



Euro-Argo Report – AST24

The Euro-Argo Research Infrastructure organises and federates European contributions to Argo (www.euro-argo.eu). The Euro-Argo ERIC (European Research Infrastructure Consortium) and its governance structure (Council, Management Board and Science and Technological Advisory Group) was set up by the European Commission in May 2014, with 9 funding countries. Currently the Euro-Argo ERIC has 11 members, one observer and one candidate. The Euro-Argo ERIC is made up of a central office based in France (Ifremer, Brest) and distributed national facilities (Figure 1). The distributed national facilities operate with direct national resources. As part of the Euro-Argo Research Infrastructure, they agree to a multi-annual commitment of resources (in particular in terms of floats to be deployed and for the data system), and to coordinate their activities through the Euro-Argo ERIC. The Euro-Argo ERIC delegates some of its activities to the national facilities who have the relevant expertise (e.g. data management and quality control, float deployment), and according to their areas of responsibility.

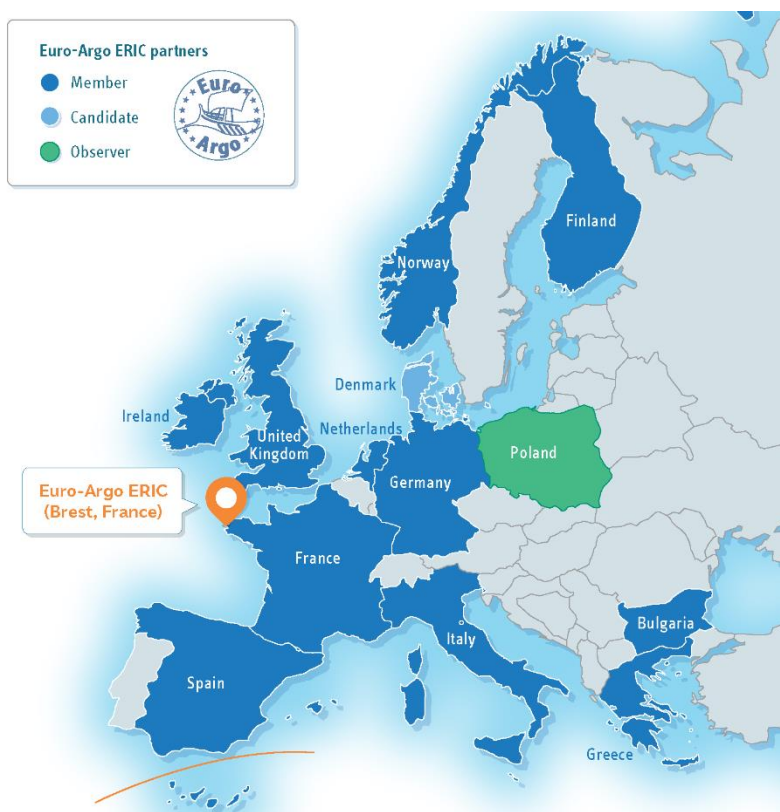


Figure 1. Euro-Argo ERIC membership in 2022

In December 2022, the Euro-Argo ERIC involved 13 countries: **11 Members**, **1 Observer** and 1 Candidate.

This report presents the contribution of EU funded Argo activities as well as the integrated view of EU plus national European contributions.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. floats deployed and their performance

In 2022, 8 EU-funded floats were deployed, including 3 core floats (funded by Orange Group) and 5 T/S/O2 floats (funded under Euro-Argo ERIC own budget) deployed during Endurance22 and Resilience cruises - deployments coordinated by Tammy Morris. These 8 floats come in addition to the 223 floats deployed by the National members. The table below shows the floats deployed, both as number of floats measuring a specific variable and per type of float.

Table 1. European floats deployed in 2022, per parameter measured (blue, 7 first columns) and per type of float (green, 5 last columns). "BGC" stands for floats measuring the 6 BGC variables and "Bio" stands for other floats equipped with 1 to 5 BGC sensors, except the Deep-O2 floats only counted in the "DEEP" column.

	Variables							Float types				
	T&S	O2	Chla	BBP	NO3	Irradiance	pH	core	BGC	Bio	Deep	Total (floats)
EU funded	8	5	0	0	0	0	0	3	0	5	0	8
Member states	223	61	35	35	20	30	21	160	20	28	15	223
total	231	66	35	35	20	30	21	163	20	33	15	231

A total of 231 floats have been deployed in 2022, with 75% of them being NKE floats. In March 2023, only 216 out of the 231 floats were still active, most of them being lost at deployment, a larger amount than usual. In next year's report, we envisage to provide a complete list of ending causes of Euro-Argo floats dead in 2022.

About 10 European floats have been recovered in 2022, mainly in marginal Seas, but also 2 in the Southern Ocean.

The launch locations of all Argo floats deployed in 2022 are shown in Figure 2.

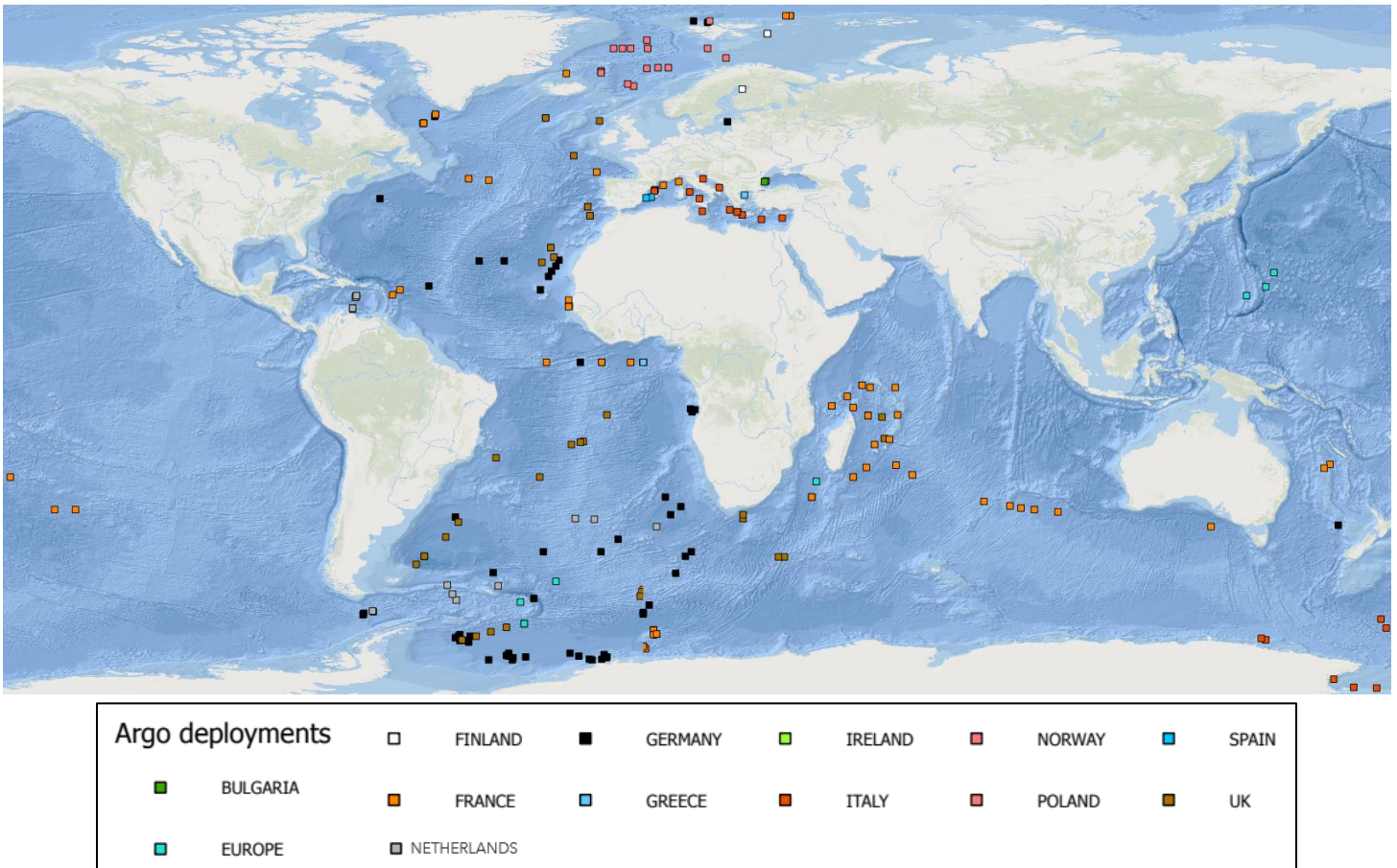


Figure 2. Deployment positions of the European floats deployed in 2022 (Credit OceanOPS)

In 2022, Euro-Argo took part in “Deployment Planning meetings” organised internationally and across ocean observing networks, resulting in coordinated launches of Argo floats in Atlantic and Indian Oceans. Euro-Argo also continued the implementation in the Nordic Seas and, on a lower level, in European Marginal Seas, for the benefit of more deployments in the Southern Oceans and Arctic Oceans, where the global Argo network coverage was on stress.

The European contribution is progressing towards the implementation of the Deep (15 floats deployed) and BGC missions (53 floats carrying at least one BGC sensor deployed) (see Table 1). A major outcome is the significant number of 20 “full BGC floats” deployed – measuring the six variables, and sometimes experimenting new observation systems, such as UVP, hyperspectral radiometry, etc. The oxygen network is again progressing with about 30% of Euro-Argo floats deployed in 2022 carrying an oxygen sensor. 15% of the deployed floats are equipped with a chlorophyll and suspended particles sensor, 13% with irradiance and 9% with pH and nitrate.

Figure 3 presents the evolution of Euro-Argo deployments since 2008. In 2022 Euro-Argo deployed 231 floats, representing 31% of the global effort, comparable to last year.

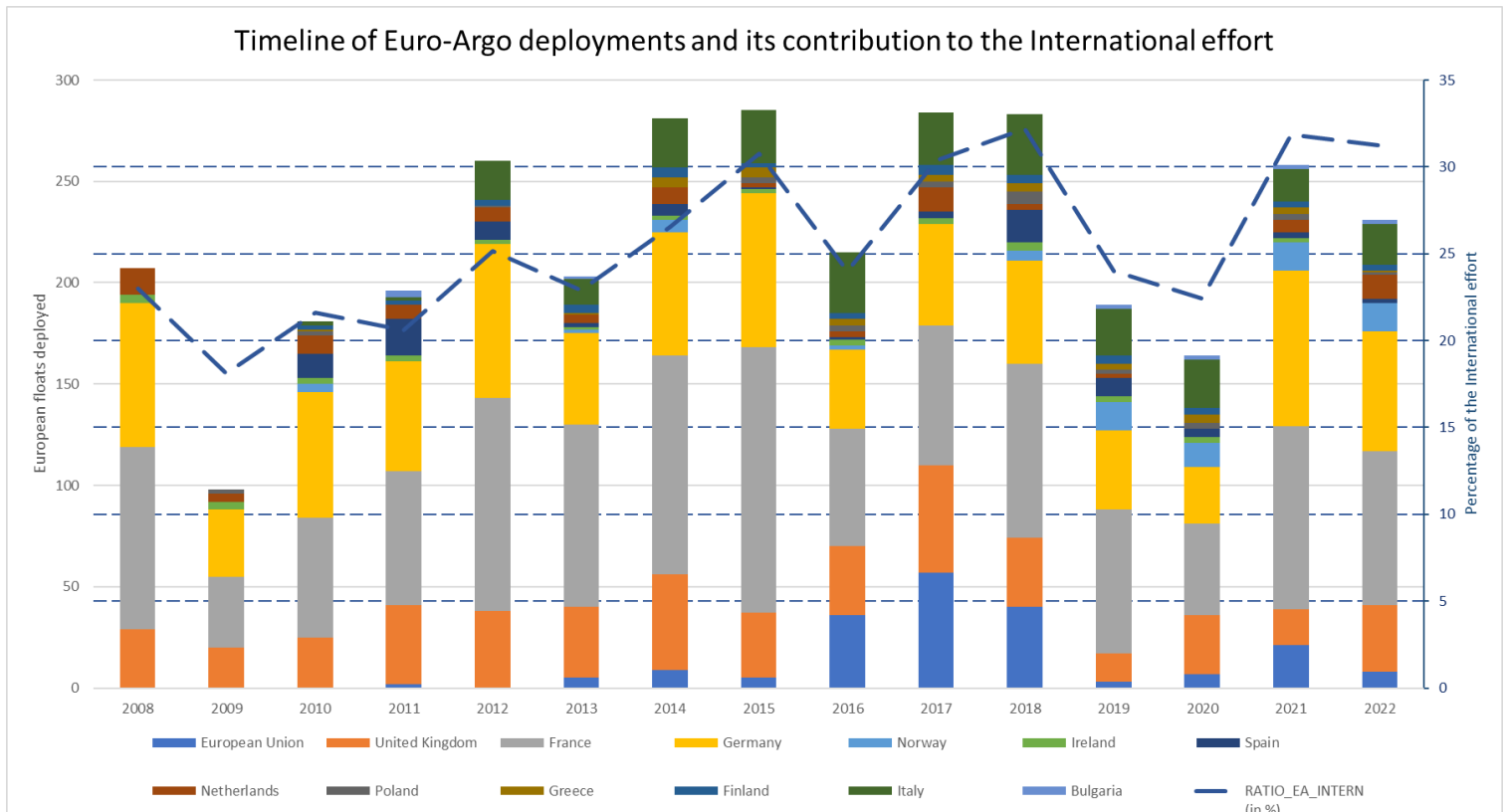


Figure 3. Timeline of Euro-Argo deployments (in number of floats, colored bars, left axis) and its contribution to the international effort (in %, blue dashed line, right axis).

These deployments relied on national programs complemented by European projects (e.g. ERC REFINE) and by national projects such as NorArgo2, ASBAN or COMFORT.

It should be observed that while the Euro-Argo number of BGC floats deployed persists or slightly increases, our relative contribution to the BGC international array is decreasing. This translates also in terms of operational floats, as shown in Figure 4.

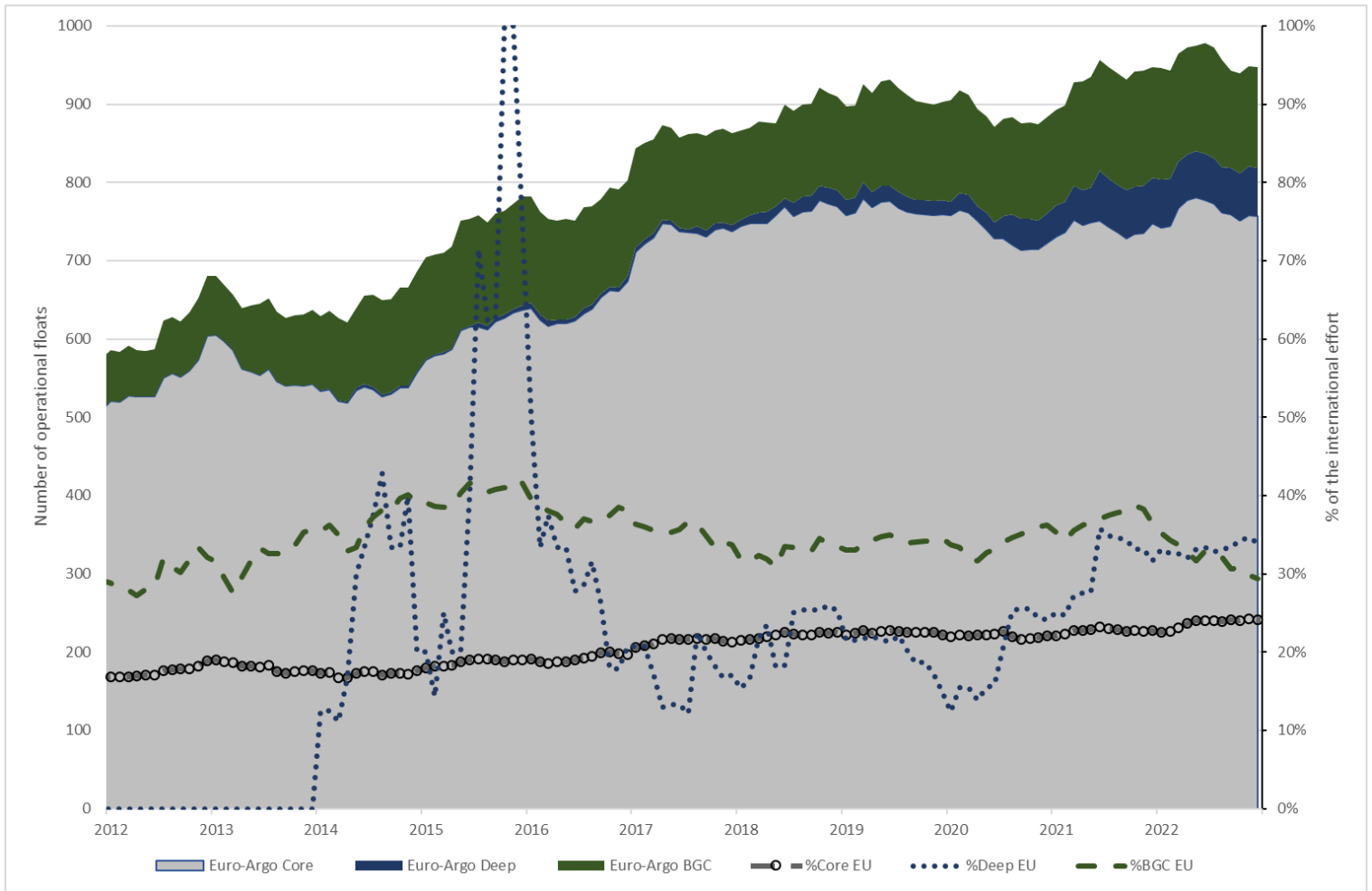


Figure 4. Evolution of the Core (T&S), BGC and Deep missions, in number of operational floats (colour, left axis) and in percentage of the international effort (blue, grey and green lines, right axis). © OceanOPS

b. technical problems encountered and solved

European partners have been affected by the pH sensor failure for sensor in the SN range [10000-11117]. This issue is supplemented by the current difficulties in pH sensor procurement. This issue has severely compromised both the quality and the amount of pH data of European floats.

As noted earlier, a larger amount of European floats were lost at deployment compared to previous years (Deep and core floats), with no clear explanation.

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)

- **European data processing & DMQC**

All European floats are processed by Coriolis and BODC DACs (respectively 83% and 17% of European profiles in 2022), and DMQC of T and S parameters is currently shared between 7 institutes (BSH, OGS, Ifremer, BODC, IMR, IOPAN and IEO), plus a small Euro-Argo ERIC contribution for some of the EU-funded floats, through subcontracting. European partners are also strongly involved in the development of DMQC procedures for Deep Argo and BGC Argo (especially for BBP, Chl-A and Irradiance) or for Argo operating in specific areas (e.g. Baltic Sea), and in the monitoring of high salinity drifting floats. Partners deploying Argo floats in the Baltic Sea are organising an Argo-Baltic DMQC workshop in April 2023 to train newcomers.

- **Abrupt Salinity Drift**

The European fleet is impacted by the abrupt salinity drift on SBS sensors. Euro-Argo maintains the international [Google spreadsheet](#) to monitor the issue. In 2022, the spreadsheet has been simplified and statistics are now computed from data taken directly from the GDAC. An important work to clean the dataset, including identification and correction of metadata, was performed in 2022. This work allowed to provide more robust statistics and to progress in the negotiation with SBS regarding warranty of data loss for CDT SN in the recall range (see below).

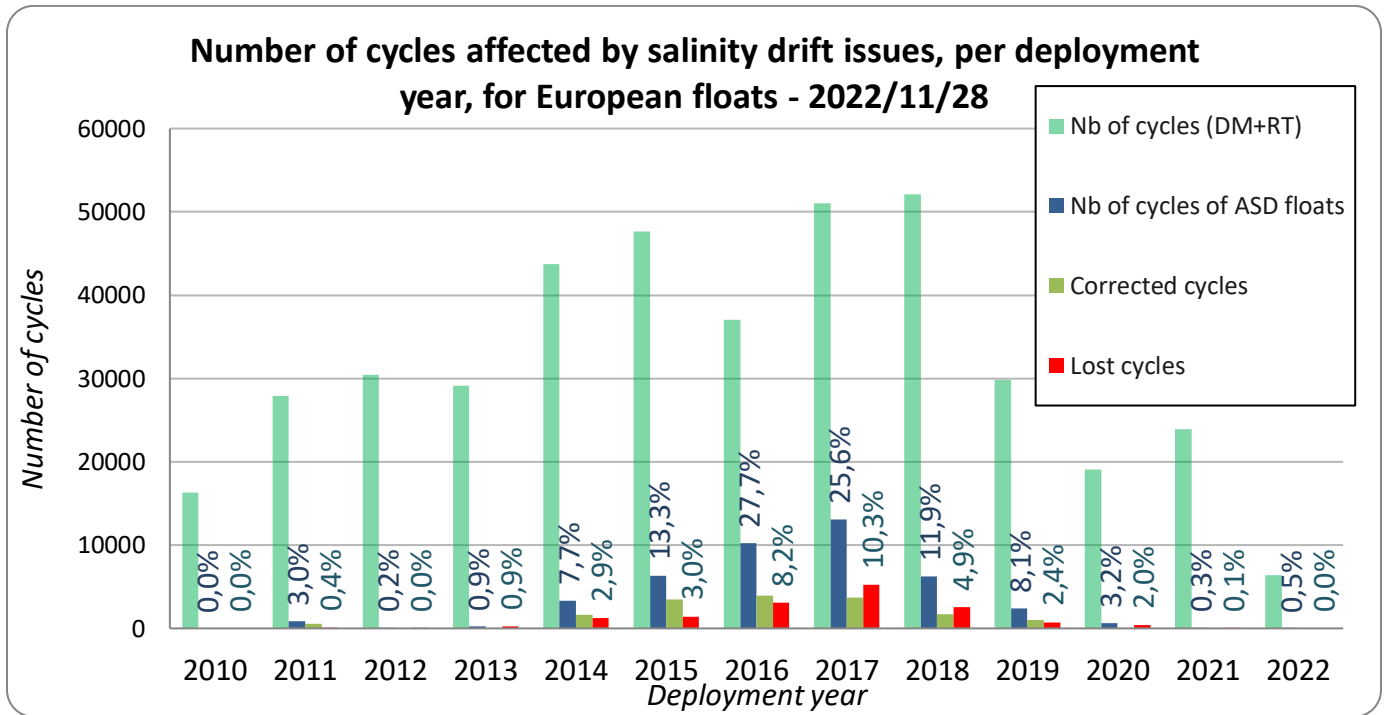


Figure 5. Percentage of cycles affected by abrupt salinity drift problem in the European fleet – as of Nov. 2022.

Figure 5 shows that (as of November 2022) the issue was most significantly present in profiles made by floats deployed in 2015-2018 (up to 10% of data lost), but is still affecting data made by floats deployed in the more recent years: 3.2% of data made by floats deployed in 2020 are impacted by a drift, with 2% of the data being lost (uncorrectable drift).

A meeting was organised late 2022 between all European partners to prepare a negotiation with SBS for the loss of data due to faulty CTD sensors in the SBS recall range (10482-11252). If focussing on this range, along the 568 floats deployed at international level, 150 floats have reached unadjustability (international fleet) and among them 32 are European floats, spread across 6 national programs: France (16), Germany (6), Norway (4) and Ireland, Italy, UK (2 each). A meeting was held (on line) with SBS in January 2023, and Europe is now waiting for feedback from SBS to agree on a final list of floats for which the warranty process that was agreed in January will be put in place (see Birgit Klein's presentation).

- **BGC data management**

Although BGC DMQC of European floats has started thanks to local initiatives, it is still disorganised and not fully funded. The organisation of BGC DMQC is presently in discussion at Euro-Argo level, with various scenarios investigated, and a consolidated proposition of organisation between various institutes involved should be set up during the course of 2023.

d. status of delayed mode quality control process

At the end of 2022, the percentage of the whole European fleet (EU-funded + National) processed in Delayed Mode amongst eligible floats (more than 1 year old) was almost 98%.

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

In 2022, the Euro-Argo ERIC coordination office was a team of ~5.3 FTE (4.3 permanent, 0.5 project-funded and 0.5 consultant). This team supports European countries to sustain and optimise the European contribution to the Argo International programme, and comes in addition to the national members' personnel.

The European contribution to Argo has still benefited from the Euro-Argo RISE EU project (Euro-Argo Research Infrastructure Sustainability and Enhancement), that has involved all the Euro-Argo ERIC members except Netherlands for a 4 year duration (until December 2022). Euro-Argo RISE was coordinated by the Euro-Argo ERIC. The project was granted 4M€, including funds for float purchase (**12 floats in total including Deep and BGC floats, all deployed prior to 2022**) and a total of more than **100**

person months per year dedicated to Argo activities in all aspects (technological development, science, data management, outreach, legislation, etc.). In 2022, Euro-Argo RISE issued recommendations for deploying Argo floats in the Arctic Ocean and in shallower areas of the European Marginal Seas. For boundary current applications, the Virtual Fleet software was created to compute and analyse simulations of virtual Argo float trajectories and had a new release early 2023.

Euro-Argo is also involved in the **EuroSea EU project** that funded **5 Deep floats and 5 BGC floats** deployed in 2021 and allows collaborations with other ocean observing networks, and in the **ENVRI-FAIR EU project** in which Euro-Argo is funded to work on improving **FAIRness** (FAIR: Findable, Accessible, Interoperable, Reusable) of **Argo data**, through the involvement of the two European Argo DACs (BODC & Coriolis).

The EU project DOORS (Developing Optimal and Open Research Support for the Black Sea), started in 2021, will also allow Europe to further develop Argo in the Black Sea and demonstrate the importance of BGC-Argo for Blue Growth development in the Black Sea as part of a multiplatform integrated observing system. The project includes the funding of sensors for 2 BGC floats that were planned to be deployed in 2022 (by Bulgaria) but postponed to 2023 due to the political situation in the countries surrounding the Black Sea.

The EU Project GEORGE, for next GEneration multiplatform Ocean obseRvinG tEchnologies for research infrastructures, started in January 2023. The overall objective of GEORGE is to advance the global technological competitiveness of European ocean observing research infrastructures (EMSO, ICOS, Euro-Argo) through the development and demonstration of a state-of-the-art biogeochemical, multi-platform observing system from sensor to data repositories, for characterisation of the ocean carbon system.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Float deployments planned for 2023 are presented in Table 2 per region and type of float. In total, Europe plans to deploy 301 floats, significantly more than the number of floats effectively deployed in 2022, but these numbers are to be taken with care because of uncertainties in funding availability for several partners, as well as unforeseen inflation in float prices. Only 4 of these floats will be funded by the Euro-Argo ERIC.

Table 2. European deployment plans for 2023: total [national + EU-funded] & (EU-funded in brackets). "T/S/O2" stands for core floats equipped with an additional oxygen sensor (DEEP floats equipped with an oxygen sensors are counted in the DEEP column), and "BGC" stands for floats with 6 BGC parameters, and "Bio" for all other floats able to measure some other BGC variables.

	Core	T/S/O2	BGC	Bio	DEEP	total
Nordic	7	4	5	4	0	20
Med Sea	15	7	3	2	2	29
Black Sea	1	1	0	2 (1)	0	4 (1)
Baltic	1 (1)	3	4	2	0	10 (1)
Southern	39	0	4	0	4	47
Arctic	8	0	3	0	0	11
Global	127	10	21	15	7 (2)	180 (2)
Total	198 (1)	25	40	25 (1)	13 (2)	301 (4)

In addition to data processing, European institutes are continuing **their R&D work for improving data quality**, through the development of new DMQC methods, both for T/S and for BGC parameters. Collaboration at European level is being enhanced and this will continue in the coming years, thanks to work carried out in **ENVRI-FAIR**. The work done to handle Argo vocabularies via the Nerc Vocabulary Server (NVS) was pursued in 2022, and Argo Reference tables are now almost all converted, which will allow to start relying on the NVS for all Argo vocabulary issues and thus increase the GDAC reliability.

BGC data management is also being organised at European level and this work will continue in 2023. A new 3-year EU project has started in September 2022 (**FAIR-EASE**) in which Euro-Argo is funded (150 k€) to develop a BGC data QC workbench that should ease the use of QC tools and methods, in particular for Oxygen, by a wide community.

European Research teams are also involved in **technological activities**, e.g. ice avoidance systems and tests of alternative sensors (RBR, TRIOS, etc.), and work carried out in current EU projects also includes **outreach and training activities**, as well as **community strengthening**. In particular, the **7th Argo Science Workshop** was hosted by Euro-Argo in Brussels on 11-13 October 2022.

Euro-Argo is concerned by the lack of resources available to fully implement OneArgo and has started to think of ways to approach key stakeholders to solve this issue. One first example of this kind of **advocacy activities** is the production of a series of general videos on Argo / Euro-Argo, as well as 10 thematic plain

language articles **showing the importance of Argo**. This work has been done in collaboration with Mercator Ocean in the framework of the EU4OceanObs initiative.

4. 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 the AST and AIC websites.

Argo data and/or products derived from Argo data are used by European operational services such as Copernicus Services and ECMWF, for satellite calibration and validation and for research carried on by the Euro-Argo ERIC partners in various domains, including Deep and BGC (see national reports for details). Regarding operational services, following the **MoU** signed in 2021 between **Euro-Argo ERIC and Mercator Ocean international / Copernicus Marine Service** to better define areas of collaboration between the two entities, another **MoU** was also signed in 2022 between **Euro-Argo ERIC and ECMWF**, one key user of Argo data in Europe, and in charge of the implementation of **the Copernicus Climate Change Service**.

Within the Euro-Argo RISE EU project, European contribution to Argo ARCs was temporarily reinforced, in particular in the Southern Ocean ARC.

5. 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 the AIC, 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-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

Here is a list of several issues that Euro-Argo would like to mention:

- Large costs increase on sensors and other float components, combined with high exchange rate variation will have a significant impact on network implementation, for 2023 and the years to come.
- Recent European floats are impacted by salty drifts. It is essential to continue to evaluate and monitor the impact in terms of data loss.
- Some European partners are currently facing difficulties in the procurement of pH sensors / floats with pH sensors.
- Funding for the NVS work will stop mid-2023 and no further development will be possible without additional resources (although efforts are ongoing to find new opportunities, in particular through EU projects). The BODC Vocabulary Management Group is responsible for supporting NVS activities, and will continue to do so, but the maintenance of the Argo metadata lists and mappings on the NVS will rely on the Argo vocabulary “editors” who are currently acting on their own funds, and this could be seen as a potential issue for the future.

- The current political situation is impacting the development of Argo in several regions of European interest: Arctic Ocean, Black Sea and Baltic Sea, including delays or cancellation of cruises for deployments.

6. 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.

See national reports.

7. 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.

The Euro-Argo ERIC maintains a summary of the European bibliography at <https://www.euro-argo.eu/Outreach/Bibliography>. It includes a subsection "Read of the Month" that proposes plain language summaries of scientific publications, one each month, advertised through Twitter. In 2021, the Bibliography section of the website was enhanced with a new presentation of the full Euro-Argo bibliography in a "sortable" table (similar to BGC-Argo bibliography). This bibliography is updated once a year in collaboration with Argo international, after the AST annual meeting.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

There is a global lengthening of the delays due to tensions at the international level and Euro-Argo is facing difficulties in terms of float and sensor procurement. However, Euro-Argo caught-up its back log of 2020-2021 in 2022 and is no longer impacted for now in terms of number of floats deployed.

9. 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 2022 and 2023 (if known) and where they might be deployed.

Europe has been involved in RBR CTD pilot studies, with a 3 head deep float prototype (for intercomparison with SBE CTDs) and an Arvor-I RBR developed within the Euro-Argo RISE project and successfully deployed in 2020, and 2 more floats equipped with RBR CTDs deployed in 2021. Two '2-Headed' and one '3-Headed' Deep Argo floats (range 4000 m depth) have also been deployed in March 2022 in the Canary basin under the framework of the EA-RISE project, through collaborative work between Ifremer & IEO. The data obtained thanks to these experiences have been useful in first assessments of the RBR CTDs potential, and Europe will continue to investigate the potential of these new CTD in the coming years, with most of the European partners planning to have part of their fleet (about 10% of the core fleet at least) equipped with RBR sensors (e.g. UK, Germany, France), following the AST recommendations (about 10% of the core fleet at least).