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Report on the Italian Argo Program for 2024

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2024)

a. Floats deployed and their performance

A total of 18 Italian floats were deployed in 2024 (see Tables 1 and 2 for details). These floats were Arvor TS DO, Arvor-Ice TS and TS DO, and Deep-Arvor designs manufactured by NKE (France). All floats transmit data via Iridium telemetry.

Floats were deployed from R/V Ammochostos (Cyprus), R/V Aegaeo (Greece), R/V Gaia Blu (Italy), Ship Aviva (Malta), R/V Laura Bassi (Italy), and Pampero II (Poland) for the Mediterranean and R/V Laura Bassi for the Southern Ocean with the help of colleagues from Greece, Malta, Italy and Cyprus.

Mediterranean and Black Sea deployments

Ten units were released in the Mediterranean (9 Arvor TS DO and 1 Deep-Arvor, see Table 1 for details). The Core-Argo floats have a park pressure at 350 dbar and maximal profiling depth at 2000 dbar while the Deep-Arvor was configured with a maximal profiling depth and parking depth at 4000 dbar, and a cycle time of 10 days. One Arvor TS DO float was deployed in the Sicily Channel and parked on the sea bottom to limit horizontal displacement and to sample that shallow area: the cycle time was set to 5 days and the parking depth was adjusted in order to be always greater than the maximum bathymetry. Three Arvor TS DO were released in the Tyrrhenian Sea, one in the Southern Adriatic, one in the Cretan Passage, one in the Levantine and two in the Alboran Sea. The Deep-Arvor was deployed in the Central Ionian Sea.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor – T/S Diss. Oxy	2903898	10-Mar-2024 04:40	35.11	23.91	71	01-Mar-2025 07:44	37.19	21.49	A	5
Arvor – T/S Diss. Oxy	4903782	28-Apr-2024 13:23	40.65	13.53	126	03-Mar-2025 05:43	39.77	11.74	A	5
Arvor – T/S Diss. Oxy	3902484	15-May-2024 08:15	34.28	33.03	58	01-Mar-2025 23:47	33.61	31.93	A	5
Arvor – T/S Diss. Oxy	7901135	20-May-2024 18:03	35.96	14.18	65	09-Nov-2024 21:57	36.56	12.04	D	5
Arvor – I DEEP	6990658	16-Aug-2024 16:10	35.69	17.73	22	02-Mar-2025 04:51	35.79	16.15	A	10
Arvor – T/S Diss. Oxy	2903928	25-Sep-2024 12:55	39.46	12.96	32	02-Mar-2025 19:44	40.24	12.63	A	5
Arvor – T/S Diss. Oxy	4903817	26-Sep-2024 01:30	40.02	11.59	32	03-Mar-2025 19:45	40.07	11.12	A	5
Arvor – T/S Diss. Oxy	3902626	17-Oct-2024 15:55	41.47	17.20	28	03-Mar-2025 18:04	41.68	17.85	A	5
Arvor – T/S Diss. Oxy	4903818	21-Oct-2024 11:19	36.67	-1.01	27	03-Mar-2025 09:48	37.24	0.37	A	5
Arvor – T/S Diss. Oxy	7901134	21-Oct-2024 19:53	36.31	-2.98	27	02-Mar-2025 20:12	36.16	-4.16	A	5

*Status in early March 2025: A = active, D = dead

**Cycle: Length of cycle in days

Table 1. Status information for the 10 Italian floats deployed in the Mediterranean Sea during 2024.

South Atlantic, South Pacific and Southern Ocean

With the help of Italian colleagues onboard the R/V Laura Bassi and in collaboration with the *Parthenope* University: a total of 3 Arvor TS and 5 Arvor TS DO all equipped with ice-detection software were deployed (2 out of 8 were recovered and re-deployed), in the Ross Sea. The adopted configuration in the Ross Ice Shelf Polynya consisted of a cycle time of 7 days and a park and maximum profile pressure of 1000 dbar (i.e. a park pressure at the seafloor).

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor – T/S ICE	5907101	25-Jan-2024 02:34	-75.11	163.83	74	07-Feb-2025 13:53	-74.66	165.69	recovered	7
Arvor–T/S DO ICE	6990623	27-Jan-2024 16:56	-77.18	169.19	7	04-Mar-2024 12:41	-77.39	169.77	D	7
Arvor–T/S DO ICE	3902580	28-Jan-2024 13:36	-77.39	174.17	63	17-Feb-2025 17:42	-76.32	173.05	recovered	7
Arvor–T/S DO ICE	5907090	29-Jan-2024 10:43	-77.70	-178.52	60	19-Feb-2025 17:33	-77.50	-178.58	recovered	7
Arvor–T/S DO ICE	1902686	01-Feb-2024 09:42	-77.99	-160.28	57	21-Feb-2025 05:34	-77.66	-161.12	A	7
Arvor–T/S ICE	4903795	02-Feb-2024 00:52	-77.16	-158.99	56	20-Feb-2025 17:36	-77.26	-159.54	recovered	7
Arvor–T/S ICE	5907104	02-Feb-2024 04:36	-76.72	-158.71	57	27-Feb-2025 19:31	-76.67	-159.05	A	7
Arvor–T/S DO ICE	5907091	02-Feb-2024 06:09	-76.48	-158.29	56	20-Feb-2025 17:45	-76.44	-159.30	A	7

**Status in early March 2025: A = active, D = dead*

***Cycle: Length of cycle in days*

Table 2. Status information for the 8 Italian floats deployed in the Ross Sea during 2024.

Overall status at the end of 2024

In summary, at the end of 2024, the Argo-Italy program had a total of 80 active floats, including 34 in the Mediterranean Sea (Figure 1), and 46 in the South Pacific, South Atlantic, and Southern Oceans (south of 60°S, see Figure 2).

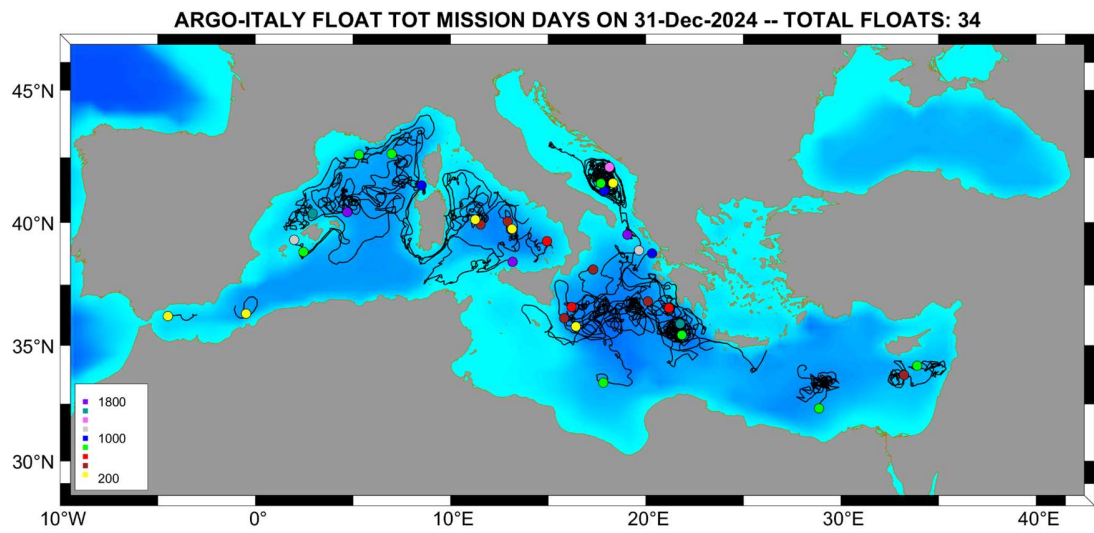


Figure 1. Trajectories and positions (circle symbols) on 31 December 2024 of the 34 Argo-Italy floats active in the Mediterranean Sea. Circles are color coded as a function of float age in days.

ARGO-ITALY FLOAT TOT MISSION DAYS ON 31-Dec-2024 -- TOTAL FLOATS: 46

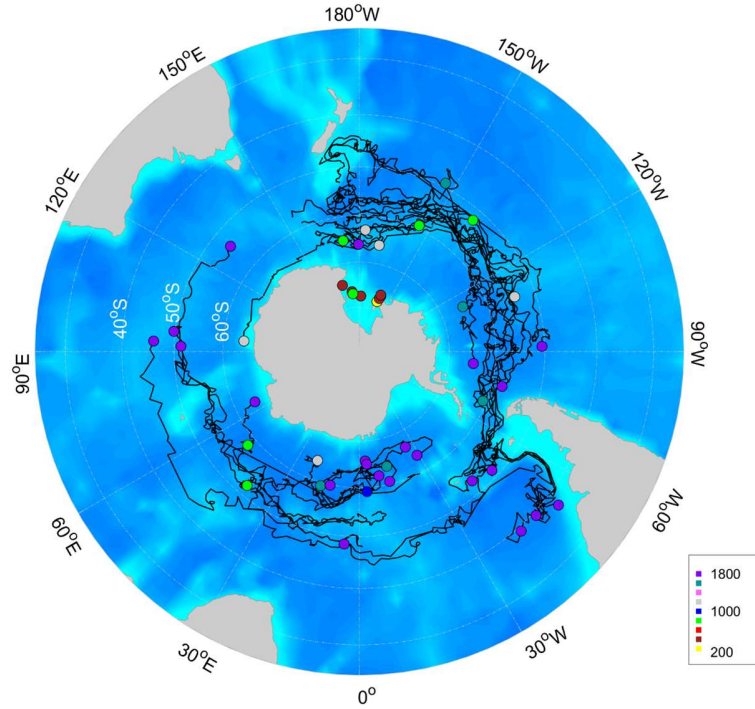


Figure 2. Trajectories and positions (circle symbols) on 31 December 2024 of the 46 Argo-Italy floats in the South Pacific, South Atlantic and Southern Oceans. Circles are color coded as a function of float age in days.

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 2012-2024. In 2024, the float population ranges from approximately 80 to 90 active instruments. The number of decommissioned floats is nearly offset by new deployments.

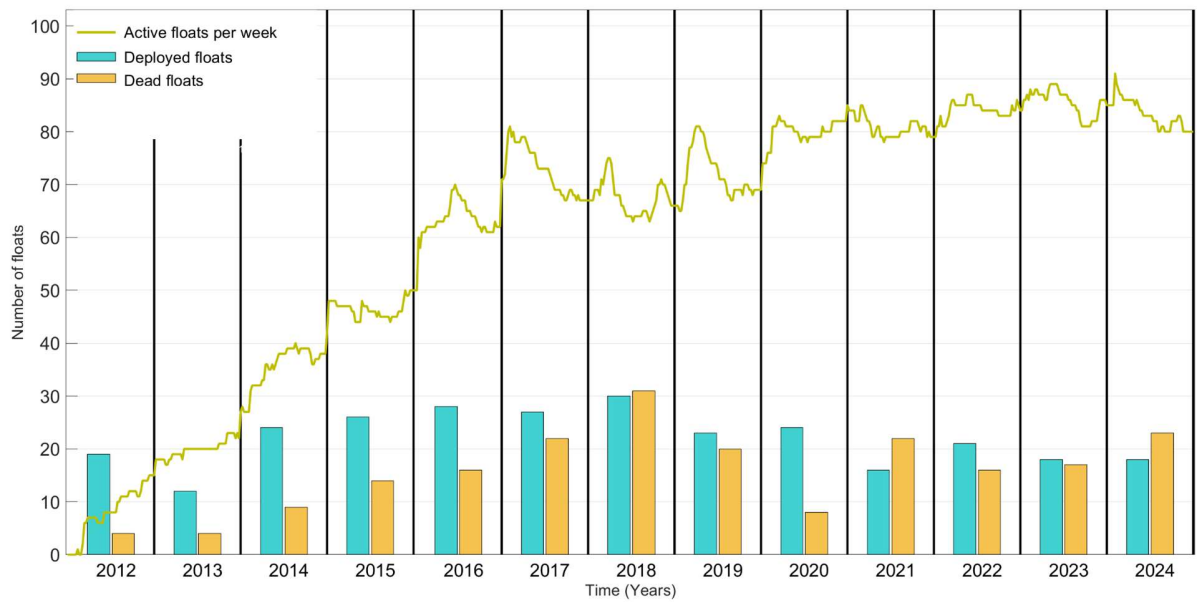


Figure 3. Temporal evolution of the number of Argo-Italy active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of 286 Argo-Italy floats have been deployed, 167 in the Mediterranean and Black Seas and 119 in the Southern Hemisphere oceans. Over a 13 year period, they have provided about 47,000 CTD profiles. Figure 4 presents a histogram depicting the number of floats across selected CTD profile classes. Figure 5 illustrates the evolution of the Italian float fleet over time by showing the number of float profiles categorized by main float types. In this diagram, Core and Core DO floats are grouped; Bio floats are intended as floats equipped with sensors for measuring 2 to 6 BGC parameters. The density coverage in the Mediterranean Sea is reported in Figure 6.

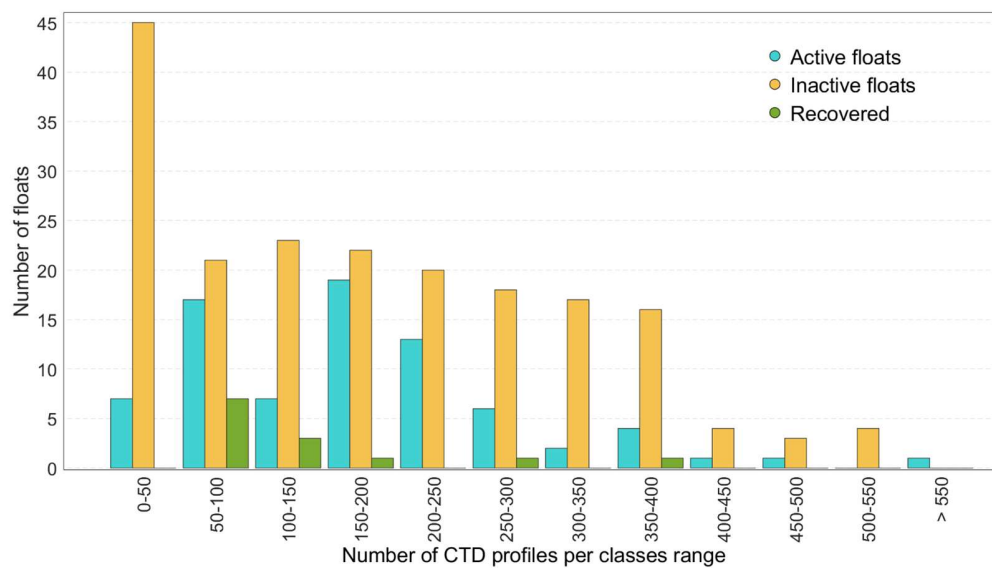


Figure 4. Histogram of the number of floats in selected CTD profile classes at the end of 2024 (orange: dead float, cyan: alive at the end of 2024, green: recovered).

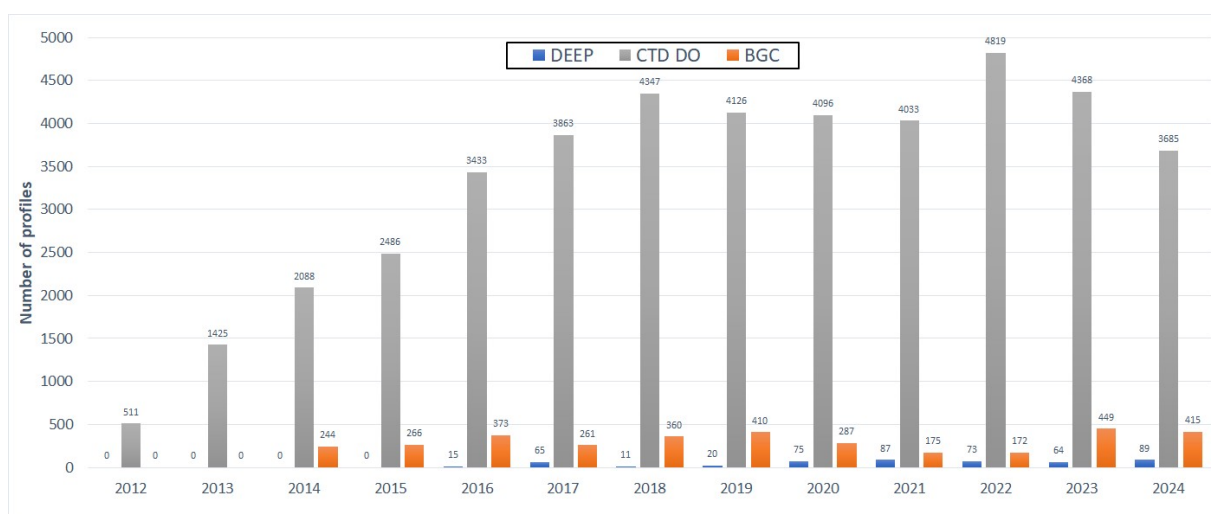


Figure 5. Number of float profiles from 2012 to 2024 sorted by main float types (orange: Bio floats, blue: Deep floats, grey: core and core DO floats).

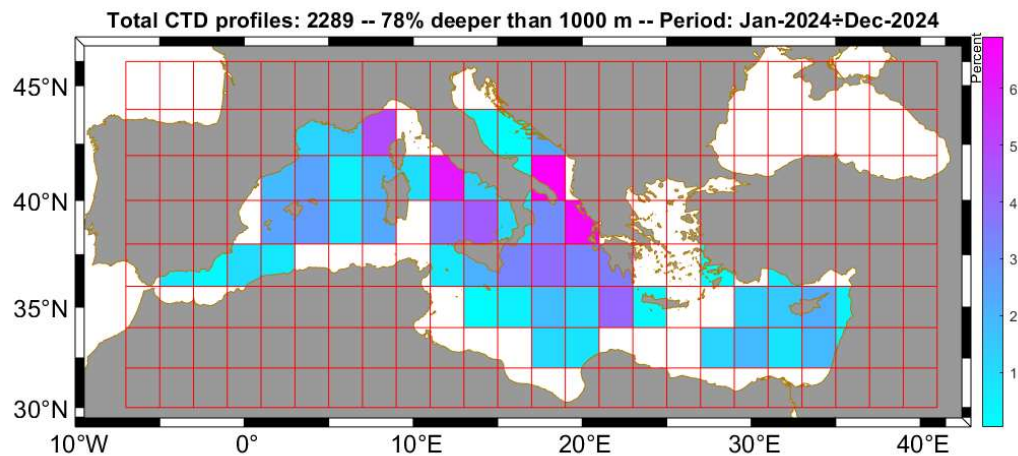


Figure 6. Density map of CTD profiles in 2024.

b. Technical problems encountered and solved

N/A

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

The data management for the Italian fleet is primarily handled by the Coriolis GDAC. Metadata and data are available in near real-time through the Coriolis web site. The status of high salinity drift is regularly updated on the dedicated share file available at <https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit#gid=1096144849>

For each Deep-Argo float analyzed in delayed mode, the following spreadsheet is updated with the optimal CPcor value applied:

https://docs.google.com/spreadsheets/d/1ai1l0gzyHHRv_n6t2M3BMWVBp1F9XO4L2XB1YhBni9U/edit?gid=278821204#gid=278821204

Plans are in place to train members of staff on the DMQC of DOXY and NITRATE.

d. 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 was done for approximately 77,5% of eligible

floats (200 out of 258 eligible floats) deployed between 2009 and 2023 in the Mediterranean and Black Seas, and Southern Ocean (all information and statistics to create the D-files have been sent to Coriolis). Physical data were quality controlled in delayed-mode following the standard Argo procedure. In particular, the OWC method in conjunction with other procedures is adopted to check and adjust the salinity data. The OWC is a statistical method based on the comparison between float salinity profiles and an accurate historical reference dataset. The high-quality ship-based CTD reference data from the near-surface to depths more than 2000 m, for QC purposes of Core and Deep-Argo float data in the Mediterranean and Black seas, was reviewed and improved. OGS collected CTD data from several research institutes at regional level and from the main European Marine Services in order to complement the official reference dataset. The reference dataset was quality controlled to obtain a good spatial distribution with more recent/contemporaneous data 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. In order to obtain an even more accurate reference dataset, the procedure developed at BSH is being adapted to marginal seas to find errors, suspicious data, large time gaps, etc. Due to the high natural variability in the water column of the Mediterranean Sea, additional qualitative checks (i.e., a comparison between nearby floats and analysis of the deepest portion of the temperature-salinity diagram) are used in conjunction with the OWC method to better interpret results and hence provide an improved quality control analysis. OGS continuously implements these procedures to better adapt them to marginal seas in order to obtain data of increasingly high quality. OGS is committed to carrying out DMQC on all the Core-Argo floats of the Mediterranean and Black seas, and on some core floats in the World Ocean, as part of the Euro-Argo RISE, MOCCA project and other European projects over the coming years.

2. Present level of, and prospects for, national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Polar, Spatial (equator, WBCs)

The Italian Ministry of Research has provided funding to buy 17 floats in 2024, including 15 Core-Argo with dissolved oxygen sensors, and 2 Core-Argo equipped with the RBR CTD. In addition, the Italian human resources per year devoted to Argo-Italy was about 50 man-months for scientific, administrative and technical personnel involved in the project in 2024. It is expected that the same level will be maintained in 2025. The Italian Ministry of Research has committed to provide funds in order to sustain the Italian contribution to Argo which is considered a high-priority infrastructure in the National Research Infrastructure Plan (PNIR). In addition to Italian national funding, in 2024 OGS received funding from the Italian PNRA (Programma Nazionale di Ricerche in Antartide) for personnel (about 8 man months) dedicated to activities related to Argo.

The ITINERIS-PNRR project [2022-2025, €5.85M] enabled Argo Italy to align with the new vision of the global Argo program by acquiring profilers dedicated to the BGC Argo and Deep Argo

missions. Therefore, in the next 5 years, Argo Italy is expected to undergo an expansion phase in terms of personnel and areas of scientific expertise, which will support new lines of research and generation of new funding.

On average over the 2020-2024 period, excluding ITINERIS-PNRR, competitive funding acquired per year grew from €43k/year before 2022 to €209k/year after 2022. This growth, which we expect to sustain over time, demonstrates Argo Italy's new capacity to support the new staff mentioned above in the medium term.

The instrumentation and management of the core-Argo mission will continue to be supported by structural funding. In the long term, we aim to demonstrate the socio-economic as well as scientific utility of the new BGC and Deep Argo missions to extend structural funding to them.

The ITINERIS floats are expected to be deployed starting from 2025 by OGS and CNR-ISMAR. At least 16 BGC and 3 Deep Argo floats will be deployed in 2025 in targeted areas of the Mediterranean Sea. BGC floats will be equipped with sensors for measuring 3, 4 or 5 EOVS (pH excluded). Moreover, some of them will be supplied with a double nitrate sensor (SUNA and OPUS), double optical sensor (RBR Tridante and SBS ECO Triplet), UVP6-LP, RAMSES Hyperspectral radiometer, IMU sensor.

- 3. Summary of deployment plans: as was done last year, please fill out this [spreadsheet](#) to help us understand the progress towards implementation of OneArgo. There is one new column this year for floats being deployed with experimental sensors such as UVP, C-sensor, etc. This spreadsheet is to be returned separately by 17 March to help prepare for the meeting. It can be sent to Megan or dropped in this [folder link](#).**

The Italian deployment plans from 2025 to 2028 have been provided as a separate contribution at https://drive.google.com/drive/folders/1a_hOVSpGMKajxd91Lv_fmP4IsmMnouNM, as requested. The main areas of interest are the Mediterranean and the Southern Oceans. Since 2023 it has been decided to equip the entire Core-Argo fleet with the dissolved oxygen sensor given the importance of this variable in water mass characterization and biogeochemical processes.

Over a longer time frame, Italy is primarily interested in maintaining mainly its contributions to the Core mission and supporting the BGC and Deep Argo missions as long as funds are available for these extensions.

- 4. Summary of any research and development efforts over the past year to try new sensors or improve float technology. This could include new collaborations with vendors or other partners.**

Under the ITINERIS projects, with the aim of reducing costs and energy consumption, our vision is to compare sensors that measure the same variable and demonstrate their reliability and potential interchangeability. In the next few years, data obtained from dual-sensor floats (one

traditional and one innovative) will be analyzed and presented to the scientific community and reported in scientific publications.

We also aim to rationalize the network of observations (in terms of number of floats and sensors for specific areas) in collaboration with operational modelers, including using ML/AI methods to reconstruct the most expensive BGC variables.

5. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on Argo websites.

Operational ocean forecasting

Data from core- and BGC-Argo floats in the Mediterranean Sea are routinely used for assimilation and forecast validation into the operational Mediterranean marine forecasting center (Med-MFC) run by the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) and the National Institute of Oceanography and Applied Geophysics (OGS). Med-MFC provides 3D daily physical and biogeochemical fields of the Mediterranean that are available on the Copernicus Marine Service at <https://data.marine.copernicus.eu/products?facets=areas%7EMediterranean+Sea>. Assessments done by the Med-MFC have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions (Coppini et al., 2023).

Specifically for the biogeochemical operational component, work done by OGS during 2024 included the inclusion of the assimilation of synthetic nitrate profiles computed using the novel PPCON Neural Network (Pietropolli et al., 2023). The new component demonstrated improvement in biogeochemical model results (Amadio et al., 2024) and overcame the drastic decrease of nitrate sensors in the Mediterranean sea starting from 2022.

Additionally, skill performance metrics of the Med-MFC biogeochemical predictions are operationally computed using BGC-Argo data and published regularly in the OGS webpage of the operational results (medeaf.ogs.it/nrt-validation).

Work done at OGS in 2024 also included the implementation of a novel 1D physical-biogeochemical model framework (GOTM-FABM-BFM, Lazzari et al., 2022; Alzare et al., 2023) that uses Argo and BGC-Argo data as virtual mooring for forcing and assimilation in the Mediterranean Sea. The new model framework has been used for model optimization and parameterization testing to support the development of the operational Marine Copernicus model for Mediterranean biogeochemistry.

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. Biogeochemical-Argo data are being used to explore carbon fluxes and analyse the impact of extreme events on marine ecosystem structure and functioning, as well as to develop and validate new satellite products.

Web pages

The websites for the Italian contribution to Argo (Argo-Italy) are <http://argo.ogs.it/#/>. The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is <http://argo.ogs.it/medargo/>.

6. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-26 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.**

N/A

7. **Outreach and communication: please describe, in brief, outreach efforts within your national program over the past year. Also, if you've issued any communications, press releases, participated in articles, etc, please send the links. We are considering our social media strategy, so please let us know which social media you engage with and the corresponding handles.**

In 2024, OGS launched the Adopt-a-Float program, attracting participation from three schools of different levels and grades. These classes adopted a float and tracked it throughout the school year, monitoring its data. Both teachers and students engaged in meetings and exchanges with the OGS team, culminating in a presentation of their findings at the end of the year.

As part of the Big Science Business Forum 2024—a business-focused conference on high technology and a key meeting point between research infrastructures and industry in Europe—scientific outreach activities were conducted during visits to research institutions within the Scientific and Innovation System of Friuli Venezia Giulia.

8. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

OGS is committed to keeping the Mediterranean and Black Sea reference dataset up-to-date. For this purpose, OGS collects CTD data from different sources (Mediterranean and Black Sea riparian countries, national and European repositories) on a yearly basis. All non-restricted data are sent to the Coriolis GDAC for quality control, as some data policies do not allow the use of those data for scientific purpose and publication.

9. Keeping the Argo bibliography ([Bibliography | Argo \(ucsd.edu\)](#)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications. There is also the thesis citation list ([Thesis Citations | Argo \(ucsd.edu\)](#)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

Argo PIs: Elena Mauri and Giorgio Dall’Olmo (OGS), Emanuele Organelli (CNR-ISMAR)

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10. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2025 and 2026 (if known) and where they might be deployed.

OGS bought one Arvor I equipped with the RBR CTD sensor in April 2023 and the float has not yet been deployed due to early failures of Arvor floats equipped with RBR CTD in 2024. It seems now that the problem was well investigated and that no further issues have been raised. Hence, this float will be deployed in 2024.

Other two Arvor with the RBR CTD were bought in autumn 2024 and they will be delivered in mid 2025.

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