Report on the Italian Argo Program for 2019

1. The status of implementation (major achievements and problems in 2019).

- <u>floats deployed and their performance</u>:

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.

Mediterranean and Black Sea deployments

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 floats (WMO 6903265, 6903264 and 6903266) which had short cycles of 3 h during most of their initial operating life to measure high-frequency processes in the Alboran Sea. Two Arvor-Deep floats were deployed in the Hellenic Trench (Ionian Sea). One of them (WMO 6903267) stopped working after 6 cycles. 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.

South Atlantic, South Pacific and Southern Ocean

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. 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. 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	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.

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.

Overall status at the end of 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 1) and 36 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 2).
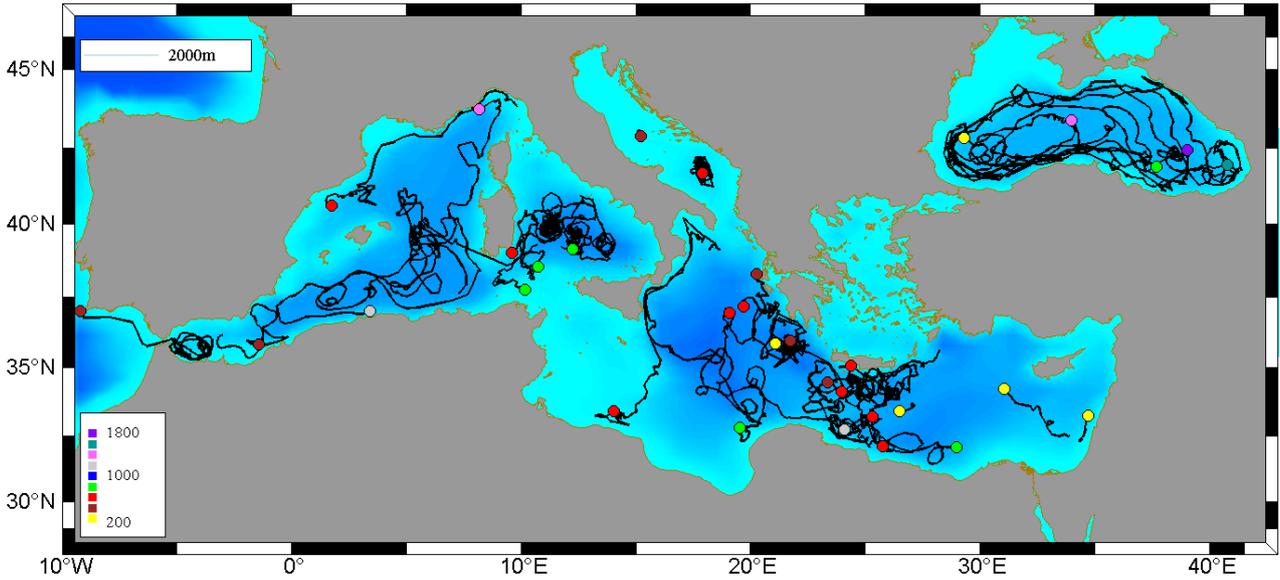
Figure 1. Trajectories and positions (circle symbols) on 31 December 2019 of the 33 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.
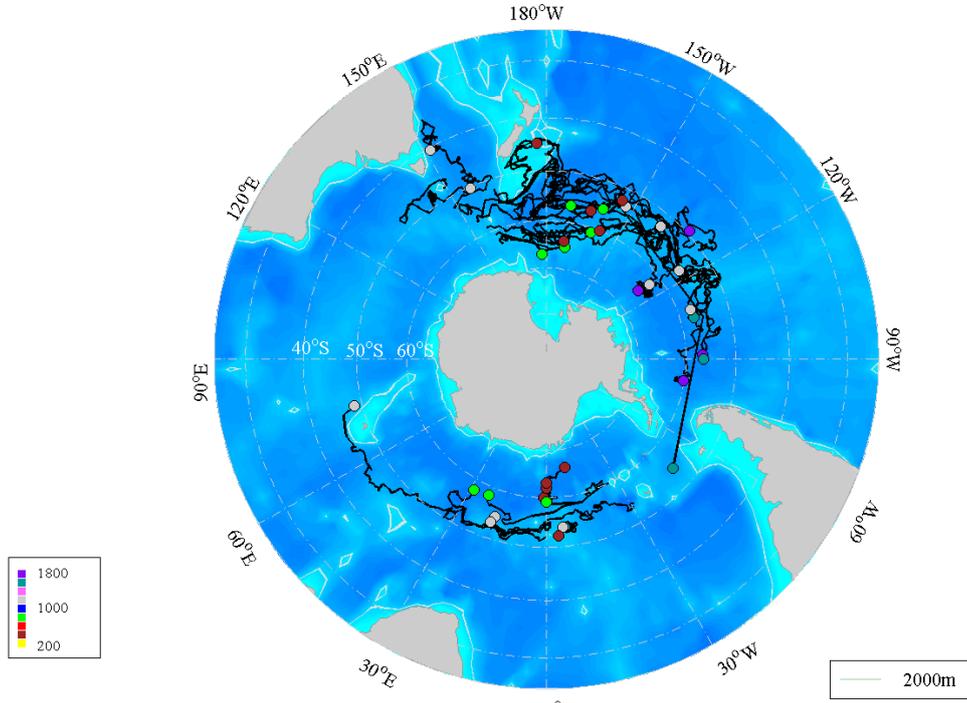
Figure 2. Trajectories and positions (circle symbols) on 31 December 2019 of the 36 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

The temporal evolution of the number of active floats is shown in Figure 3 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2019. The

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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.
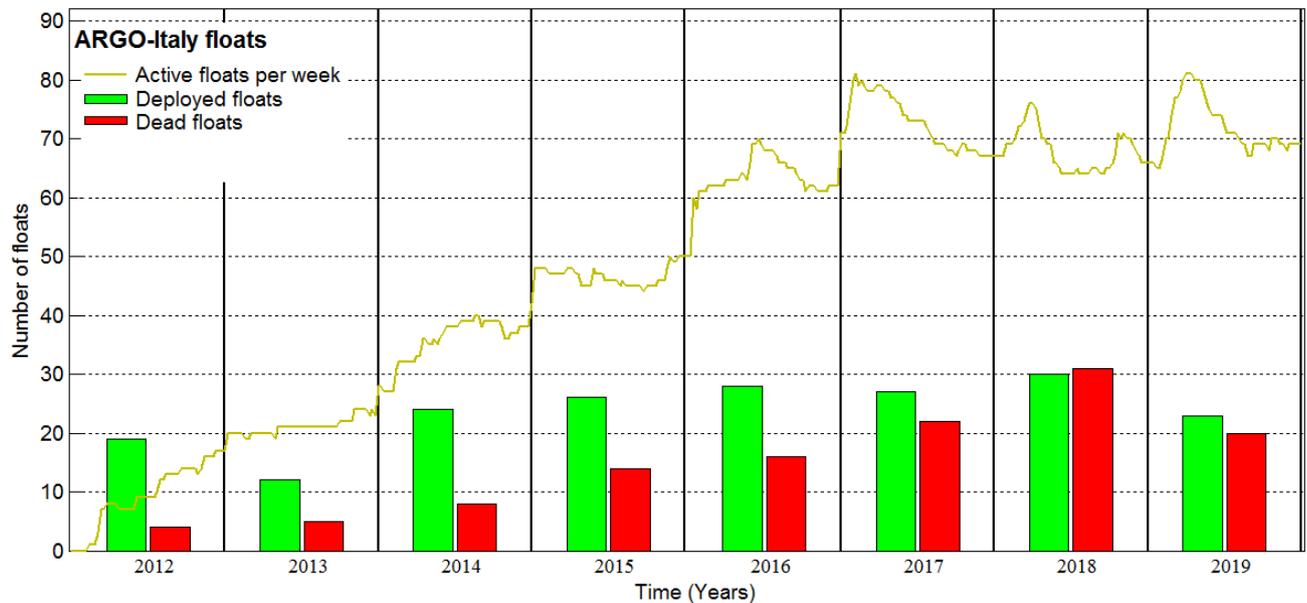

Figure 3. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

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 histograms of number of CTD profiles per float is shown in Figure 6. Fortyfour 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.

- technical problems encountered and solved

Mediterranean and Black Sea

Two floats stopped functioning prematurely before the end of the year 2019. The Arvor-Deep float (WMO 6903267) deployed southeast of Greece stopped transmitting data after 6 cycles. The cause for this malfunction is still under investigation by NKE. The Arvor-I (WMO 6903265, equipped with an oxygen optode) was deployed in the Alboran Sea in March 2019 with fast cycles of 3 h. This float had problems to profile correctly and eventually stranded on the Moroccan coast. It was recovered and we are still trying to have it shipped back to NKE in France for repair.

- status of contributions to Argo data management (including status of pressure corrections, technical files, etc)

The data management for the Italian float is mostly done by the Coriolis GDAC. Metadata and data are available through the Coriolis web site in near real-time.

- status of delayed mode quality control process

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 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 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.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Italian Ministry of Research has provided funding to buy 21 floats in 2019, including 5 instruments with dissolved oxygen sensors and 1 full BGC float. In addition, the Italian human resources per year devoted to Argo-Italy was about 50 man-months for technical, administrative and scientific personnel involved in the project in 2019. It is expected that the same level will be maintained in 2020, including the procurement of 20 additional standard floats and 2 deep floats. The Italian Ministry of Research 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 EC projects (e.g. Euro-Argo RISE) for several activities related to Argo.

3. Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

The Italian deployment plans for 2020 and 2021 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the oceans of the South Hemisphere.

Year	T/S floats (some of them with DO)		BGC floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2020	12 2 12	Mediterranean Black Sea South Hemisphere	1 0	Mediterranean Black Sea	1	Mediterranean	**28**
2021	12 2 12	Mediterranean Black Sea South Hemisphere	0 1	Mediterranean Black Sea	1	Mediterranean	**28**

Table 3. Italian float deployment plans for 2020-2021.

On the longer time frame, Italy is interest to maintain contributions to the Argo Core mission and the BGC and Deep Argo extensions with numbers similar to those listed in Table 3. OGS is committed to carry out the DMQC for all the Argo floats of the Mediterranean and Black seas and for some floats in the World Ocean as part of the ARGO-ITALY and Euro-Argo RISE projects over the next years.

The website for the Italian contribution to Argo (Argo-Italy) was improved and upgraded (http://argoitaly.ogs.trieste.it/). The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is http://nettuno.ogs.trieste.it/sire/medargo/. A completely new web site for Argo-Italy is also available at http://maos.inogs.it/#/projects/argo-italy .

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers.

Operational ocean forecasting.

All Argo temperature and salinity data in the Mediterranean (along with other in-situ and remotely sensed data) are routinely assimilated into the Mediterranean Forecasting System (MFS) operational forecasting system run by the Italian Istituto Nazionale di Geofisica e Vulcanologia (INGV) and which is a component of the Copernicus Marine Environment Monitoring Service (CMEMS). Assessments have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions. In particular, studies on the optimization of float sampling and cycling characteristics for the Mediterranean have been performed, as well as the development of methodology for the assimilation of Argo float sub-surface velocities into numerical models.

Ocean science.

Argo data are being used by several researchers in Italy to improve the understanding of marine properties (e.g. circulation, heat storage and budget, and mixing) in both the Mediterranean Sea and the Southern Ocean (see some examples in the bibliography below).

5. Issues that your country wishes to be considered and resolved by the AST.

N/A

6. Number of CTD cruise data added to the Argo reference database by Italian PIs in 2017.

N/A

7. Italian contribution to Argo bibliography in 2019.

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