CALYPSO PILOT EXPERIMENT 2018

27 May – 2 June 2018

R/V ALLIANCE & R/V SOCIB

Lagrangian Drifter and Float Deployments

by

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1. Introduction

The main objective of CALYPSO, an ONR DRI project, is to improve our understanding on the 3D dynamics in the upper ocean through which water and properties are transported from the surface to depths below the mixed layer, by exploring the dynamics of the frontal areas in the Alboran Sea (southwest Mediterranean Sea) at scales ranging between 1 and 100 km using data collected by ship-born instruments (CTD, underway-CTD, ADCP, etc.), Lagrangian platforms (drifters and floats), gliders and satellites. As part of CALYPSO, a pilot experiment was carried out in the Alboran Sea on 27 May – 2 June 2018 with the participation of international scientists (from the US, Spain, Italy) on two vessels: the NATO R/V ALLIANCE and the Spanish R/V SOCIB.

This report provides information on the deployments of 86 drifters and 1 float provided by OGS (Italy), RSMAS/UM (Florida) and SIO/UCSD (California) during the CALYPSO Pilot experiment. After a brief description of the Lagrangian instruments (section 2), details on the deployments are given in tables and graphs (section 3). Preliminary results can be found in section 4. Conclusions and recommendations for future CALYPSO experiments in the same area are in the last section 5.

2. Lagrangian instruments

a. SVP-type drifters

Standard Surface Velocity Program (SVP) drifter

The Surface Velocity Program (SVP) drifter is the standard drifter of the Global Drifter Program (Niiler, 2001; Lumpkin and Pazos, 2006; Centurioni, 2018). It consists of a spherical surface buoy tethered to a weighted nylon drogue that allows it to track the horizontal motion of water at a nominal depth of 15 m (Fig. 1). A tether strain gauge measures the tension of the buoy-drogue connection to monitor the drogue presence. The new design, also called mini, has a surface buoy of reduced diameter (30.5 cm diameter) which contains alkaline batteries, a satellite Iridium transmitter and a thermistor to measure Sea Surface Temperature (SST). The sampling and transmission period was set to 5 min. The 33 SVP drifters used during the CALYPSO Pilot campaign were manufactured by the Lagrangian Drifter Laboratory (LDL) at SIO/UCSD in La Jolla, California.

The Surface Velocity Program Barometer (SVPB) drifter

This drifter is an SVP fitted with an atmospheric pressure sensor (barometer) on the surface buoy to measure the atmospheric pressure at the sea level (Fig. 2). It has the same surface buoy and drogue as the SVP drifter. See Centurioni et al. (2016, 2018) for more details. The data are telemetered to Iridium satellite every hour. The 2 SVPB drifters used during the experiment were manufactured by Pacific Gyre in Oceanside, California. They were kindly provided by the E-SURFMAR program and the Global Drifter Program, as barometer upgrades (ESURFMAR funded) of drifters purchased by the LDL (funded by the NOAA grant "the Global Drifter Program" (http://eumetnet.eu/activities/observations-programme/current-activities/e-surfmar/, http://gdp.ucsd.edu/ldl_drifter/index.html).

The Directional Wave Spectra (DWS) drifter

This is essentially the surface buoy of an SVP drifter for which the drogue was replaced by a small (~50 cm) stabilizing chain (Fig. 3, Centurioni et al. 2017). It is equipped with a high-performance GPS engine paired with in-house developed software algorithms for onboard computation of the Directional Wave Spectrum (DWS). Location, SST, voltage and wave parameters are transmitted to Iridium satellite at 30 min intervals or longer. The transmission interval is programmable over the air. The 2 DWS drifters used here were designed and produced by the LDL in La Jolla, California.

Fig. 1. SVP drifter (surface buoy and folded holey sock drogue).

Fig. 2. SVPB drifter (surface buoy with barometer and folded holey sock drogue).

b. CODE drifters

The Coastal Ocean Dynamics Experiment (CODE) drifter was designed by Davis (1985) to measure the currents within the top meter of the water column, mostly in coastal areas and marginal seas. It is composed of a slender, vertical, 1-m-long negatively buoyant tube with four drag-producing vanes extending radially from the tube over its entire length and four small spherical surface floats attached to the upper extremities of the vanes to provide buoyancy (Poulain, 1999). The water-following characteristics of the CODE were studied by Davis (1985) and Poulain and Gerin (2018). It was demonstrated that CODE drifters follow the currents with an accuracy of about 3 cm/s, even under strong wind conditions. The wind-induced slippage was estimated to be 0.1% of the local wind speed.

The CODE drifter used in the CALYPSO Pilot campaign is similar to the design manufactured by Technocean/DBi (Fig. 4). It was constructed by an Italian company and was equipped with a SPOT/GlobalStar TRACE module, which includes a GPS receiver to measure position with high accuracy (<10 m) and high frequently (every 10 min). An autonomy of about 1 month is expected (Gerin et al., 2018). A total of 14 CODE were operated during the CALYPSO Pilot campaign.

Fig. 3. DWS drifter (surface buoy with ballasting chain).

Fig. 4. CODE drifter (antenna, vanes and orange balls).

c. CARTHE drifters

CARTHE drifters were developed to be compact, easy to transport and assemble, and 85% biodegradable (Novelli et al., 2017) so that very large deployments can be attempted in the ocean while being ecofriendly. About 1000 of these drifters were deployed during a single cruise in the Gulf of Mexico (D'Asaro et al., 2018). A total of 35 of these drifters were used in the CALYPSO Pilot experiment. They were set to transmit their GPS positions every 5 min via the GlobalStar satellite system.

Fig. 5. CARTHE drifters (6 units)

d. Arvor profiling float

An Arvor profiling float is an Argo float manufactured by NKE in Hennebont, France. It consist of a tubular body in stainless steel (Fig. 6). A SBE CTD, GPS receiver and Iridium transmitter are fitted near is top. It changes its buoyancy by exchanging oil with and external rubber bladder located at its bottom extremity. One float was available for the CALYPSO Pilot campaing. It was initially programmed to profile every 6 h down to 350 m. Its parking depth was set up to 350 m and the vertical resolution was 1 m. The cycle period was subsequently reduced to 3 h. This float is part of the Argo-Italy program, the Italian contribution to the global Argo array. After the experiment, the float will be programmed with the standard MedArgo (Poulain et al., 2007) parameters, that is, alternated profiles to 700 and 2000 m with 5-day cycles.

Fig. 6. Arvor float (with from top to bottom: Iridium antenna, CTD and bladder).

3. Deployments

The drifter and float deployments were conducted between 27 May and 1 June 2018. They are described hereafter in chronological order. All times are UTC.

27-28 May 2018

A total of 8 drifters were deployed from R/V ALLIANCE across the western limb of the West Alboran Gyre, including 2 SVPB, 2 DWS and 4 SVP drifters (Fig. 7). The deployment coordinates are listed in Table 1. All drifters were deployed from mid-ship starboard or port side, in ship speeds of 0-8 kts.

Table 1. Deployment information for the drifters released on 27-28 May 2018

IMEI	WMO	DATE/TIME	TYPE	LAT	LON
300234065706140	6102503	27-MAY-18 22:41:24	SVPB	N35 36.694	W3 53.908
300234065513740	-	27-MAY-18 23:19:58	DWS	N35 39.831	W3 50.741
300234065612140	6102565	27-MAY-18 23:56:10	SVP	N35 42.349	W3 46.596
300234065612150	6102566	28-MAY-18 1:13:27	SVP	N35 45.416	W3 42.375
300234065612170	6102567	28-MAY-18 1:43:32	SVP	N35 48.238	W3 38.152
300234065612180	6102568	28-MAY-18 2:16:16	SVP	N35 51.094	W3 33.856
300234065513750	-	28-MAY-18 3:00:04	DWS	N35 53.883	W3 29.672
300234065706150	6102504	28-MAY-18 3:33:53	SVPB	N35 56.879	W3 25.248

Fig. 7. Deployment of an SVP drifter during the night (27-28 May 2018).

28-29 May 2018

A total of 6 CARTHE drifters were deployed from R/V ALLIANCE in the region south of Almerìa Island in the evening of 28 May 2018. Another group of CARTHE drifters (7 units) were released across the northward jet (western limb of Eastern Alboran Gyre) on 29 May morning (Fig. 8). All drifters were deployed at mid-ship port side with ship speeds up to 9 kts. The deployment coordinates of these CARTHE drifters are listed in Table 2.

Fig. 8. Deployment of a CARTHE drifter.

Table 2. Deployment information for the CARTHE drifters released on 28-29 May 2018.

DATE/TIME	NUMBER	LAT	LON
28-MAY-18 21:06:15	0050	N35 45.960	W3 12.971
28-MAY-18 21:39:16	0025	N35 47.847	W3 07.752
28-MAY-18 22:15:48	0279	N35 49.936	W3 01.853
28-MAY-18 22:52:16	0036	N35 51.794	W2 55.903
28-MAY-18 23:28:04	0029	N35 47.573	W2 52.528
28-MAY-18 23:54:52	0313	N35 44.305	W2 49.963
29-MAY-18 7:18:09	0035	N35 51.999	W2 14.092
29-MAY-18 7:48:42	0437	N35 51.997	W2 18.732
29-MAY-18 8:25:03	0093	N35 51.996	W2 24.240
29-MAY-18 8:57:19	0443	N35 51.995	W2 29.150
29-MAY-18 9:31:18	0445	N35 51.996	W2 34.041
29-MAY-18 10:06:20	0464	N35 51.997	W2 39.119
29-MAY-18 10:39:39	0175	N35 51.994	W2 43.818

30 May 2018

An Arvor float was deployed from R/V ALLIANCE at the beginning of a transect in the core of the northward flow. It was manually lowered over the starboard side of the ship (mid-ship) with a rope, while the ship was sailing at 1-2 kts (Fig. 9). Waves were 1 m in height and wind less than 20 kts. Deployments coordinates are given in Table 3.

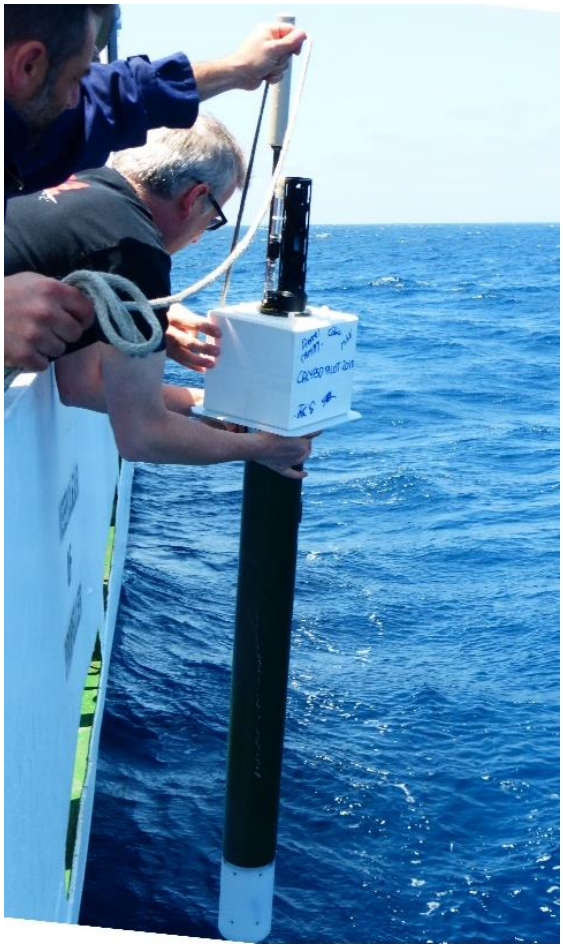

Fig. 9. Deployment of the Arvor float.

Table 3. Deployment information for the Arvor float deployed on 30 May 2018.

IMEI	WMO	DATE/TIME	TYPE	LAT	LON
300234064800050	3901974	30-MAY-18 11:18	Arvor	N35.8404	W2.2125

Six CARTHE drifters and one CODE drifters were deployed from R/V ALLIANCE across the northward jet (western limb of Eastern Alboran Gyre) on 30 May 2018 (Fig. 10). All drifters were deployed at mid-ship port side with ship speeds of 4-5 kts. The deployment coordinates of these drifters are listed in Table 4.

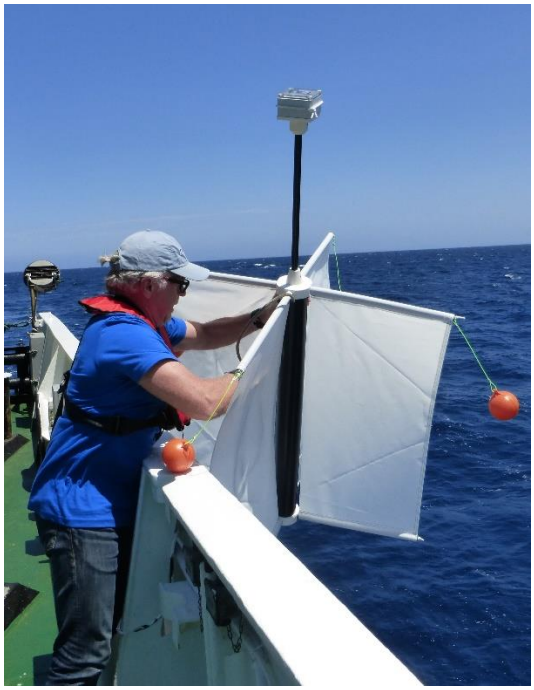

Fig. 10. Deployment of a CODE drifter.

Table 4. Deployment information for the drifters released on 30 May 2018.

DATE/TIME	NUMBER	LAT	LON	TYPE
30-MAY-18 11:15:36	0460	N35 50.401	W2 12.675	CARTHE
30-MAY-18 11:48:13	0434	N35 50.776	W2 15.412	CARTHE
30-MAY-18 12:34:26	0454	N35 51.466	W2 18.713	CARTHE
30-MAY-18 13:07:27	5658	N35 51.997	W2 21.362	CODE
30-MAY-18 14:06:35	0442	N35 52.703	W2 25.874	CARTHE
30-MAY-18 14:58:40	0155	N35 53.181	W2 30.199	CARTHE
30-MAY-18 15:48:46	0227	N35 53.788	W2 34.266	CARTHE

31 May 2018

On 31 May afternoon, both R/V ALLIANCE and R/V SOCIB deployed a total of 51 drifters in an array centered on the northward jet/front. The inner tight array was deployed in about 1 h 20 min, whereas R/V ALLIANCE finished the spiral (Fig. 11) after 3 h 40 min. For R/V ALLIANCE drifters were deployed mid-ship and tail (starboard side) at 8 kts for the inner array (stations 1 to 11) and 14 kts for the outside spiral (stations 12 to 17). On R/V SOCIB, the drifters were deployed from the aft working deck with the ship slowing down to 2-3 kts for deployments and speeding up to 12 kts between the stations. Fig. 12 shows the deployment of SVP drifters. The deployment coordinates of these drifters are listed in Tables 5 and 6.

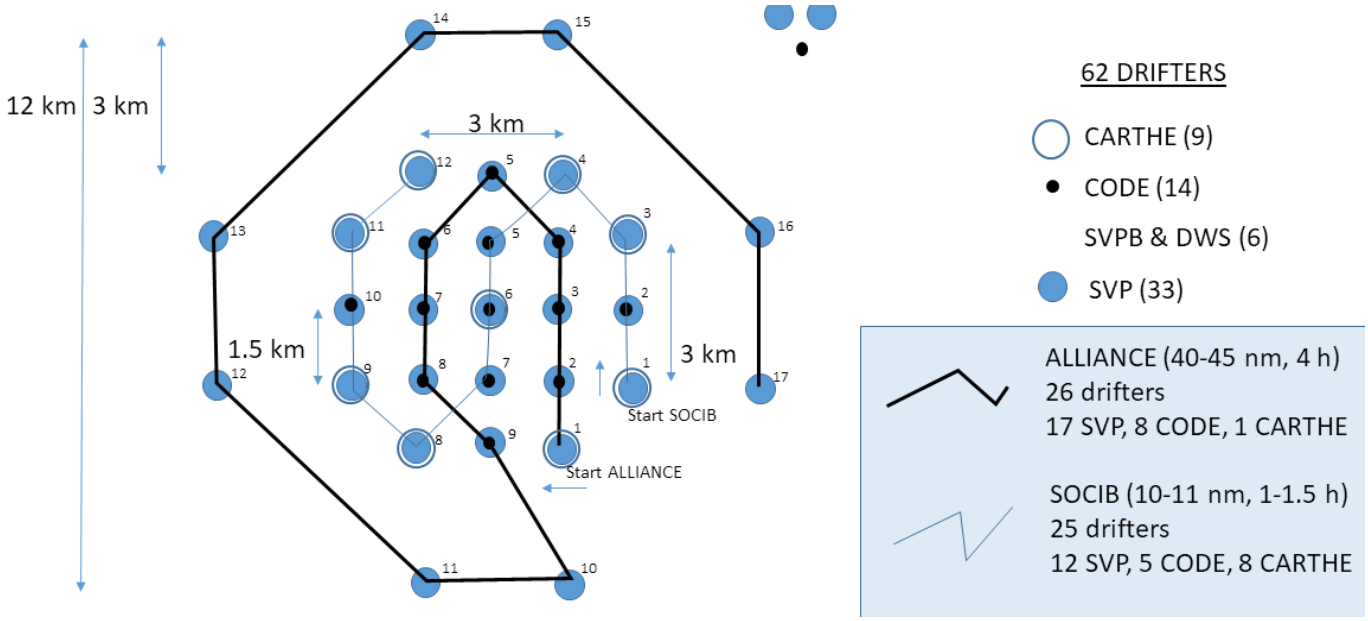

Fig. 11. Drifter deployment array and ship tracks for 31 May 2018.

Fig. 12. Deployment of SVP drifters from R/V ALLIANCE (left) and R/V SOCIB (right).

Table 5. Deployment information for the drifters released from R/V ALLIANCE on 31 May 2018. The numbers of the SVP drifters correspond to the last 4 digits of their IMEI numbers.

STATION	DATE/TIME	LAT	LON	DRIFTER TYPE/NUMBER
1	31-MAY-18 13:39:19	N35 55.313	W2 15.676	SVP 0140 CARTHE 0481
2	31-MAY-18 13:47:47	N35 55.289	W2 14.633	SVP 0150 CODE (T10) 567
3	31-MAY-18 13:55:59	N35 55.325	W2 13.625	SVP 0160 CODE (T12) 5679
4	31-MAY-18 14:04:02	N35 55.331	W2 12.631	SVP 0170 CODE (T13) 5678
5	31-MAY-18 14:13:38	N35 56.110	W2 11.642	SVP 0180 CODE (T29) 5580
6	31-MAY-18 14:25:13	N35 56.914	W2 12.653	SVP 0260 CODE (T30) 5654
7	31-MAY-18 14:32:09	N35 56.928	W2 13.674	SVP 0540 CODE (T31) 565
8	31-MAY-18 14:38:13	N35 56.901	W2 14.657	SVP 0580 CODE (T32) 5656
9	31-MAY-18 14:48:04	N35 56.104	W2 15.655	SVP 1120 CODE (T33) 5657
10	31-MAY-18 15:00:08	N35 55.297	W2 17.637	SVP 1130
11	31-MAY-18 15:12:38	N35 56.915	W2 17.633	SVP 1140
12	31-MAY-18 15:31:31	N35 59.366	W2 14.631	SVP 1190
13	31-MAY-18 15:39:08	N35 59.343	W2 12.624	SVP 1290
14	31-MAY-18 15:55:40	N35 56.909	W2 09.638	SVP 1430
15	31-MAY-18 16:03:58	N35 55.266	W2 09.648	SVP 1590
16	31-MAY-18 16:20:22	N35 52.854	W2 12.651	SVP 1860
17	31-MAY-18 16:28:08	N35 52.867	W2 14.662	SVP 2130

Table 6. Deployment information for the drifters released from R/V SOCIB on 31 May 2018. The numbers of the SVP drifters correspond to the last 4 digits of their IMEI numbers.

STATION	DATE/TIME	LAT	LON	DRIFTER TYPE/NUMBER
01	31-MAY-18 13:47	N35 54.59	W2 14.51	SVP 2190 CARTHE 0200
02	31-MAY-18 13:53	N35 54.59	W2 13.59	SVP 2280 CODE (T02) 5672
03	31-MAY-18 14:00	N35 54.59	W2 12.59	SVP 2430 CARTHE 0203
04	31-MAY-18 14:09	N35 55.36	W2 11.63	SVP 2490 CARTHE 0213
05	31-MAY-18 14:18	N35 56.10	W2 12.64	SVP 2580 CODE (T05) 5675
06	31-MAY-18 14:24	N35 56.09	W2 13.62	SVP 3130 CARTHE 0226 CODE (T6) 5674
07	31-MAY-18 14:31	N35 56.09	W2 14.65	SVP 3140 CODE (T07) 5673
08	31-MAY-18 14:40	N35 56.90	W2 16.64	SVP 3150 CARTHE 0364
09	31-MAY-18 14:47	N35 57.70	W2 14.64	SVP 3170 CARTHE 0394
10	31-MAY-18 14:53	N35 57.71	W2 13.65	SVP 3180 CODE (T09) 5676
11	31-MAY-18 14:59	N35 57.69	W2 12.67	SVP 3260 CARTHE 0424
12	31-MAY-18 15:08	N35 56.92	W2 11.65	SVP 3270 CARTHE 0425

1 June 2018

On 1 June morning, the last CARTHE drifters were released from R/V ALLIANCE across a sharp front in the middle of the northward current. There was little wind and the sea was calm. The deployment coordinates are listed in Table 7.

Table 7. Deployment information for the CARTHE drifters released from R/V ALLIANCE on 1 June 2018.

DATE/TIME	NUMBER	LAT	LON
01-JUN-18 7:12:04	0196	N36 17.854	W2 12.324
01-JUN-18 7:19:42	0430	N36 17.855	W2 12.833
01-JUN-18 7:29:42	0448	N36 17.856	W2 13.532
01-JUN-18 7:39:59	0451	N36 17.851	W2 14.262
01-JUN-18 7:46:56	0455	N36 17.841	W2 14.785
01-JUN-18 7:55:40	0457	N36 17.841	W2 15.477
01-JUN-18 8:04:34	0521	N36 17.836	W2 16.185

The drifter and float data were processed in real time by several systems at OGS, RSMAS/UM and SIO/UCSD. The status of the instruments, along with their trajectories, was monitored using web-based systems easily reachable due to the good internet connection onboard R/V ALLIANCE. In addition, all the drifter and float data were inserted into Goggle Earth for display with the measurements of other instruments (ship ADCP and underway, gliders, etc.). Fig. 13 shows three graphical systems used in the main scientific laboratory on R/V ALLIANCE for planning and monitoring the deployments of the Lagrangian instruments.

Fig. 13. Graphical displays of the drifter data used on R/V ALLIANCE for planning the drifter deployment and viewing their trajectories in real time.

4. Preliminary results

Most of the drifters were released in the western limb of the Eastern Alboran Gyre, a swift northward current. Fig. 14 shows the drifter and float locations on 2 June at 12.30 UTC, with 2-day long trajectories. The majority of the drifters stayed in the jet and veered in the CW direction upon approaching the Spanish coast, to continue eastward and then southward, along the Eastern Alboran Gyre, towards the Algerian coast.

By 4 June 2018, many drifters have reached the Algerian coastal waters (Fig. 15). Some went to the west, some stranded on the coast or were picked up and some entered into the Algerian Current and proceeded eastward along the Algerian coast.

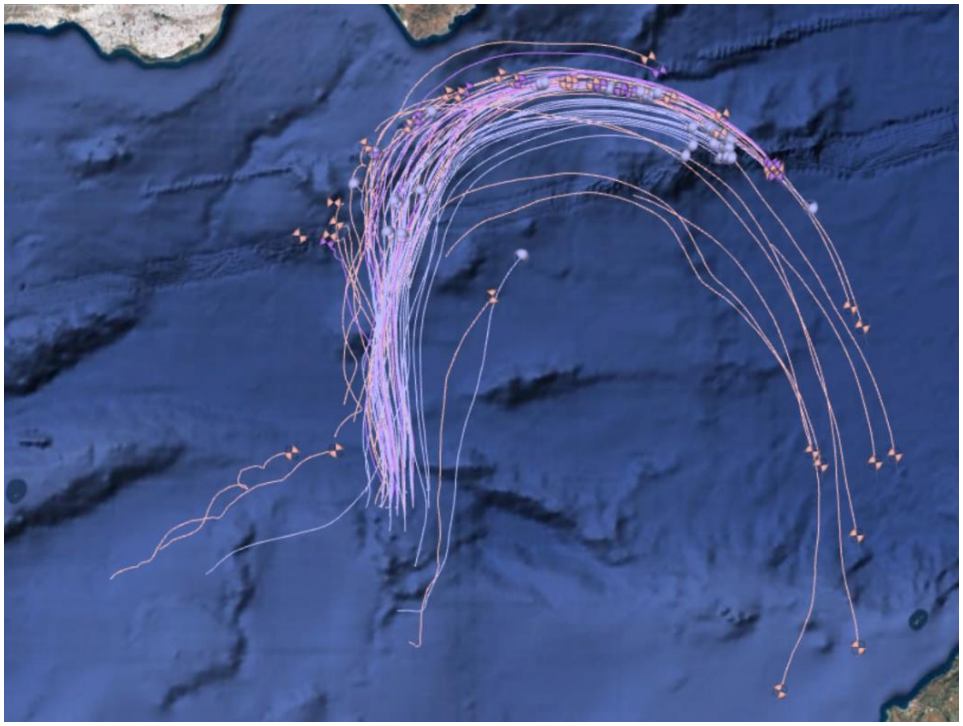

Fig. 14. Google Earth snapshot of the drifter positions on 2 June at 12.30 UTC with 2-day long trajectory tails.

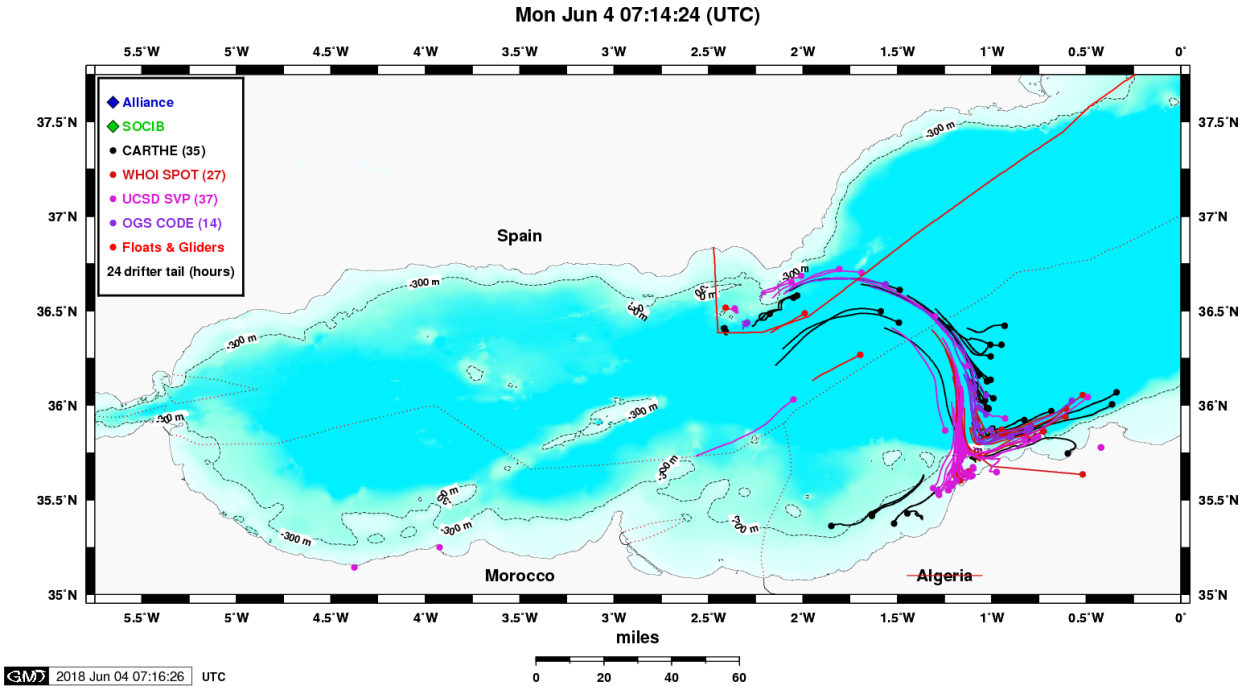

Fig. 15. RSMAS/UM graph showing the drifter positions on 4 June at 7:24 UTC with 1-day long trajectory tail.

Fig. 16 summarizes the motion of the drifters and float from their deployment on 27 May – 1 June and 12 June 2018. Two drifters were trapped in the Western Alboran Gyre. One drifter was caught in a small anticyclonic eddy south between the Almerìa Island and Morocco. Many drifters swirled around the Eastern Alboran Gyre, ending up near the Algerian coast where unfortunately some of them stranded or were picked up. Subsequently, some of them went to the west slowly and chaotically, whereas the others were caught by the Algerian Current and moved eastward rapidly until they reached the longitude of Algiers where they appeared to detach from the coastal current, proceed offshore and eventually be trapped in an anticyclonic eddy.

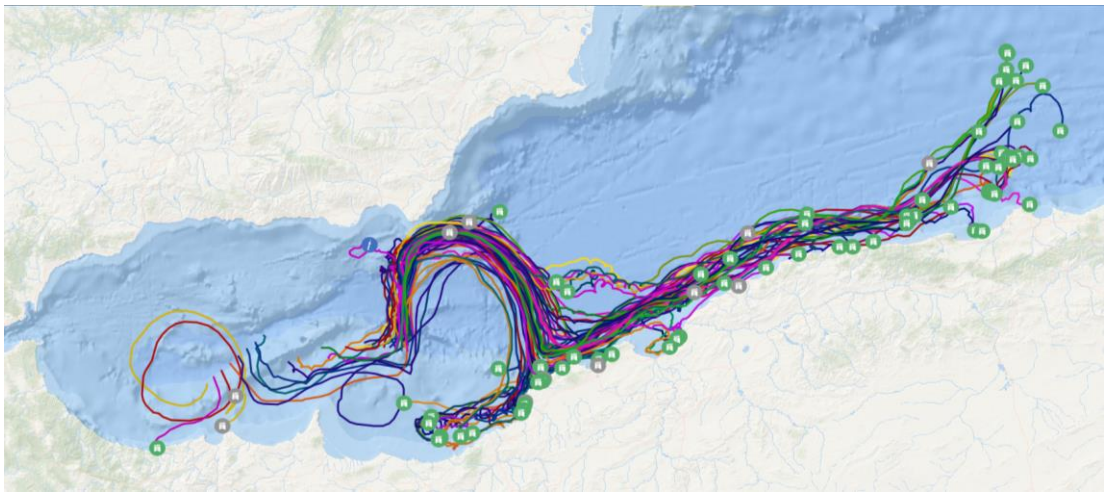

Fig. 16. OGS display with the drifter and float positions on 12 June at about 23:00 UTC with their entire trajectories from deployment.

The Arvor float, originally deployed in the northward jet with the drifters, detached from it after about 2 days and proceeded slowly towards the west in the coastal waters off Almerìa, Spain (Fig. 17). It measured temperature and salinity every 6 h between 350 m and the surface (Fig. 18). A seasonal thermocline is seen near 20-30 m. Near the deployment location in the jet, the low-salinity Atlantic Water (AW) was found from the surface to about 120-130 m depth. The halocline separating the AW on top, and the Mediterranean Water below, is shoaling slowly to about 50 m in the Spanish coastal waters. High-frequency oscillations are evident in the thermocline and halocline presumably due to tidal signals.

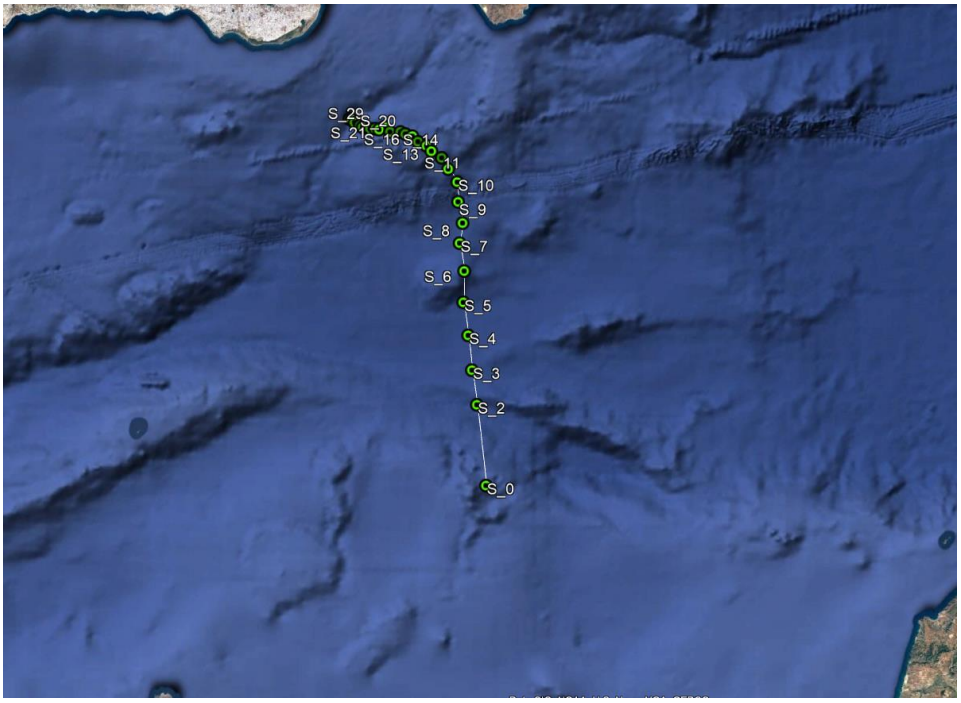

Fig. 17. Trajectory of the Arvor float WMO 3901974 between 30 May (deployment) and 6 June 2018. Surfacing positions are indicated with circle symbols and numbers.

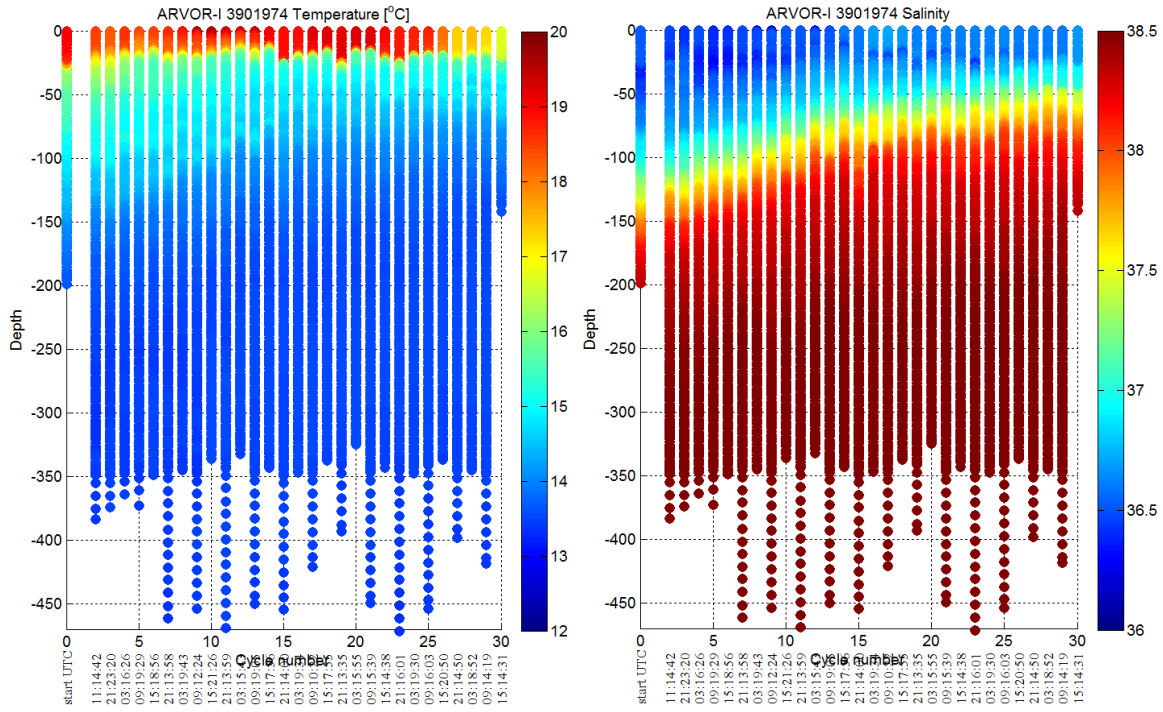

Fig. 18. Temperature (left) and salinity (right) versus depth and time (or cycle number) measured by the Arvor float WMO 3901974 between 30 May and 6 June 2018.

5. Conclusions and recommendations

Overall the drifter and float operations carried on during the CALYPSO Pilot experiment on 27 May – 2 June 2018 went very well. The deployment operations were performed by the various teams onboard R/V ALLIANCE and SOCIB in a coordinated and efficient way. The data collected by the Lagrangian instruments during and after the campaign are of good quality and will provide new and interesting results on the dynamics and circulation in the Alboran Sea and Western Mediterranean.

A few recommendations for the future CALYPSO experiments in the Alboran Sea are:

1. Drifters can be deployed safely at ship speed as high as 14 kts. This will allow to deploy arrays of a large number of drifters quasi-synoptically.

2. For R/V Alliance, GPS fixes should be made near the deployment locations with hand-held GPS. The bridge GPS is different because the ship is long (~100 m).

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