ARGO-ITALY:

ANNUAL REPORT 2020

Elena Mauri, Pierre-Marie Poulain, Riccardo Gerin, Milena Menna, Giulio Notarstefano, Antonio Bussani, Piero Zuppelli, Massimo Pacciaroni, Annunziata Pirro, Riccardo Martellucci, Giusy Fedele, Antonella Gallo

Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Trieste, Italy

Approved for release by: .....

Dr. Cosimo Solidoro

Director, Oceanography Section

TABLE of CONTENTS

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 including the Ross Sea, and comprises 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 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 has been funded by the Italian Ministry of University and Research (MUR) 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/. A new web site was created in the last years to have a better and more flexible view of the activities: http://maos.inogs.it/#/

This report summarizes the activities of ARGO-ITALY in 2020 in terms of procurements of the instruments, their preparation and their deployments. Information about data processing and archiving is also given. Plans for 2021 and beyond are included in the last section.

2. Argo float activities in 2020

2.1 Float procurement

The following Argo floats were purchased in 2020 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. Five units were shipped to New Zealand and three units to South Africa for deployments in the Southern Ocean and Ross Sea in December 2020, January and February 2021. One unit was shipped to IOLR in Haifa (Israel) and deployed in the Eastern Mediterranean Sea in September 2020 (from R/V Bat-Galim). Two units were shipped to CMRE in La Spezia and deployed in the Tyrrhenian Sea and Sicily Channel in October 2020 (from R/V Alliance). Two units will be shipped to CMRE (La Spezia) in Italy and they will be deployed in the Black Sea in 2021 (from R/V Alliance). Two units will be shipped to Istanbul in summer 2021 and will be deployed south-east and south-west of Crete by Seakeeper. One Arvor with dissolved oxygen sensor will be probably deployed in the Southern Adriatic Pit in spring 2021 from R/V Laura Bassi. Plans for the deployment of the remaining platforms have to be finalized.

2. Two Deep-Argo floats (Deep-Arvor) from NKE, Lorient, France. These deep floats are equipped with a Sea-Bird CTD (SBE 41 CP) (and Aanderaa optode sensor) and transmit data via Iridium. Unfortunately, the floats were tested in the hyperbaric chamber and the hydraulic pump showed performance problems at 4000 dbar. Hence, floats were sent back to NKE, the hydraulic group was changed, and eventually they were tested again in the hyperbaric chamber and in the Ifremer pool. Floats were then sent to OGS but NKE warned us that one of them could have problems with the hull once deployed at sea. So, this Deep-Argo will be sent back to NKE in March 2021 for further investigation. The other Deep-Argo float will be deployed in the western Ionian in May/June 2021 from the R/V Laura Bassi.

2.2 Float deployments

In total, **24 Italian floats** were deployed in 2020 (see Tables 1 and 2 for details). These floats were 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 8 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 one Arvor-I float (WMO 6903784) which had short cycles of 3 h during most of their initial operating life to measure high-frequency processes in the Sicily Channel.
Most floats were deployed from research vessels of opportunity (i.e., R/V Alliance, R/V Dallaporta, R/V Laura Bassi, R/V Pourquoi Pas?, R/V Bat-Galim for the Mediterranean and R/V Akademik for the Black Sea) with the help of colleagues from CMRE, France, Italy, Israel and Bulgaria (Figure 1).

Figure 1. Arvor-I with ice detection AI2600-19EU011 on R/V Laura Bassi before deployment in the Ross Sea Polynya, January 2020.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor - T/S Core	6903780	14-Mar-2020 09:43	40.18	13.99	66	03-Feb-2021 06:16	41.97	10.68	A	5
Arvor - T/S Core	6903779	17-Mar-2020 11:45	41.59	10.40	66	01-Feb-2021 05:56	40.27	11.61	A	5
Arvor - T/S Diss. Oxy	6903781	25-Jun-2020 16:20	41.62	17.62	43	17-Jan-2021 06:22	42.40	17.98	A	5
Arvor - T/S Core	**6903782**	**23-Jul-2020 22:52**	**43.03**	**28.75**	**40**	**31-Jan-2021 06:06**	**43.30**	**35.96**	**A**	**5**
Arvor - T/S Core	6903784	24-Aug-2020 10:20	35.92	14.17	230	03-Feb-2021 05:56	37.19	16.92	A	5
Arvor - T/S Core	6903785	16-Sep-2020 07:26	32.95	34.77	1	17-Sep-2020 02:31	32.91	34.78	D	5
Arvor - T/S Diss. Oxy	6903786	16-Sep-2020 09:01	33.06	34.5	29	04-Feb-2021 06:16	34.04	35.21	A	5
Arvor - T/S Core	6903787	25-Oct-2020 19:23	39.81	14.12	21	03-Feb-2021 05:59	39.48	13.24	A	5
Arvor - T/S Core	6903788	28-Oct-2020 14:20	35.6	14.88	164	04-Feb/2021 05:57	35.57	17.76	A	5

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

Table 1. Status information for the 9 Italian floats deployed in the Mediterranean and Black Sea (bold) during 2020.

In total, 8 floats stopped functioning before the end of the year 2020. The Arvor-I float 6903784 was deployed western of Malta in August 2020. It was initially programmed to cycle at 3 h intervals (down to about 500 m) in order to study the internal waves (oscillatory vertical motion in the water column), and was switched to a 5 days cycling period at the end of September. The Arvor-I 6903785 stopped functioning prematurely just after the deployment. It was deployed in the Levantine Sea and stopped transmitting data after one cycle. The cause for this malfunction is due to the internal vacuum problem. The value was around 730 instead of the normal value of 610. The float was tested at OGS before being shipped to Israel and the internal vacuum was in the right range of values. We did not have the chance to test again the float before the deployment and we eventually lost it at sea

Ten 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 Laura Bassi while sailing from New Zealand to the Ross Sea. Two Italian floats were deployed in the Ross Sea polynya. Seven floats out of 10 are ice detection type. The Arvor-Ice uses an Ice Sensing Algorithm (ISA, pressure evolution and satellite visibility) based on temperature and pressure readings to abort surfacing when sea ice is present at the sea surface. All floats (with the exception of those in the Ross Sea polynya) were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. The adopted configuration for the polynya area was a drifting and profiling depth of 1000 dbar and a cycling period of 5 days. The floats were still active in early 2021. The two Arvor-I deployed along the Polynya successfully transmitted at the end of the austral winter after more than 10 months below the ice.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-T/S Diss. Oxy	6903767	09-Jan-2020 06:36	-55.00	173.04	41	04-Feb-2021 06:14	-54.15	-148.91	A	10
Arvor-T/S Diss. Oxy	6903768	09-Jan-2020 16:39	-57.03	173.30	41	04-Feb-2021 06:08	-55.64	-169.97	A	10
Arvor-T/S ICE	6903769	10-Jan-2020 03:30	-59.03	174.61	40	05-Feb-2021 04:38	-56.48	-159.57	A	10
Arvor-T/S ICE	6903770	10-Jan-2020 13:27	-61.03	176.18	40	05-Feb-2021 11:30	-60.25	-155.24	A	10
Arvor-T/S ICE	6903771	10-Jan-2020 23:18	-63.04	177.85	40	04-Feb-2021 19:29	-60.39	-157.88	A	10
Arvor-T/S ICE	**6903772**	**28-Jan-2020 04:20**	**-77.37**	**174.56**	**99**	**16-Jan-2021 06:47**	**-75.71**	**171.10**	**A**	**5**
Arvor-T/S ICE	**6903773**	**28-Jan-2020 17:35**	**-77.20**	**169.32**	**89**	**31-Jan-2021 05:41**	**-75.26**	**163.97**	**A**	**5**
Arvor-T/S ICE	6903774	17-Feb-2020 04:12	-64.00	0.02	37	03-Feb-2021 06:18	-60.37	-9.25	A	10
Arvor-T/S ICE	6903775	17-Feb-2020 08:41	-63.00	0	37	03-Feb-2021 05:24	-64.43	-7.41	A	10
Arvor-T/S ICE	6903776	17-Feb-2020 13:56	-62.00	0	37	03-Feb-2021 06:14	-60.61	6.59	A	10
Arvor-T/S Diss. Oxy	6903777	18-Feb-2020 10:56	-60.24	0.13	37	04-Feb-2021 06:30	-58.81	6.66	A	10
Arvor-T/S Core	6903778	19-Feb-2020 19:55	-53.98	-0.02	36	05-Feb-2021 06:03	-52.93	-1.32	A	10
Arvor-T/S Core	6903789	27-Dec-2020 04:47	-57.03	173.04	5	06-Feb-2021 05:46	-56.18	174.67	A	10
Arvor-T/S ICE	6903791	28-Dec-2020 00:43	-61.03	173.16	5	07-Feb-2021 05:46	-61.91	174.71	A	10
Arvor-T/S ICE	6903790	28-Dec-2020 09:45	-63.04	173.18	5	07-Feb-2021 05:46	-65.14	-179.88	A	10

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

Table 2. Status information for the 15 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2020.

In summary, at the end of 2020, the ARGO-ITALY program had a total of 85 active floats, including 36 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 2) and 48 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S, Figure 3).

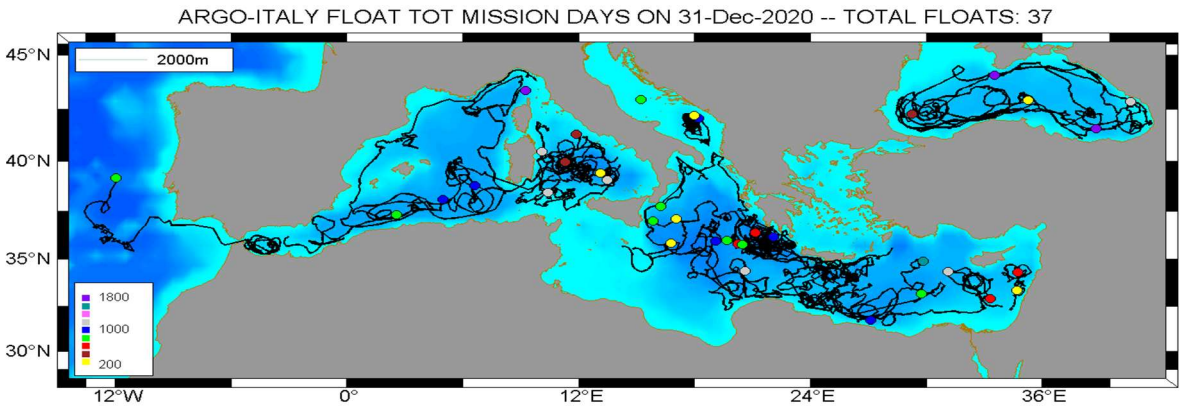

Figure 2. Trajectories and positions (circle symbols) on 31 December 2020 of the 37 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.

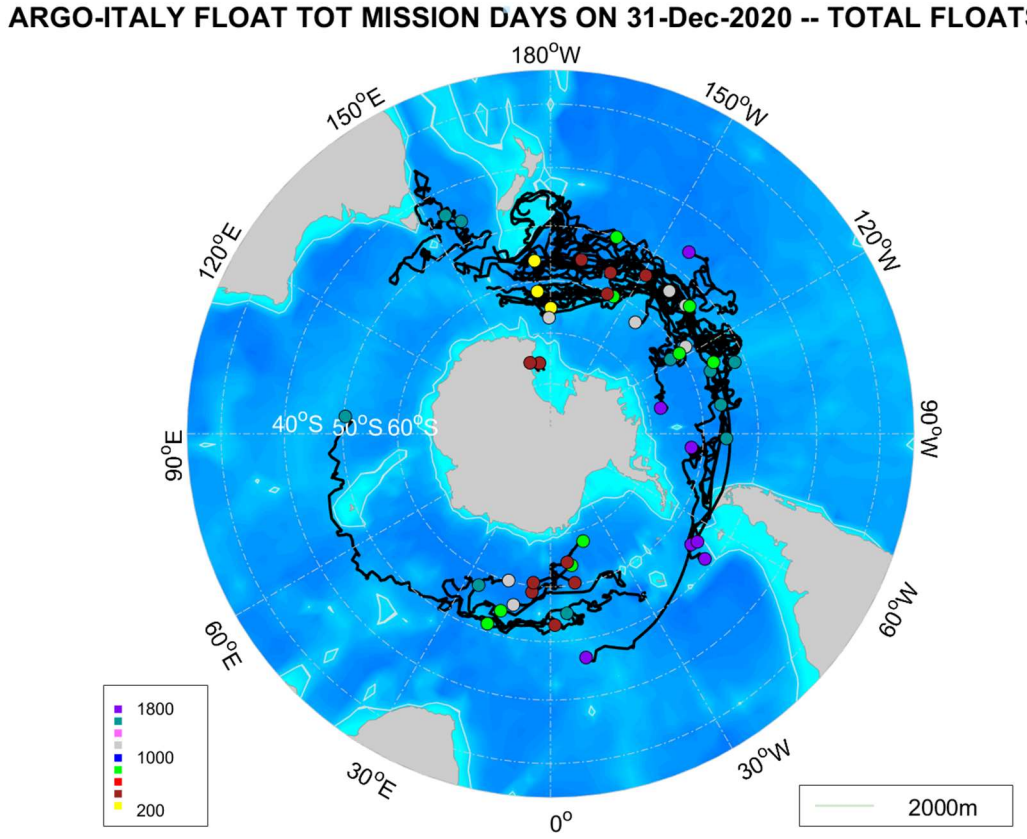

Figure 3. Trajectories and positions (circle symbols) on 31 December 2020 of the 48 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

The temporal evolution of the number of active floats is shown in Figure 4 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2020. The float population in 2012-2020 is essentially increasing with a maximum of 85 active instruments in 2020. In 2020, the number of deployments exceeded the number of dead floats.

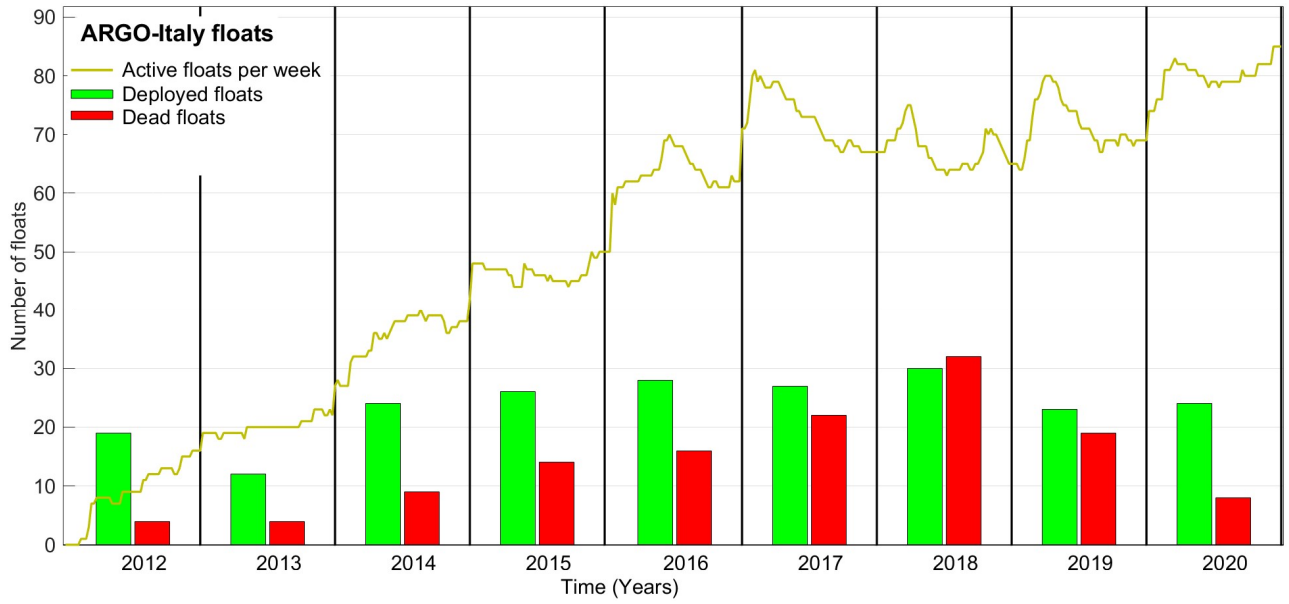

Figure 4. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **213 ARGO-ITALY floats** have been deployed, 126 in the Mediterranean and Black seas, and 87 in the oceans of the Southern Hemisphere. In less than 9 years, they have provided about **28700 CTD profiles**. The histograms of the number of CTD profiles per float is shown in Figure 5. Sixtyseven floats have done more than 180 profiles.
In total (during 2012-2020), ~6 % of the floats have failed just after deployment, while only one of those deployed in 2020 did not work after deployment.

After about 9 years of activities in the Mediterranean and Black seas, the maximum operating life of the ARGO-ITALY floats is about 5.5 years (~2010 days, see Figure 6). If we consider all the floats (dead + alive) the mean half-life is about 700 days for all floats in the Mediterranean and Black seas (Figure 6, top). Excluding the floats still alive but with life <= 700 days, we obtain a better estimate of mean half-life reaching 900 days (Figure 6, middle). Arvor and Provor floats show the longest performance crossing the 2000 mission days threshold (Figure 6, 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 7). The longest performance is attributed to the Arvor floats with more than 2300 mission days (Figure 7, bottom).

Note that these survival rate statistics have to be interpreted with caution since most of the floats are still alive (37 floats out of 126 units for the Mediterranean and Black seas, 48 floats out of 87 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.).

Table 3 summarizes the main statistics of the ARGO-ITALY floats for the period 2012-2020. In 2020, more than 4400 CTD profiles were obtained with Italian Argo floats. These profiles

provided data on a total vertical distance of more than 5800 km in 2020. For the period 2012-2020, the 213 floats of ARGO-ITALY provided data on a total vertical distance around 32000 km in about 28700 profiles.

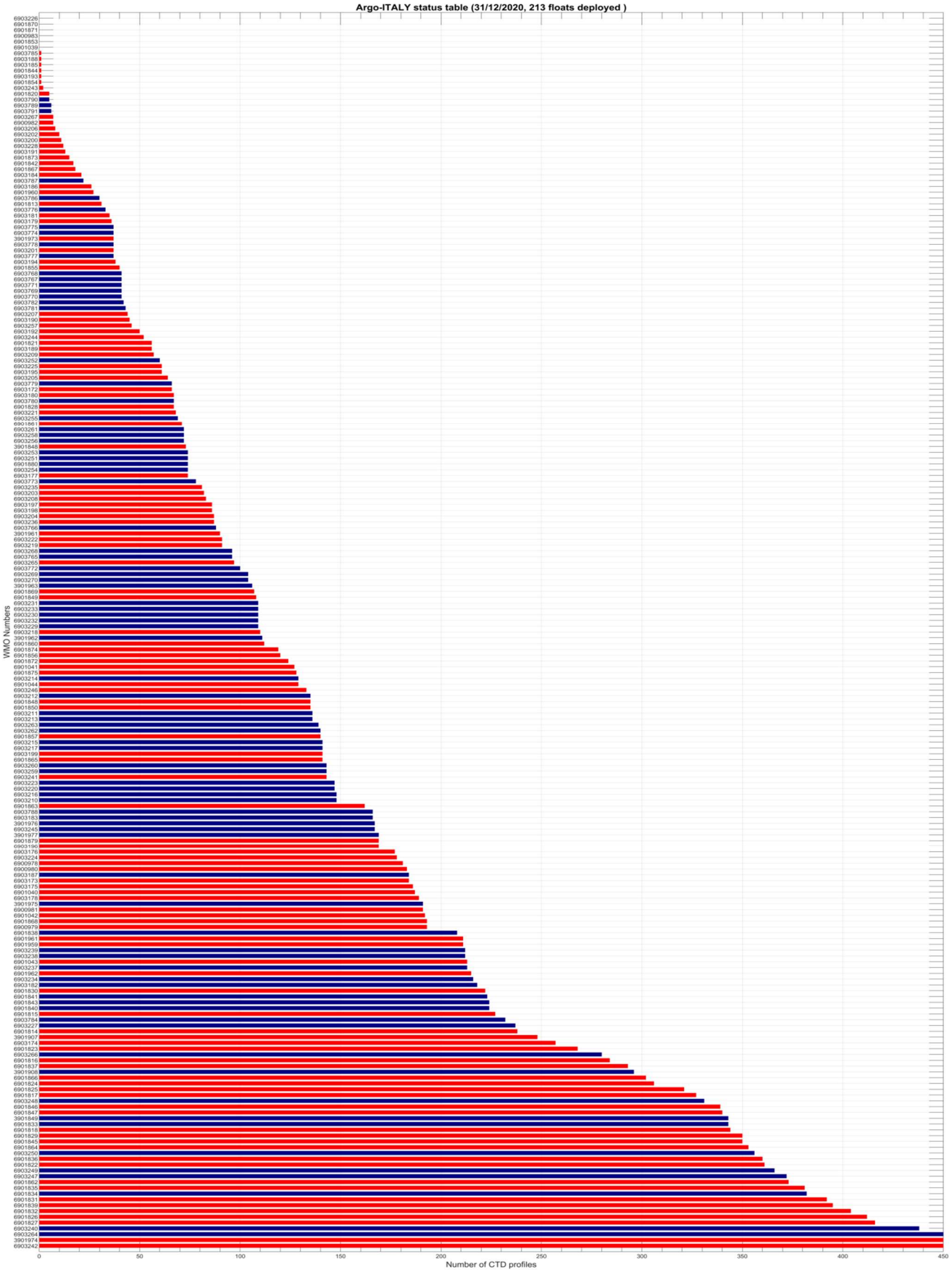

Figure 5. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2020).

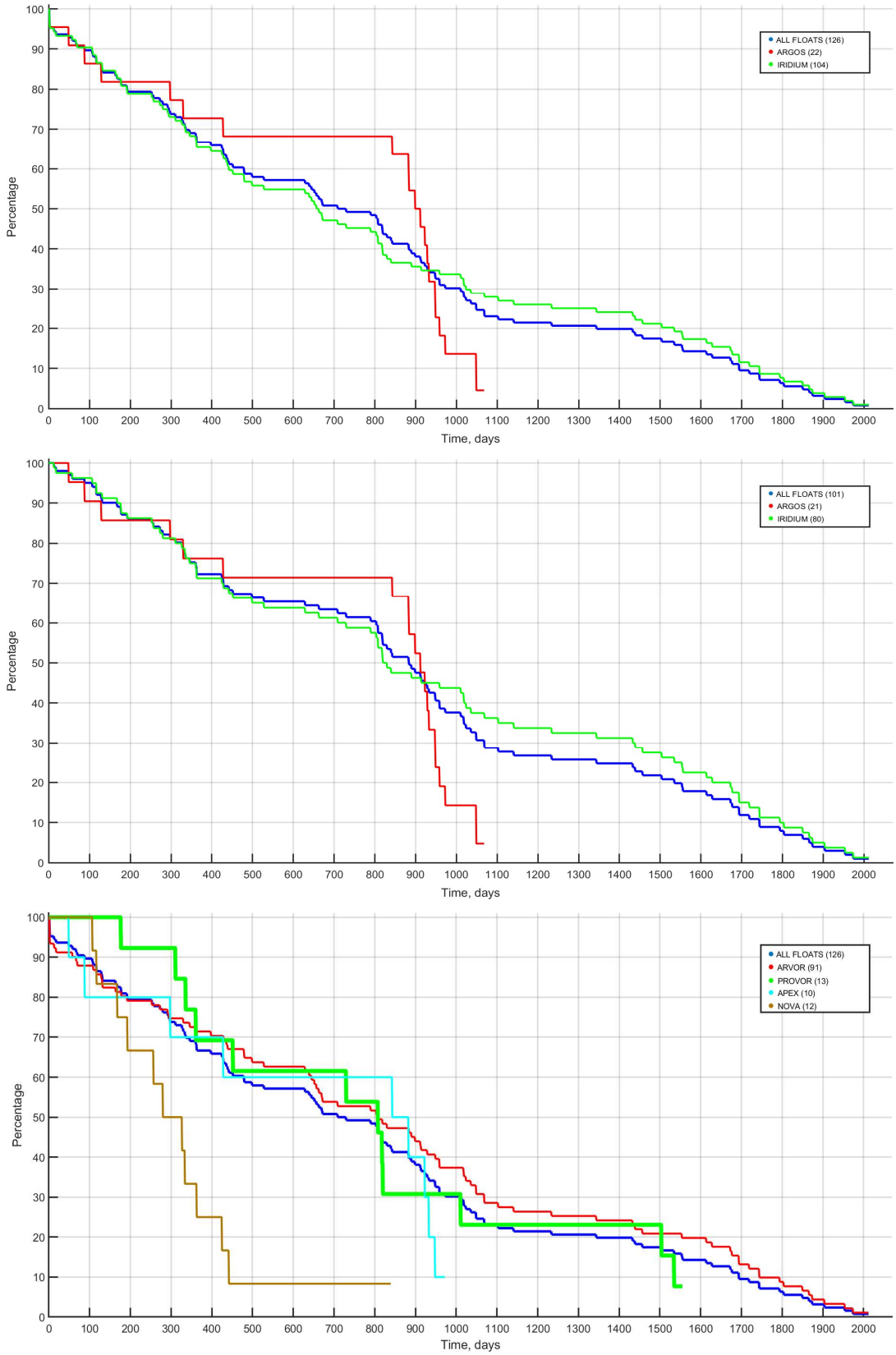

Figure 6. Survival rate diagrams for the ARGO-ITALY floats in the Mediterranean and Black seas, separated by transmission mode (top and middle) and float type (bottom).

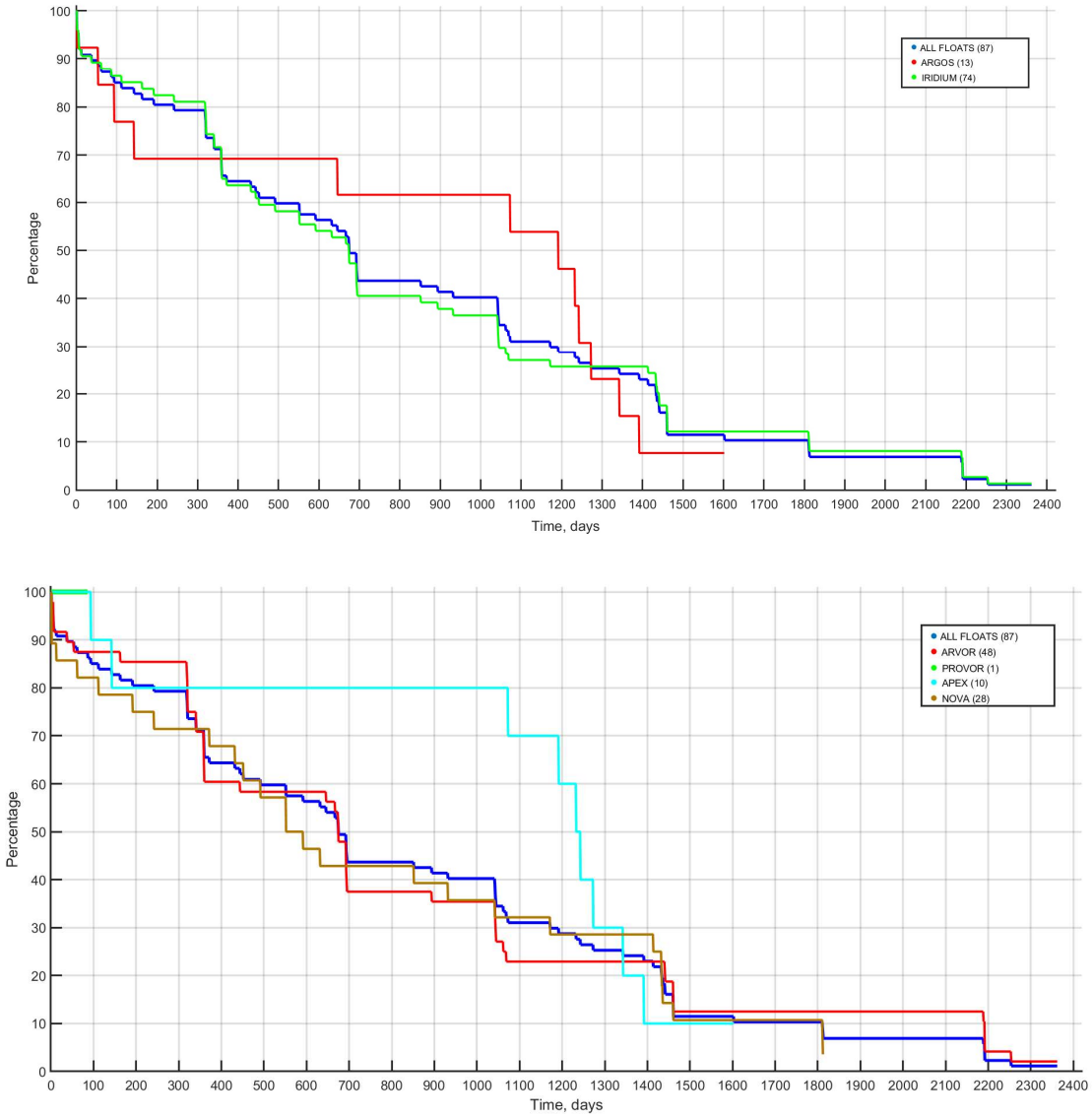

Figure 7. Survival rate diagrams for all the ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Ocean, separated by transmission mode (top) and float type (bottom).

Year	2012	2013	2014	2015	2016	2017	2018	2019	2020	2012-2020
Deployments										
CTD floats deployed in Med	13	7	13	11	9	8	16	10	8	95
CTD floats deployed in BS	4	1	2	1	1	2	0	1	1	13
CTD floats deployed in SO, South Pacific and Atlantic	2	3	7	10	15	17	8	10	15	87
Bio floats deployed	0	0	3	4	1	0	5	0	0	13
Deep floats					2	0	1	2	0	5
Total floats deployed	**19**	**11**	**25**	**26**	**28**	**27**	**30**	**23**	**24**	**213**
CTD profiles										
CTD profiles in Med	400	1099	1560	1743	2358	2147	2962	2646	2213	17128
CTD profiles in BS	105	236	323	268	260	298	298	280	268	2336
CTD profiles in SO, South Pacific and Atlantic	6	90	205	475	815	1418	1087	1200	1615	6911
Bio profiles	0	0	244	266	373	261	360	410	287	2201
Deep profiles					15	65	11	20	75	186
Total profiles	**511**	**1425**	**2332**	**2752**	**3821**	**4189**	**4718**	**4556**	**4458**	**28762**
Vertical distances (km)										
Distance in Med	440	902	1485	1813	2195	2307	2156	2037	2077	15412
Distance in BS	71	210	283	257	247	294	295	287	300	2244
Distance in SO, Souther Pacific and Atlantic	2	125	380	875	1374	2658	2020	2260	2914	12608
Distance of bio floats	0	0	199	245	335	248	293	392	279	1991
Distance of deep floats					50	194	43	69	235	591
Total distance (km)	**513**	**1237**	**2347**	**3190**	**4201**	**5701**	**4807**	**5045**	**5805**	**32846**

Table 3. Statistical information on the performance of the ARGO-ITALY floats in 2012-2020.

3. Drifter activities in 2020

3.1 Drifter procurement

Drifters were not purchased in 2020 using ARGO-ITALY funding. All the drifter activities carried out in 2020 were managed using drifters purchased in 2017 and 2018. However, in 2020 the tender procedure was started to purchase new instrumentation in 2021, putting together the 2019 and 2020 budgets.

3.2 Contribution to Drifter Demonstration and Research 2020 (DDR20) experiment

The DDR20 sea trial, sponsored by NATO-ACT, was performed to demonstrate the effective use of a network of freely-drifting mini-robots (drifters) to characterize the littoral marine environment at small scales. A swarm of drifting instruments were operated for 2 days in the vicinity of the Arno River mouth in the eastern Ligurian Sea (Poulain and Ampolo-Rella, 2020; Poulain, 2020).

ARGO-Italy contributed to this experiment with 5 CODE drifters, whose trajectories are shown in Figure 8 and the relative status information is listed in Table 4.

Argos/IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Type	Depth of current measurement (m)
oTrace28	08-Oct-2020 09:44	43.29	10.2	10-Oct-2020 08:37	43.15	10.32	CODE	0.5
aTrace45	08-Oct-2020 11:17	43.27	10.23	26-Oct-2020 00:40	43.45	10.27	CODE	0.5
gTrace44	08-Oct-2020 11:27	43.27	10.2	10-Oct-2020 09:51	43.13	10.34	CODE	0.5
aTrace46	08-Oct-2020 11:39	43.27	10.2	10-Oct-2020 12:32	43.13	10.37	CODE	0.5
mTrace27	08-Oct-2020 12:27	43.26	10.19	26-Oct-2020 06:23	43.28	10.35	CODE	0.5

Table 4. Status information for the Italian drifters deployed during the DDR20 experiment in October 2020.

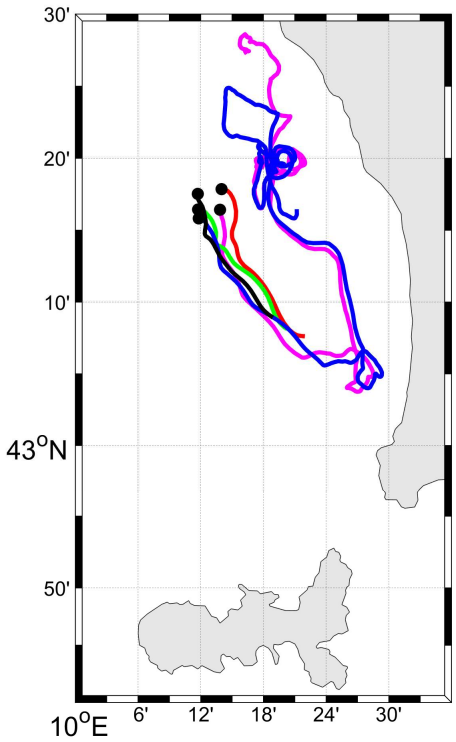

Figure 8. Trajectories and deployment positions (black dots) of five OGS-Italian drifters deployed north of Elba Island, south of the Arno River mouth, in October 2020.

3.3 Contribution to the Mediterranean Recognized Environmental Picture 2020 (MREP20) experiment

The main scientific objectives of the MREP20 sea trial sponsored by NATO-ACT were: to investigate the frontal variability in the eastern Sicily Channel and the associated mesoscale and sub mesoscale features; to study the influence of the 3D oceanographic variability associated with a front in the Sicily Channel on the acoustic propagation and potential improvement deriving from the combined data assimilation (Poulain and Oddo, 2020).

ARGO-Italy contributed to this experiment with 8 SVP, 3 CODE and one DWS drifters, some of them recovered during DDR20, whose trajectories are shown in Figure 9 and the relative status information are listed in Table 5.

Argos/IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Type	Depth of current measurement (m)
a300234068340270	28-Oct-2020 14:59	35.52	14.81	15-Mar-2021 06:38	35.83	14.54	SVP	15
a300234068340250	28-Oct-2020 15:38	35.44	14.74	17-Feb-2021 21:00	31.24	29.94	SVP	15
a300234068340260	28-Oct-2020 15:52	35.41	14.71	27-Feb-2021 15:00	31.44	26.92	SVP	15
a300234068340280	02-Nov-2020 11:44	35.41	14.71	22-Jan-2021 12:00	30.83	19.93	SVP	15
a300234068340290	02-Nov-2020 11:56	35.44	14.73	17-Mar-2021 04:00	37.51	19.92	SVP	15
a300234068340350	02-Nov-2020 12:20	35.5	14.79	23-Feb-2021 19:00	32.81	22.52	SVP	15
a300234068340450	02-Nov-2020 12:32	35.52	14.81	14-Feb-2021 05:00	32.31	29.77	SVP	15
a300234068340550	02-Nov-2020 12:42	35.55	14.84	16-Mar-2021 17:00	32.19	30.76	SVP	15
pTrace28	02-Nov-2020 11:39	35.4	14.7	01-Dec-2020 12:00	34.98	14.38	CODE	0.5

hTrace44	02-Nov-2020 12:14	35.48	14.77	04-Dec-2020 16:49	37.66	18.79	CODE	0.5
bTrace46	02-Nov-2020 12:47	35.56	14.85	22-Nov-2020 05:24	35.66	17.41	CODE	0.5
a300234065514550	28-Oct-2020 15:19	35.48	14.77	04-Jan-2021 13:00	33.98	15.5	DWS	0

Table 5. Status information for the Italian drifters (CODE, SVP and DWS) deployed during the MREP20 experiment in November 2020.

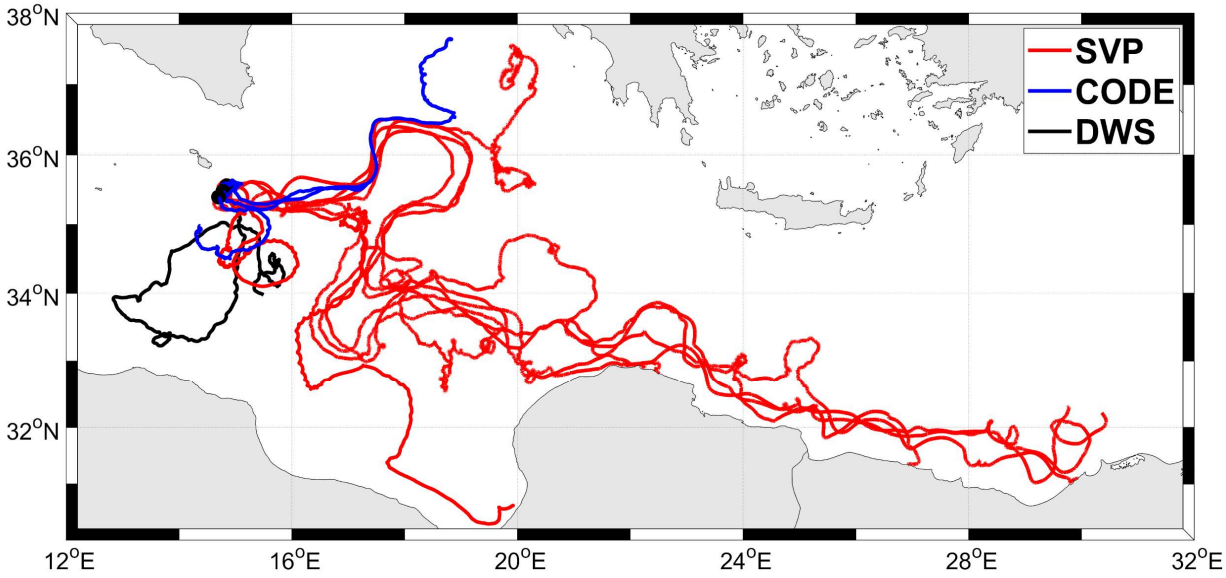

Figure 9. Trajectories of the drifters deployed in the Sicily Channel during the MREP20 experiment. Drifter data are updated to March 2021.

3.4 Deployments of SVP drifters in the Southern Ocean

Table 6 shows the status information of the ten SVP drifters deployed in January 2020 in the South Pacific both south-east of New Zealand (Figure 10) and in the Ross Sea (Antarctica; Figure 11) from R/V Laura Bassi, with the help of Italian colleagues as a contribution to the PNRA (Programma Nazionale di Ricerca in Antartide) project. Three of these drifters were still alive in March 2021 (Table 6).

Argo-Italy drifters contributed also to the PNRA project in the South Atlantic, with the deployment of 8 SVP along the Good Hope Transect (Figure 12; Table 7) from the R/V Agulhas II. Five of these drifters are still alive in March 2021 (Table 7).

In December 2020 further 5 italian drifters were deployed from the R/V Laura Bassi in the South Pacific (Figure 13; Table 8). All these drifters are still alive in March 2021 (Table 8).

Argos/IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Type	Depth of current measurement (m)
a300234068240470	09-Jan-2020 18:03	-54.77	172.76	25-Sep-2020 18:00	-49.62	-138.69	SVP	15
a300234068240260	09-Jan-2020 23:23	-57.02	173.27	16-Mar-2021 03:00	-43.41	-138.05	SVP	15
a300234068240290	10-Jan-2020 03:07	-59.03	174.6	13-Nov-2020 07:00	-49.44	-134.36	SVP	15
a300234068059690	10-Jan-2020 12:54	-61.03	176.18	16-Mar-2021 06:04	-51.07	-98.15	SVP	15
a300234068240270	10-Jan-2020 23:09	-63.04	177.85	16-Mar-2021 06:04	-64.14	-121.8	SVP	15
a300234068240480	20-Jan-2020 17:50	-76.37	-157.56	19-Oct-2020 07:00	-70.34	-154.53	SVP	15
a300234068240640	20-Jan-2020 18:04	-76.34	-157.54	19-Mar-2020 10:00	-74.73	-166.69	SVP	15
a300234068240690	20-Jan-2020 18:20	-76.33	-157.48	15-Feb-2020 02:00	-75.82	-163.04	SVP	15
a300234068240610	20-Jan-2020 23:34	-76.3	-157.47	07-Feb-2020 09:00	-76.56	-163.43	SVP	15
a300234068240550	20-Jan-2020 23:38	-76.28	-157.46	08-Feb-2020 20:00	-76.4	-163.5	SVP	15
a300234068240710	20-Jan-2020 23:45	-76.27	-157.46	21-Feb-2020 21:00	-75.41	-161.01	SVP	15

a300234068240720	21-Jan-2020 15:44	-76.18	-159.99	02-Feb-2020 23:00	-76.53	-162.96	SVP	15
a300234068059530	21-Jan-2020 22:21	-76.33	-160.01	23-May-2020 19:00	-72.71	-161.45	SVP	15
a300234068058520	22-Jan-2020 01:06	-76.5	-160.01	22-Mar-2020 22:00	-75.7	-166.86	SVP	15
a300234068240820	22-Jan-2020 06:11	-76.85	-160.03	30-Jul-2020 00:00	-69.52	-153.63	SVP	15
a300234068059040	22-Jan-2020 08:49	-77.16	-160.07	11-Mar-2020 05:00	-76.99	-163.27	SVP	15

Table 6. Status information for the Italian drifters deployed in the South Pacific and Ross Sea (Southern Ocean) in January 2020.

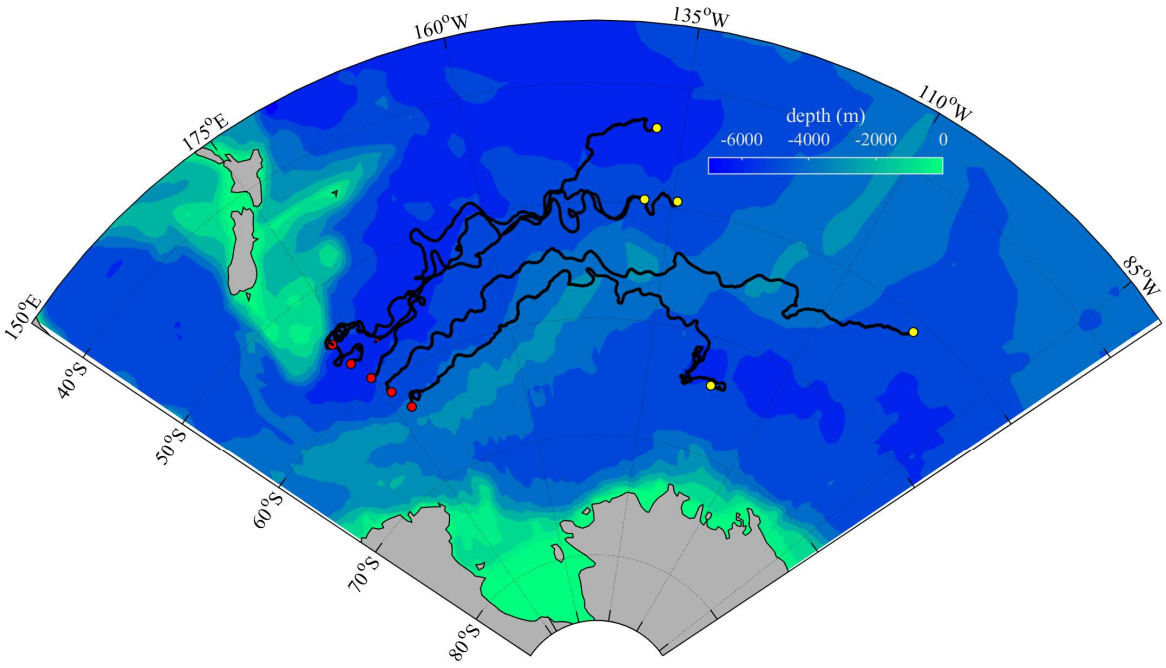

Figure 10. Trajectories and deployment positions (red dots) and last position (yellow dots) of the five Italian drifters deployed in the Southern Pacific in January 2020. Drifter data are update to March 2021.

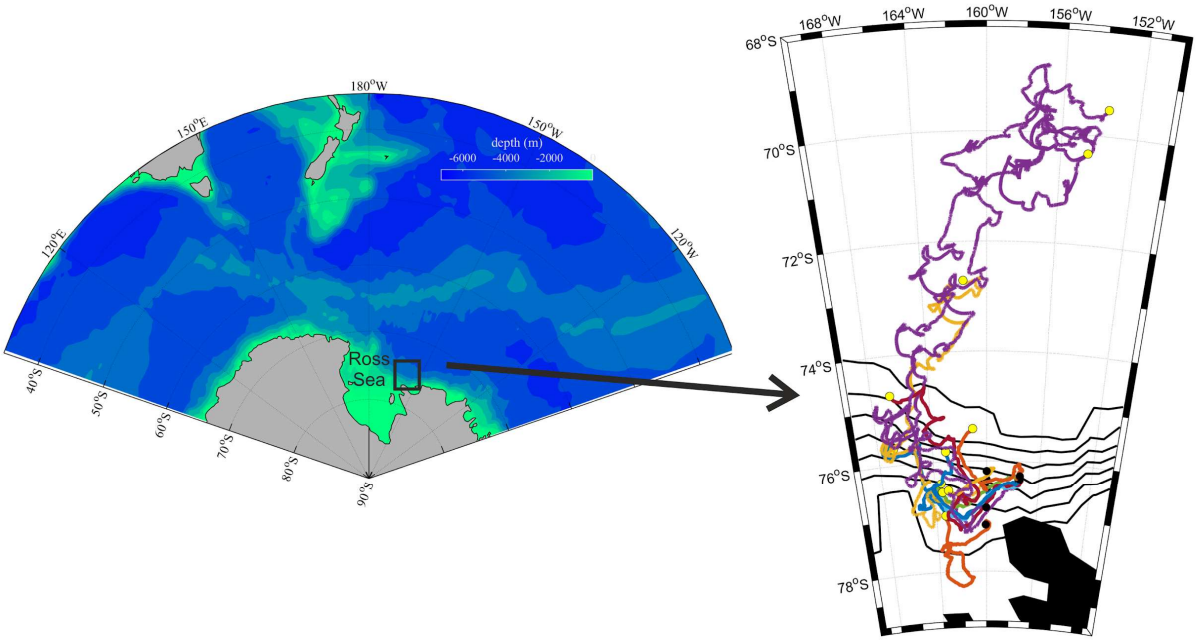

Figure 11. Left panel: geographical location of the Ross Sea. Right panel: trajectories and deployment positions (black dots) and last position (yellow dots) of the eleven Italian drifters deployed in the Ross Sea (Antarctica) in January 2020.

Argos/IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Type	Depth of current measurement (m)
a300234066415940	17-Feb-2020 03:50	-64	0.02	17-Mar-2021 06:00	-57.67	31.1	SVP	15
a300234066415930	17-Feb-2020 08:20	-63	0	17-Mar-2021 06:00	-61.92	21.39	SVP	15
a300234066416130	17-Feb-2020 13:34	-62	0	19-Aug-2020 12:00	-60.43	7.09	SVP	15
a300234066415970	17-Feb-2020 19:14	-61	0	19-Aug-2020 07:00	-57.89	11.05	SVP	15
a300234066415950	18-Feb-2020 10:56	-60.24	0.13	01-Oct-2020 20:07	-54.15	24.17	SVP	15

a300234066415960	18-Feb-2020 20:29	-58	0.02	17-Mar-2021 06:04	-53.36	53.09	SVP	15
a300234066415980	19-Feb-2020 07:31	-56	0	17-Mar-2021 06:00	-47.6	65.48	SVP	15
a300234066416160	19-Feb-2020 19:55	-54	-0.09	17-Mar-2021 06:00	-46.38	89.33	SVP	15

Table 7. Status information for the Italian drifters deployed in the South Atlantic (Southern Ocean) in February 2020.

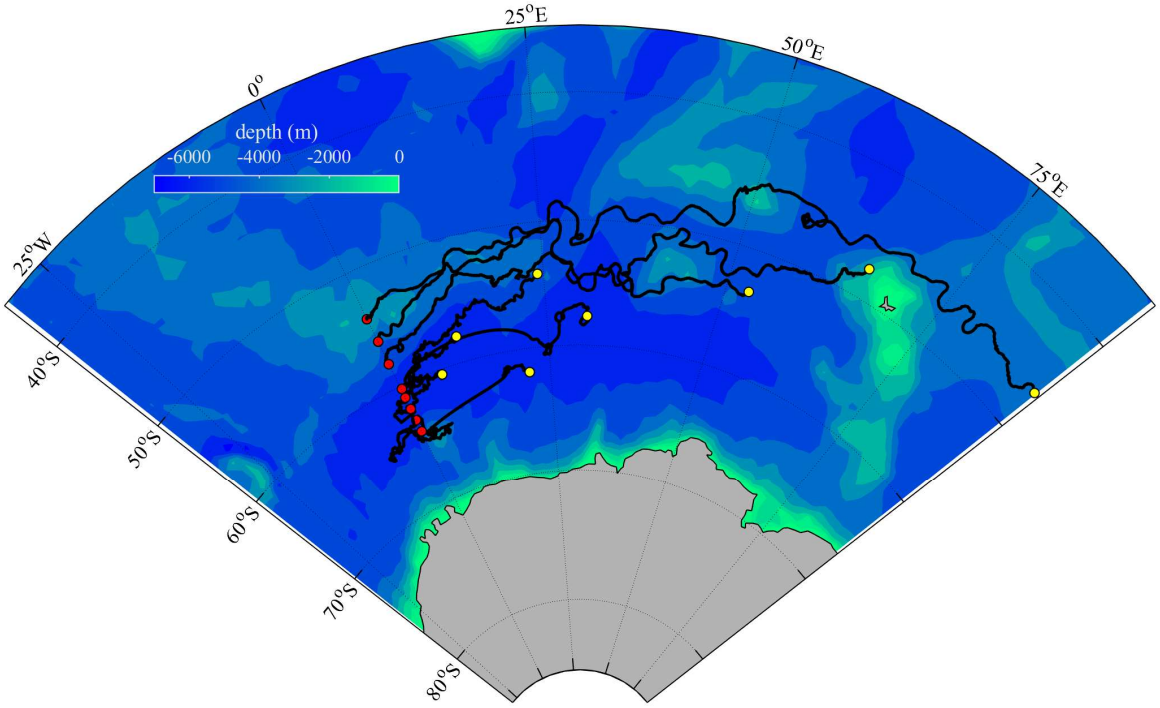

Figure 12. Trajectories, deployment positions (red dots) and last position (yellow dots) of the five Italian drifters deployed in the South Atlantic in February 2020. Drifter data are updated to March 2021.

Argos/IMEI	Deploy Date	Lat	Lon	Last Date	Lat	Lon	Type	Depth of current measurement (m)
a300234068340620	26-Dec-2020 23:36	-56.02	172.85	17-Mar-2021 06:00	-47.43	174.89	SVP	15
a300234068340700	27-Dec-2020 04:43	-59.02	173.13	17-Mar-2021 06:01	-53.86	178.32	SVP	15
a300234068340640	27-Dec-2020 14:36	-59.03	173.13	17-Mar-2021 06:03	-54.83	-166.55	SVP	15
a300234068340580	28-Dec-2020 00:01	-61.03	173.15	17-Mar-2021 05:03	-59.81	176.58	SVP	15
a300234068340670	28-Dec-2020 12:45	-63.03	173.18	17-Mar-2021 06:00	-61.84	-162.91	SVP	15

Table 8. Status information for the Italian drifters deployed in the South Pacific (Southern Ocean) in December 2020.

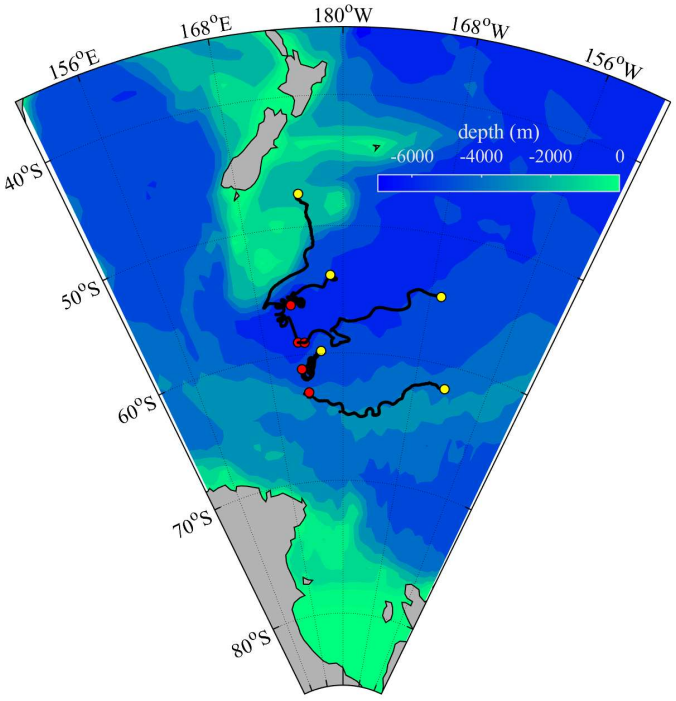

Figure 13. Trajectories, deployment positions (red dots) and last position (yellow dots) of the five Italian drifters deployed in the South Atlantic in December 2020. Drifter data are updated to March 2021.

4. Glider activities in 2020

4.1 Glider component procurement and glider maintenance

After the glider mission in Antarctica, the SeaGlider SG661 "Marco" was sent to the factory for the battery refurbishment and sensor calibration in late spring 2020. In May 2020, after a year, the Slocum glider 402 and 403 returned back to OGS after a complete factory refurbishment(Teledyne).

4.2 Glider testing

The gliders and receiving stations in the Lab were deeply tested before each deployment. The SeaGlider SG661 was extensively tested on board the RV Laura Bassi before the deployment in the Ross Sea. A standard test was performed on the SeaGlider SG554 before the deployment in the South Adriatic Sea and the backup receiving station was set up.

The Slocum glider unit 402 and unit 403 were deeply tested at the OGS laboratory during the summer after their refurbishment and firmware update. They were both ballasted for the South Adriatic Sea waters. In addition, a simulated mission was performed on the Slocum 402 unit for 2 days to verify the reliability of the system (which has had some problems in the past).

4.3 Glider laboratory

In 2020, to guarantee the glider recovery using a crane from the RV Laura Bassi, the field team has been equipped with new gears. In particular, the following items were acquired:

- 2 m x 2 m nylon net with large links (4,5 cm x 4,5 cm);
- positive buoyant rope (10 m);
- steel carabiner with quick release.

Additionally, a few consumable goods were purchased for the OGS glider laboratory.

4.4 Glider operations

In 2020, two glider missions were performed using the SeaGliders SG661 and SG554: one in the Ross Sea in mid-January and the second in the South Adriatic in June.

During the first mission, the SeaGlider "Marco" was deployed on 18 January in the Ross Sea in the framework of the ESTRO project (Figure 16). The main goal of the project was to study the water masses and dynamics in the East Ross Sea using both gliders and traditional ship CTD casts. It was the first time that a glider was used to explore that area and the mission lasted for 8 days (the glider was recovered on 26 January). The glider collected data of pressure, temperature, conductivity, oxygen, from the surface down to a deep of 500 m (Figure 17).

During the second mission the SeaGlider SG554 was operated for 20 days (from 12 June to 2 July) in the South Adriatic Sea (Figure 18) in the framework of the Convex20 experiment to assess the hydrographical characteristics present in June in the area of the South Adriatic pit after the winter deep convection (Figure 19). The experiment was coordinated in conjunction with another scientific project, the Saildrone Atlantic to Mediterranean (ATL2MED) mission, in which two autonomous wind-powered vehicles sailed from Cabo Verde to Trieste, Italy, demonstrating

how fit-for-purpose technology can be used to increase ocean observation. The mission was conceived to join all the CO2 site measurements along the track and inter-calibrate all the oceanographic measurements performed by the different platforms. One example of the comparison in the South Adriatic site is posted in figure 23. During the mission, the autonomous surface and subsurface vehicles worked together for a few days in the Adriatic Sea. The saildrones joined the OGS-led glider study in the Southern Adriatic close to the E2M3A station, providing surface observations to complement the glider observations along the water column.

The glider covered 430 km, collecting 250 profiles of pressure, temperature, conductivity, oxygen, chlorophyll, CDOM and backscatter from the surface down to 950 m depth. (Figure 16).

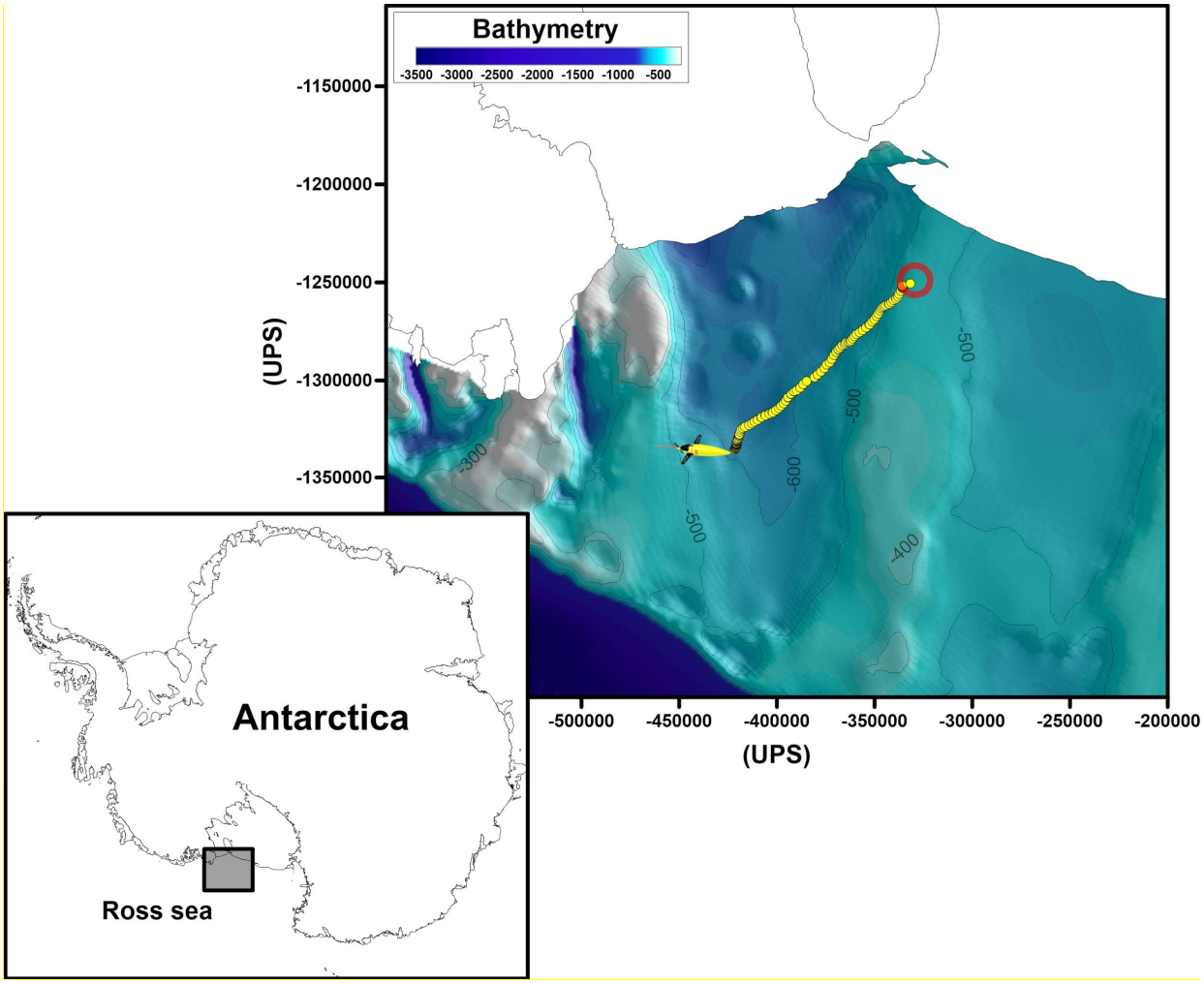

Figure 16. SeaGlider SG661 trajectory during the ESTRO20 experiment in the Ross Sea. The glider symbol indicates the last position of the instrument. Yellow symbols correspond to surfacing locations. The red circle indicates the last waypoint. Geographic bathymetry grid of Ross Sea bathymetry based on contours generated by Fred Davey with grid created by Frank Nitsche.

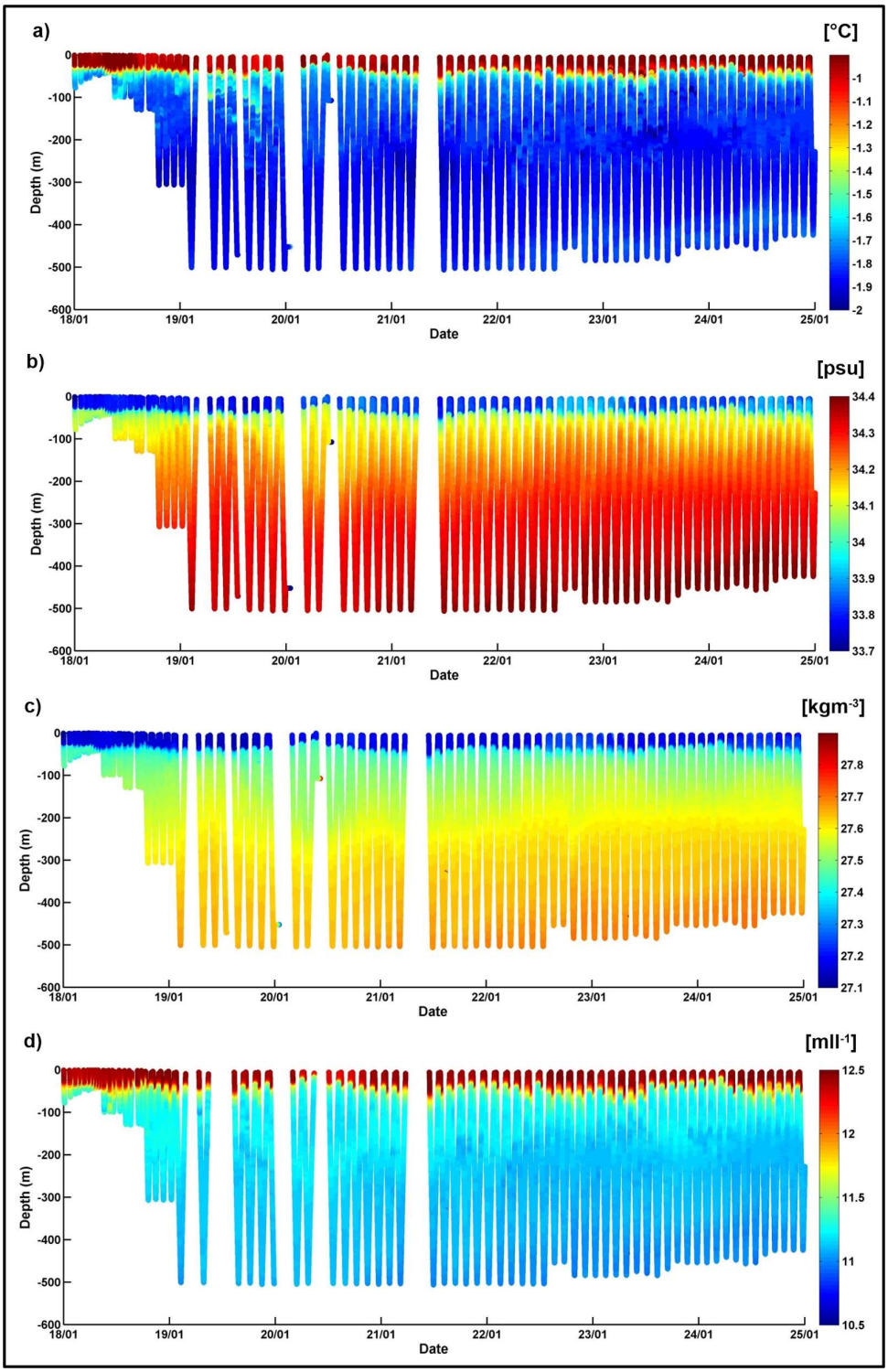

Figure 17: Color-coded vertical section of temperature (a), salinity (b), density (c) and dissolved oxygen (d) along the glider path during the ESTRO experiment in the Ross Sea..

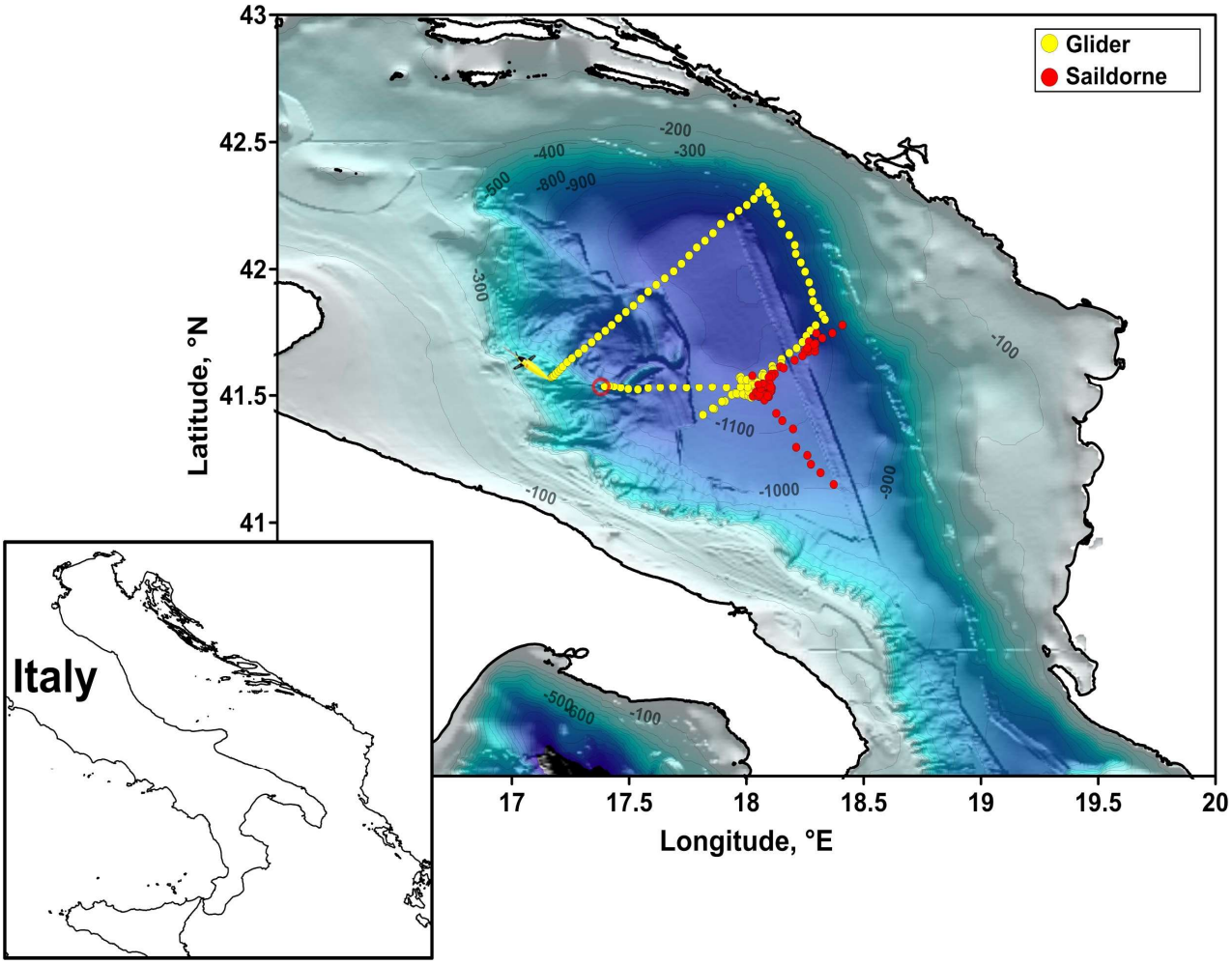

Figure 18: Study area and geographical position of the glider surfacing (yellow dot) and saildrone (red dot). The glider symbol indicates the last position of the instrument. The red circle indicates the last waypoint.

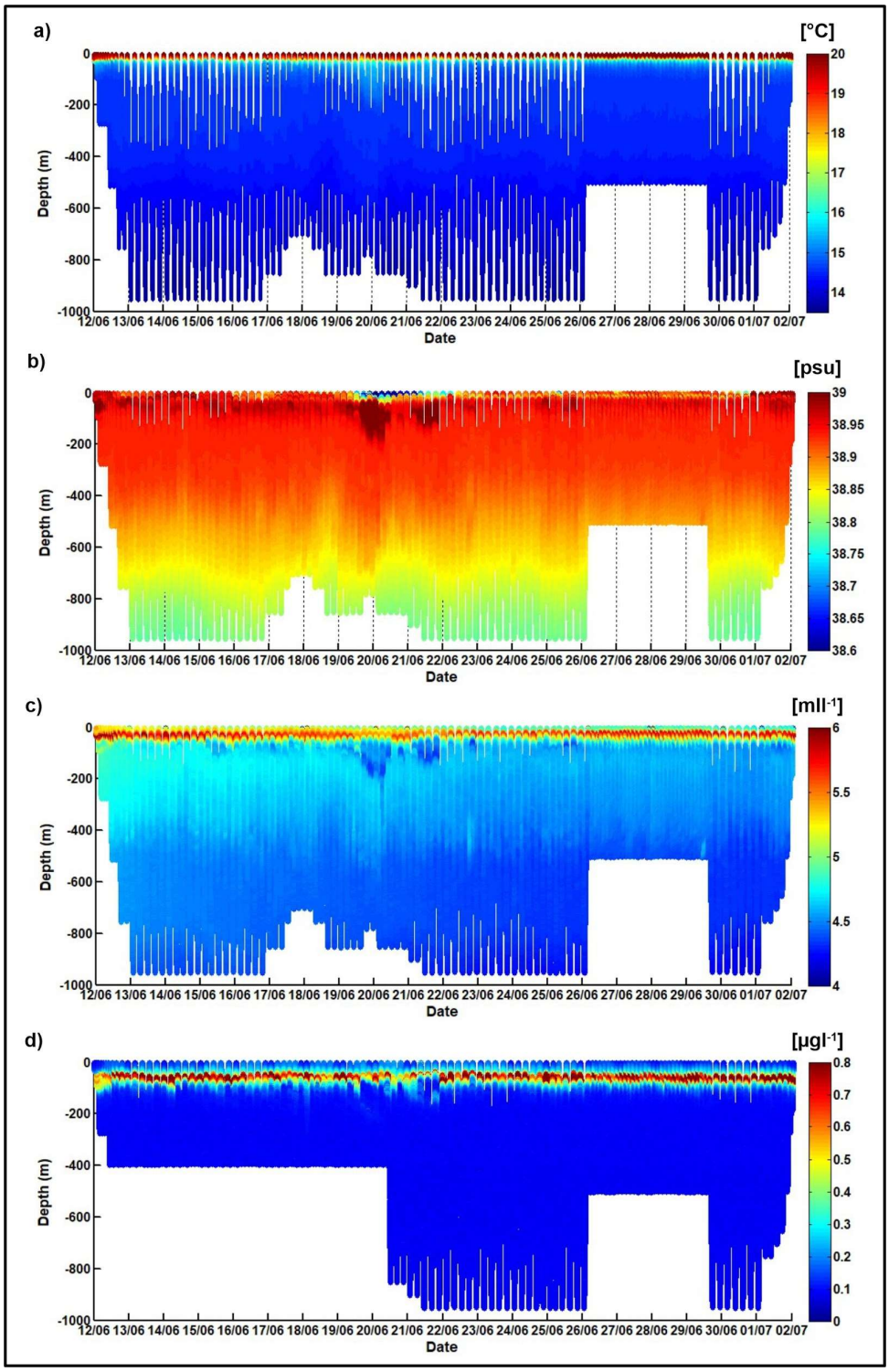

Figure 19: Color-coded vertical section of temperature (a), salinity (b), dissolved oxygen (c) and chlorophyll a (d) along the glider path during the ESTRO experiment in the South Adriatic Sea.

ATL2MED Mission

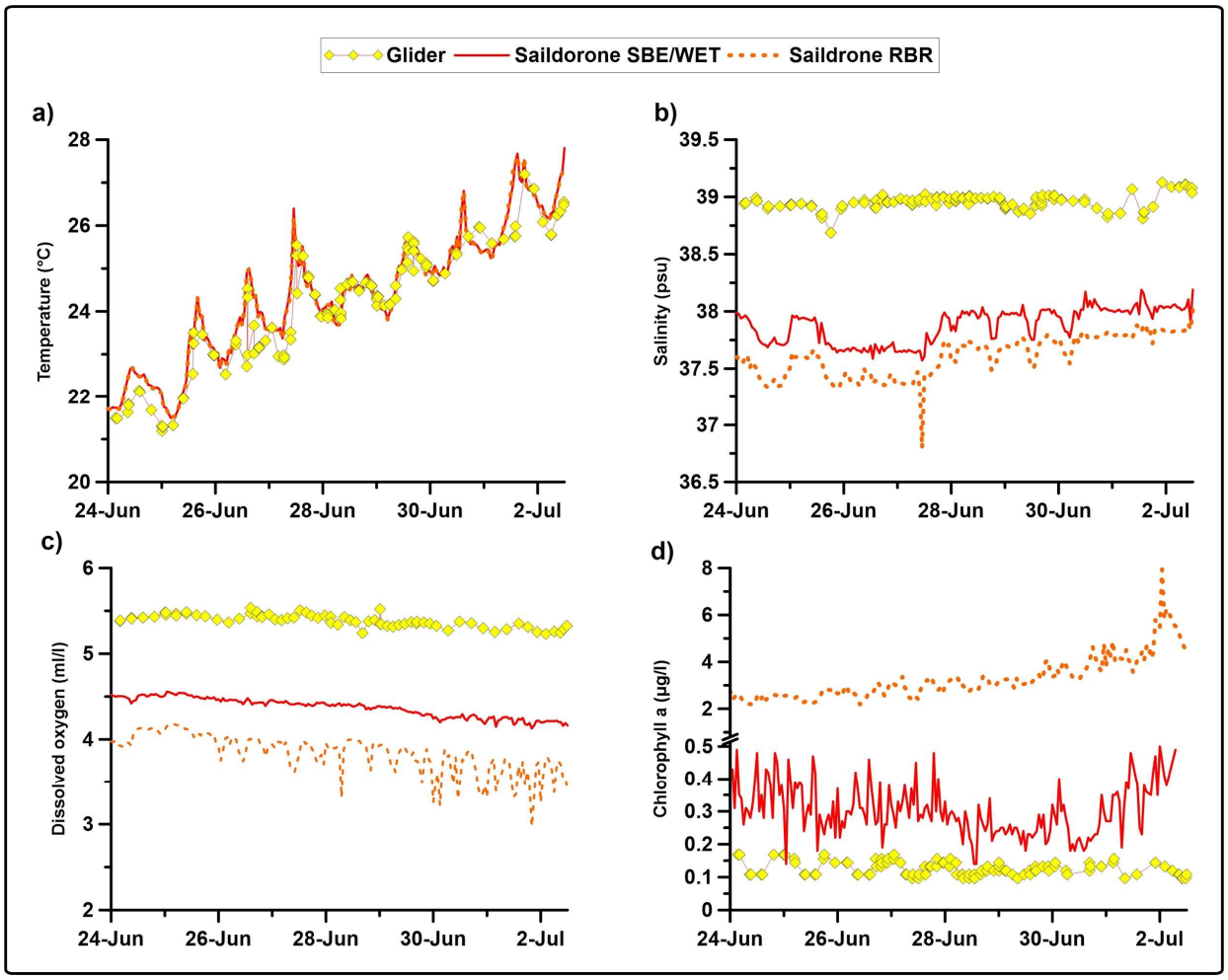

Figure 19: Surface temperature, salinity, oxygen and chlorophyll concentration measurement comparisons between different sensors on board the glider (yellow diamond) and saildrone (red line for SBE37, SBE37 ODO and Wetlab ECO FL-S G4; orange dashed line for rbr-global sensors). Measurements on the saildrone were taken approximately at the surface, while the glider measurements are of temperature and salinity at about 0.5 m, oxygen and chlorophyll respectively at about 2 m and 1 m.

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
Other webpages (password protected) with technical information and other parameters were available in real time to the OGS glider pilots. The scripts and the webpages were improved and optimized for the real-time data elaboration and generation of images. In particular, the plot of additional technical parameters were generated and posted on the piloting dedicated web pages.

A big effort was made to uniform the glider data format and parameter naming. This need is dictated by the fact that OGS owns different glider models mounting different payloads. Other than temperature and salinity also the glider oxygen data for the whole recorded missions were

deeply investigated. Oxygen concentration dataset was corrected by using in-situ validated oxygen measurements (Winkler samples, Winkler-calibrated float data, ...). The detailed computation that implied a complex procedure is reported in two documents: Gerin R. et al. (2020a,b) and Gerin R. and Martellucci (2020).

5. Other activities in 2020

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 about 80 out of about 120 eligible 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 2010-2019. 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 both of the inter-annual and the seasonal variability of the Mediterranean Sea, mostly in the upper and intermediate layers of the water column. For these 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 45 out of about 70 eligible floats. A new delay-mode operator was hired in October 2020. She is currently under training and she will be mainly involved with floats deployed in the Mediterranean and Black Seas.

5.3 Italian contribution to Argo bibliography in 2020

Akazawa F., Alraddadi T., Ananda P., Andre X., Arhan M., Atmadipoera A., Babin M., Balan S., Ballestero D., Baringer M., Barre N., Beebeejaun M., Belbeoch M., Belchi Pedro V., Bellingham C., Bernard V., Bittig H., Blain S., Boebel O., Boetius A., Boss E., Bourles B., Bower A., Boyer T., Brandt P., Buck J., Byon J., Cabanes C., Cancouët R., Carton X., Carval T., Chai F., Chen D.,

Chen J., Claustre H., Coatanoan C., Conan P., Coppola L., Cowley R., Cravatte S., Czeschel R., D'Ortenzio F., Dall'Olmo G., Danchenkov M., Daubord C., Davidson F., Davis R., De Jong F., Delcroix T., Desbruyeres D., Diggs S., Dong M., Donnelly M., Dumas F., Durand F., Dutreuil V., Echevin V., Eldin G., Escher S., Fach B., Felipe Silva Santos L., Fennell S., Fisher J., Font J., Fontaine L., Freeland H., Gaboury I., Gao G., Garzoli Silvia L., Giese H., Gilbert D., Gilson J., Gladyshev S., Gouriou Y., Gowers K., Grant F., Greenan B., Haapala J., Hacker P., Hardman-Mountford N., Hasegawa T., Hermes J., Horton C., Hosoda S., Ignazewski M., Ishikawa K., Ito S., Jayne S., Jeon Y., Ji F., Jianping X., Jin W., Jo H., Johnson Gregory C., Johnson K., Jordi F., Ju C., Kang H., Kang K., Kassis D., Kihm C., Kikuchi T., Kim S., Kim Y., Klatt O., Keeley B., Klein B., Kobayashi K., Kolodziejczyk N., Koltermann K., Korres G., Körtzinger A., Kusaka A., Kuwano-Yoshida A., Lagadec C., Latarius K., Lazar A., Lazarevich P., Le Reste S., Lebreton N., Lehmann L., Lim B., Liu Z., Loisel H., Louazel S., Lovell J., Luis Ochoa De La Torre J., Maes C., Martinez E., Mata Mauricio M., Maurer T., Maze G., Mctaggart K., Meincke J., Merceur F., Michida Y., Mitarai S., Molinari B., Moon-Sik S., Morel Y., Mork Kjell A., Morrow R., Moutin T., Naoki S., Notarstefano G., O'conchubhair D., Oguz T., Oke P., Oke P., Ouellet M., Owens B., Paba V., Pacciaroni M., Park H., Park J., Parrilla G., Peacock T., Pelegri Josep L., Petersen S., Peterson I., Phillips H., Plant J., Poteau A., Poulain P.-M., Pouliquen S., Prieur L., Prigent A., Provost C., Purkey S., Purokoski T., Purokoski T., Qiu B., Quadfasel D., Radhakrishnan R., Ramalho Dos Santos Ferreira T., Rannou Jean P., Ravichandran M., Rees A., Reverdin G., Rintoul S., Riser S., Robbins P., Roemmich D., Rohardt G., Rojas R., Roquet F., Ross T., Rudels B., Rudnick D., Rykova T., Ryoo S., Sallee Jean B., Sallee J., Santos A., Saout-Grit C., Sauzede R., Scanderbeg M., Schimanski J., Schmechtig C., Schmid C., Schmidtko S., Schneehorst A., Seo J., Serpette A., Shikama N., Shimizu Y., Shirooka R., Slabakova V., Speich S., Stanev E., Stawarz M., Sterl A., Stocks K., Suga T., Suk M., Sutton P., Svendsen E., Szczechowski C., Takeuchi K., Taupier-Lepage I., Tenorio-Feranandez L., Thierry V., Thompson P., Tran A., Troisi A., Trull T., Tuomi L., Turton J., Tutasi P., Udaya Bhaskar T., Uitz J., Ulloa O., Van Der Zwet W., Van Wijk E., Velez-Belchi P., Vialard J., Vivier F., Walczowski W., Walicka K., Walsh I., Wang H., Watanabe T., Weller R., Wright R., White M., Wijffels S., Wong A., Woody C., Xie S., Xing X., Xu J., Yamada H., Youn Y., Yuan D., Zenghong L., Zenk W., Zhang J., Zhang Y., Zhou J., Zilberman N., King B. (2020). Argo float data and metadata from Global Data Assembly Centre (Argo GDAC). SEANOE. 10.17882/42182

Angel Benavides Ingrid M., Bellingham C., Bernard V., Berry A., Bollard M., Buck J., Bussani A., Cabanes C., Cancouët R., Carse F., Carval T., Chapman S., Coatanoan C., Donnelly M., Evrard E., Garcia Juan A., Gourcuff C., Gowers K., Haapala J., Herbert G., Kassis D., King B., Klein B., Lagadec C., Latarius K., Le Traon P.-Y., Loubrieu F., Maze G., Merceur F., Mork Kjell A., Notarstefano G., Obolensky G., O'Conchubhair D., Paba V., Pacciaroni M., Petit De La Villeon L., Poffa N., Poulain P.-M., Pouliquen S., Quesnel L., Slabakova V., Small E., Sterl A., Thierry V., Tokunaga S., Turton J., Vélez-Belchí P., Walczowski W., Walicka K., Wright R. (2020). Monitoring the Oceans and Climate Change with Argo. MOCCA project 5 – year achievements. Euro-Argo ERIC. 10.13155/74328

Kokkini Z., Mauri E., Gerin R., Poulain P.-M., Simoncelli S., Notarstefano G. (2020). On the salinity structure in the South Adriatic as derived from float and glider observations in 2013-2016. Deep-Sea Research Part II, 171, 104625.

Poulain P.-M, Mauri E., Gerin R., Chiggiato J., Schroeder K., Griffa A., Borghini M., Zambianchi E., Falco P., Testor P. and Mortier L. (2020). On the dynamics in the southeastern Ligurian Sea in summer 2010. Continental Shelf Research (196), 104083.

Wong Annie P. S. , Susan E. Wijffels, Stephen C. Riser, Sylvie Pouliquen, Shigeki Hosoda, Dean Roemmich, John Gilson, Gregory C. Johnson, Kim Martini, David J. Murphy, Megan Scanderbeg, T. V. S. Udaya Bhaskar, Justin J. H. Buck, Frederic Merceur, Thierry Carval, Guillaume Maze, Cécile Cabanes, Xavier André, Noé Poffa, Igor Yashayaev, Paul M. Barker, Stéphanie Guinehut, Mathieu Belbéoch, Mark Ignaszewski, Molly O'Neil Baringer, Claudia Schmid, John M. Lyman,, Kristene E. Mctaggart, Sarah G. Purkey, Nathalie Zilberman, Matthew B. Alkire, Dana Swift, W. Brechner Owens, Steven R. Jayne, Cora Hersh, Pelle Robbins, Deb West-Mack, Frank Bahr, Sachiko Yoshida, Philip J. H. Sutton, Romain Cancouët, Christine Coatanoan, Delphine Dobbler, Andrea Garcia Juan, Jerôme Gourrion, Nicolas Kolodziejczyk, Vincent Bernard, Bernard Bourlès, Hervé Claustre, Fabrizio D'ortenzio, Serge Le Reste, Pierre-Yve Le Traon, Jean-Philippe Rannou, Carole Saout-Grit, Sabrina Speich, Virginie Thierry, Nathalie Verbrugge, Ingrid M. Angel-Benavides, Birgit Klein, Giulio Notarstefano, Pierre-Marie Poulain, Pedro Vélez-Belchí, Toshio Suga, Kentaro Ando, Naoto Iwasaska, Taiyo Kobayashi, Shuhei Masuda, Eitarou Oka, Kanako Sato, Tomoaki Nakamura, Katsunari Sato, Yasushi Takatsuki, Takashi Yoshida, Rebecca Cowley, Jenny L. Lovell, Peter R. Oke, Esmee M. Van Wijk,, Fiona Carse, Matthew Donnelly, W. John Gould, Katie Gowers, Brian A. King, Stephen G. Loch, Mary Mowat, Jon Turton, E. Pattabhi Rama Rao, M. Ravichandran, Howard J. Freeland, Isabelle Gaboury, Denis Gilbert, Blair J. W. Greenan, Mathieu Ouellet, Tetjana Ross, Anh Tran, Mingmei Dong, Zenghong Liu, Jianping Xu, Kiryong Kang, Hyeongjun Jo, Sung-Dae Kim47 And Hyuk-Min Park (2020). Argo Data 1999–2019: Two Million Temperature-Salinity Profiles and Subsurface Velocity Observations From a Global Array of Profiling Floats. Frontiers in Marine Science, Vol. 7, article 700.

5.4 OGS technical reports related to ARGO-ITALY published in 2020

Gerin R., Martellucci R., Mauri E., Kokkini Z., Medeot N., Nair R., Zuppelli P., Comici C. and Pachou A. (2020a). Oxygen concentration in the South Adriatic Sea: the gliders measurements. Rel. 2020/36 Sez. OCE 11 MAOS, Trieste, Italy, 31 pp.

Gerin R. and Martellucci (2020). Float 6901865 oxygen data calibration. REL. 2020/35 OCE 10 MAOS, Trieste, Italy, 6 pp.

Gerin R., Martellucci R., Notarstefano G. and Mauri E. (2020b). Float oxygen data calibration with discrete Winkler samples in the South Adriatic Sea. REL. 2020/30 OCE 9 MAOS, Trieste, Italy, 21 pp.

NOTARSTEFANO G. AND N. CREATI (2020). Argo App for data reading, plotting and comparison. Rel. 2020/16 Sez. OCE 5 MAOS

6. Plans for 2021 and beyond

6.1 Floats

The Italian Ministry of Research has provided funding to buy 20 floats in 2021, including 4 instruments with dissolved oxygen sensors, 5 standard T/S floats, 7 standard T/S floats with Ice Detection Algorithm implemented, 3 bio-Argo floats and an ALAMO float.

The Italian deployment plans for 2021 and 2022 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	
2021	10 1 7	Mediterranean Black Sea South Hemisphere	1 1	Mediterranean Black Sea	2	Mediterranean	**22**
2022	10 1 10	Mediterranean Black Sea South Hemisphere	2 0	Mediterranean Black Sea	0	Mediterranean	**23**

Table 9. Italian float deployment plans for 2021-2022.

In 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 plan to buy 60 SVP and 7 CODE drifters with the funding available in 2020-2021. Drifter deployment plans for 2021 and 2022 are described in Table 10.

Year	Drifters	
	Quantity	Area
2021	20 SVP	Southern Ocean
	10 SVP	Mediterranean
	7 CODE	Mediterrnaean
2022	10 SVP	Southern Ocean
	20 SVP	Mediterranean

Table 10. ARGO-ITALY drifter deployment plans for 2021-2022.

6.3 Gliders

In 2021, we expect to run the south Adriatic Sea missions using the SeaGlider SG554 and SG661 to monitor pre and post dense water formation phases and to refurbish the SG554 at the factory. Additionally, we plan to test at sea the two Slocum gliders.

6.4 Other

MUR is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2020 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, ocean gliders and drifters.

7. Distribution list

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

Luca Centurioni (lcenturioni@ucsd.edu)
Laurent Mortier (mortier@locean-ipsl.upmc.fr)
Pierre-Yves Le Traon (pierre-yves.letraon@mercator-ocean.fr)
Enrico Zambianchi (enrico.zambianchi@uniparthenope.it)
Annalisa Griffa (agriffa@rsmas.miami.edu)
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

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 crew of the fishing boat “Marianna”.

9. References

Poulain, P.-M., 2020. Demonstration experiment and design of network for oceanographic and acoustic measurements. Report CMRE-MR-2020-17.

Poulain, P.-M., Ampolo Rella, M., 2020. DDR20 Cruise Report. CMRE Technical Report A06.5.1.3.

Poulain, P.-M, Oddo, P., 2020. Cruise Report and datasets collected during the MREP20 sea trial. CMRE Technical Report, A06.4.2.1.

Mangoni, O., V. Saggiomo, F. Bolinesi, F. Margiotta, G. Budillon, Y. Cotroneo, C. Misic, P. Rivaro, M. Saggiomo, and S. Ban (2017). Phytoplankton blooms during austral summer in the Ross Sea, Antarctica: Driving factors and trophic implications. PLoS ONE 12. DOI: 10.1371/journal.pone.0176033