Report on the Italian Argo Program for 2016

1. The status of implementation (major achievements and problems in 2016).

- floats deployed and their performance:

In total, **28 Italian floats** were deployed in 2016 (see Tables 1 and 2 for details). These floats were Arvor, Deep Arvor and Provor designs manufactured by NKE (France), Apex floats produced by Teledyne Webb Research (USA) and Nova/Dova profilers manufactured by MetOcean (Canada). The majority of the floats transmit data via Iridium telemetry (Arvor-I, Provor Bio, Provor Nut, Nova/Dova) and only a few have Argos telemetry (Apex).

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 the deep float WMO 6903200 which has cycles of 10 days.

Most floats were deployed from research vessels of opportunity (i.e., R/V Minerva I, R/V Tethys II, R/V Aegaeo and R/V OGS Explora for the Mediterranean and R/V Mare Nigrum for the Black Sea) with the help of colleagues from Italy, France, Greece, Romania and Bulgaria. The French Navy deployed three floats in the Tyrrhenian Sea from the F/S Belle Poule (Figure 1).

Figure 1. Arvor-I float being deployed in the Tyrrhenian Sea by the French Navy in June 2016.

Two Nova floats equipped with SBE 63 optical dissolved oxygen sensor (also called Dova) were deployed in the Tyrrhenian and Levantine Seas in spring and fall 2016, respectively.

One float equipped with biogeochemical and optical sensors (Provor Nut) was deployed in the South Adriatic Sea. The Provor Nut is a Provor CTS 4 with Iridium global telephone network

(RUDICS) for data telemetry and a GPS receiver for position. It measures at 1 dbar vertical resolution not only temperature and salinity (SBE CTD) but also irradiance at three wavelengths (412 nm, 490 nm, 555 nm), fluorescence of colored dissolved organic matter, fluorescence of chlorophyll-a, backscattering coefficient (530nm) and attenuation coefficient (660 nm), dissolved oxygen (Aanderaa optode) and nitrate (SUNA) concentrations.

Two deep floats (Deep Arvor) were deployed in the deep areas of the Mediterranean Sea southwest of Greece. For the first one (Figure 2, see also Pacciaroni et al., 2016) the maximal profiling depth and the parking depth were both set to 4000 dbar in order to ground the float on the sea floor and minimize its horizontal displacement. In contrast, the second float was programmed to sample from, and drift at, a pressure level of 3000 dbar in order to avoid frequent grounding.

Figure 2. Deep Arvor float (WMO 6903200) before deployment on the R/V Aegaeo on 8 June 2016.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle**
Nova	6903179	25-Feb-2016 12:39	41.25	10.5	35	13-Feb-2017 11:04	40.43	13	AS	5
Provor Nut	6903197	07-Apr-2016 21:46	41.57	17.38	83	10-Feb-2017 10:37	41.17	18.14	A	5
Apex	6903196	14-May-2016 04:24	37.1	17.4	44	09-Feb-2017 02:29	38.39	18.22	A	5
Dova	6903180	31-May-2016 21:42	41.33	12.08	52	10-Feb-2017 12:03	39.67	9.94	A	5
Arvor-I	6901833	01-Jun-2016 08:59	42.24	39.87	51	13-Feb-2017 09:06	44.38	35.32	A	5
Arvor-I	3901848	04-Jun-2016 16:32	40.08	13.34	42	10-Feb-2017 12:16	40.63	12.06	A	5
Arvor-I	3901849	05-Jun-2016 11:43	39.26	10.77	41	11-Feb-2017 12:10	39.52	6.62	A	5
Apex	6903198	06-Jun-2016 09:15	34.4	26.02	46	12-Feb-2017 06:09	32.82	30.89	A	5
Arvor-D	6903200	08-Jun-2016 05:47	35.25	22.77	11	03-Aug-2016 06:12	35.16	22.44	D	10
Apex	6903199	24-Jun-2016 10:09	43.73	9.69	16	10-Feb-2017 08:36	42.61	9.67	A	5
Nova	6903201	21-Oct-2016 00:24	33	33	36	03-Feb-2017 01:53	33.99	32.4	A	5
Arvor-D	6903203	07-Dec-2016 23:51	35.35	22.98	15	12-Feb-2017 06:12	35.61	22.67	A	5
Dova	6903204	08-Dec-2016 14:38	34.18	25.25	14	11-Feb-2017 04:03	33.87	25.83	A	5

**Status in early February 2017: A = active, D = dead; AS = active but drifting at surface.*
***Cycle: Length of cycle in days.*

Table 1. Status information for the 13 Italian floats deployed in the Mediterranean and Black Sea (grey rows) during 2016.

Southern Hemisphere deployments

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 on-board the R/V Italica while sailing from New Zealand to the Ross Sea (Figure 3). These floats included 8 Nova and 2 Dova floats. 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.

Figure 3. A Nova float ready to be deployed on R/V Italica in January 2016.

Five Italian floats were also deployed in the South Atlantic Ocean (Table 2) with the help of Italian colleagues on-board the South African R/V Agulhas II. These floats included 4 Nova and 1 Dova floats and were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar.

Overall status at the end of 2016

In summary, at the end of 2016, the ARGO-ITALY program had a total of **62 active floats**, including 37 instruments in the Mediterranean Sea, 5 in the Black Sea (Figure 4) and 20 in the South Pacific, South Atlantic and Southern Oceans (south of 60˚S) (Figure 5).

Since 18 February 2012, a total of **109 ARGO-ITALY floats** have been deployed. In less than 5 years, they have provided about **11000 CTD profiles**. In total, 12 floats (11 %) have failed just after deployment.

The temporal evolution of the number of active floats is shown in Figure 6 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2016. The float population in 2012-2016 is essentially increasing and reaching 60-70 active instruments in 2016. In 2015 and 2016 the annual numbers of deployments (26 and 28, respectively) were related to annual losses of 13 in 2015 and 14 in 2016.

Model	WMO	Deploy date	Lat	Lon	Cycles	Last_TX date	Lat	Lon	Status*	Cycle**
Nova	6903181	17-Jan-2016 16:41	-50.98	173.15	0	28-Jan-2016 00:44	-50.62	173.65	D	10
Dova	6903183	17-Jan-2016 21:55	-51.98	173.19	57	13-Feb-2017 02:20	-52.34	179.59	A	10
Nova	6903182	18-Jan-2016 03:09	-53.01	173.17	72	11-Feb-2017 11:16	-43.92	177.7	A	10
Nova	6903184	18-Jan-2016 12:29	-54.99	173.53	20	26-Jul-2016 13:59	-56.13	177.17	D	10
Nova	6903185	18-Jan-2016 17:01	-55.99	173.4	0	18-Jan-2016 17:22	-56.02	173.44	D	10
Nova	6903186	19-Jan-2016 02:10	-58	173.28	26	15-Sep-2016 13:57	-56.46	179.81	D	10
Nova	6903187	19-Jan-2016 11:20	-60	173.32	40	12-Feb-2017 14:08	-55.59	-164.17	A	10
Nova	6903189	19-Jan-2016 16:06	-61	173.33	40	02-Feb-2017 13:53	-60.65	-166.46	A	10
Dova	6903190	19-Jan-2016 20:41	-62	173.4	40	12-Feb-2017 14:19	-60.96	-167.34	A	10
Nova	6903188	20-Jan-2016 01:09	-63	173	0	20-Jan-2016 01:26	-62.96	173.6	D	10
Nova	6903193	04-Feb-2016 06:50	-58	0	0	04-Feb-2016 07:11	-58.02	0	D	10
Nova	6903192	04-Feb-2016 21:23	-55	-0.03	38	08-Feb-2017 13:53	-51.19	20.9	A	10
Dova	6903191	05-Feb-2016 15:10	-51.5	0	13	15-May-2016 13:45	-50.69	4.71	D	10
Nova	6903194	06-Feb-2016 11:14	-48.01	3.6	38	10-Feb-2017 14:03	-50.46	38.37	A	10
Nova	6903195	07-Feb-2016 09:45	-44.96	6.55	38	11-Feb-2017 13:56	-44.43	19.99	A	10

**Status in early February 2016: A = active, D = dead; ANP = active without positions.*
***Cycle: Length of cycle in days.*

Table 2. Status information for the 15 Italian floats deployed in the Southern Ocean during 2016.

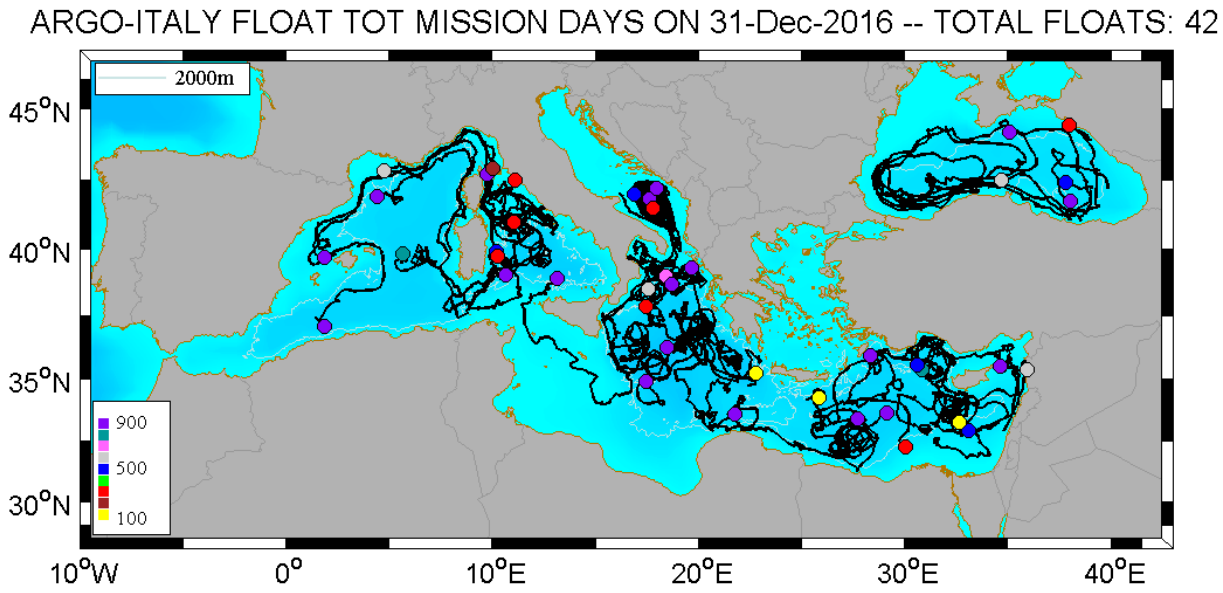

Figure 4. Trajectories and positions (circle symbols) on 31 December 2016 of the 42 ARGO-ITALY floats active in the Mediterranean and Black Sea at the end of 2016. The circle symbols are color-coded as a function of float age in days.

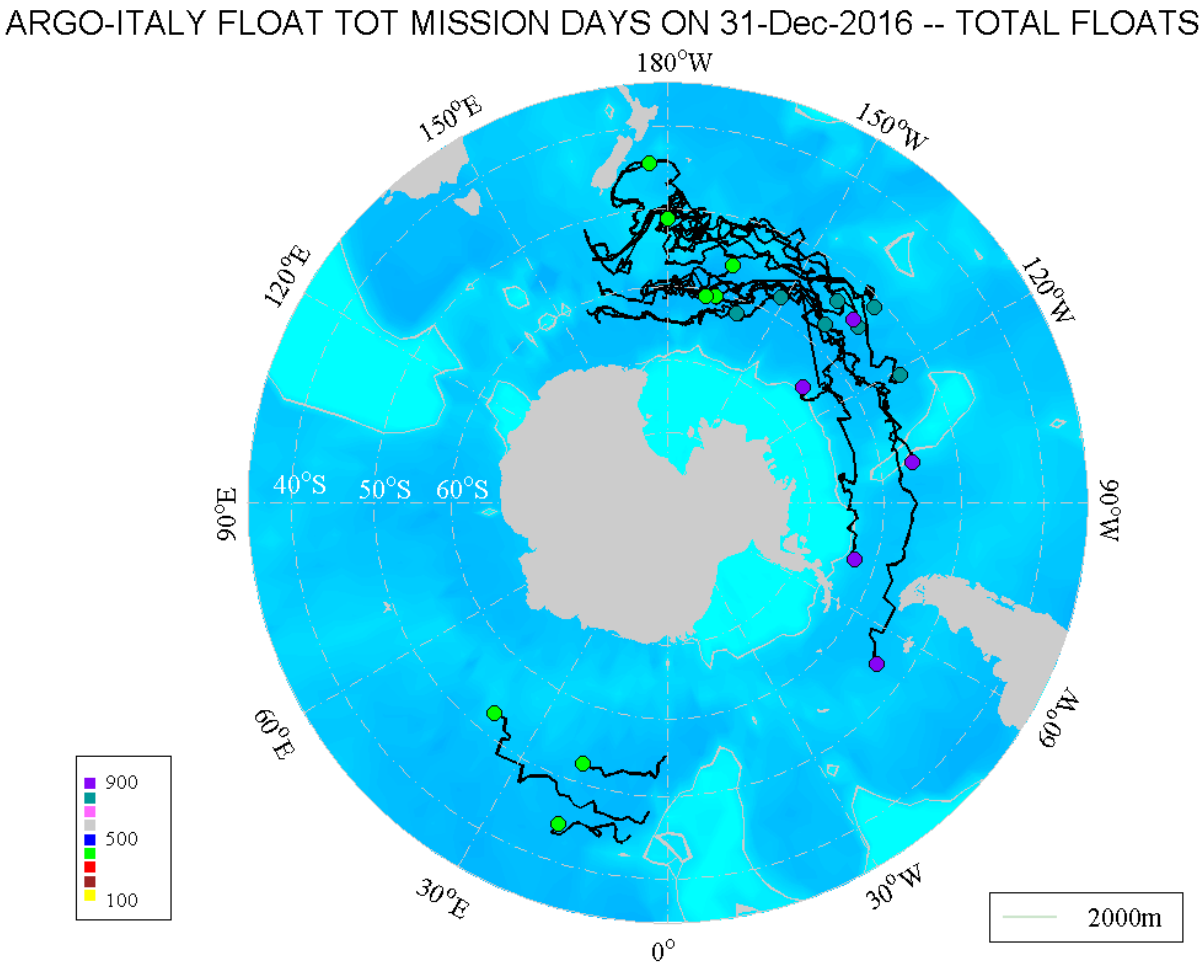

Figure 5. Trajectories and positions (circle symbols) on 31 December 2016 of the 20 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

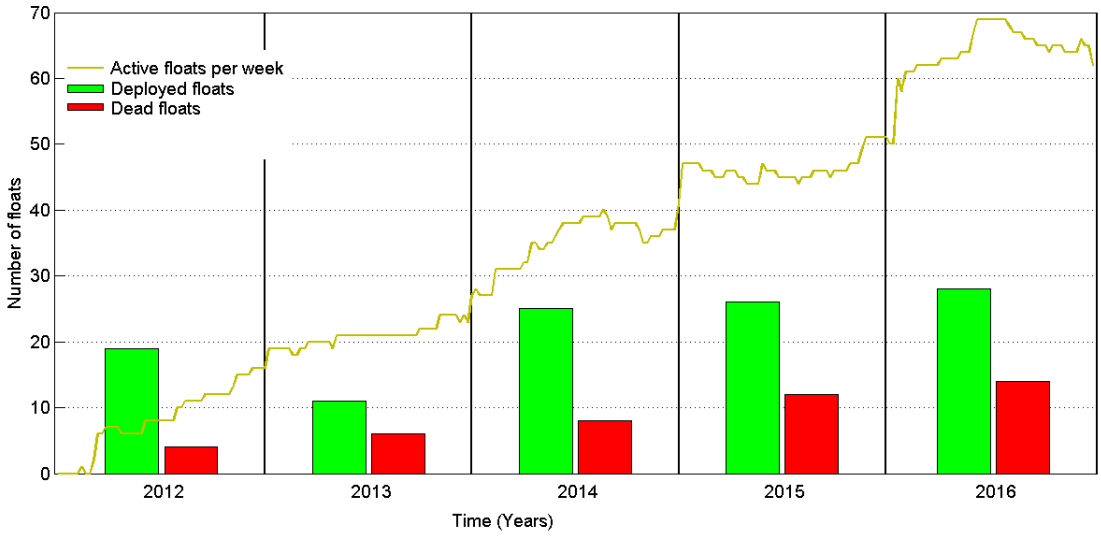

Figure 6. Temporal evolution of the number of active floats with weekly resolution and histogram of the annual float deployments and losses.

- technical problems encountered and solved

Mediterranean and Black Sea

The Nova float WMO 6903179 deployed in the Tyrrhenian Sea on 13 February 2016 suffered a malfunction after cycle 35 (on 9 August 2016) and subsequently remained at the surface. The deep Arvor float WMO 6903200 which was deployed on 8 June 2016 provided only 10 profiles and stopped transmitting after 3 August 2016. The cause of this failure has still to be investigated but we suspect that excessive grounding could have created problems. The second deep Arvor float WMO 6903203 deployed in December 2016 and programmed to profile down to 3000 dbar and to drift at a parking depth of 3000 dbar did not show problems and was still alive in early 2017, although its oxygen profiles appeared drastically erroneous.

Southern Hemisphere

The Nova/Dova floats deployed in the Southern Hemisphere in early 2016 have low survival rates and after a year (in early 2017) only 8 floats (out of 15 units, i.e., about 53%) were still fully operational.

In the South Pacific and Southern Ocean (Pacific Sector south of 60ºS) float WMO 6903181 stayed at the surface and stopped transmitting after about 9 days. Float WMO 6903184 stopped transmitting after 20 cycles. Floats WMO 6903185 and 6903188 failed right after deployment. Float WMO 6903186 stopped transmitting after 26 cycles.

In the South Atlantic Ocean float WMO 6903193 failed at deployment and the Dova float WMO 6903191 stopped transmitting after only 13 cycles.

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

The data management for the Italian float was 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 37 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 2010-2016. 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. 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 adopt 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 the reliability of the analysis. The DMQC of the Italian floats deployed in the Southern Ocean, the South Pacific and South Atlantic) is kindly performed by CSIRO in Hobart, Tasmania.

References

Pacciaroni M., Poulain P.-M., Civitarese, G., Pavlidou A., Velaoras D. and Bussani, A. (2016) Deep-Arvor programming and deployment in the Western Cretan passage. Rel. 2016/56 Sez. OCE 28 MAOS, 18 pp.

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 30 floats in 2016, including 5 instruments with dissolved oxygen sensors and 10 floats with Ice Sensing Algorithm (ISA). 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 2016. It is expected that the same level will be maintained in 2017, including the procurement of 20 additional standard floats and 3 floats with biogeochemical/optical sensors. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2017 as founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from EC (CMEMS, MOCCA) and ONR (CINEL) projects 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 2017 and 2018 are detailed in Table 3. 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	
2017	15 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	0	Mediterranean	**35**
2018	13 2 15	Mediterranean Black Sea Southern Ocean	2 1	Mediterranean Black Sea	2	Mediterranean	**35**

Table 3. Italian float deployment plans for 2016-2017.

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 Sea as part of the CMEMS and MOCCA 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/ .

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.

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 2016.

N/A

7. Italian contribution to Argo bibliography in 2016.

Buongiorno Nardelli, B., R. Droghei, and R. Santoleri (2016) Multi-dimensional interpolation of SMOS sea surface salinity with surface temperature and in situ salinity data. Remote Sensing of Environment, 180, 392-402, http://dx.doi.org/10.1016/j.rse.2015.12.052

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Fratianni, C., N. Pinardi, F. Lalli, S. Simoncelli, G. Coppini, V. Pesarino, A. Bruschi, M. L. Cassese, and M. Drudi (2016) Operational oceanography for the Marine Strategy Framework Directive: the case of the mixing indicator. Journal of Operational Oceanography, 9, s223-s233, http://dx.doi.org/10.1080/1755876X.2015.1115634

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