ARGO-ITALY:

ANNUAL REPORT 2019

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1. Introduction

ARGO-ITALY is the Italian component of a worldwide in situ global observing system, based on autonomous profiling floats, surface drifters, gliders and ship-of-opportunity measurements. It is primarily focused on the Italian seas, the Mediterranean and Black seas and the Southern Ocean, and includes observations of temperature, salinity, currents and biogeochemical/optical properties of seawater. The ARGO-ITALY objective is to provide a significant and sustained Italian contribution to the global ocean monitoring.

ARGO-ITALY contributes to international programs such as Argo and Euro-Argo (global monitoring of water properties with profiling floats), GDP (Global Drifter Program to measure near-surface temperature and currents), EGO (gliding vehicles to measure water properties) and SOOP (Ship-Of-Opportunity Program to temperature profiles) which have been developed to monitor the entire World Ocean on a long term basis.

ARGO-ITALY is a cost-effective long-term monitoring system that is a unique source of information to study the role of the oceans, and the Mediterranean Sea in particular, on the climate system. It also provides the data required by operational ocean monitoring systems in order to improve significantly extended forecasts of the atmosphere and oceans. ARGO-ITALY contributes to programs of operational oceanography, such as MONGOOS (Mediterranean Oceanography Network for the Global Ocean Observing System) and is essential for the production of marine core and downstream services products of Copernicus Marine Environment Monitoring Service (CMEMS). It is also an important component of GEOSS (Global Earth Observation System of Systems).

ARGO-ITALY is funded by the Italian Ministery of Instruction, University and Research (MIUR) since 2011. The operation of instruments at sea and the collection of data began in February 2012. A dedicated web site was developed to help with the internal organization of the project, to publish graphical and tabulated summaries and photographs on the operation of instruments in near-real time, and to post news, related links, small project calls, etc. related to ARGO-ITALY. The web address is: http://argoitaly.ogs.trieste.it/

This report summarizes the activities of ARGO-ITALY in 2019 in terms of procurements of the instruments, their preparation and their deployments. Information about data processing and archiving is also given. Plans for 2020 and beyond are included in the last section.

2. Argo float activities in 2019

2.1 Float procurement

The following Argo floats were purchased in 2019 with funds of ARGO-ITALY:

1. Eight Arvor-I floats, five Arvor-I floats with dissolved oxygen sensor and seven Arvor-I with sea ice detection algorithm from NKE, Lorient, France. These instruments were acquired via the Euro-Argo ERIC. They are fitted with a Sea-Bird CTD (SBE 41 CP) (and Aanderaa optode sensor) and transmit data via Iridium. Seven units were shipped to New Zealand and five units to South Africa for deployments in the Southern Ocean and Ross Sea in January and February 2020. Two units were shipped to IOLR in Haifa (Israel) and deployed in the Eastern Mediterranean Sea in September 2019 (from R/V Bat-Galim). Two units were shipped to IO-BAS (Varna) in Bulgaria and one of them was deployed in the Black Sea in December 2019 (from R/V Akademik). One unit was deployed in the Eastern Mediterranean Sea in October 2019 (from R/V Laura Bassi). One platform had an electrovalve malfunctioning and was shipped back to NKE for fixing (the float has been fixed and it is now at OGS)

2. One full-BGC float from NKE, Lorient, France. It is a Provor CTS 4 float with Iridium global telephone network (RUDICS) for data telemetry and a GPS receiver for position. It measures at 1 m vertical resolution not only temperature and salinity (Sea-Bird CTD) but also irradiance at three wavelengths (412 nm, 490 nm, 555 nm), fluorescence of Colored Dissolved Organic Matter (CDOM), fluorescence of chlorophyll-a, backscattering coefficient (530 nm) and attenuation coefficient (660 nm). It is also equipped with an Aanderaa optode oxygen sensor, a SUNA nitrate sensor and a Seafet pH sensor. This float is going to be shipped to OGS (Spring 2020).

2.2 Float deployments

In total, **23 Italian floats** were deployed in 2019 (see Tables 1 and 2 for details). These floats were Provor, Arvor-I and Arvor-Ice designs manufactured by NKE (France). All floats transmit data via Iridium telemetry.

One float was deployed in the Black Sea and 12 units were released in the Mediterranean (Table 1). In the Mediterranean, most floats have a parking depth at 350 dbar and maximal profiling depths alternating at 700 and 2000 dbar. In the Black Sea, the parking depth was set to 200 dbar. They all have cycles of 5 days except for 3 Arvor-I-DO float (WMO 6903265, 6903264 and 6903266) which had short cycles of 3 h during most of their operating life to measure high-frequency processes. Two Arvor-Deep floats were deployed in the Hellenic Trench (Ionian Sea). One of them (WMO 6903267) stopped working after 6 cycles only and the cause is still under investigation by NKE. The second deep Arvor (WMO 6903268) was deployed at about the same location in October 2019 and has performed 22 up to February 2020; it is configured with a parking depth of 3500 m and a maximal profiling depth of 4000 m.

Most floats were deployed from research vessels of opportunity (i.e., R/V Dallaporta, R/V Laura Bassi, R/V Pourquoi Pas?, R/V Aegaeo, R/V Bat-Galim for the Mediterranean and R/V Akademik for the Black Sea) with the help of colleagues from France, Italy, Greece, Israel and Bulgaria (Figures 1, 2).

Figure 1. Arvor-I deployment from R/V Pourquoi Pas? in the eastern Mediterranean in March 2019.

Figure 2. Arvor Deep 18EU003 on R/V Laura Bassi before deployment in the Hellenic trench in October 2019.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-I	6903259	03-Mar-2019 00:05	34.44	23.73	69	02 -Feb-2020 06:05	35.89	21.87	A	5
Arvor-I	6903260	05-Mar-2019 00:05	34.06	25.33	69	04-Feb-2020 06:09	34.30	22.84	A	5
Arvor-I-DO	6903262	18-Mar-2019 14:35	37.09	18.86	66	02-Feb-2020 06:20	39.54	19.57	A	5
Arvor-I-DO	6903263	23-Mar-2019 16:02	43.01	15.11	65	02-Feb-2020 06:32	42.90	15.27	A	5
Arvor-I	6903264	30-Mar-2019 00:30	35.96	-4.28	410	02-Feb-2020 21:02	36.47	-10.77	A	5
Arvor-I-DO	6903265	30-Mar-2019 18:50	36.01	-4.27	98	13-May-2019 14:29	35.81	-5.74	D	5
Arvor-I-DO	6903266	05-Apr-2019 11:37	36.17	-3.01	207	05-Feb-2020 06:29	36.68	0.31	A	5
Arvor-D	6903267	19-Jul-2019 21:30	36.50	21.48	6	30-Jul-2019 21:25	36.55	21.32	D	10
Arvor-I	6903269	11-Sep-2019 16:15	32.32	34.31	31	04-Feb-2020 21:11	33.56	35.08	A	5
Arvor-I	6903270	12-Sep-2019 00:44	32.50	33.89	31	05-Feb-2020 20:53	34.52	32.07	A	5
Arvor-D	6903268	22-Oct-2019 22:00	36.60	21.47	23	06-Feb-2020 04:25	35.60	22.00	A	5
Arvor-I-DO	6903765	25-Oct-2019 11:49	33.47	27.14	22	03-Feb-2020 06:13	33.50	26.31	A	5
Arvor-I	**6903766**	**02-Dec-2019 19:24**	**43.18**	**29.00**	**15**	**06-Feb-2020 06:05**	**42.01**	**30.00**	**A**	**5**

**Status in early February 2020: A = active, D = dead;*
***Cycle: Length of cycle in days.*

Table 1. Status information for the 13 Italian floats deployed in the Mediterranean and Black Sea (bold) during 2019.

In total, 2 floats (out of 13) stopped functioning before the end of the year 2019. The Arvor-Deep (WMO 6903267) deployed in the eastern Ionian Sea stopped transmitting data after 6 cycles. The Arvor-I-DO float 6903265 was deployed in the Alboran Sea in March 2019. It was initially programmed to cycle at 3 h intervals in the upper layer of the sea (down to about 200 m) in order to study the internal waves (oscillatory vertical motion in the water column) which are prominent in this area (reaching an amplitude of 10-20 m). It performed 98 cycles before stopping transmissions after stranding on 13 May 2019.

Five Italian floats were deployed in the South Pacific Ocean and the Pacific sector of the Southern Ocean (Table 2) with the help of Italian colleagues onboard the R/V Araon while sailing from New Zealand to the Ross Sea. All these floats are ice detection type. The Arvor-Ice uses an Ice Sensing Algorithm (ISA) based on temperature readings to abort surfacing when sea ice is present at the sea surface (Pacciaroni et al., 2017). All floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar.
The floats were still active in early 2020.

Five Italian floats were deployed in the South Atlantic Ocean in February 2019 (Table 2) with the help of Italian colleagues onboard the R/V Agulhas II (Figure 4). These floats are Arvor-Ice model. All the floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. They were all still active in early 2020.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-I-ICE	6903252	08-Feb-2019 04:15	-48.60	168.00	38	04-Feb-2020 20:38	-44.73	177.42	A	10
Arvor-I-ICE	6903254	09-Feb-2019 08:45	-57.00	168.18	37	27-Jan-2020 21:19	-52.42	-154.51	A	10
Arvor-I-ICE	6903253	10-Feb-2019 03:07	-59.01	168.58	37	28-Jan-2020 20:33	-56.78	-163.47	A	10
Arvor-I-ICE	6903251	10-Feb-2019 11:35	-61.01	168.94	37	28-Jan-2020 20:43	-59.93	-157.53	A	10
Arvor-I-ICE	6901880	10-Feb-2019 20:27	-63.00	169.33	37	28-Jan-2020 05:48	-64.14	-171.71	A	10
Arvor-I-ICE	6903255	28-Feb-2019 17:35	-63.99	0.00	36	05-Feb-2020 06:12	-66.06	-9.32	A	10
Arvor-I-ICE	6903256	28-Feb-2019 21:53	-63.00	0.00	36	05-Feb-2020 21:11	-59.56	-1.63	A	10
Arvor-I-ICE	6903257	01-Mar-2019 03:45	-62.00	0.00	35	27-Jan-2020 21:04	-62.00	0.00	A	10
Arvor-I-ICE	6903258	01-Mar-2019 21:07	-59.92	-4.50	35	27-Jan-2020 21:00	-60.06	1.22	A	10
Arvor-I-ICE	6903261	08-Mar-2019 19:59	-54.03	-4.50	35	03-Feb-2020 21:10	-52.22	-3.83	A	10

**Status in early February 2020: A = active, D = dead.*
***Cycle: Length of cycle in days.*

Table 2. Status information for the 10 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2019.

In summary, at the end of 2019, the ARGO-ITALY program had a total of 69 active floats, including 33 instruments in the Mediterranean Sea, 1 in the Atlantic Ocean (it escaped from the Mediterranean through the Strait of Gibraltar), 5 in the Black Sea (Figure 3) and 36 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 4).

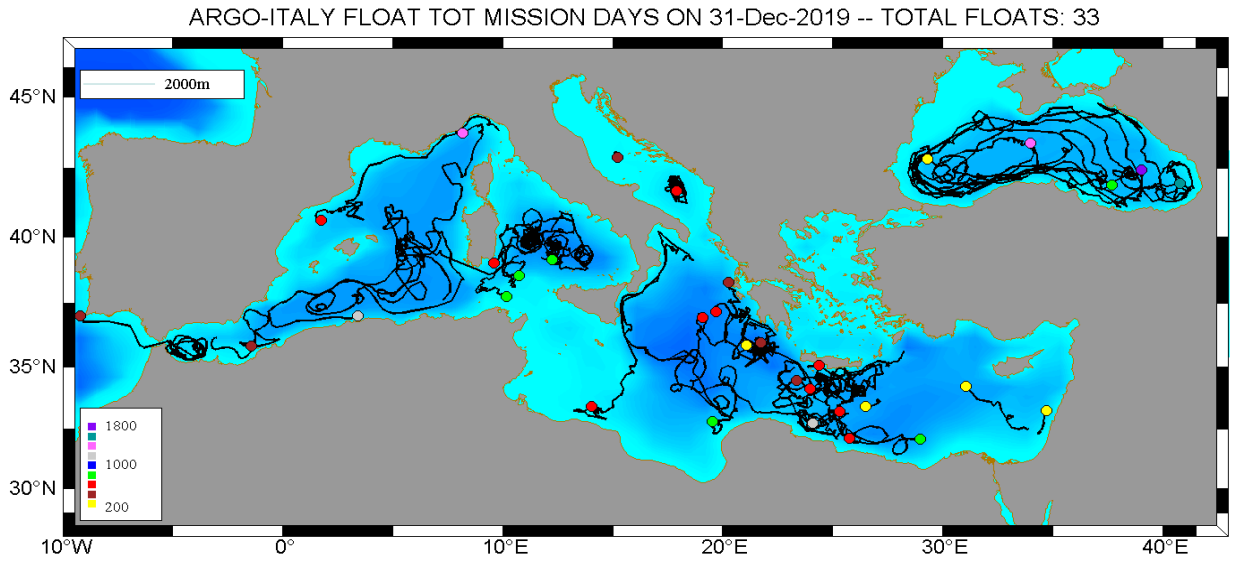

Figure 3. Trajectories and positions (circle symbols) on 31 December 2019 of the 33 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.

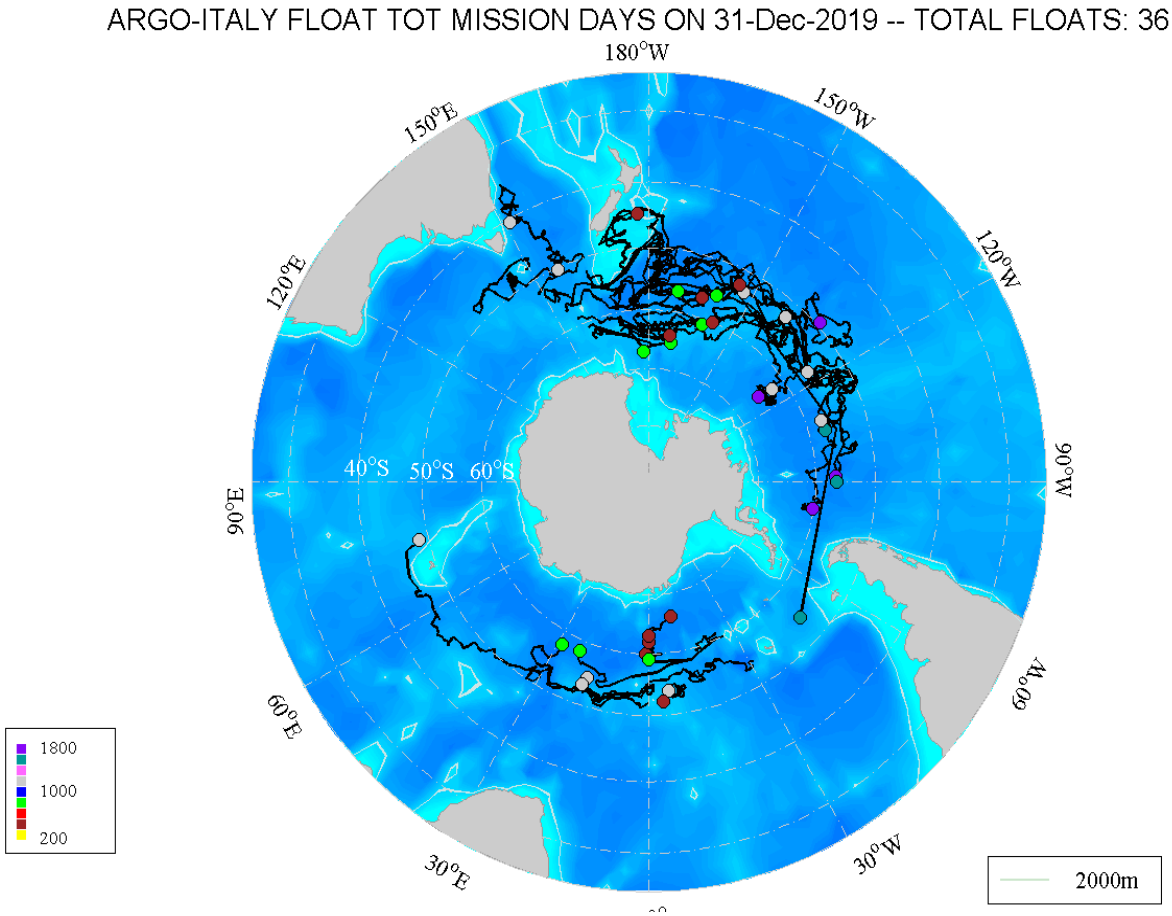

Figure 4. Trajectories and positions (circle symbols) on 31 December 2019 of the 36 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

The temporal evolution of the number of active floats is shown in Figure 5 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2019. The float population in 2012-2019 is essentially increasing and reaching a plateau around 70 active instruments in 2017-2019. In 2019, the number of deployments exceeded the number of dead floats.

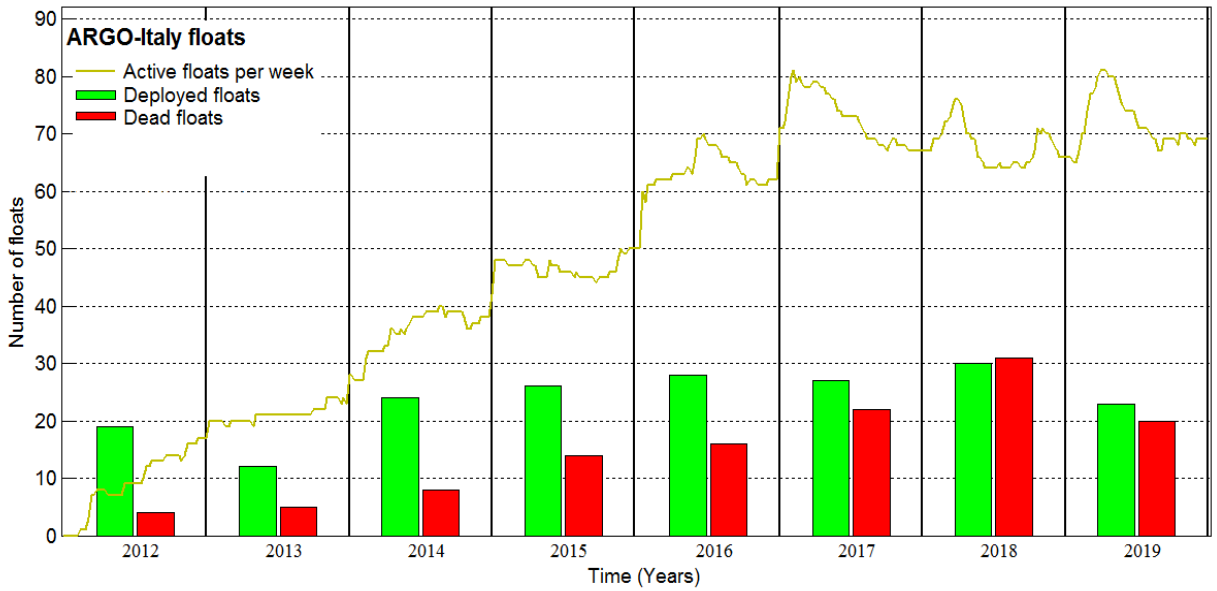

Figure 5. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **189 ARGO-ITALY floats** have been deployed, 117 in the Mediterranean and Black seas, and 72 in the oceans of the Southern Hemisphere. In less than 8 years, they have provided about **24300 CTD profiles**. The histogram of number of CTD profiles per float is shown in Figure 6. Forty-four floats have done more than 180 profiles. In total (during 2012-2019), ~6 % of the floats have failed just after deployment, while 100 % of those deployed in 2019 successfully worked after deployment.

After about 8 years of activities in the Mediterranean and Black seas, the maximum operating life of the ARGO-ITALY floats is about 5 years (~1950 days, see Figure 7). If we consider all the floats (dead + alive) the mean half-life is about 550 days for all floats in the Mediterranean and Black seas (Figure 7, top). Excluding the floats still alive but with life <= 550 days, we obtain a better estimate of mean half-life reaching 890 days (Figure 7, middle). Arvor and Provor floats show the longest performance crossing the threshold of 1200 mission days (Figure 7, bottom).

For the floats deployed in the South Pacific, South Atlantic and Southern Ocean the maximal operating life is about 6.5 years, and the mean half-life is approaching two years (Figure 8). The longest performance is attributed to the Arvor floats with more than 1600 mission days (Figure 8, bottom).

Note that these survival rate statistics have to be interpreted with caution since most of the floats are still alive (33 floats out of 117 units for the Mediterranean and Black seas, 36 floats out of 72 in the Southern Hemisphere). Furthermore, these statistics include the floats with all the types of "end of operating life" (low battery power, stranding, involuntary and voluntary recovery, etc.).

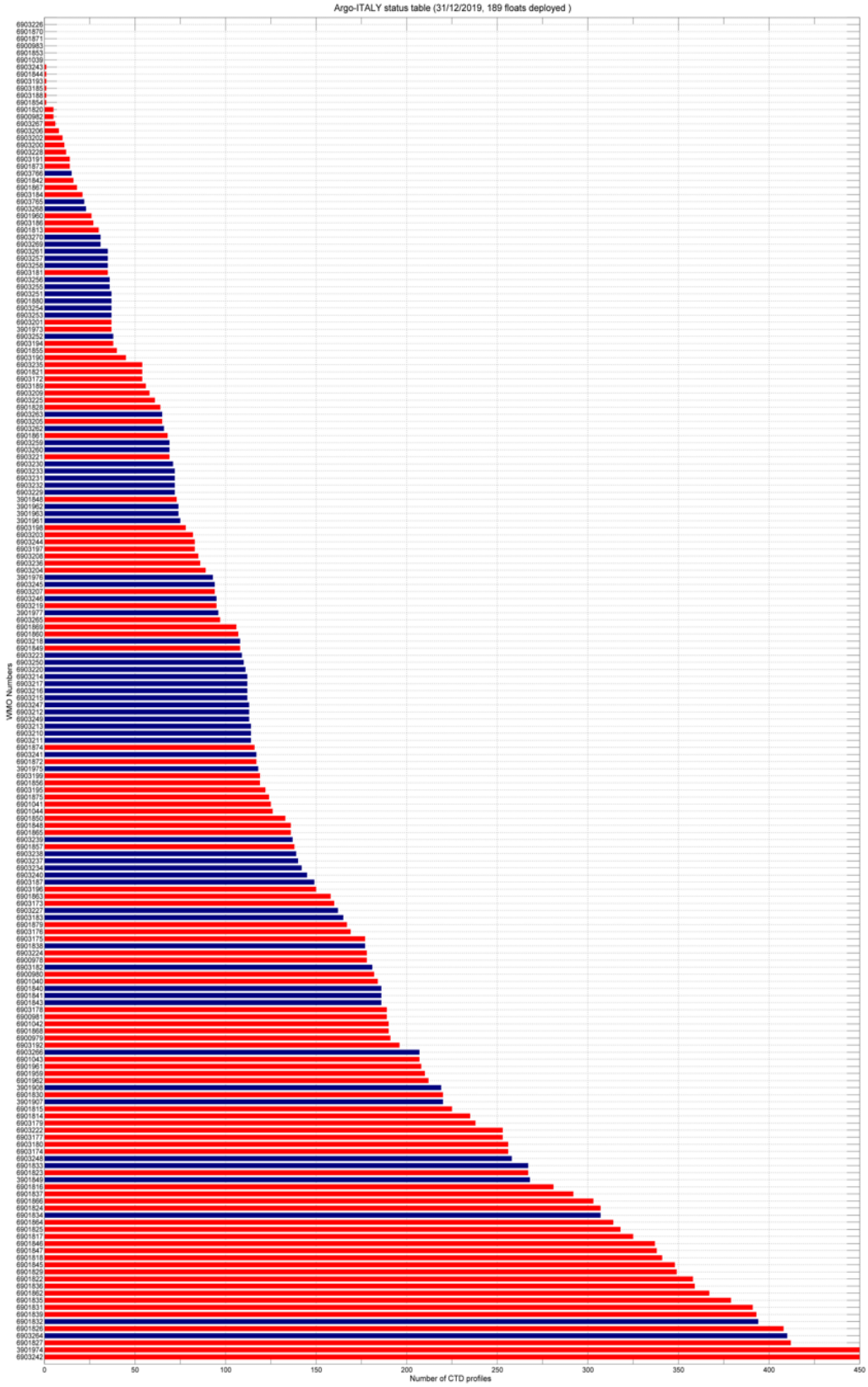

Figure 6. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2019).

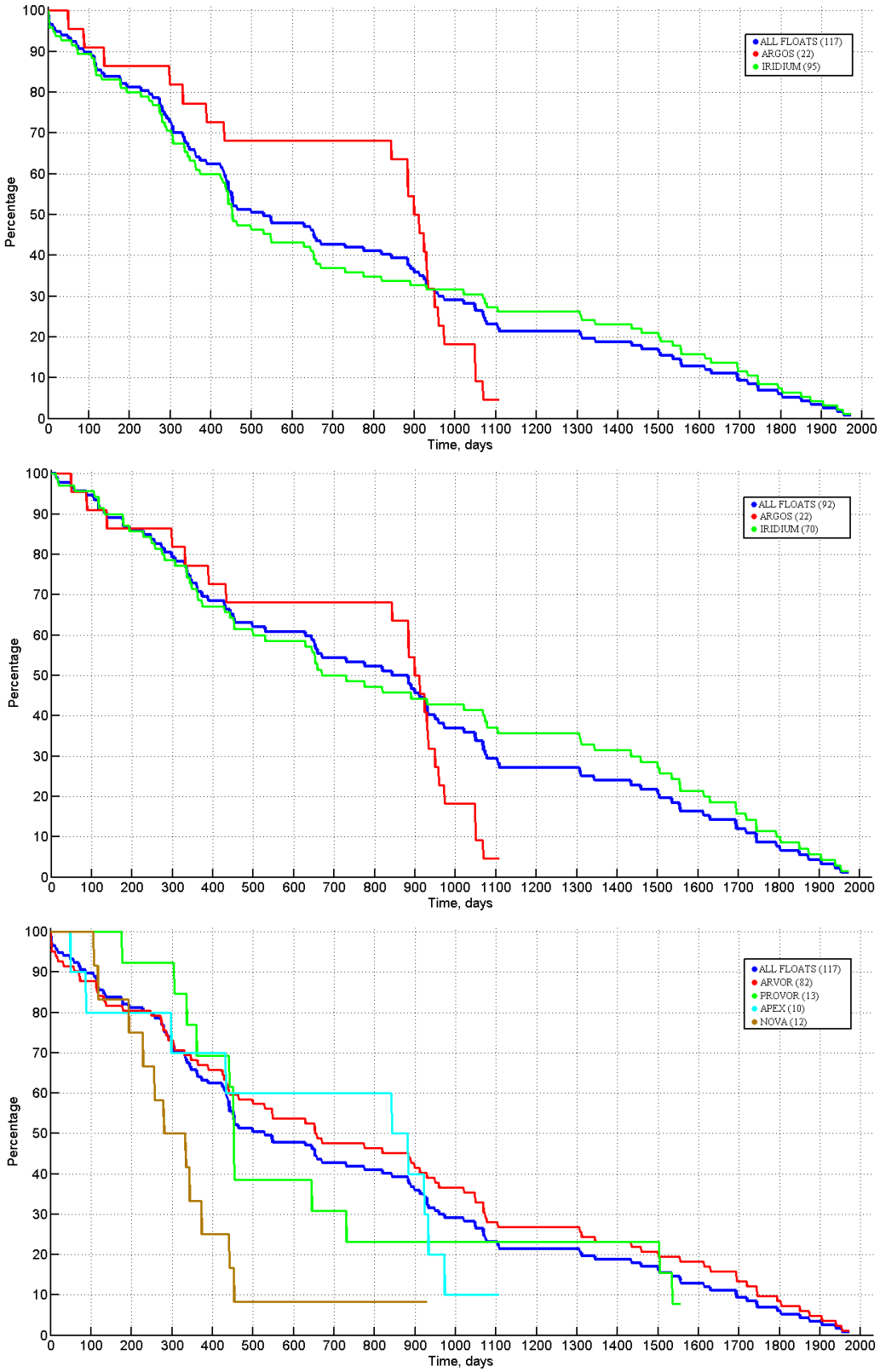

Figure 7. Survival rate diagrams for the ARGO-ITALY floats in the Mediterranean and Black seas, separated by transmission mode (top and middle) and float type (bottom).

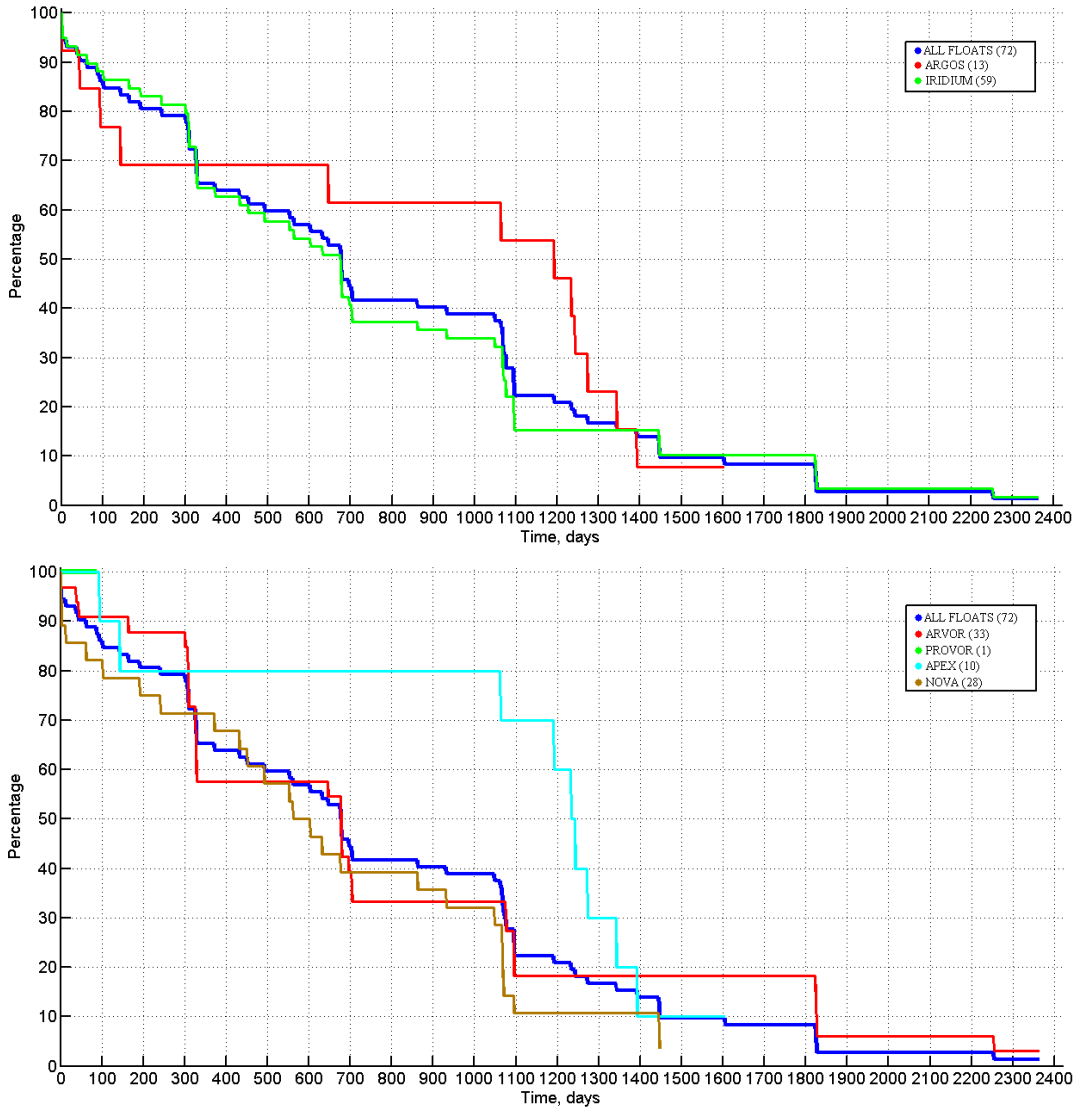

Figure 8. Survival rate diagrams for all the ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Ocean, separated by transmission mode (top) and float type (bottom).

Table 3 summarizes the main statistics of the ARGO-ITALY floats for the period 2012-2019. In 2019, more than 4500 CTD profiles were obtained with Italian Argo floats. These profiles provided data on a total vertical distance of more than 5000 km in 2019. For the period 2012-2019, the 189 floats of ARGO-ITALY provided data on a total vertical distance around 27000 km in about 24300 profiles.

Year	2012	2013	2014	2015	2016	2017	2018	2019	2012-2019
Deployments									
CTD floats deployed in Med	13	7	13	11	9	8	16	10	87
CTD floats deployed in BS	4	1	2	1	1	2	0	1	12
CTD floats deployed in SO, South Pacific and Atlantic	2	3	7	10	15	17	8	10	72
Bio floats deployed	0	0	3	4	1	0	5	0	13
Deep floats					2	0	1	2	5
Total floats deployed	**19**	**11**	**25**	**26**	**28**	**27**	**30**	**23**	**189**
CTD profiles									
CTD profiles in Med	400	1099	1560	1743	2358	2147	2962	2646	14915
CTD profiles in BS	105	236	323	268	260	298	298	280	2068
CTD profiles in SO, South Pacific and Atlantic	6	90	205	475	815	1418	1087	1200	5296
Bio profiles	0	0	244	266	373	261	360	410	1914
Deep profiles					15	65	11	20	111
Total profiles	**511**	**1425**	**2332**	**2752**	**3821**	**4189**	**4718**	**4556**	**24304**
Vertical distances (km)									
Distance in Med	440	902	1485	1813	2195	2307	2156	2037	13335
Distance in BS	71	210	283	257	247	294	295	287	1944
Distance in SO, Souther Pacific and Atlantic	2	125	380	875	1374	2658	2020	2260	9694
Distance of bio floats	0	0	199	245	335	248	293	392	1712
Distance of deep floats					50	194	43	69	356
Total distance (km)	**513**	**1237**	**2347**	**3190**	**4201**	**5701**	**4807**	**5045**	**27041**

Table 3. Statistical information on the performance of the ARGO-ITALY floats in 2012-2019.

3. Drifter activities in 2019

3.1 Drifter procurement

Drifters were not purchased in 2019 using ARGO-ITALY funding. All the drifter activities carried out in 2019 were managed using drifters purchased in 2017 and 2018.

3.2 Activities onboard R/V Laura Bassi

Five Italian SVP drifters were deployed in the Eastern Mediterranean during October 2019 (Figure 10), using the availability of the R/V Laura Bassi in transit from the Adriatic Sea to the Suez Canal. Table 4 shows the status information of these drifters. The drifter IMEI 300234065619150 was deployed along the Peloponnese coast (black track in Figure 10), whereas the other four drifters were deployed in the centre of the Levantine basin and were entrapped in the anticyclonic Mersa-Matruh gyre (green, magenta, red and blue tracks in Figure 10).

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status*
a300234065619150	22-Oct-2019 22:01	36.6	21.48	22-Nov-2019 17:04	36.05	23.05	A
a300234065618290	25-Oct-2019 11:56	33.62	27.18	13-Feb-2020 06:00	32.83	27.72	A
a300234065618270	25-Oct-2019 13:21	33.48	27.5	13-Feb-2020 06:00	32.57	27.23	A
a300234065618280	25-Oct-2019 16:02	33.24	28.11	13-Feb-2020 06:00	32.38	27.91	A
a300234065619140	25-Oct-2019 18:10	33.06	28.59	13-Feb-2020 06:00	34.63	32.58	A

**Status in February 2020: A = active, D = dead*

Table 4. Status information for the Italian drifters deployed from R/V Laura Bassi in October 2019.

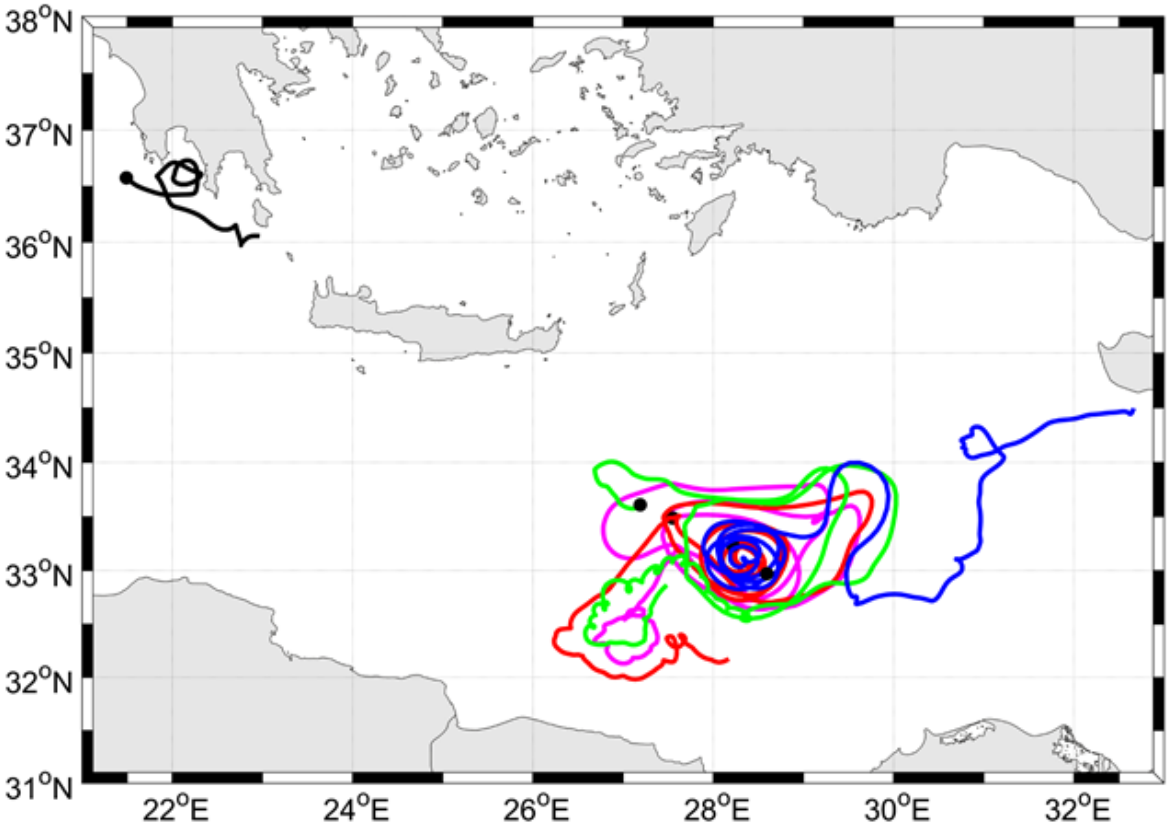

Figure 10. Trajectories and deployment positions (black dots) of five Italian drifters deployed in the eastern Mediterranean from the R/V Laura Bassi in October 2019.

3.3 Contribution to the MELMAS project

In 2019 the ARGO-ITALY contribution to the MELMAS project activity consists in 3 CODE-OGS, listed in Table 5. The trajectories of the MELMAS drifters are shown in Figure 11.

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status
bTrace18	20-Feb-2019 19:00	31.89	34.08	13-Apr-2019 15:17	36.29	35.6	D
bTrace19	20-Feb-2019 19:48	31.97	34.08	13-Apr-2019 14:39	35.73	34.88	D
bTrace20	20-Feb-2019 20:35	32.05	34.08	11-Apr-2019 18:36	34.11	34.98	D

**Status in February 2020: A = active, D = dead*

Table 5. Status information for the Italian CODE drifters deployed in the Levantine Basin in February 2019.

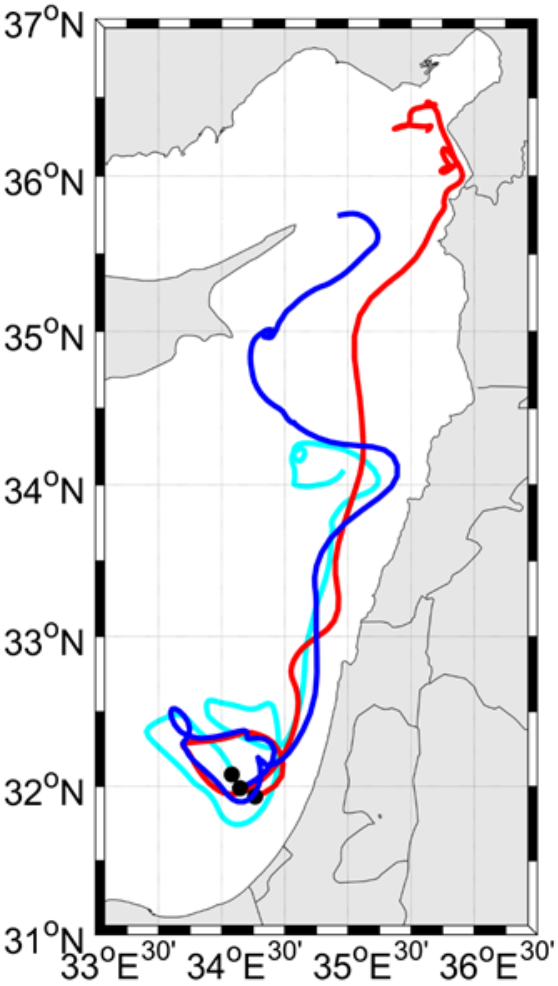

Figure 11. Trajectories of the CODE-OGS drifters deployed in the Levantine Basin during February 2019.

3.4 Monitoring of the Tyrrhenian coast

Two CODE-OGS drifters, given in 2018 to colleagues of the LOSEM (Laboratorio di Oceanologia Sperimentale ed Ecologia Marina) laboratory, University of Tuscia, were used in 2019 to monitor the circulation of the Tyrrhenian coast (see Table 6). Two drifters were deployed in March 2019 in the Gulf of Gaeta; their trajectories are shown in Figure 12. Other two drifters were deployed in July 2019 along the Civitavecchia coast; their trajectories are shown in Figure 13. Further details about these experiments, their motivation and comparisons with other data can be found in Martellucci et al. (2019).

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status*
lTrace27	22-Mar-2019 06:54	41.24	13.59	22-Mar-2019 11:00	41.23	13.58	D
jTrace28	22-Mar-2019 06:58	41.24	13.59	22-Mar-2019 10:57	41.23	13.58	D
lTrace28	09-Jul-2019 12:20	41.77	12.22	11-Jul-2019 18:30	41.93	12.07	D
mTarce28	19-Jul-2019 06:13	41.77	12.23	20-Jul-2019 14:09	41.83	12.2	D

**Status in February 2020: A = active, D = dead*

Table 6. Status information for the Italian drifters deployed off the Civitavecchia coast.

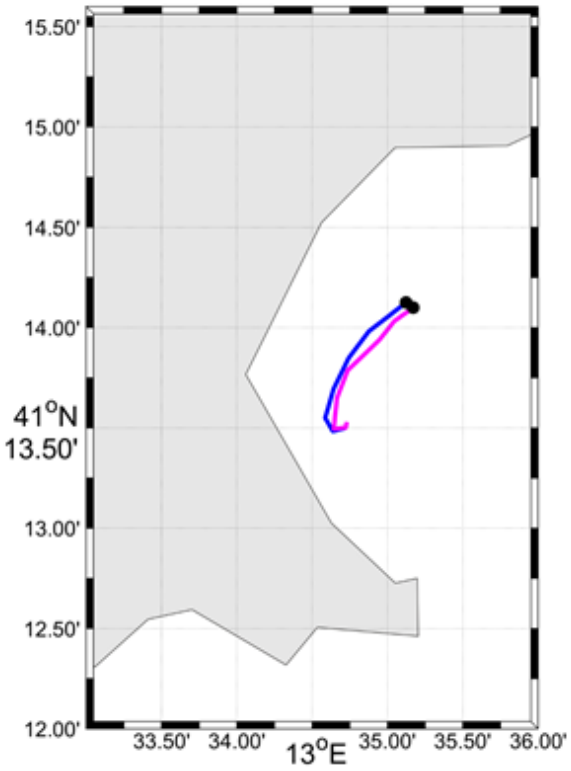

Figure 12. Trajectories of the CODE-OGS drifters deployed in the Gulf of Gaeta during March 2019.

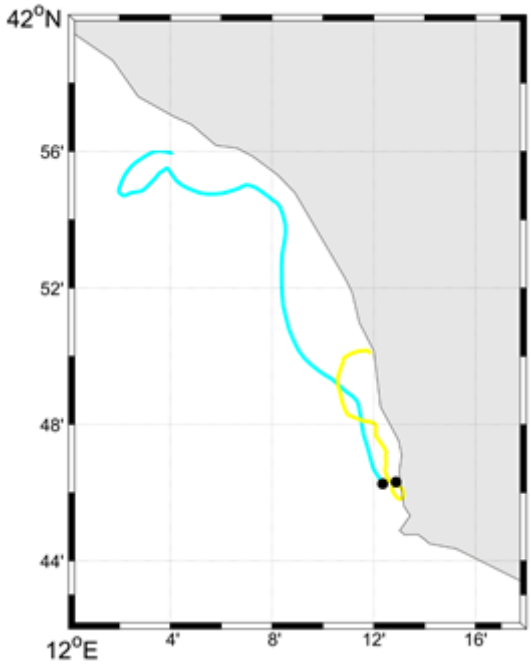

Figure 13. Trajectories of the CODE-OGS drifters deployed off the Civitavecchia coast during July 2019.

3.5 Contribution to LOGMEC 2019

Nine CODE-OGS low-cost drifters and one DWS were released in the Ligurian Sea in support of the LOGMEC19 experiment (LOng-term Glider Missions for Environmental Characterization 2019) in May 2019 (Table 7; Figure 14). This experiment was realized in collaboration with CNR-ISMAR and CMRE, to study surface circulation/dispersion and to calibrate the CNR HF radar system.

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status*	Type
aTrace35	02-May-2019 09:13	43.81	9.95	25-Jul-2019 19:01	42.31	6.47	D	CODE
aTrace42	02-May-2019 09:34	43.81	9.95	03-Aug-2019 17:30	41.07	1.14	D	CODE
aTrace40	02-May-2019 09:44	43.81	9.94	30-Aug-2019 20:22	41.61	6.43	D	CODE
aTrace41	02-May-2019 10:11	43.8	9.93	04-Aug-2019 21:54	41.55	6.65	D	CODE
aTrace37	02-May-2019 10:19	43.79	9.94	12-May-2019 10:12	43.51	7.48	D	CODE

aTrace38	02-May-2019 10:26	43.79	9.93	12-May-2019 13:00	43.57	7.54	D	CODE
aTrace43	02-May-2019 10:49	43.79	9.92	20-Jul-2019 00:13	40.94	6.87	D	CODE
aTrace36	02-May-2019 10:54	43.78	9.92	14-Aug-2019 19:12	39.79	8.11	D	CODE
aTrace39	02-May-2019 11:01	43.78	9.91	23-Jul-2019 00:35	41.56	6.51	D	CODE
a300234065414430	02-May-2019 11:10	43.78	9.91	08-May-2019 15:01	44.36	8.59	D	DWS

**Status in February 2020: A = active, D = dead*

Table 7. Status information for the Italian CODE and DWS drifters deployed in the Ligurian Sea in May 2019.

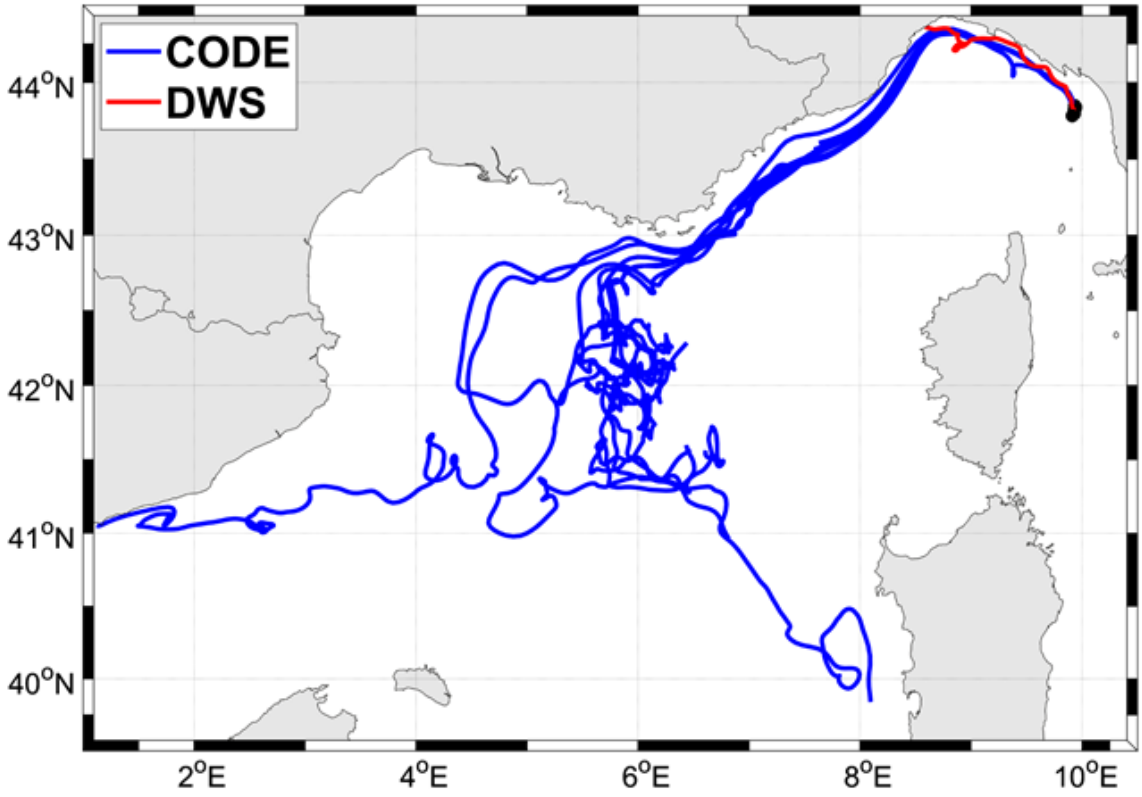

Figure 14. CODE (blue tracks) and DWS (red track) drifters deployed in the Ligurian Sea in May 2019.

3.6 Deployments of SVP drifters in the Southern Ocean

Table 8 shows the status information of the ten SVP drifters deployed in February and March 2019 in the South Pacific (Figure 15) and South Atlantic (Figure 16) from R/V Araon and R/V Agulhas II, respectively, with the help of Italian colleagues as a contribution to the PNRA (Programma Nazionale di Ricerca in Antartide) project. Six of these drifters were still alive in February 2020 (Table 8).

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status*
a300234065710080	09-Feb-2019 09:42	-55.03	167.72	13-Feb-2020 18:04	-49.79	-166.81	A
a300234065619570	09-Feb-2019 18:25	-57	168.18	14-Feb-2020 04:04	-47.87	-145.54	A
a300234065710130	10-Feb-2019 03:08	-59.01	168.58	14-Feb-2020 06:00	-51.18	-125.99	A
a300234065710210	10-Feb-2019 11:45	-61.01	168.94	14-Feb-2020 05:00	-56.88	-140.02	A
a300234065710170	10-Feb-2019 20:28	-63.01	169.33	14-Feb-2020 06:00	-56.87	-129.3	A
a300234065619160	28-Feb-2019 17:30	-63.99	0	16-Aug-2019 00:00	-62.79	-1.34	D
a300234065619540	28-Feb-2019 21:15	-63	-0	14-Jul-2019 02:28	-59.08	-0.02	D
a300234065619170	01-Mar-2019 03:10	-62	0	18-Sep-2019 01:49	-55.76	20.82	D
a300234065619520	01-Mar-2019 20:34	-59.92	-4.5	29-Jul-2019 02:00	-56.77	4.22	D
a300234065619180	08-Mar-2019 19:20	-59.92	-4.5	14-Feb-2020 06:00	-44.48	50.68	A

**Status in March 2018: A = active, D = dead*

Table 8. Status information for the Italian drifters deployed in the South Pacific and South Atlantic (Southern Ocean) in 2019.

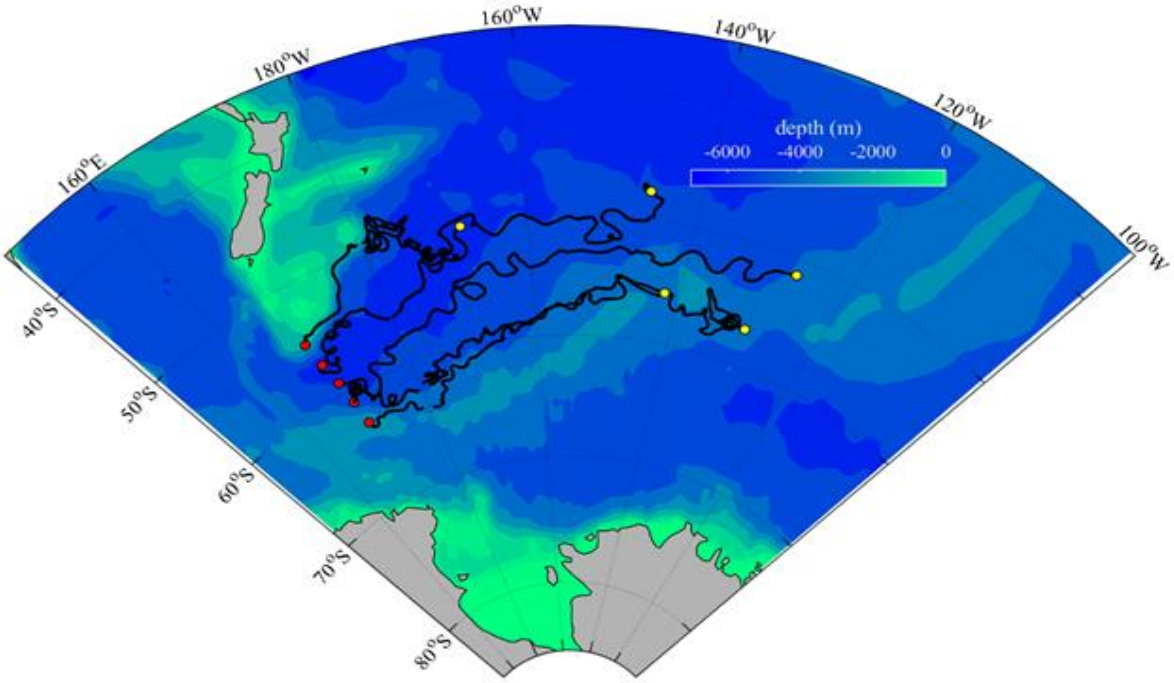

Figure 15. Trajectories, deployment positions (red dots) and last positions (yellow dots) of the five Italian drifters deployed in the South Pacific in February 2019. Drifter data are updated to February 2020.

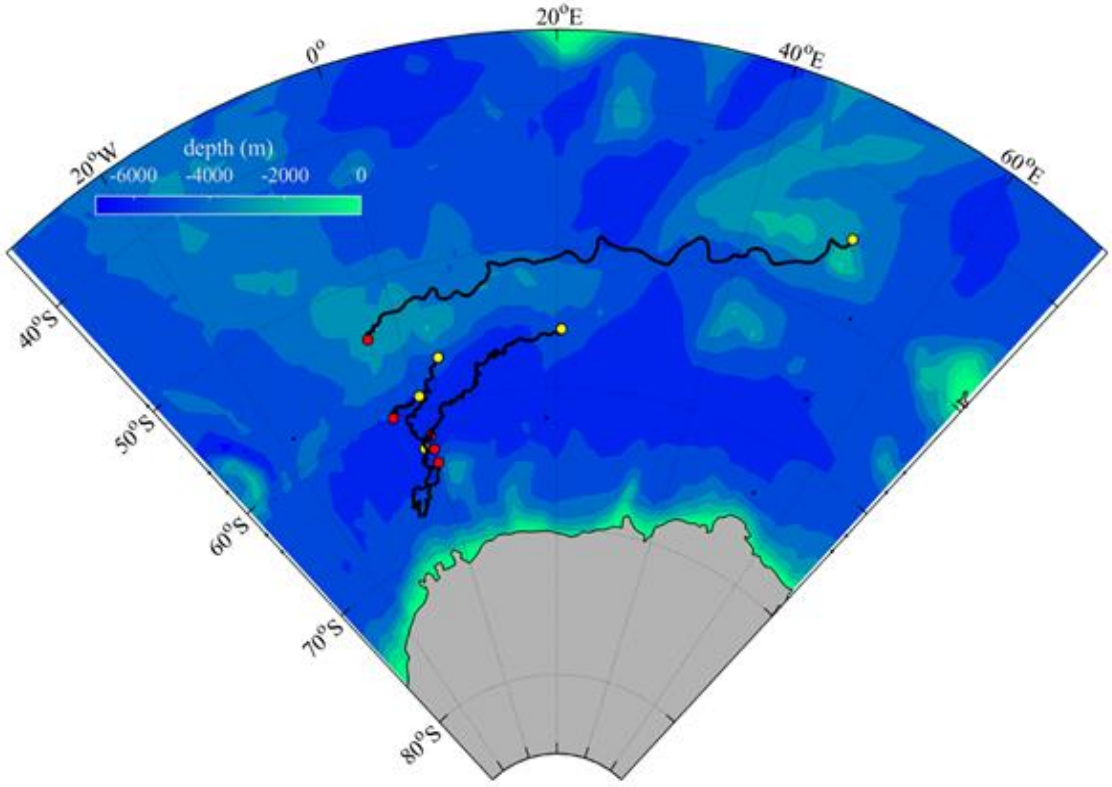

Figure 16. Trajectories, deployment positions (red dots) and last position (yellow dots) of the five Italian drifters deployed in the South Atlantic in February-March 2019. Drifter data are updated to February 2020.

3.7 Deployments of SVP drifters in the North Atlantic Ocean

Three drifters were deployed in the tropical North Atlantic Ocean, off the Senegal coast, in June 2019 (Table 9; Figure 17). They were operated in water only for a few days before being picked up prematurely by local fishermen.

IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Status
a300234063466260	20-Jun-2019 08:08	13.94	-17.02	06-Jul-2019 09:00	13.96	-16.91	D
a300234063461270	20-Jun-2019 08:33	13.9	-17.04	20-Jun-2019 13:00	13.84	-17.02	D
a300234063463240	20-Jun-2019 08:52	13.93	-17.07	24-Jun-2019 14:00	13.93	-17.01	D
a300234063465240	20-Jun-2019 09:29	13.97	-17.05	24-Jun-2019 14:00	13.96	-16.96	D

Table 9. Status information for the Italian drifters deployed in the North Atlantic Ocean in 2019.

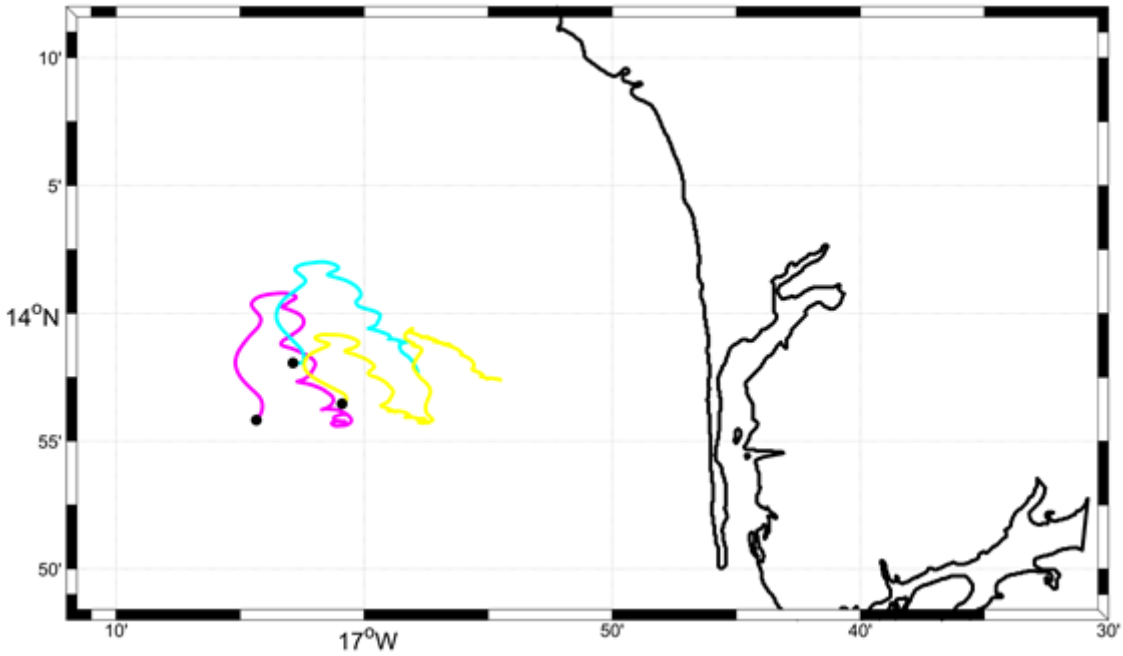

Figure 17. Trajectories of the three SVP italian drifters deployed in the North Atlantic Ocean, off the southern Senegal coast, in June 2019.

4. Glider activities in 2019

4.1 Glider component procurement and glider maintenance

In fall 2018, the SeaGlider "Amerigo" was sent to the factory for sensor calibration, battery replacement and firmware update. It returned to OGS, after one year, in fall 2019.

4.2 Glider testing

The gliders were tested before their deployment. In particular, the Slocum glider "unit 403" was tested at the OGS laboratory in January 2019 and was ballasted for the South Adriatic Sea waters. The SeaGlider "Amerigo" and its entire processing chain were extensively tested after the refurbishment at the factory and the update of the glider and base-station firmwares starting in October 2019.

4.3 Glider laboratory

In 2019, only consumable goods were purchased for the OGS glider laboratory.

4.4 Glider operations

The OGS Slocum glider "unit 403" was deployed in the South Adriatic Sea on 29 January 2019 for the CONVEX19 experiment (Figure 16). The purpose of the experiment was to study the post convection and the effect of the deep water formation in the South Adriatic Sea. The glider covered the transect Bari – Dubrovnik and was recovered after 10 days on 9 February 2019. The instrument collected the following data: pressure, temperature, conductivity (salinity) and oxygen down to almost 1000 m depth. The chlorophyll, CDOM and backscatter data were collected from the surface to 400 m depth for the first half of the mission and then down to the maximum depth reached by the glider (Figure 17).

The SeaGlider "Marco" was deployed on 12 February 2019 southeast of Cyprus for the MELMAS project (Figure 18). The main goal of the MELMAS (Monitoring of the Eastern Levantine with Mobile Autonomous Systems) project is to measure the currents and water mass properties in the eastern areas of the Levantine Basin (Eastern Mediterranean Sea) and to study the complex circulation features governing the dynamics near the Israeli coast and in the open sea. The glider covered 1200 km and was recovered on 18 April 2019 after 64 days at sea. The instrument collected scientific data (pressure, temperature, conductivity, oxygen, chlorophyll, CDOM and backscatter) down to almost 1000 m depth (600 m for the biological parameters; see Figure 19).

The SeaGlider "Amerigo" was successfully operated across the South Adriatic Sea from 21 November to 1 December 2019 (PreConvex20 experiment; Figure 20). The purpose of the experiment was to study the pre-convection condition of the water column in the North Adriatic Sea. The glider covered the transect Bari – Dubrovnik. It was piloted down to almost 1000 m depth in the area of the Pit, collecting high frequency data of pressure, temperature, conductivity, oxygen, chlorophyll, CDOM and backscatter (Figure 21).

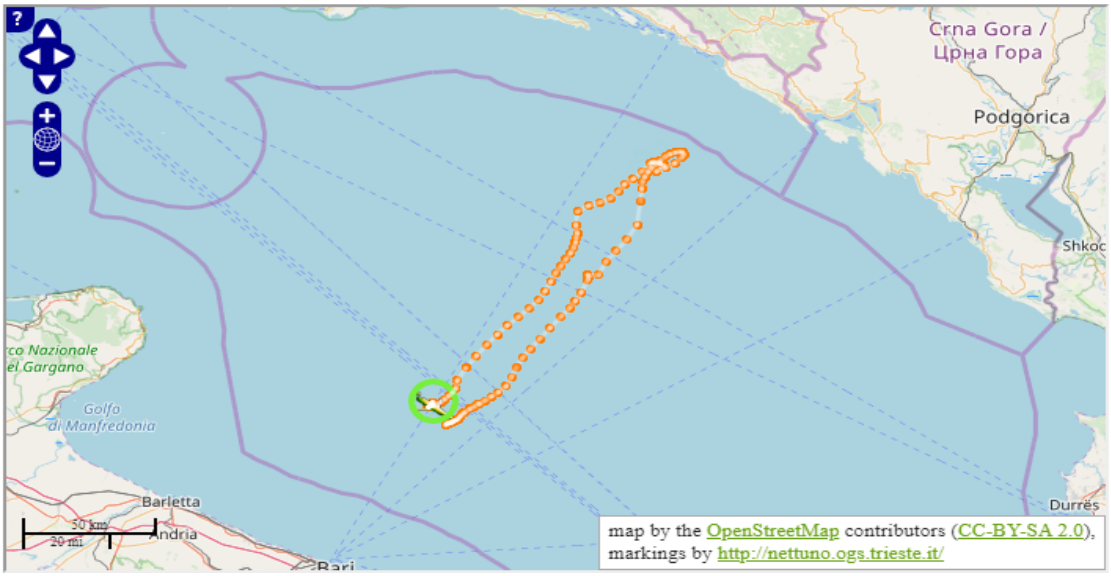

Figure 16. Glider "unit 403" trajectory during the CONVEX19 experiment in the South Adriatic Sea. The glider symbol indicates the last position of the instrument. Orange symbols correspond to surfacing locations.

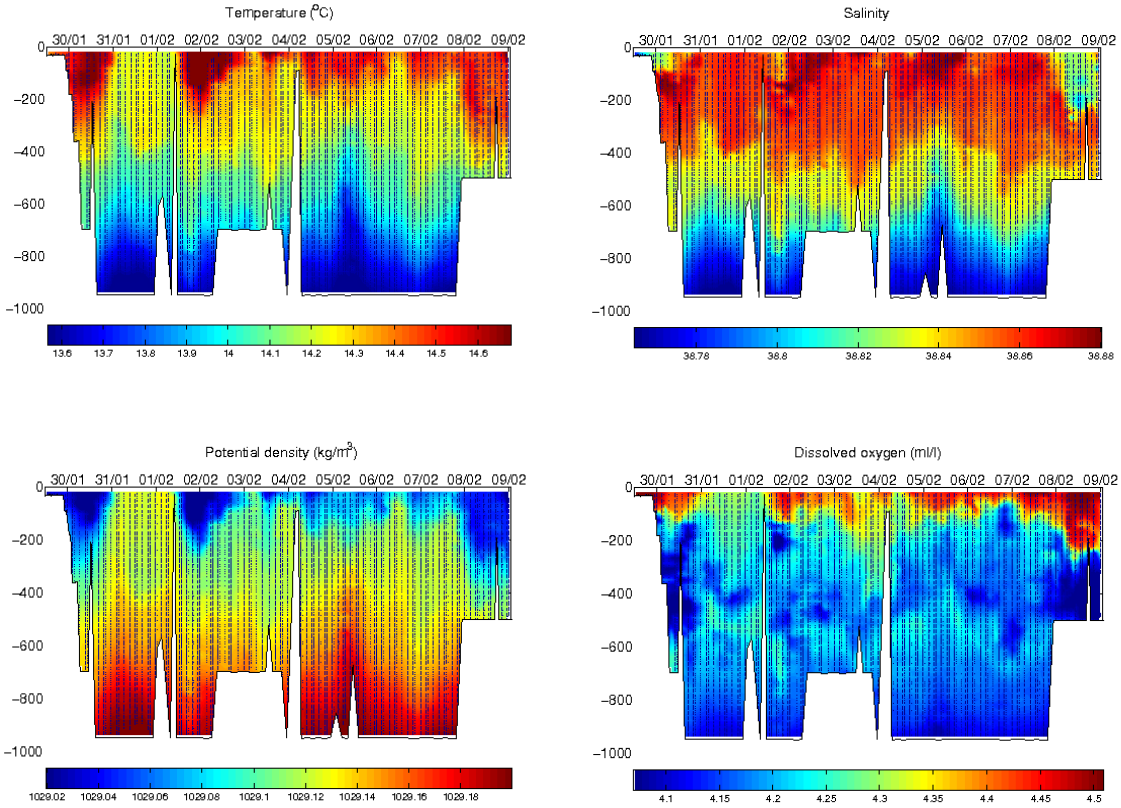

Figure 17. Color-coded vertical section along the glider path of temperature (top-left), salinity (top-right), potential density (bottom-left) and dissolved oxygen (bottom-right) during the CONVEX19 experiment in the South Adriatic Sea.

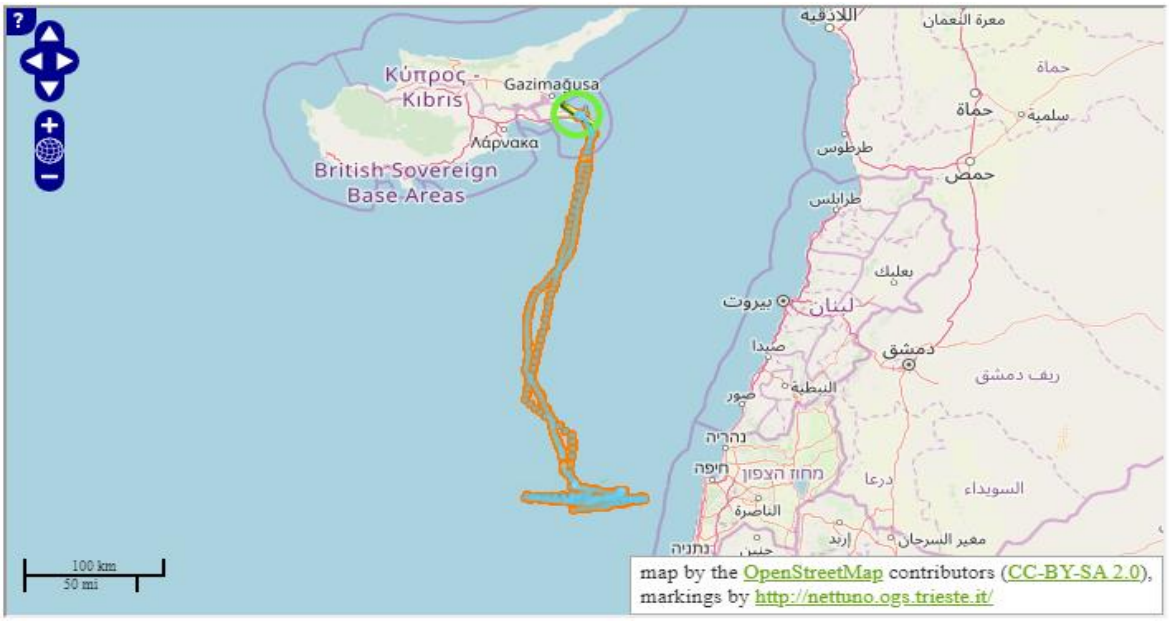

Figure 18. SeaGlider "Marco" trajectory during the MELMAS experiment south of Cyprus. The glider and the green circle symbols indicate the last position of the instrument and the last waypoint, respectively. Orange symbols correspond to surfacing location.

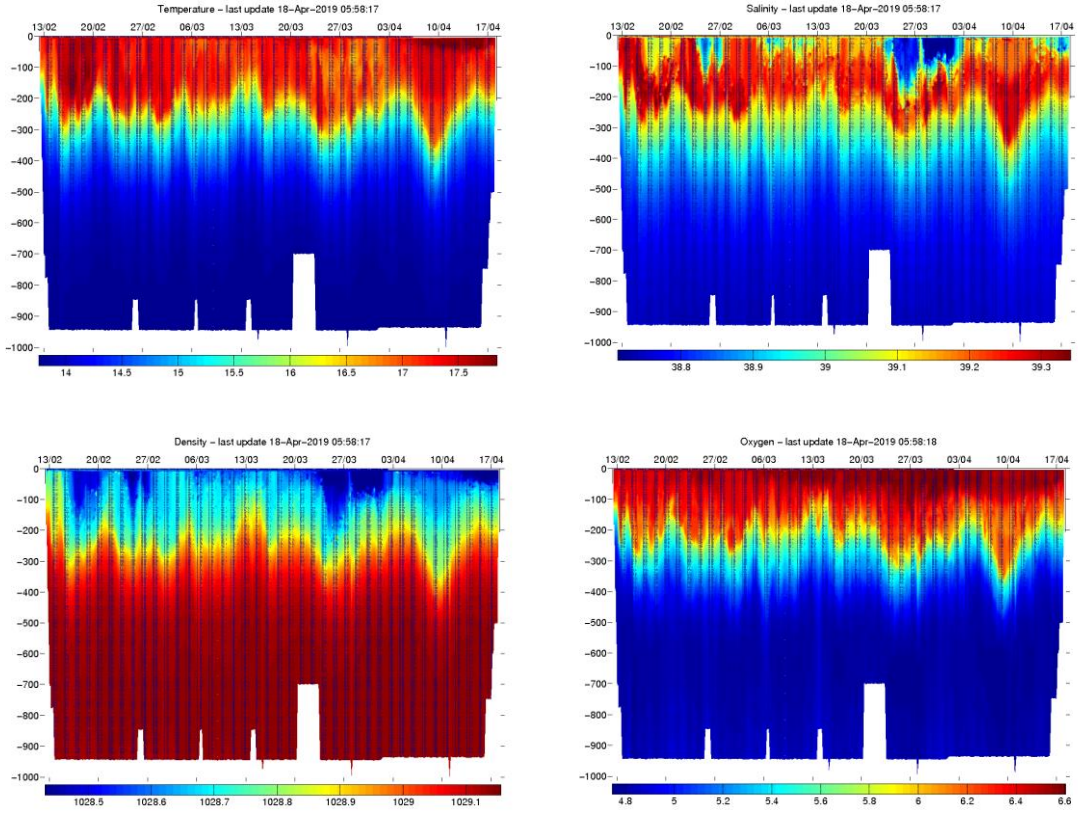

Figure 19. Color-coded vertical section along the glider path of temperature (top-left), salinity (top-right), density (bottom-left) and dissolved oxygen (bottom-right) during the MELMAS experiment (12 February - 18 April 2019).

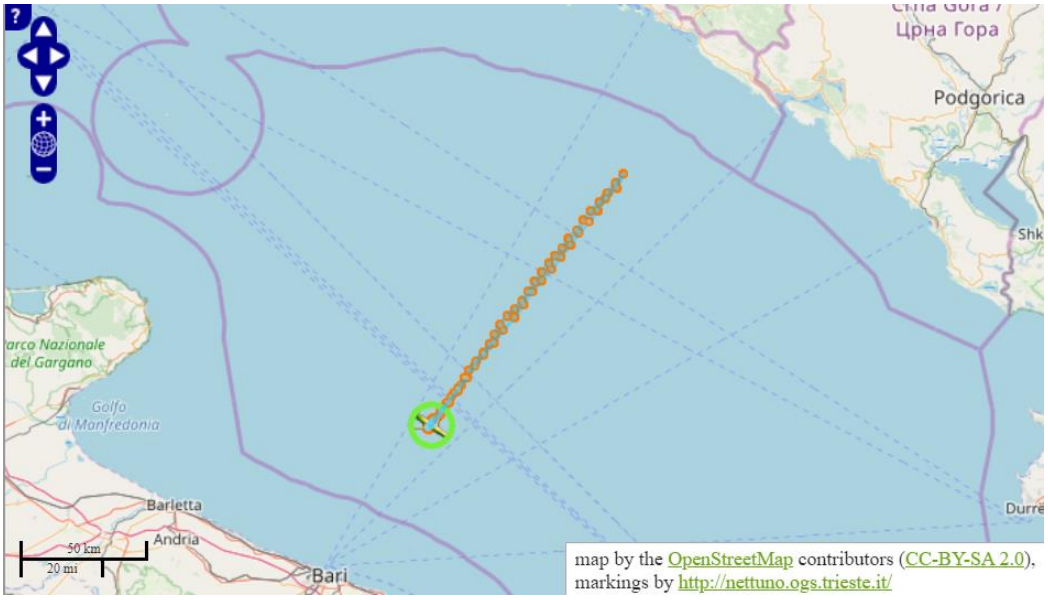

Figure 20. SeaGlider "Amerigo" trajectory during the PreCONVEX20 experiment in the South Adriatic Sea. The glider and the green circle symbols indicate the last position of the instrument and the last waypoint, respectively. Orange symbols correspond to surfacing locations.

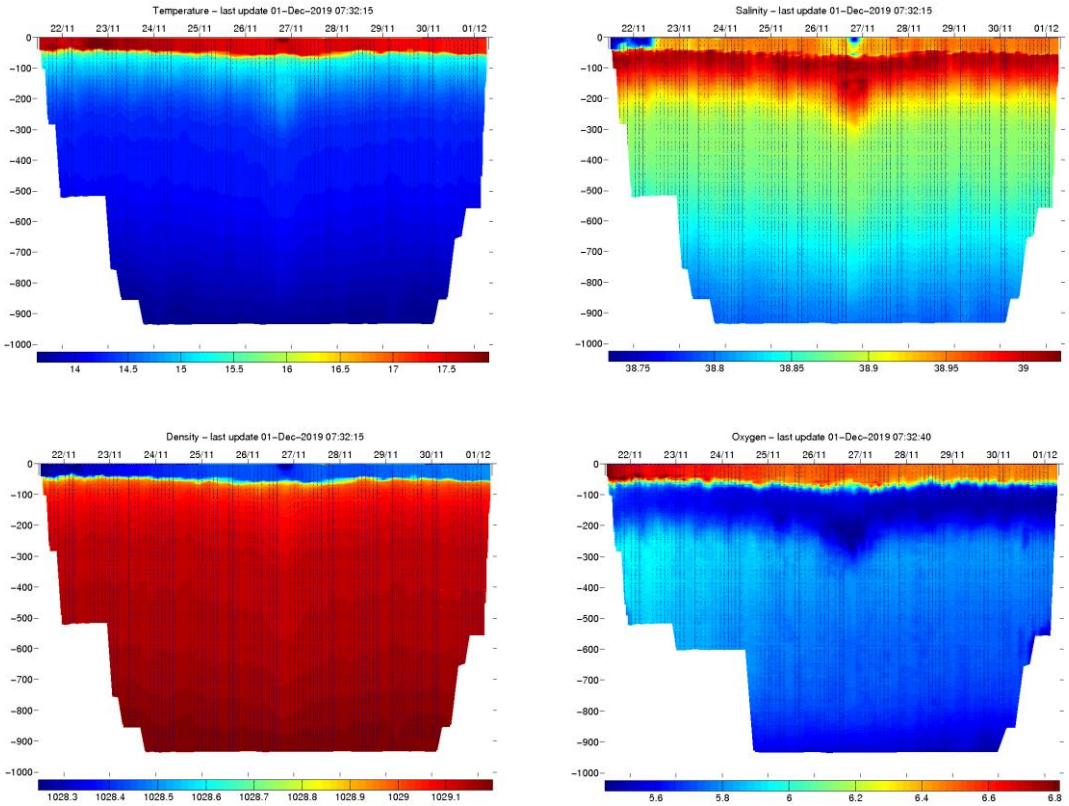

Figure 21. Color-coded vertical section along the glider path of temperature (top-left), salinity (top-right), density (bottom-left) and dissolved oxygen (bottom-right) during the PreCONVEX20 experiment (21 November - 1 December 2019).

4.5 Glider data processing and webpage

The glider data acquired during all the missions were processed and displayed in real time on the webpage: http://nettuno.ogs.trieste.it/sire/glider/glider_mission_now.php. The scripts and the webpage were improved and optimized for the real-time data elaboration and generation of images.

Other webpages (password protected) with technical information and other parameters were available in real time to the OGS glider pilots.

5. Other activities in 2019

5.1 Near real-time data processing

The data of drifters, floats and gliders were processed and archived in near real-time at OGS. This processing includes some editing and the production of graphics and tables which are posted on the ARGO-ITALY web pages. In parallel, the raw drifter and float data were sent to global Data Assembly Centers (AOML/NOAA, Miami, Florida for the drifters and Coriolis, Ifremer, Brest, France for the floats). In addition, the SVP drifter and float data were distributed in near real-time on the Global Telecommunication System (GTS) and were identified by a WMO number.

The data of BGC and Bio floats were processed by Coriolis and made available in near-real time (files in Argo NetCDF format with real time QC) on the DAC server (ftp.ifremer.fr/ifremer/argo/dac/coriolis).

5.2 Delayed Mode quality control of Argo physical data

The delayed mode quality control (DMQC) of the physical data (pressure, temperature and salinity) provided by the Italian floats in the Mediterranean and Black seas was done for 58 floats (all information and statistics to create the D-files sent to Coriolis). The temperature and salinity data of those floats were quality controlled following the standard Argo procedure, covering the period 2010-2018. The float salinity calibration needs an accurate reference dataset and these data have to be quite close in time and space to the float measurements. The latter is necessary, in order to reduce the effects of both the inter-annual and the seasonal variability of the Mediterranean Sea, mostly in the upper and intermediate layers of the water column. For this reasons, OGS collected CTD data in complement of the official reference dataset using two approaches: personal contacts and regional data services. The standard statistical method adopted by the Argo community for the salinity correction is strictly affected by the natural changes in the water column of the Mediterranean Sea and hence a careful interpretation of the method results is necessary. For this reason, we adopted other qualitative checks (i.e., the comparison between nearby floats and analysis of the deepest portion of the temperature-salinity diagram) in order to increase reliability of the analysis. The DMQC of the Italian floats deployed in the Southern Ocean (and South Pacific and Atlantic oceans) started in 2019 and was applied to 22 floats.

5.3 Italian contribution to Argo bibliography in 2019

The following papers involving Italian scientists were published in 2019. They use Argo data for basic oceanographic research and operational oceanography purposes.

Callieri, C.; Slabakova, V.; Dzhembekova, N.; Slabakova, N.; Peneva, E.; Cabello-Yeves, P. J.; Di Cesare, A.; Eckert, E. M.; Bertoni, R.; Corno, G.; Salcher, M. M.; Kamburska, L.; Bertoni, F.; Moncheva, S. (2019). The mesopelagic anoxic Black Sea as an unexpected habitat for Synechococcus challenges our understanding of global "deep red fluorescence". The ISME Journal 13, pages 1676–1687, 2019.

Ciani, D.; Santoleri, R.; Liberti, G. L.; Prigent, C.; Donlon, C.; Buongiorno Nardelli, B. (2019). Copernicus Imaging Microwave Radiometer (CIMR) Benefits for the Copernicus Level 4 Sea-Surface Salinity Processing Chain. Remote Sensing 2019, 11(15), 1818; https://doi.org/10.3390/rs11151818.

Ciappa, A. (2019). A study on causes and recurrence of the Mid-Mediterranean Jet from 2003 to 2015 using satellite thermal and altimetry data and CTD casts. Journal of Operational Oceanography. https://doi.org/10.1080/1755876X.2019.1632617.

Cossarini, G.; Mariotti, L.; Feudale, L.; Mignot, A.; Salon, S.; Taillandier, V.; Teruzzi, A.; D'Ortenzio, F. (2019). Towards operational 3D-Var assimilation of chlorophyll Biogeochemical-Argo float data into a biogeochemical model of the Mediterranean Sea. Ocean Modelling Volume 133, January 2019, Pages 112-128.

Ferrarin, C.; Davolio, S.; Bellafiore, D.; Ghezzo, M.; Maicu, F.; Mc Kiver, W.; Drofa, O.; Umgiesser, G.; Bajo, M.; De Pascalis, F.; Malguzzi, P.; Zaggia, L.; Lorenzetti, G.; Manfè, G. (2019). Cross-scale operational oceanography in the Adriatic Sea. Journal of Operational Oceanography 86-103.

Mauri E., Sitz L., Gerin R., Poulain P.-M., Hayes D. and Gildor H. (2019). On the Variability of the Circulation and Water Mass Properties in the Eastern Levantine Sea between September 2016–August 2017. Water 2019, 11, 1741 24 pp.

Menna M., Poulain P.-M., Ciani D., Doglioli A., Notarstefano G., Gerin R., Rio M.-H, Santoleri R., Gauci A. and Drago A. (2019). New Insights of the Sicily Channel and Southern Tyrrhenian Sea Variability. Water 2019, 11(7), 1355.

Kokkini Z., Mauri E., Gerin R., Poulain P.-M., Simoncelli S. and Notarstefano G. (2019). On the salinity structure in the South Adriatic as derived from float and glider observations in 2013–2016. Deep-Sea Research Part II.

Kubin E., Poulain P.-M., Mauri E., Menna M. and Notarstefano G. (2019). Levantine Intermediate and Levantine Deep Water Formation: An Argo Float Study from 2001 to 2017. Water 2019, 11, 1781.

Napolitano E., Iacopo R., Ciuffari T., Reseghetti F., Poulain P.-M. and Notarstefano G. (2019). The Tyrrhenian Intermediate Water (TIW): Characterization and formation mechanisms. Progress in Oceanography 170 (2019) 53–68.

Pinardi, N.; Cessi, P.; Borile, F.; Wolfe, C. L. P. (2019). The Mediterranean Sea Overturning Circulation. Journal of Physical Oceanography. https://doi.org/10.1175/JPO-D-18-0254.1

Salon, S.; Cossarini, G.; Bolzon, G.; Feudale, L.; Lazzari, P.; Teruzzi, A.; Solidoro, C.; Crise, A. (2019). Novel metrics based on Biogeochemical Argo data to improve the model uncertainty evaluation of the CMEMS Mediterranean marine ecosystem forecasts. Ocean Sci. 15, 997–1022.

Sciascia, R.; Magaldi, M. G.; Vetrano, A. (2019). Current reversal and associated variability within the Corsica Channel: The 2004 case study. Deep Sea Research Part I: Oceanographic Research Papers Volume 144, February 2019, Pages 39-51.

Storto, A.; Masina, S.; Simoncelli, S.; Iovino, D.; Cipollone, A.; Drevillon, M.; Drillet, Y.; von Schuckman, K.; Parent, L.; Garric, G.; Greiner, E.; Desportes, C.; Zuo, H.; Balmaseda, M. A.; Peterson, K. A. (2019). The added value of the multi-system spread information for ocean heat content and steric sea level investigations in the CMEMS GREP ensemble reanalysis product. Climate Dynamics 53, pages 287–312.

Terzić, E.; Lazzari, P.; Organelli, E.; Solidoro, C.; Salon, S.; D'Ortenzio, F.; Conan, P. (2019). Merging bio-optical data from Biogeochemical-Argo floats and models in marine biogeochemistry. Biogeosciences 16, 2527–2542, 2019.

Troupin C., Pascua A., Ruiz S., Olita A., Casa B., Margirier F., Poulain P.-M., Notarstefano G., Torner M., Fernandez J. G., Rujula M. A., Muñoz C., Alou E., Ruiz I., Tovar-SÁNCHEZ A., Allen J. T., Mahadevan A., and TINTORÉ J. (2019). The AlborEX dataset: sampling of sub-mesoscale features in the Alboran Sea. Earth Syst. Sci. Data, 11, 129–145, 2019.

Yang, C.; Storto, A.; Masina, S. (2019). Quantifying the effects of observational constraints and uncertainty in atmospheric forcing on historical ocean re-analyses. Climate Dynamics 52, pages 3321–3342.

5.4 OGS technical reports related to ARGO-ITALY published in 2019

Notarstefano G. (2019). The reference dataset in the Mediterranean and Black Seas for DMQC activity. 2019/15 OCE 3 MAOS.

Pacciaroni M., Poulain P.-M., Notarstefano G. and Bussani A. (2019). High-frequency data of Arvor-I WMO 6903242 South of Malta. Rel. 2019/26 Sez. OCE 8 MAOS.

Poulain P.-M., Gerin R., Mauri E., Menna M., Notarstefano G., Bussani A., Zuppelli P. and Pacciaroni M. (2019). ARGO-Italy: annual report 2018. Rel. 2019/23 Sez. OCE 7 MAOS.

Poulain P.-M., Ozgokmen T, Guigand C., Gino C. and Centurioni L. (2019). CALYPSO 2019 EXPERIMENT 28 March – 10 April 2019 R/V POURQUOI PAS? Lagrangian Drifter and Float Deployments. 2019/28 Sez. OCE 10 MAOS 24 pp.

6. Plans for 2020 and beyond

6.1 Floats

With the funding available in 2019-2020, we plan to acquire the following instruments:

- 20 standard Argo floats with Iridium telemetry. Five of these floats will have additional oxygen sensors. Seven will have the Ice Sensing algorithm (ISA);
- 2 Arvor-Deep floats that provide profiles of temperature and salinity up to 4000 m deep.

The Italian deployment plans for 2020 and 2021 are detailed in Table 9. The main areas of interest are the Mediterranean and Black seas and the Southern Ocean.

Year	T/S floats (some of them with DO)		BGC floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2020	11 2 12	Mediterranean Black Sea South Hemisphere	1	Mediterranean Black Sea	2	Mediterranean	**28**
2021	14 2 10	Mediterranean Black Sea South Hemisphere	1	Mediterranean Black Sea	1	Mediterranean	**28**

Table 9. Italian float deployment plans for 2020-2021.

On the longer time frame, Italy is interested to maintain contributions to the Argo Core mission and the BGC and Deep Argo Extension with numbers similar to those listed in Table 9. OGS is committed to carry out DMQC on all the Argo floats of the Mediterranean and Black seas, and on some floats in the World Ocean, as part of the CMEMS, Euro-Argo RISE and other European projects over the coming years.

6.2 Drifters

We are in the process to buy 80 new drifters with the funding available in 2019-2020. Drifter deployment plans for 2020 and 2021 are described in Table 10.

Year	SVP drifters	
	Quantity	Area
2020	24 16	Southern Ocean Mediterranean
2021	20 20	Southern Ocean Mediterranean

Table 10. ARGO-ITALY drifter deployment plans for 2019-2020.

6.3 Gliders

After the January 2019 mission, the OGS Slocum Gliders have been sent to Teledyne to be completely checked and refurbished. The delivery of the two glider was delayed to the beginning of 2020.

The OGS Slocum Gliders are planned to be operated in the South Adriatic Sea to monitor pre and post dense water formation phases. One of the Seagliders will be operated as part of the ESTRO project in the Antarctica in winter 2020.

6.4 Other

MIUR is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2019 as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from other projects for activities related to Argo.

7. Distribution list

This report will be distributed, amongst others, to the ARGO-ITALY International Scientific Advisory Committee:

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Nadia Pinardi (n.pinardi@sincem.unibo.it)

8. Acknowledgements

We would like to thank the following individuals for their help with the logistics of drifter, float and glider operations:

Stefano Kuckler
OGS, Trieste, Italy

Saliou Faye
Centre de Recherche Oceanographique de Dakar Thiaroye (CRODT-ISRA), Maristella Berta ISMAR-CNR,

Pierpaolo Falco, Yuri Cotroneo, Luigi Marziani, Pasquale Castagno and Giorgio Budillon
Parthenope University, Naples, Italy

Violeta Slabakova and Atanas Palazov
Institute of Oceanology-BAS,Varna, Bulgaria

Dimitris Kassis
HCMR, Athens, Greece

Hezi Gildor and Tal Ozer
IOLR, Haifa, Israel

The captains and crews of R/V Dallaporta, R/V Laura Bassi, R/V Pourquoi Pas?, R/V Aegaeo, R/V Bat-Galim for the Mediterranean and R/V Akademik for the Black Sea and the crue fishing boat “Marianna”.

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