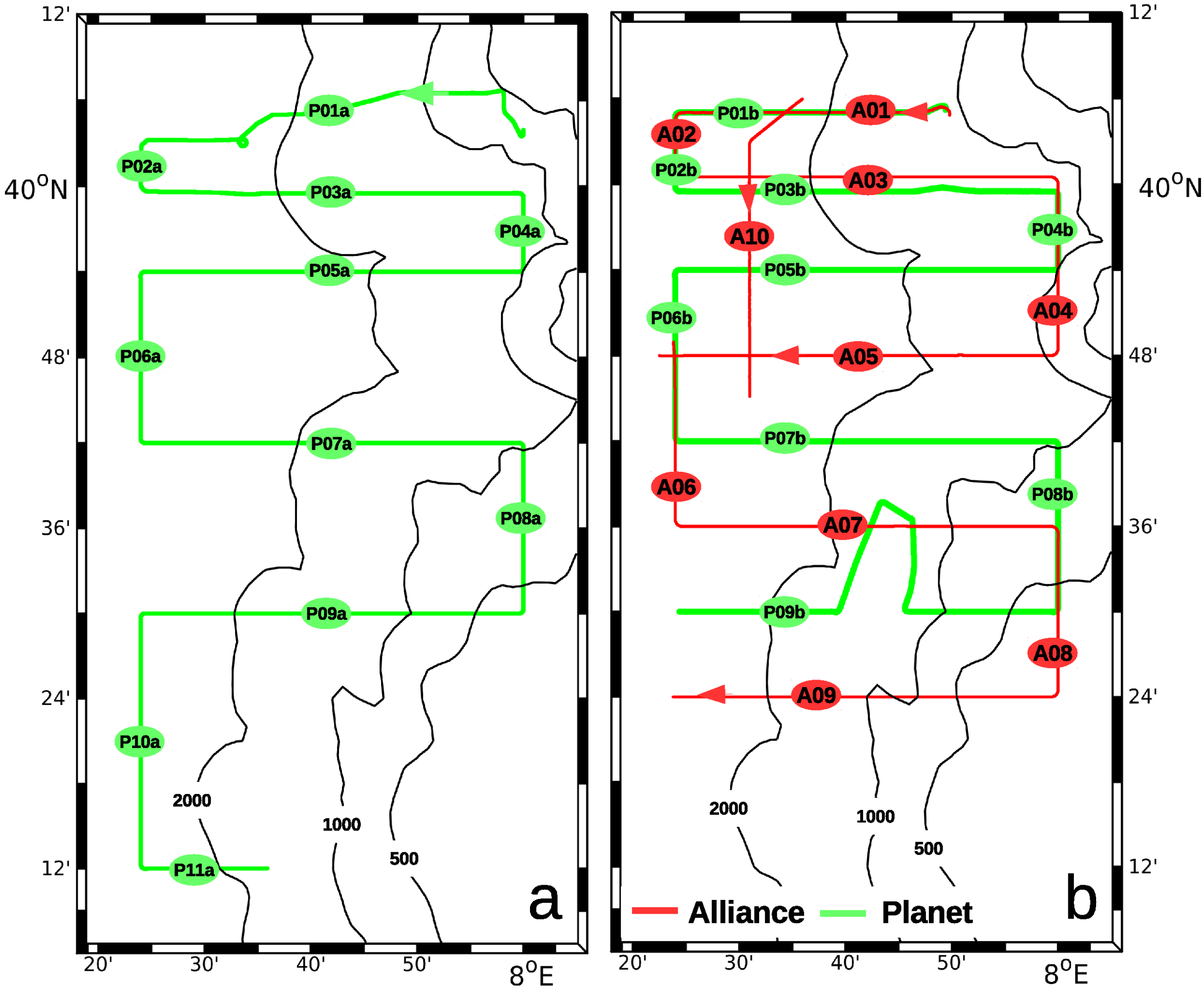

Figure 8. (a) CTD chain track of *Planet* during Leg 2. Tracks are numbered consecutively P01a, . . ., P11a. (b) CTD chain tracks P01b,. . ., P09b of *Planet* and ScanFish tracks A01, . . ., A10 of *Alliance* during Leg 3. Black lines indicate water depth [m].

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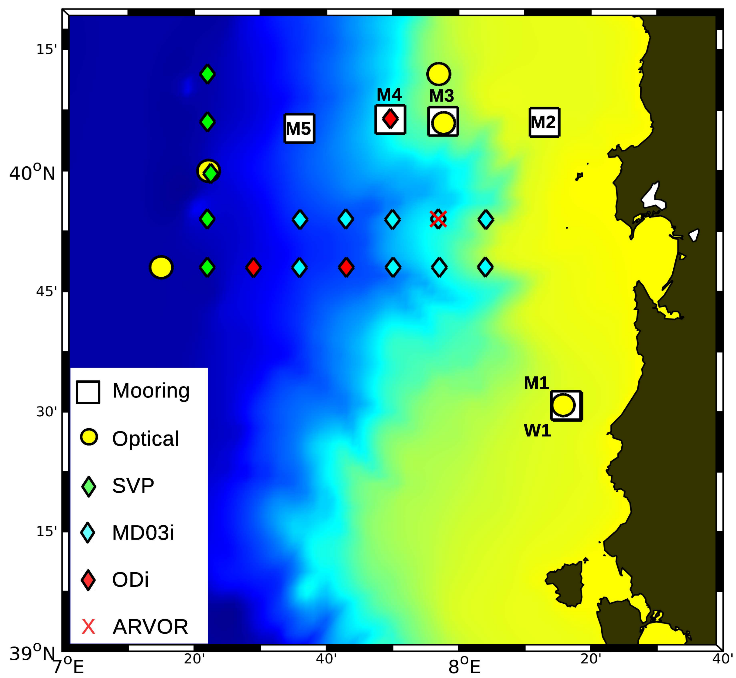

Figure 9. Positions of moorings, optical stations, and deployment positions of surface drifters (SVP, MD03i, ODi are drifter types) and the ARVOR-I float. The colour code for the water depth is the same as in Fig. 2.

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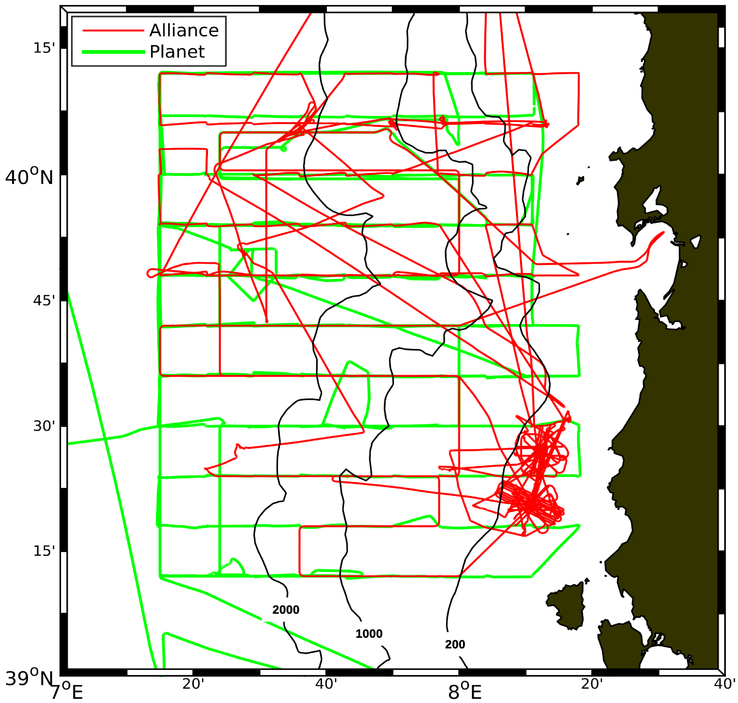

Figure 10. Ship tracks of *Alliance* and *Planet*. Black lines indicate water depth [m].

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Table 1. Partners of the experiment

Acronym	Name	Country
ACSA	Architecture et Conception de Systemas Avantes	France
AMP	Area Marina Protetta Peninsola del Sinis	Italy
CMRE	Centre for Maritime Research and Experimentation	NATO
DGA	Direction Générale de l'Armement	France
DSTL	Defence Science Technology Laboratory	United Kingdom
HLS	Heat, Light and Sound Research	United States of America
IAMC	Istituto per l'Ambiente Marino Costiero	Italy
IIM	Istituto Idrografico della Marina	Italy
ISMAR	Istituto di Scienze Marine	Italy
MARKDO	Marinekommando	Germany
MIT	Massachusetts Institute of Technology	United States of America
MWC	Maritime Warfare Centre	United Kingdom
NRL	Naval Research Laboratory	United States of America
OGS	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale	Italy
ONR	Office of Naval Research	United States of America
SOCIB	Sistema de Observación Costero de las Illes Balears	Spain
PSU	Portland State University	United States of America
TWR	Teledyne Webb Research	United States of America
UEA	University of East Anglia	United Kingdom
UPMC	Université Pierre et Marie Curie	France
WTD71	Wehrtechnische Dienststelle für Schiffe und Marinewaffen, Maritime Technologie und Forschung	Germany

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Table 2. Specifications of the gliders provided for the experiment. *Greta*, *Natalie*, and *SEA004* were deployed only during Leg 2 within the framework of the acoustic experiments, *Laura* and *Sophie* served as backup. For the specifications of the sensors, see the web sites of the manufacturers in Section 2. *PAM=passive acoustic monitoring system

name	*make*	*rating [dbar]*	*owner*	Sensors and special properties
Clyde	Slocum	200	PSU	CTD, PAM*
Dora	Slocum	1000	CMRE	CTD (pumped), propeller
Elettra	Slocum	200	CMRE	2×CTD (pumped and unpumped)
Greta	Slocum	200	CMRE	CTD, PAM*
Jade	Slocum	1000	CMRE	CTD (pumped), propeller
Laura	Slocum	200	CMRE	CTD
Natalie	Slocum	200	CMRE	CTD, PAM*
Noa	Slocum	1000	CMRE	CTD, *Wetlabs* puck
Sophie	Slocum	200	CMRE	CTD, 504 nm irradiance, *Wetlabs* puck
WTD71	Slocum	200	WTD71	CTD (pumped)
Zoe	Slocum	200	CMRE	CTD, 504 nm irradiance, *Wetlabs* puck
Fin	Seaglider	1000	UEA	SBE CT sail, O_2, 2×pH/pCO_2
Minke	Seaglider	1000	UEA	SBE CT sail, O_2
Kong	Seaglider	1000	UEA	SBE CT sail, PAM*
SEA003	SeaExplorer	650	ACSA	GPCTD, O_2, Chl A, CDOM, Bs770nm
SEA004	SeaExplorer	650	ACSA	PAM*

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Table 3. Details of the moorings. All times are UTC. *RCM* stands for the Aanderaa current meters of the RCM series (http://www.aanderaa.com)

	W1	M1	M2	M3	M4	M5
Longitude	08°16.44′ E	08°16.22′ E	08°12.98′ E	07°57.65′ E	07°49.68′ E	07°35.39′ E
Latitude	39°30.71′ N	39°30.80′ N	40°05.98′ N	40°06.14′ N	40°06.36′ N	40°05.24′ N
Water depth	150	150	150	700	1300	2100
Deployment	08 June 07:47	08 June 07:14	10 June 06:42	10 June 11:30	10 June 15:56	11 June 07:18
Recovery	20 June 13:28	20 June 13:55	23 June 14:10	23 June 11:47	23 June 08:45	23 June 06:06
0 m	Waverider	Meteo buoy				
1 m		CTD				
20 m				CTD	CTD	CTD
100 m				CTD	CTD	CTD
		ADCP 300 kHz	ADCP 300 kHz			ADCP 300 kHz
200 m				CTD	CTD	CTD
				ADCP 150 kHz	ADCP 150 kHz	RCM
500 m				CTD	CTD	CTD
				RCM	RCM	RCM
1000 m					CTD	CTD
					RCM	RCM
1500 m						CTD
						RCM

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Table 4. The observation schedules of *Alliance* and *Planet* and data availability of deployed systems.

June date	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	
	Leg 1						Leg 2									Leg 3					Total
NRV *Alliance*																					
lCTD casts		10	8	8	11	14		1	11	5		10	14	4	1	1		5	3		106
Optical stations		1	1	1	1	1															5
Deployment of gliders			6	5																	11
Deployment of moorings			2		3	1															6
Deployment of drifters		7	5	2	2	1															17
Deployment of floats			1																		1
ScanFish tows																xxxxxxxxxx					
Recovery of moorings															2			4			6
Recovery of gliders					1													10			11
Thermosalinograph	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																				
Shipborne ADCP	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																				
Ship meteorology	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																				
RV *Planet*																					
lCTD casts			8	17	19	16					10	18	19	18	17	8					150
uCTD casts						2	6		5	17	6										36
CTD chain tows							xxxxxxxxxxx									xxxxxxxxxxx					
lCTD (chain calibration)							10		1							7		5			23
Shipborne ADCP					xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																
Ship meteorology	xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																				
Data availability of deployed systems																					
Gliders			xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																		
Moorings W1, M1			xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																		
Moorings M2–M5					xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																
Surface drifters		xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																			
Sub-surface float			xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx																		

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Table 5. Summary of all observations. The variables names $p, pCO2, pH, T, S, U, V$ refer to pressure, CO_2 partial pressure, pH value, temperature, salinity, zonal and meridional velocity, respectively. Only those variables are mentioned which are relevant for the articles in the Special Issue.

* Additional parameters are available from these systems but they are beyond the scope of this article.

Instrument	Data type	Variables	June Period	Track length [km]	Data volume	Remarks
Gliders	3D trajectory	$T, S, p, pH, pCO2^*$	08–23	3278	133 glider days 5731 profiles	
ScanFish	3D trajectory	T, S, p^*	21–23	365	535 profiles	resolution < 1321m
Thermo-salinograph	2D trajectory	T, S @2.5 m depth	06–25	3158		resolution < 10m
Surface drifters	2D trajectory	U, V, T	08–25		17 drifters	6-h sampling interval
Floats	2D trajectory	U, V, T, S	08–25		1 float	within observational domain
	vertical profile	T, S	08–28		3 profiles	within observational domain
lCTD casts	vertical profile	T, S, p^*,	07–24		279 profiles	spatially crowded on Leg 2
uCTD casts	vertical profile	T, S, p	11-16		36 profiles	
CTD chain	vertical profile	T, S, p	11–14 21–23	722	> 100 000 profiles	resolution < 10m
ADCP (ship)	vertical profile	U, V	07–25	5561	> 400 000 profiles	
Moorings	time series	T, S, U, V^*	08–23			
Meteorol. obs.	time series		06–25			shipborne and on M1