ACTIVITY REPORT 2022

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EUROARGO

EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM FOR OBSERVING THE OCEAN

Foreword

More than ever, Euro-Argo is an ERIC, a European Research Infrastructure Consortium, which carries out a dual objective. One of its main goals is to collect highly quality-controlled *in situ* observation. This data is already enacted as essential for the scientific progress in the knowledge of the functioning and the evolution of the oceans. But another of its crucial concerns, less well known, is also to maintain and disseminate a synoptic view of the ocean for operational applications in weather and climate forecast, operational oceanography, and health monitoring of the ocean. For a number of years, these duties have been fulfilled not only for the Core variables – i.e. salinity and temperature measured by Argo floats – but also for the biogeochemical essential observing variables, like dissolved oxygen, Chlorophyll-a (Chla-a), nitrates among others.

Obviously, Euro-Argo is one major piece of the global ocean observing puzzle. Firstly, by striving to contribute to a quarter of the new global, in-depth and multidisciplinary OneArgo design, defined at international level. Euro-Argo ERIC also stands out for one of its key strengths, which perfectly reflects the collaborative spirit it has been developing since its creation: the complementary nature of its activities. Thus, it is a historic complement to satellite remote sensing, providing invaluable calibration and validation. In addition, it is constantly aiming to be fully embedded in the big picture of other *in situ* observation networks. Last but not least, Euro-Argo obviously completes the global interpolation and forecasting capacity provided by numerical models, that in turn extend from physical behaviors to the ecosystem depictions.

This report therefore shows key performance indicators that cover both the contribution to scientific excellence and operational efficiency of Euro-Argo. It also relates how the system evolves to incorporate new sensors, to enhance its coverage – namely to the poles and the Marginal Seas – and to ease the usage into new applications of the data produced. Indeed, 2022 was the year of the outcomes of the very structural European project, Euro-Argo RISE, fostering the best interactions between all nodes and the Euro-Argo ERIC Office. This made indeed this yearly report thicker than ever!

However, 2022 was also shadowed by the comeback of inflation, which, combined with the ramping growth of the network capacity and coverage to OneArgo, questions the financial sustainability of Euro-Argo ERIC by contributing member countries.
By showing so many achievements together with a transparent insight into the challenges to be overcome in a very near future, reading this report should help advocating for new resources.

Jean-Marie Flaud
Chair of Euro-Argo ERIC Council

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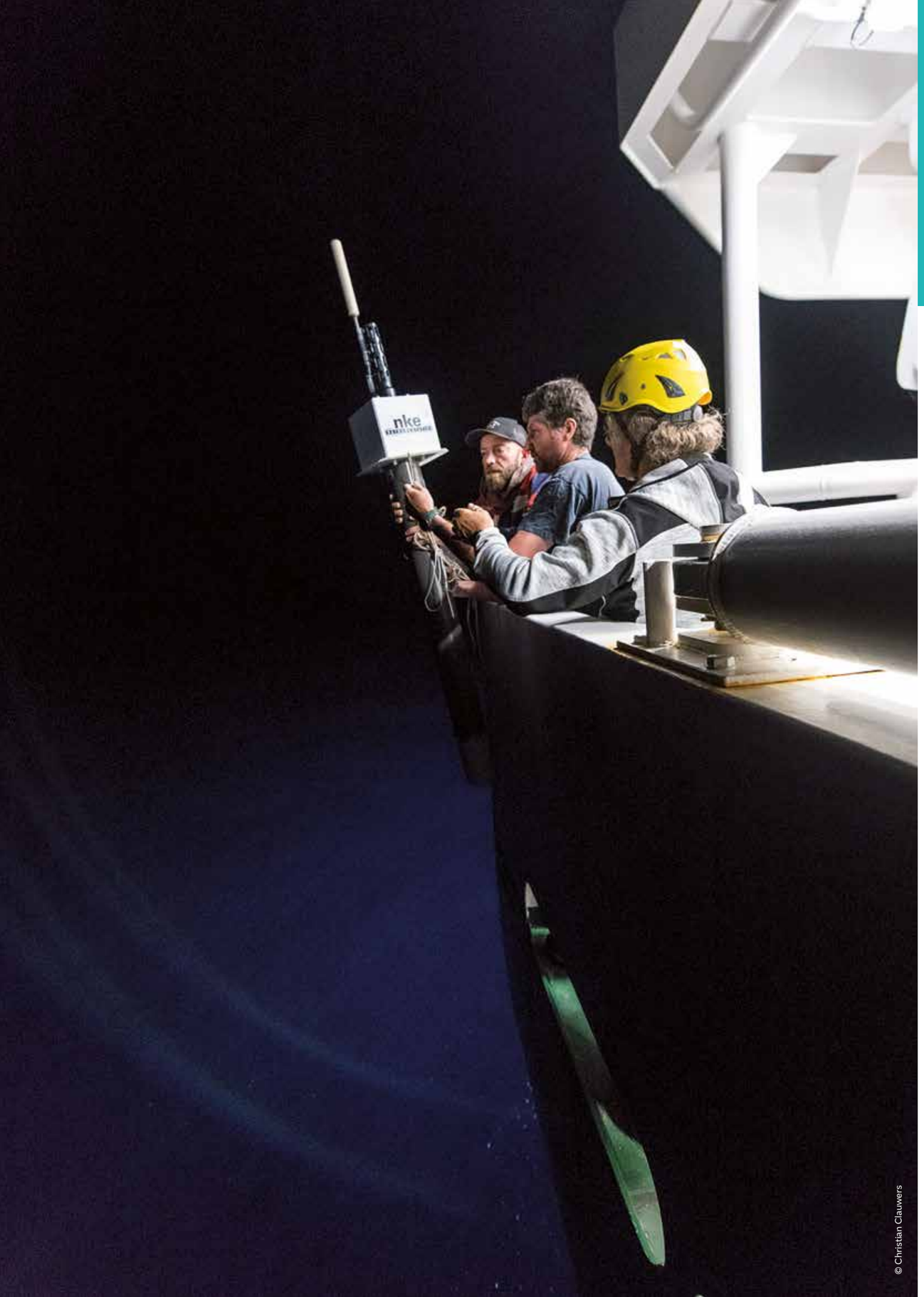

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Deployment of a Core Float during the TAIPro cruise, on board the Research Vessel Belgica II.

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Executive summary

2022 was a milestone year for Euro-Argo ERIC, with the completion of a major and defining project for the ERIC, Euro-Argo RISE, and the elaboration of a new strategy for the next decade, as well as the implementation and long-term sustainability plans for the next five years. Euro-Argo ERIC managed to deliver on all its service commitments and projects, in line with the five objectives of the five-year plan 2019-2023 and already on the tracks for OneArgo global, full-depth and multidisciplinary design, targeted by the international Argo community by 2033.

EUROPEAN PROJECTS IN A NUTSHELL

- **2 projects ended in 2022:**
  Euro-Argo RISE and ERIC Forum
- **2 new projects in 2022:**
  FAIR-EASE and GEORGE

Euro-Argo RISE project has advanced the European contribution towards OneArgo through four pillars: technology, data management, services to users and community enhancement. Among its achievements, it has tested new sensors to support OneArgo and improved data quality control procedures and data access, through open-source software and the sharing of code and expertise on the collaborative platform "Euroargodev".

EURO-ARGO MAIN OUTREACH ACHIEVEMENTS

- **1** successful Argo Science Workshop (ASW7) meeting
- **24** news items published
- **3** publications published
- **3** videos released
- **10** scientific publications highlighted through Euro-Argo "Reads of the month"

The Argo Science Workshop (ASW7) gathered the international Argo community.

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7 FIGURES ABOUT THE EUROPEAN CONTRIBUTION TO ARGO IN 2022

231 floats deployed/reaching 31% of the global effort Including:
- **15** Deep floats
- **53** floats carrying at least one BGC sensor
- **20** "full BGC floats" measuring all variables

30% of Euro-Argo floats deployed **carrying an oxygen sensor**

almost **80%** of the **data from Core floats (measuring temperature and salinity) were quality-controlled** to reach the accuracy needed for climate applications

© GEOMAR

Deployment of a BGC float.

MAJOR EVOLUTION OF EURO-ARGO ERIC GOVERNANCE

© S. Lesbats/Ifremer

The Euro-Argo ERIC Office team in Brest, France.

3 **key documents drafted:**
- Euro-Argo new strategy for the next decade
- implementation and long-term sustainability plans for the next five years

1 **clear and common framework for the central procurement of floats** managed by Euro-Argo ERIC Office in Brest, reflecting the collaborative spirit established with the national members.

1 **new Program Manager**, Yann-Hervé De Roeck
& 1 **new more business-like approach** to assess the ERIC Office financial status

1 FIVE-YEAR PLAN OBJECTIVES

Over the past seven years, the Euro-Argo ERIC has demonstrated its ability to develop and manage the European contribution to the international Argo programme. Many activities and services have been implemented and need to be continued through the next phase of Argo.

▸ See the full five-year plan on https://doi.org/10.13155/71936

The five-year plan articulated five objectives against which its achievements will be measured in the coming years. The challenges of this next phase are multiple:

- Core Argo activities need to be maintained.
- Extensions towards the OneArgo "global, full-depth and multidisciplinary" design need to be further developed in a sustainable way ("OneArgo: A New Paradigm for Observing the Global Ocean", https://doi.org/10.4031/MTSJ.56.3.8, 2022).
- Engagement with existing and new end-users is necessary to meet societal needs.

Euro-Argo is not alone and must evolve within a landscape of complementary Research Infrastructures (RIs). The development of an integrated ocean observing system is being pursued by various observation coordination bodies (GOOS at global level, AtlantOS and SOOS at basin levels, EOOS at European scale) in their respective strategies. They all contribute to the UN Decade of Ocean Science for Sustainable Development. Euro-Argo must contribute to this landscape to complement the other observation networks as efficiently as possible.

To face these challenges, the five Euro-Argo objectives are interconnected and many partners are involved → **Figure 1**.

This report describes the activities carried out by the Euro-Argo ERIC with respect to the five objectives.

THE FIVE OBJECTIVES OF THE 2019-2023 FIVE-YEAR PLAN




Objective 1	Objective 2	Objective 3	Objective 4	Objective 5
Sustain the existing Core Argo mission.	**Develop the extension of Euro-Argo** contribution to Argo according to the Euro-Argo strategy as a contribution to the "Global, full-depth and multidisciplinary Argo" design.	**Develop scientific and technological coordination** with other ocean observing networks and contribute to a Global Ocean Observing System (GOOS) design and its European contribution through European Ocean Observing System (EOOS) initiative.	**Develop the engagement with European Argo user communities and stakeholders and reinforce Euro-Argo visibility.**	**Operate the Euro-Argo ERIC Office** under good governance.

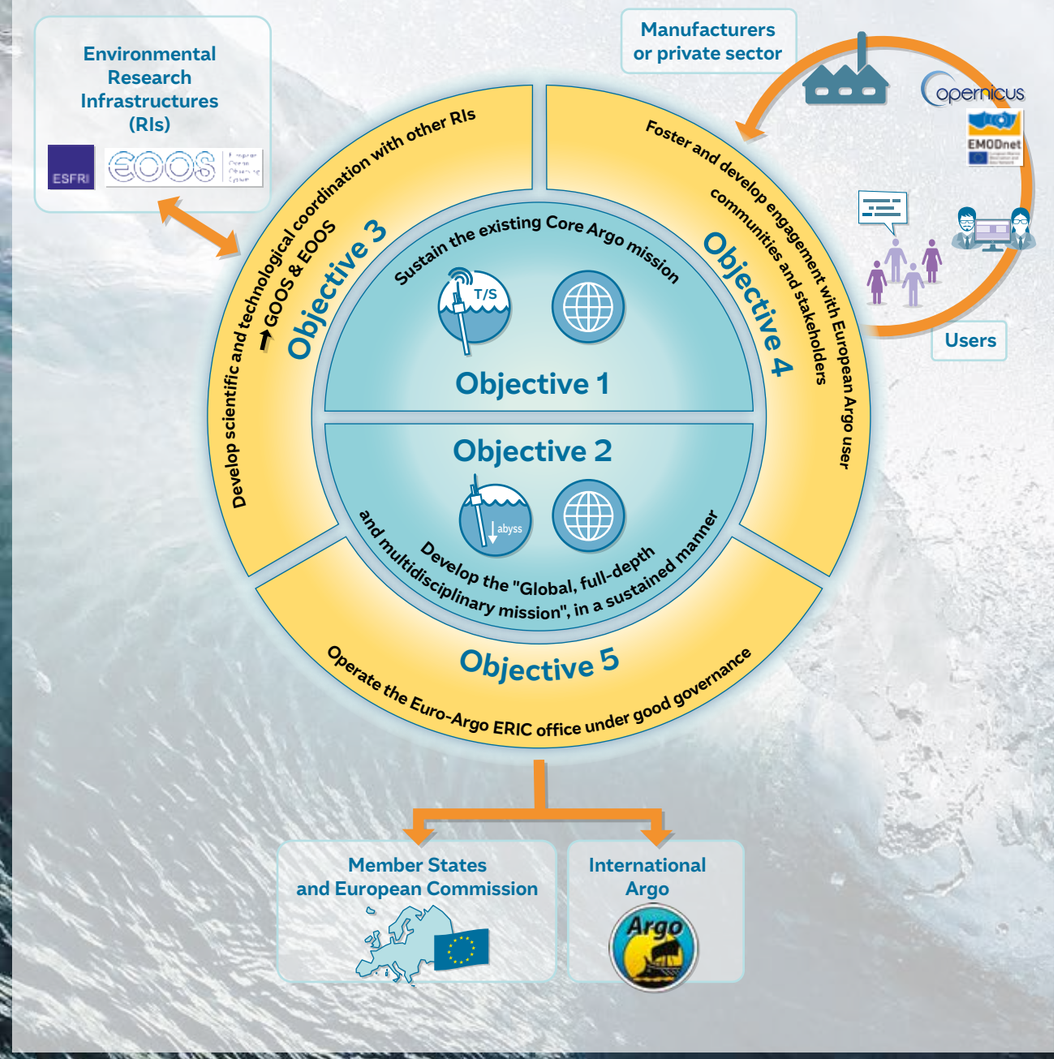

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Figure 1: The five objectives of the five-year plan and the involved partners.

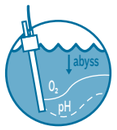
2 REVIEW OF 2022 ACTIVITIES

2022 was a milestone year for Euro-Argo ERIC, with the completion of a major and structuring project for the ERIC: Euro-Argo RISE, the organisation of the international Argo Science Workshop (ASW7) and the replacement of the Euro-Argo Program Manager. The Euro-Argo Office and the national members managed to fulfil all the commitments both in projects and services, in line with the five objectives of the five-year plan.

Objective 1

Objective 2

SUSTAIN THE EXISTING CORE ARGO MISSION AND EXTEND THE EURO-ARGO CONTRIBUTION TO THE ONEARGO DESIGN



Network implementation

→ 2022 float deployments

In 2022 Euro-Argo deployed 231 floats → Figure 2, representing 31% of the global international deployments effort, but still below its objective of implementing OneArgo in terms of active floats. → Figure 5 p. 18 & Box 1 p. 11. Despite strong national programme commitments, the overall contribution of Euro-Argo decreased due to the absence of significant centralised European funding.

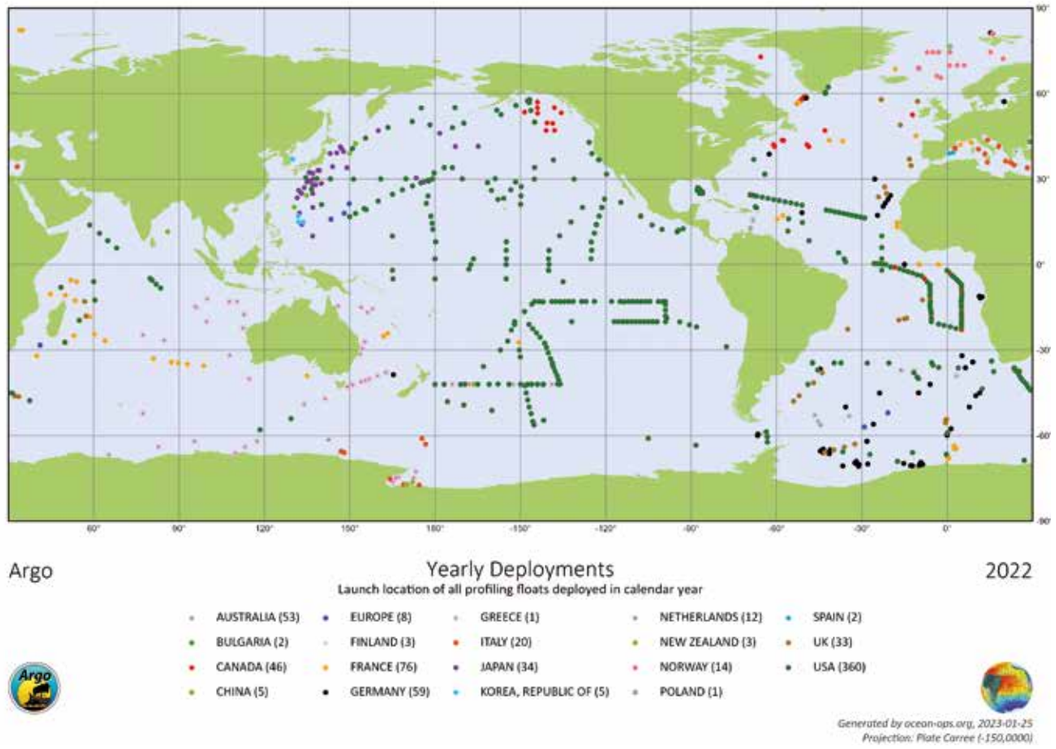


Figure 2: Launch locations of all Argo floats deployed in 2022: 231 Euro-Argo units among the 739 deployed in 2022, representing 31% of the deployments of the global effort. © OceanOPS/AIC

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Deployment of a Core float.

Number of floats	Variables							Float types				
	T/S	O_2	Chl-a	Suspended particles	Nitrate	Downwelling irradiance	pH	Core	BGC	Bio	Deep	Total
Nordic Seas	16	11	6	6	4	6	4	5	4	4	3	**16**
Mediterranean Sea	18	7	3	3	1	3		11		7		**18**
Black Sea	2	2								2		**2**
Baltic Sea	2	1	1	1	1	1		1		1		**2**
Southern Ocean	48	8	1	1		1		39		2	7	**48**
Arctic Ocean	10	1						9		1		**10**
Global Ocean outside the specific regions above	135	36	24	24	14	19	17	98	16	16	5	**135**
Total	**231**	66	35	35	20	30	21	163	20	33	15	**231**
Total international & Euro-Argo % of this international effort	**744 (31%)**	208 (32%)	152 (23%)	152 (23%)	131 (15%)	42 (71%)	132 (16%)	480 (34%)	21 (95%)	211 (16%)	32 (47%)	**744 (31%)**

Table 1: Euro-Argo float deployments in 2022, in number of floats measuring a particular variable (orange), and by float types (blue). BGC stands for BioGeoChemical float (measuring all six variables) & Bio stands for every BGC float measuring only one to five of the variables.

→ **Table 1** shows the distribution of 2022 deployment by basins, by parameters measured (in orange) and types of floats (in blue). The objective is to gradually increase the number of Deep and BGC deployments targeting 260 float deployments in total (including 125 Core floats, 60 BGC and 75 Deep) by 2030, to fulfil the OneArgo target.

© S. Vidé

Last summer, France deployed five floats under the ice or in the marginal ice zone in the Arctic Ocean, for the ARCTICGO project.

BOX 1. WHAT IS **THE ONEARGO DESIGN?**

OneArgo is the new "global, full-depth and multidisciplinary" Argo programme design, including the three missions Core Argo, BGC Argo and Deep Argo.

It will revolutionise ability to observe and predict the impact of climate change on oceanic heat uptake, global water cycle and sea level rise, as well as ocean ecology, carbon uptake, and marine resource modelling.
Most importantly, it will increase end-user value and the benefits for society at large, for instance through more accurate climate projections enabling better societal adaptation or better climate intelligence to sensitive industries (agriculture, energy, aquaculture, fisheries, insurance, and resources extraction).

▸ See Owens et al. (2022) "OneArgo: A New Paradigm for Observing the Global Ocean", Marine Technology Society Journal, https://doi.org/10.4031/MTSJ.56.3.8, 2022

Objectives of OneArgo:

- Sustaining the original Core mission including the spatial coverage towards polar regions and Marginal Seas (and increased spatial resolution in the tropics and western boundary currents).
- Enhancing and expanding the two new missions: extending to the full ocean depth through the Deep Argo mission and including ocean BioGeoChemical measurements, through the BGC Argo mission. → Figure 3
- Ensuring data management teams are ready and able to handle the new data streams, especially for the BGC mission and its six variables.
- Strengthening national and international partnerships.
- Enhancing strong community support and advocacy.

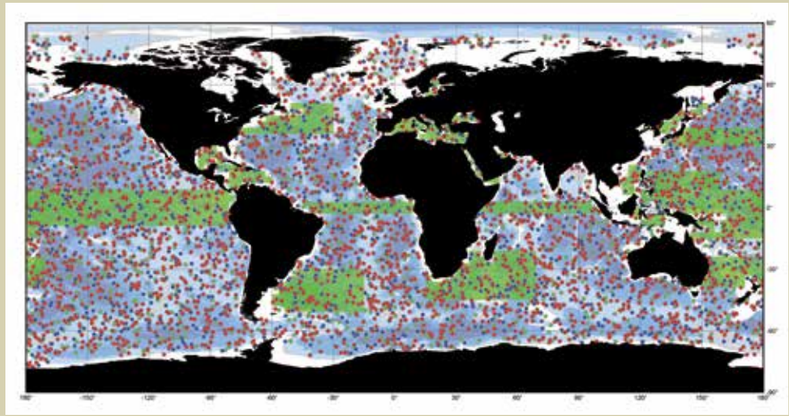

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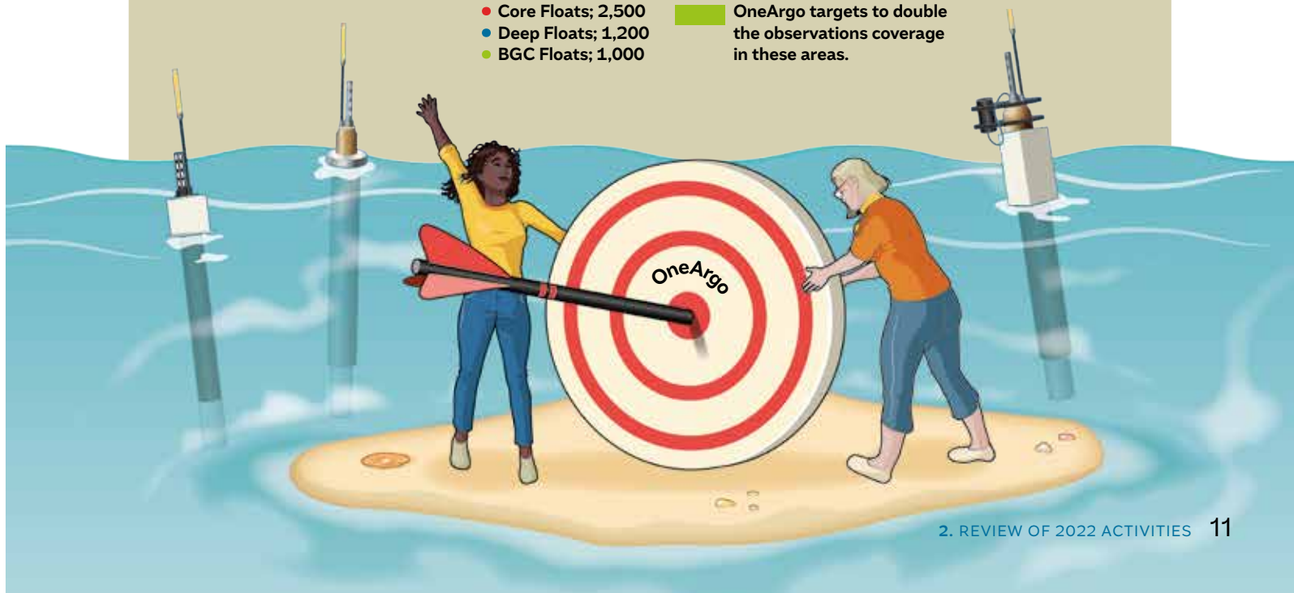
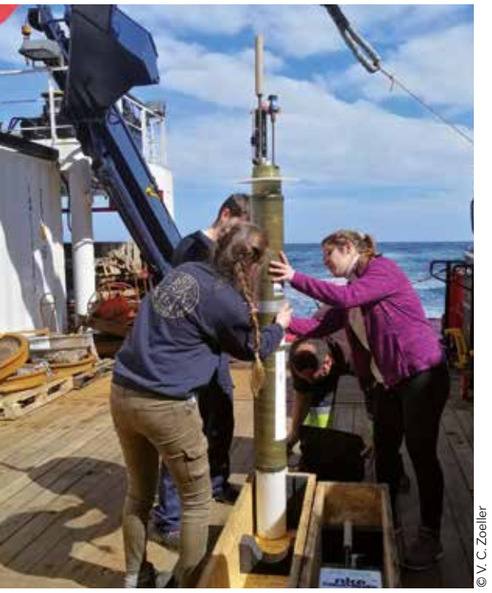
Figure 3: OneArgo target network of 4,700 floats by 2030. Central to OneArgo is that BGC and Deep floats now contribute to the Core float data stream.





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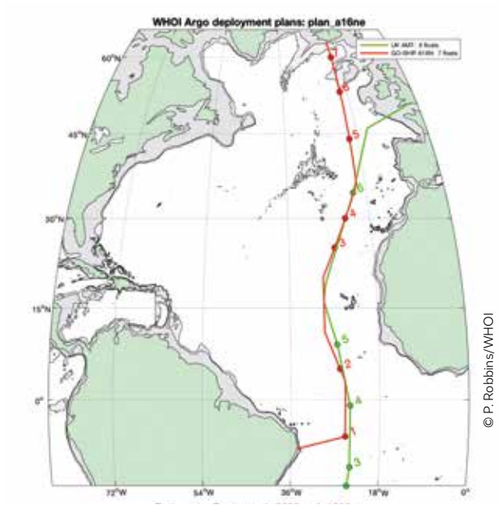
A Deep float ready to be deployed (on the left) and being prepared at Ifremer facility (on the right).



© P. Robbins/WHOI

Example of a deployment map resulting from international cooperation in the Atlantic: WHOI and UK (NOC) consulted over the positions of BGC floats and ensured minimal overlap.

Euro-Argo took part in "Basins Deployment Planning meetings" organised internationally and across ocean observing networks, resulting in coordinated launches of Argo floats in Atlantic and Indian Oceans. Euro-Argo continued its implementation in the Nordic Seas and, to a lesser extent, in European Marginal Seas, enabling more deployments to be carried out in the Southern Oceans and Arctic Oceans, where the global Argo network coverage was on stress. → Table 1 p.10

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) → Figure 7 p. 19 & Table 1 p. 10.

A major outcome was the significant number of 20 "full BGC floats" deployed. These floats measure all six variables, and sometimes experimenting with new observation systems, such as Underwater Vision Profiler (UVP), hyperspectral sensors, etc. They will provide unique data for better understanding and predicting the ocean, its role in the climate system and its health. The implementation of OneArgo comes at a major cost increase for the network. OneArgo also brings challenges regarding reliability of some sensors (e.g. pH). This comes with an increased need for data monitoring.

The oxygen network is progressing further with about 30% of Euro-Argo floats deployed in 2022 carrying an oxygen sensor → Table 1 p. 10. 15% of the deployed floats are equipped with a chlorophyll and suspended particles sensor, 13% with irradiance and 9% with pH and nitrate (the most expensive sensors of the BGC suite).

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

OneArgo is the new "global, full-depth and multidisciplinary" Argo programme design, including the three missions: Core Argo, BGC Argo and Deep Argo → Box 1 p. 11. Our first challenge is to maintain the Core array, despite the increasing cost of these original floats. OneArgo is characterised by progressively increasing the rate of deployment of Deep and BGC floats, whose individual costs are respectively two and five times higher than Core floats. The estimate for the OneArgo design therefore at least triples the current annual expenditure. The question of new sources of financing arises, both through the contribution of national partners and through direct financing by the European Commission, recognizing the operational and collective significance of OneArgo for the European Union as a whole.

It is noteworthy that while the Euro-Argo number of BGC floats deployed remains stable or slightly increases, our relative contribution to the BGC international array is decreasing, notably with the development of the GO-BGC (Global Ocean Biogeochemistry Array) US major project (500 floats funded, representing half the desired global number of 1000 BGC floats for OneArgo).

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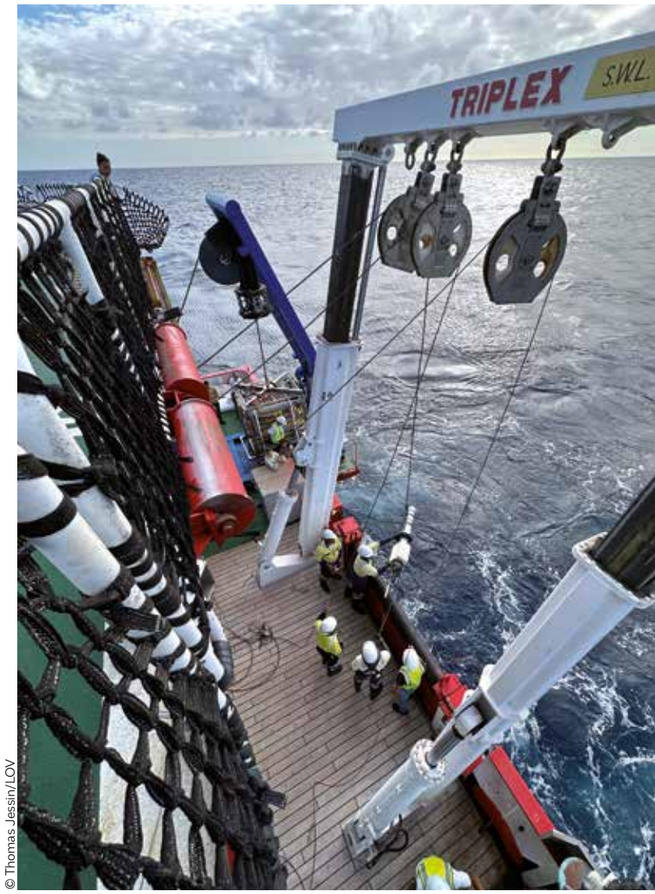

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A BGC float before its deployment in the frame of the German C-SCOPE project

Deployment of a CTS5 Jumbo float of the REFINE project in the context of the Indian Ocean cruise organized by Monaco Explorations in fall.

© N. Lebreton/SHOM

A BGC float tested at Ifremer facility.

logistics (follow-up of the manufacturing process, delivery dates, coordination of the telecommunication, contracts opening, etc.), to carry out the acceptance tests at Ifremer testing facilities (seawater basin for real profiling down to 20 metres, hyperbaric chamber for the Deep floats) and finally to ship the equipment either to the purchasing institutes, or directly to the deployment vessels.

At the end of the year, an updated procedure in line with a collaborative objective has been adopted (see p. 35). Through complementary contributions to the ERIC operational budget paid by the members, Euro-Argo Office is entrusted with the development and consolidation of the European component of OneArgo, while relying on these same members to ensure the deployment and monitoring of a given number of floats.

→ 2022 Floats procurement

Since 2017, a service of centralised float procurement has been set up for Euro-Argo ERIC and its partners, allowing it to provide floats for the three Argo missions (Core, Deep and BGC).

For floats purchased through this service, Euro-Argo Office technical team offered to handle for members the inbound

COUNTRY/INSTITUTE	Number of floats					
	Total	Core	Core + DO	DEEP + DO	BGC 6 variables	BGC (< 6 variables)
BULGARIA/IO-BAS	3	1	2			
ITALY/OGS	17	11	2	2		2
NETHERLANDS/KNMI	6	6				
NORWAY/IMR	6	2	2			2
POLAND/IOPAN	4		3			1
ERIC (EU projects + ERIC)	1			1		
Total	37	20	9	3	0	5

Table 2: ERIC float procurement in 2022 (by country and float types), on behalf of Euro-Argo members.

© Euro-Argo ERIC

An Arvor float with RBR CTD tested at Ifremer facility.

© Inua Production

Datarmor, the supercomputing facility for ocean data processing, hosts the European Argo GDAC at Ifremer.

Data management

Europe hosts one of the two Argo Global Data Assembly Centres (GDAC): Coriolis/Ifremer, in France, and two of the eleven Argo Data Assembly Centres (DAC): Coriolis/Ifremer, and BODC in the UK. In 2022, 45588 Argo data profiles were processed by these two DACs → Figure 11 p. 21.

Delayed Mode Quality Control (DMQC) of the European floats is performed by several institutes.

The number of data users visiting the GDAC is almost constant but the number of ftp sessions has been gradually increasing since 2014. → Figure 12 p. 21. All this free and open access data is then used by the operational oceanography and the scientific community. → Figures 4 & 13 p. 21.

In addition to the data processing itself, European partners made progress in different aspects of Argo data management, in the framework of the Euro-Argo RISE and ENVRI-FAIR EU projects. These efforts were presented to the international community at the 23rd Argo Data Management Team (ADMT) meeting in December:

– suggestions have been proposed to adapt both Real Time Quality Control (RTQC) and DMQC procedures for Argo data in the Baltic Sea, where the hydrological properties are very different from the open ocean and the traditional methods and tests are not appropriate. The detailed work is presented in the **Euro-Argo RISE deliverable D2.7**;

– several experiments made both within Euro-Argo RISE and in national projects contributed to the validation of the RBRargo|2k CTD **(see Euro-Argo RISE deliverable D2.9)**;

– salinity and temperature data measured by several Deep 2-headed and 3-headed floats tested within the Euro-Argo RISE project and carrying RBR CTDs in addition to SBE CTDs were further used by the international Argo RBR data task team to validate the RBRargo|6k CTD (this work is still in progress). The Deep float experiment final evaluation and recommendations were also provided **(see Euro-Argo RISE deliverable D3.3)**;

– the work carried out to improve the quality of Deep Argo data was pursued, leading to new recommendations for data adjustment in Delayed Mode **(see Euro-Argo RISE deliverable D3.2)**;

– as part of Euro-Argo RISE project, an assessment of the salinity data of the Argo floats in the Southern Ocean was performed **(see Euro-Argo RISE deliverable D5.3)**, using the Profile Classification Method developed within Euro-Argo RISE WP2 **(see Euro-Argo RISE deliverable D2.4)**;

– monitoring of the Abrupt Salinity Drift (ASD) occurrences in the international Argo fleet was continued and further improved with the retrieval of some information directly from the GDAC, enhanced data and metadata consistency checks and additional statistics. Together with our Japanese partners, the question of malfunctioning CTDs was discussed with SeaBird, the manufacturer. As a result, an agreement on a warranty procedure was reached in early 2023;

– within ENVRI-FAIR, work on using the NERC Vocabulary Server for Argo was pursued, with an agreement at ADMT level to use GitHub to handle vocabulary issues. The Argo ontology and tools necessary for web and machine-to-machine requests (Sparql and EOV broker) were improved.

At European level, the possible scenarios for the organisation of the BGC Argo data management in Europe were further discussed.

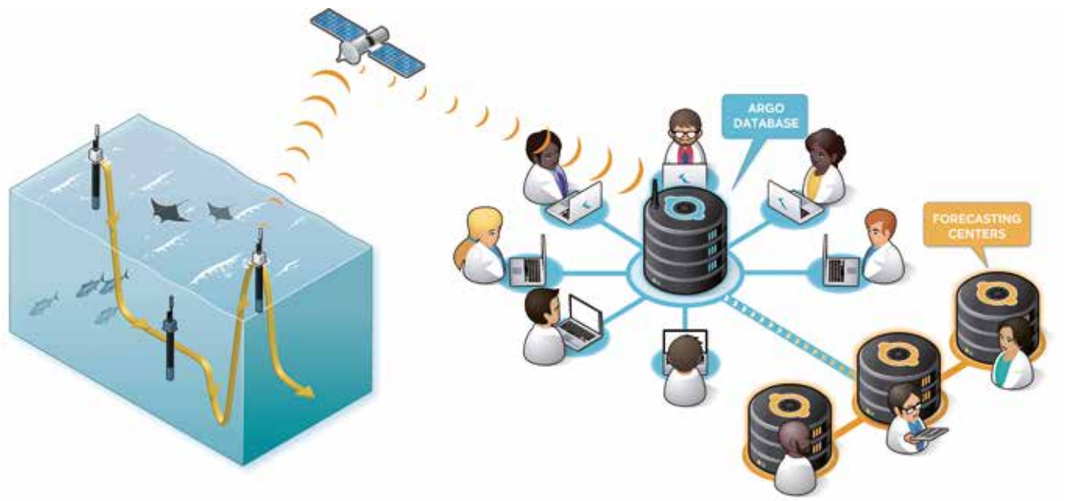


Figure 4: Transmission and use of Argo data, from the float cycle to the forecasting centers. © Thomas Haessig

© C. Schmid

The 23rd Argo Data Management Team (ADMT) Meeting hosted in Miami, Florida, in December.

KPIs about Euro-Argo network implementation and data processing

→ Number of European float deployments

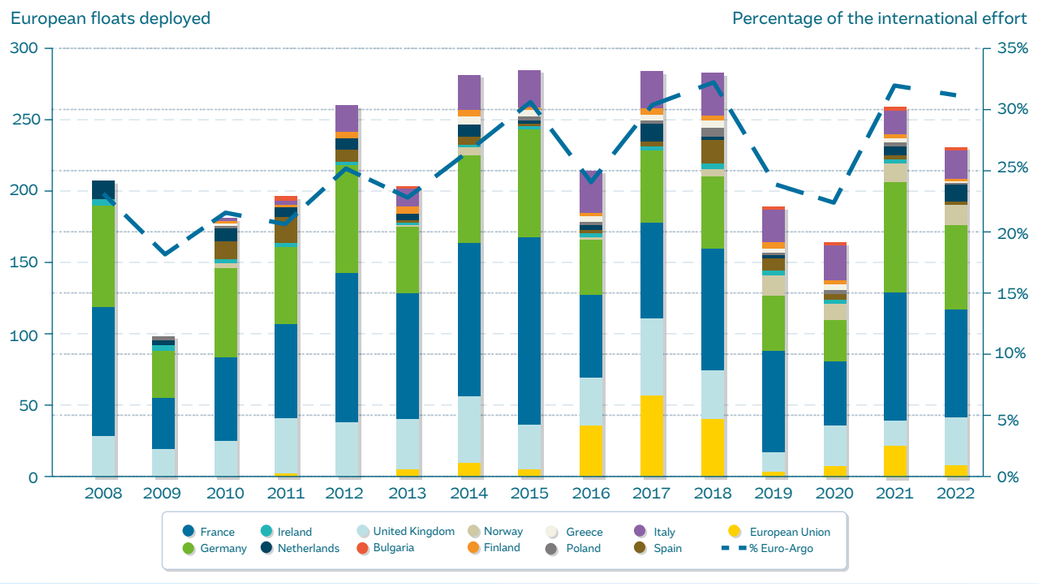


Figure 5: Evolution of Euro-Argo deployments in number of floats (colors, left axis) and as a percentage of the international effort (blue dashed line, right axis). © OceanOPS/AIC

→ Number of Euro-Argo operational floats (active at given time)

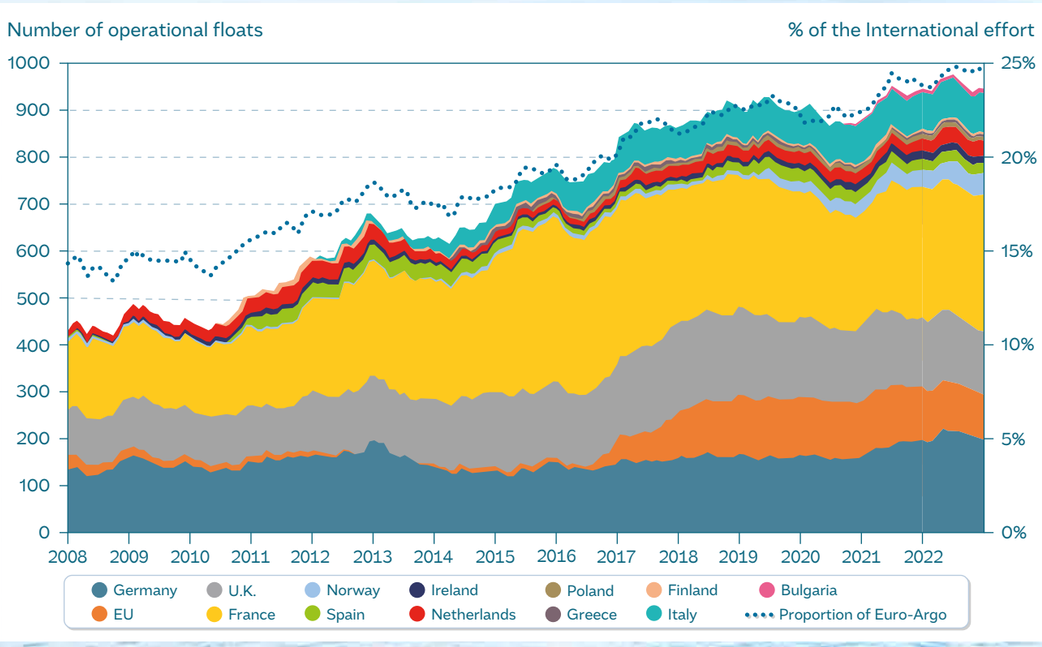


Figure 6: Evolution of the European contribution to the Argo network in number of operational floats (colour, left axis) and in percentage of the international effort (blue dashed line, right axis). © OceanOPS/AIC

→ Number of Euro-Argo operational floats for each of the three missions of OneArgo (Core, BGC and Deep)

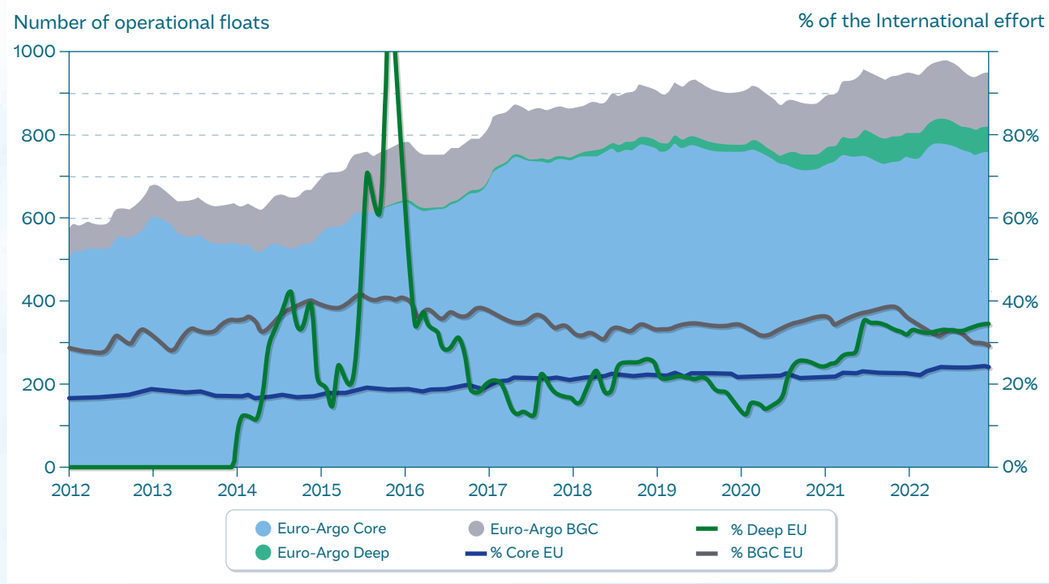


Figure 7: Evolution of the Core, BGC and Deep missions, in number of operational floats (colour, left axis) and in percentage of the international effort (blue, grey and green lines, right axis). © OceanOPS/AIC

→ Number of Euro-Argo operational floats measuring a given variable

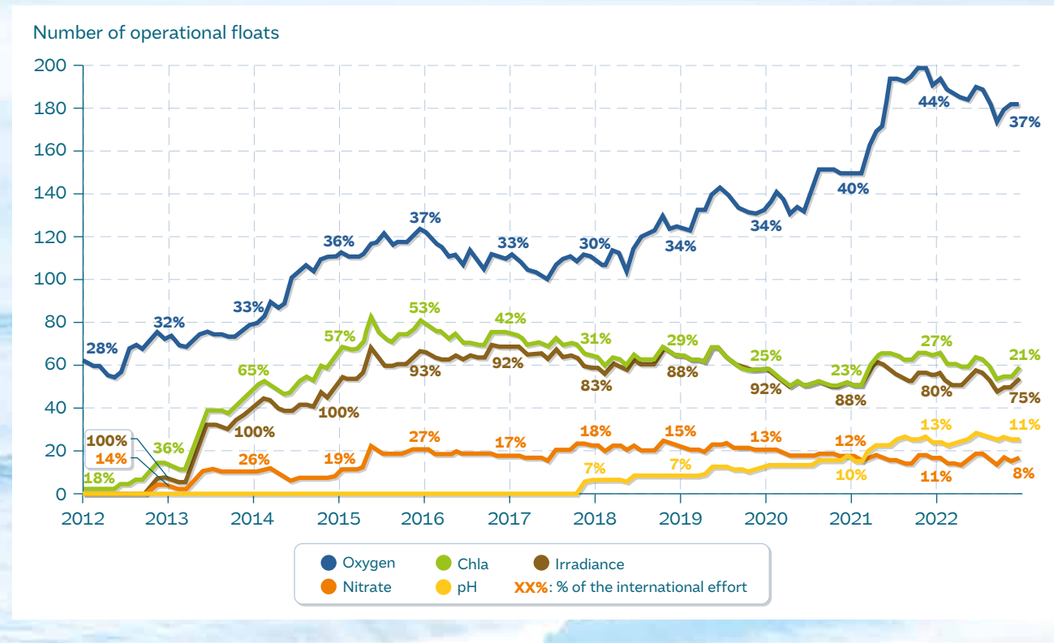


Figure 8: Evolution of the European contribution to four of the six BGC parameters, in number of active Euro-Argo floats measuring that variable (left axis, solid curve), and percentage of active Euro-Argo floats measuring that variable in the global array (percentage of each year on the curves). © OceanOPS/AIC

→ Number of floats reaching the 50, 100 or 150 cycles target

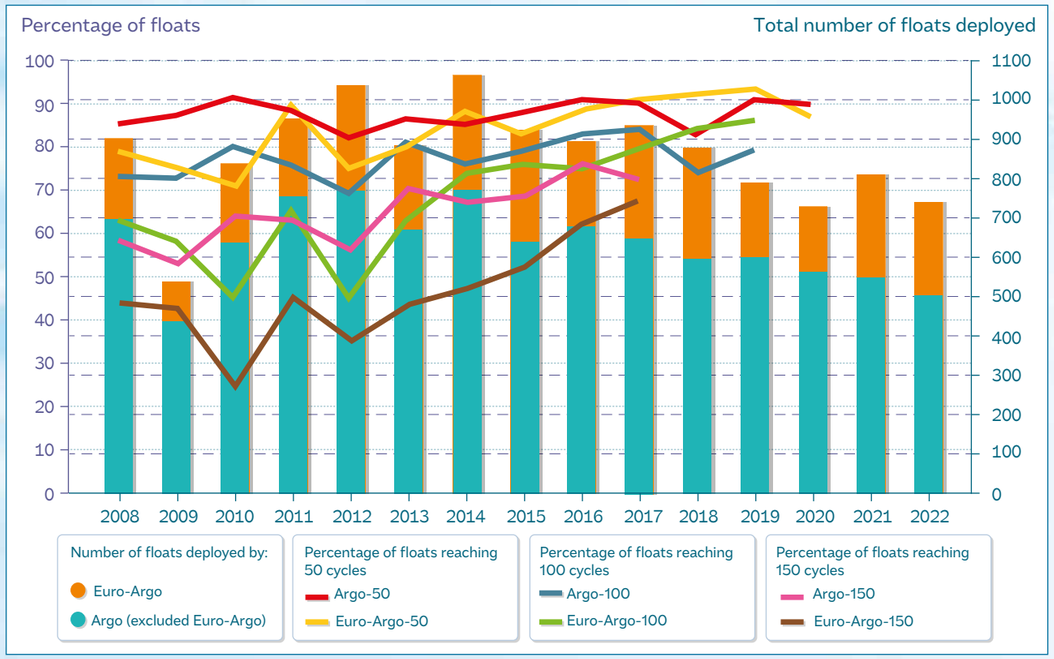


Figure 9: Percentage of floats reaching the 50, 100 or 150 cycles target compared to the Argo fleet (coloured lines, left axis) and total number of floats deployed (right axis). Since 2015, the performance of the Euro-Argo fleet has steadily improved both in reliability (50 cycles) and longevity (150 cycles target). © OceanOPS/AIC

→ Number of floats per manufacturer

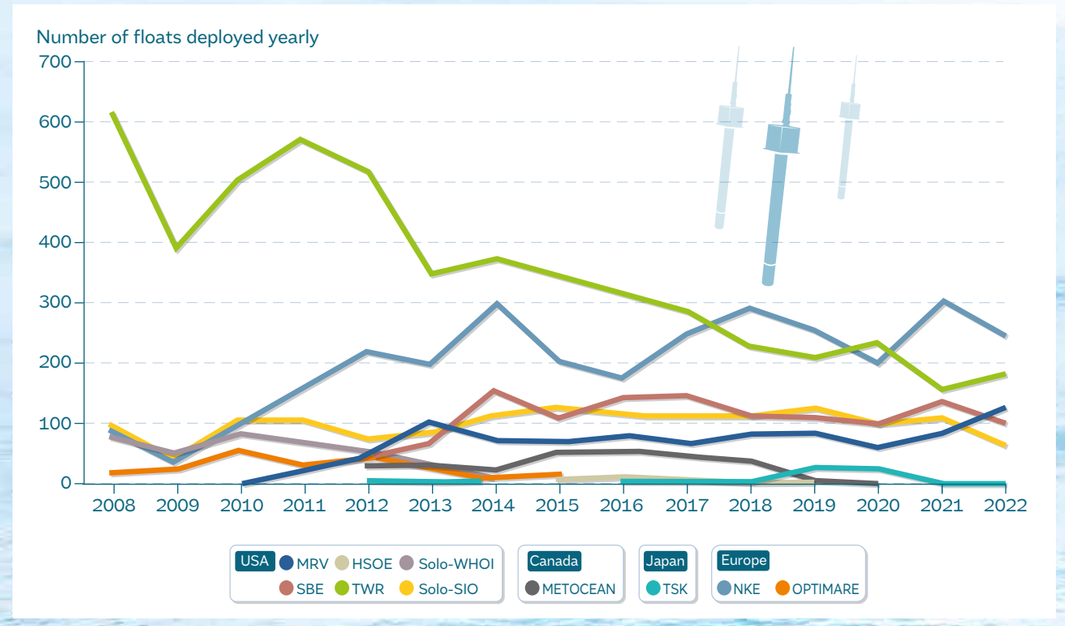


Figure 10: Evolution of number of floats deployed per year, grouped by float manufacturer. © OceanOPS/AIC

KPIs regarding users, data access and publications

→ Number of available profiles collected by Euro-Argo floats

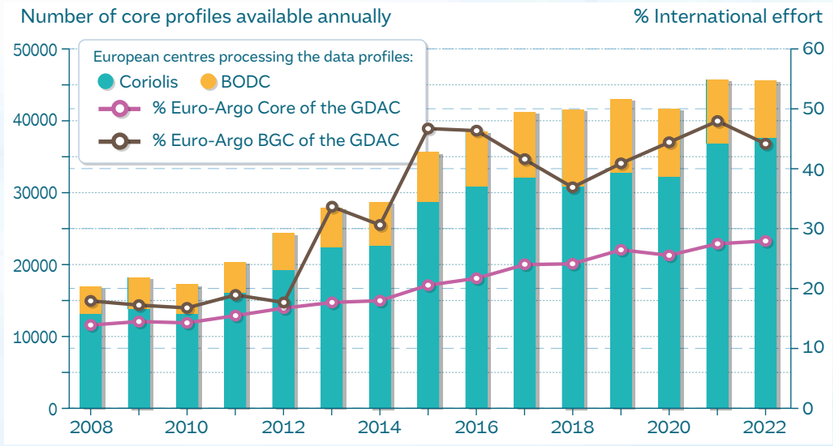


Figure 11: Argo data profiles processed by Coriolis and BODC DACs per year: in number of profiles (left axis, blue: Coriolis and orange:BODC) and in percentage of the total number of profiles available on the GDAC (right axis). © Ifremer/GDAC

→ Number of users and data access

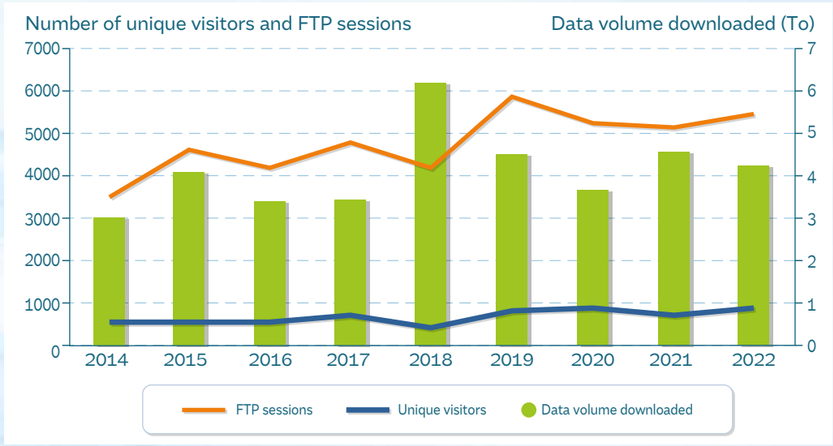


Figure 12: Evolution of the Argo data access, through the average number of visitors per month, the number of sessions per year and the volume of data files downloaded per year.

→ Number of publications

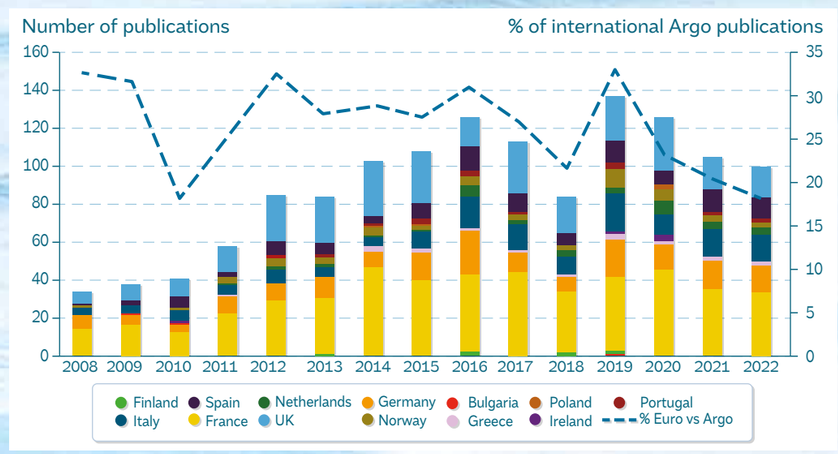


Figure 13: Euro-Argo publications per year (defined as publications using Argo data with first author's affiliation in a European country) in number of publications (left axis) and in percentage of the international Argo publications (right axis).

© IEO/CSIC

One 3-headed float deployed in the Canary Basin. The configuration parameters used were first a 3-day cycles and then 10-day cycles.

Technical developments

In the framework of the Euro-Argo RISE project (see p. 42-43), tests continued for the implementation of OneArgo at the European level, and recommendations arise to move forward on the diversification of the Deep and BGC sensors, as well as the geographic extensions towards coastal areas and the high latitude regions. These various tests are described hereafter and the documents summarising the recommendations are now available on the Euro-Argo RISE project webpage.

→ Alternative BGC sensors: tests of RAMSES hyperspectral sensor in the Baltic

After its deployment in the Baltic Proper in 2021 and 86 cycles reached, the BGC float (WMO 6903706) fitted with a RAMSES hyperspectral sensor was recovered in April by the Finnish Research Vessel Aranda. It is worth noting that no sign of biofouling was detectable. After the previous tests in the Mediterranean Sea in 2021, this experience demonstrated that the RAMSES sensor is applicable for both areas **(see Euro-Argo RISE deliverable D4.12)**. Despite its increased energy consumption and the cost associated with the transmission of additional data, the higher radiometric qualities of RAMSES – both higher sensitivity and spectral resolution – offer new perspectives for the BGC Argo array.

→ Intercomparison of Deep CTDs: deployments of 3-head and 2-head floats in the Canary Basin

3-headed prototypes and 2-headed prototypes (RBRargo | 6kCTD sensor on cap and a SBE61 on the side) were deployed by IEO in the Canary Basin in March during the RAPROCAN campaign, to compare the SBE and RBR CTDs. After 19 cycles, one of the 2-headed floats increased its energy consumption and was recovered in September. All the other multi-headed floats are still functioning and provide means to evaluate the performance of the new generation of Deep sensors. These experiments provided several recommendations, both upstream to continue the exchanges with the manufacturers, and downstream for deployments and related data analysis **(see Euro-Argo RISE deliverable D3.3)**. This work will help the European and international Argo community to further progress on the Deep CTD accuracy and stability and better characterise the deep water masses evolution.

The BGC float recovered in the Baltic Proper in April by FMI.

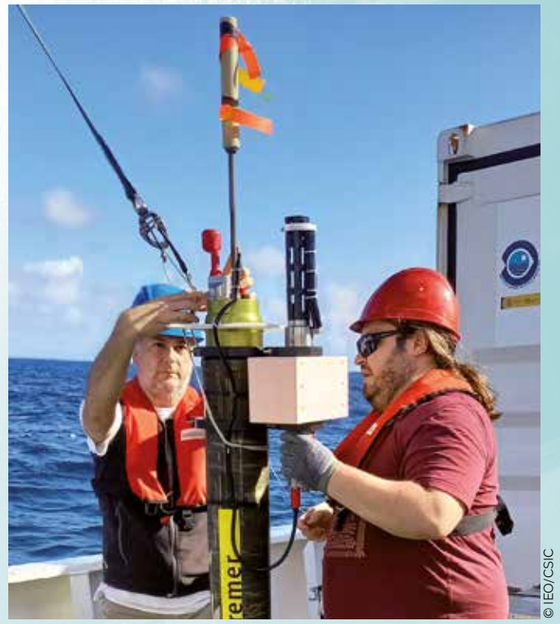
© FMI

→ Shallower water areas: recommendations and additional mooring tests in the Baltic and Black Seas

After the previous experiments in the three European Marginal Seas, recommendations for the operations of Argo floats in shallower waters (≤ 50m) were provided in September **(see Euro-Argo RISE deliverable D6.8)**. The most critical configuration parameters were defined, such as the park and profile pressure and the cycle time. This technical document also highlighted that shallow and coastal operations require a higher human-platform interaction to pilot the float, the tailoring of the existing monitoring systems, the in-house development of warning procedures and a faster real time data decoding. It also included a checklist for people interested in deploying Argo floats in these areas.

In parallel, other tests continued in even shallower waters. Argo floats were tested in the inner waters of the Gdansk Bay in Poland by IO PAN, in 15m waters and 40m waters. The float was attached to a line with a dead anchor and an acoustic release, allowing it to move freely along the line and to the surface to transmit the data. These experiments showed the feasability of this technique which can be very useful in the continuous monitoring of small, semi-enclosed basins.

With the same philosophy, a float was deployed in the harbour of Varna in Bulgaria by IO-BAS, and ballasts were gradually added in order to investigate whether a float had sufficient buoyancy to overcome the hydrodynamic forces exerted during mooring. This experience aimed at investigate about technical problems that arised on an other float deployed in 2020. The main outcome was that a buoyancy force below 1kg was not big enough in this area under these sea conditions to keep the antenna device floating and could hamper its emergence for data transmission.



© IEO/CSIC

The 2-headed float being prepared by IEO-CSIC and Ifremer.

→ High latitude regions: best practices document

To enhance deployments and operations of Argo floats in the high latitude regions, experiences and best practices for under ice operations were collected and analysed by European partners. National activities by BSH, FMI, IMR, IO PAN, Sorbonne Université (SU)/CNRS and Ifremer largely contributed in gathering experience and data from these areas, together with the expertise of AWI and SHOM. As a result, recommendations, guidelines and tools are now gathered in a document accessible on the Euro-Argo website **(see Euro-Argo RISE deliverable D5.1)**. It also provides a cheat sheet for users to take the necessary steps towards float deployment as well as tools to improve the planning of the various operations. Updated version of these tools to assist deployment is also available at Euroargodev github.

Deployment of a CTS5 Jumbo float of the REFINE project during the Indian Ocean cruise organised by Monaco Explorations in fall.

©Thomas Jessin/MEV-LOV

→ Other improvements in the framework of REFINE project

The BGC Argo programme was also enhanced through the ERC REFINE project: eight REFINE floats were deployed, introducing among others the new CTS5 Jumbo float, the Underwater Vision Profiler of the 6th generation (UVP6) with taxonomic identification and the radiometric measurement of hyperspectral reflectance. The new CTS5 Jumbo profiler is a 60% increased battery version of the CTS5 profiler. This increase allowed new sensors to be fitted, often with higher power consumption, without compromising the overall lifetime of the profiler. The REFINE project was an opportunity to use two new sensors. The first was the UVP6, which allows by imaging to measure the size of particles through 18 size classes (from several tens of microns to a few mm). For the first time, this sensor also performed object classification into large taxonomic groups using artificial intelligence. The classification results, along with the particle size distribution is then transmitted to the shore, in addition to the size distribution, a method for the identification of particles into large taxonomic groups. The second innovation was the integration of two hyperspectral radiometers (RAMSES, TriOs) allowing more accurate measurement of upward and downward light fields than conventional four-channel spectrometers. The simultaneous use of two sensors measuring opposite light fluxes was a continuation of the work begun in the Euro-Argo RISE project which led to the integration of a single sensor. It made possible the determination of the seawater reflectance, which can then be compared with the reflectance measured by Ocean Color satellites such as the future NASA PACE mission.

In situ O_2 sensors intercomparison dedicated float.

© P. Rousseau/Ifremer

→ Other improvements in the framework of PIANO project

To enhance R&D on Deep 6000 float and realise an intercomparison of *in situ* O2 sensors, Ifremer carried out technical activities in the framework of the PIANO project.

The main technological challenges for the extension of the measurements to 6000m were the development of the float body and the hydraulic system for moving the float in the water column:

– the pressure vessel was successfully tested for 250 cycles;

– the pre-study of the hydraulic system was almost finalised at the end of the year, before the detailed study in 2023.

The year 2023 will be devoted to the choice of a design and to the realization of the detailed study, in view of the manufacturing, the assembly and the development of the first prototypes.

In situ O2 sensor comparison led to the development of a design to optimally position the sensors on the Deep Arvor float head. The two O2 sensors Aanderra 4330 & JFE Advantec Rinko were integrated on the same float to evaluate if Rinko's performances were compliant with Argo network standards. This requested specific hardware & software developments. At-sea deployment of the two floats is scheduled for 2023.

Pressure resistant enclosures for the 6000m profiler.

© C. Renaut/Ifremer

Objective 3

CONTRIBUTE TO A GLOBAL OCEAN OBSERVING SYSTEM

Develop stronger partnership with other Marine RIs

The activities developed in the EOOS context → **Box 2**, aim to strengthen the joint efforts towards standardised sensors, data flows, cross-validation, joint deployments, complementarity of the spatial and temporal coverage. All these activities are progressing in the marine domain. In complement, other EU-funded, water monitoring projects work on the continuum from river source to sea. Euro-Argo ERIC also collaborates with marine and other environmental Research Infrastructures on data management and FAIRness **(see p. 44-45)**.

Within the EuroSea project, Euro-Argo data experts contributed to the definition of a new Standard Operating Procedure (SOP) for the use of oxygen sensors on Ocean Gliders. The SOP was endorsed by the Global Ocean Observing System (GOOS) and its glider component, OceanGliders. Coherence of Argo and Glider data should facilitate the use of data from both networks to make oxygen sensor data more accessible to scientists.

In September, Euro-Argo ERIC and CNR co-designed and participated in one of the Eurofleets+ Floating Universities for early-stage researchers of marine related sciences. The general objective of the course was to provide theoretical background – with three days of lectures and one day of group work – and practical experience in conducting instrumental measurements of seawater physical and chemical properties, during three days of field activities. This event was a first step towards stronger collaboration between Euro-Argo ERIC and Eurofleets+, including the development of joint activities such as training programmes, deployments and recoveries of Argo floats, etc.

© Katrin Schroeder/CNR

Operational Engineer from the Euro-Argo ERIC Office trained the students on how to deploy, operate and recover an Argo float.

BOX 2. EURO-ARGO ERIC **INVOLVEMENT IN EOOS**

EOOS European Ocean Observing System

ALIGNING, INTEGRATING AND PROMOTING EUROPE'S OCEAN OBSERVING CAPACITY

Euro-Argo ERIC is an active member of the Operations Committee of the European Ocean Observing System (EOOS) set up by EuroGOOS to coordinate and integrate European ocean observing. The committee includes the ocean observing-dedicated ERICs (Euro-Argo ERIC, LifeWatch, EMBRC, EMSO and ICOS) as well as other infrastructures and networks of European nature (JERICO-RI, DANUBIUS-RI, GROOM2, Eurofleets). It serves as an important vehicle for coordination and exchanges. Beyond EOOS, Euro-Argo ERIC collaborates with other research infrastructures mostly through publicly-funded research and innovation projects.

© Antoine Poteau/LOV

Group picture at the 23rd Argo Steering Team (AST) meeting, organised in Monaco in March.

Strengthening Euro-Argo position in the international context

Euro-Argo progress and in particular the results of the Euro-Argo RISE and – to a lesser extent – ENVRI-FAIR projects were presented and discussed both at the 23rd Argo Steering Team (AST) meeting in Monaco in March **(see p. 28)** and at the 23rd Argo Data Management Team meeting in Miami, USA, in December **(see p. 16)**.

The 7th international Argo Science Workshop was organised by Euro-Argo as an hybrid event, in Brussels, on October 11th-13th. It aimed bringing together ocean science researchers that have used Argo data and products to further improve our knowledge of the changing oceans and highlight the opportunities that the new OneArgo **(see p. 11)** array is opening. In that spirit, a round table discussion on "Ensuring the sustainability of OneArgo" was organised. The key message from the discussion was the importance of strengthening the advocacy efforts of the OneArgo community towards funding bodies.

To reinforce the visibility of the Argo international program and of its European contribution, Euro-Argo ERIC instigated a "European Ocean Observing Awareness campaign" in collaboration with Mercator Ocean international and EU4OceanObs and presented together with OceanOPS the Ocean Observers initiative at the CommOCEAN2022 event **(see p. 32)**.

Support to national and European initiative to expand the European Argo community

To facilitate interactions between non-Euro-Argo ERIC institutes/countries and the Euro-Argo ERIC governance structure, especially the Management Board (MB), the scope of the Argo Task Team in EuroGOOS was reviewed. The Task Team will provide a platform for exchange of expertise and generation of advice. In the future, it may organise science and/or users' meetings and training about Argo issues, coordinate the participation in the Argo Steering Team (AST) and Argo Data Management Team (ADMT) meetings. In addition the Task Team will develop the collaboration with users and stakeholder communities in non-ERIC EU member countries, join forces on float deployment coordination and foster the cooperation with Research Vessel operators to support the deployment of Argo floats. Most importantly, the Task Team should support and facilitate the process for new countries wishing to join the Euro-Argo ERIC.

The new Terms of Reference of the Argo Task Team have been adopted and the co-Chairs nominated in December. The new Argo Task Team will start its operations in 2023.

Objective 4

DEVELOP ENGAGEMENT WITH THE EUROPEAN ARGO USER COMMUNITIES & STAKEHOLDERS AND REINFORCE EURO-ARGO VISIBILITY

Major events

At the end of January, ENVRI-FAIR (see p. 44-45) held the 11th ENVRI week as an online event. On this occasion, progress on the Marine Subdomain work package (WP9) was presented, through a session co-chaired by Euro-Argo ERIC and Ifremer. In particular, the Marine Essential Observation Variable (EOV) broker development status – the web tool allowing users to select parameters without knowing the specific architecture/vocabulary convention of each data provider – were described by Ifremer and the NOC/BODC (see p. 44).

In March, the 23rd AST meeting was organised in Monaco, during the Monaco Ocean Week, as a hybrid event. In addition to the usual sessions, public lectures were made by Susan Wijffels and Hervé Claustre. Moreover, a UN Ocean Decade Forum was organised, whose objective was to bring together observing networks (e.g. GO-SHIP, AniBOS, etc.) and their data users, in order to better understand both the needs of the users and to communicate the networks strategies and services.

The 3rd EuroSea Annual Meeting took place in May at the University of Cádiz, Spain. The goal of the event was to share project progress, strengthen internal project collaboration and communication, and exchange ideas, through various cross-WPs workshops organised throughout the week. It was the opportunity for Euro-Argo to participate for instance in discussions regarding the governance of ocean observing networks and share views on different governance models.

In June, the DOORS project (see p. 47) held its General Assembly in Burgas, Bulgaria, to review and discuss the progress of the project. The meeting included a special session where marine Research Infrastructures discussed how to better reach out to scientists and policy makers of the Black Sea countries, notably to strengthen their impact and, possibly, enlarge their membership in the region.

At the end of June, EuroSea (see p. 45) and OceanPredict co-organised an "Ocean predict workshop" as a hybrid event. The workshop explored observation and ocean prediction efforts in a global context, discussing issues and developing recommendations for solutions. The recommendations from the final round table discussion highlighted, among others, the need for better communication and closer collaboration of the observation and prediction communities.

© Euro-Argo ERIC

All the speakers of the special session on Argo floats at the "Marine & Inland Waters Research Symposium" event.

© Euro-Argo ERIC

More than 100 participants attended the 7th Argo Science Workshop (ASW7) in person, and more than 50 virtually, from about 15 countries.

In July, the Board of European Environmental Research Infrastructures (BEERi) met on-line with representatives of European Commission DG Research & Innovation to discuss how the Horizon Europe Framework Programme could foster the digitalisation of Research Infrastructures (RIs) and the development of shared services to address key scientific and societal challenges, and strengthen the role of European RIs in global networks (standardisation, interoperability, etc.). Aspects of the ERIC Regulation and its implementation that raise specific and/or critical issues for the RIs of the environmental domain, and the development of the contribution of the ENVRI Community to Copernicus were also addressed. Finally, the question of how to better articulate the work of the ENVRI cluster with the work of the Commission in view of the Paris Agreement and other conventions (biodiversity, desertification, etc.) were discussed.

In September, Euro-Argo ERIC, represented by HCMR, OGS and the ERIC Office, joined the "Marine & Inland Waters Symposium" in Porto Heli, Greece, for a special session on Argo floats contribution to the marine research and operational monitoring of the Mediterranean Sea – Evolution, Achievements, and Future Needs, in the framework of Euro-Argo RISE project (see p. 42-43).

Sylvie Pouliquen gave a lecture on "European Research Infrastructures and oceanographic data in Europe". On the same day, a special session was held to discuss the extension of the Argo network in the Mediterranean Sea.

© Euro-Argo ERIC

Sylvie Pouliquen at the One Ocean Summit in February.

In September, Euro-Argo was also involved in a GOOS webinar organised on "Argo Data – how to access and use this freely available dataset". This was held as a one hour session with a short video on the Argo data management system from Euro-Argo ERIC and a Q&A session with a panel of four Argo experts. This webinar participated in increasing Argo awareness among possible new data users.

ESFRI

Update of KPIs in view of the ESFRI monitoring

In the context of the Euro-Argo ERIC monitoring by the European Strategy Forum on Research Infrastructures (ESFRI), the Office reviewed its Key Performance Indicators (KPIs **see p. 18-19 and 20-21**) in light of the recommendations issued by the ESFRI Working Group on Monitoring RIs Performance. The ERIC KPIs were found to be acceptably aligned with the recommendations. A second assessment will be carried out in 2023 when the conclusions of the ESFRI monitoring panel are available.

Table 3: Events in 2022: the events organised by Euro-Argo ERIC are in blue and the ones attended by Euro-Argo Office are in grey (dark grey: with a specific talk, presentation or training; light grey: attended as guests).

Events	Dates (2022)
ENVRI week (see p. 44)	January 31st – February 4th
One Ocean Summit (see p. 30)	February 9th – 11th
Argo Steering Team (AST) 23	March 21st – 25th
EuroSea Annual Meeting (see p. 45)	May 9th – 13th
Argo Germany Users meeting	June
CMEMS Coordination meeting - BGC data	June
GOOS Co-design workshop	June
DOORS General Assembly (see p. 47)	June 7th – 9th
Ocean Predict Workshop	June 29th – July 1st
ENVRI-European Commission-ERIC	July 6th
Marine & Inland Waters Symposium	September 17th – 19th
Eurofleets + Floating University	September 17th – 23rd
FAIR-EASE Kick Off meeting (see p. 48)	September 20th – 22nd
7th Argo Science Workshop	October 11th – 13th
MARBLUE2022	October 11th – 13th
CommOcean2022 (see p. 30)	November 30th – December 1st
Euro-Argo RISE final meeting (see p. 42)	November 29th – 30th
Argo Data Management Team (ADMT) 23 (see p. 16)	December 5th – 9th

© Euro-Argo ERIC

Euro-Argo RISE final leaflet (print version).

Communication plan and tools

Activities aiming at increasing Euro-Argo visibility were pursued, through 24 news items published on the Euro-Argo website, and sent to a large audience in two News Briefs campaigns (in June and November). One of these news items featured examples of successful float recovery, through two videos. This highlighted that the web portal **https://floatrecovery.euro-argo.eu/** launched by Ifremer and Euro-Argo was efficient to plan and facilitate recovery operations. The 2021 Euro-Argo Activity Report was released with a new section dedicated to the Euro-Argo members main achievements of the year. To increase its visibility, Euro-Argo also held a common booth "Studying the ocean to better understand it" at the One Ocean Summit, organized in the context of the French Presidency of the Council of the European Union and with the support of the United Nations.

Video of a BGC float recovery during the PIRATA FR32 campaign.

→ Two leaflets about the final results of Euro-Argo RISE project

The "Euro-Argo RISE Final results" leaflet was published in two print and digital versions to give an overview of all the achievements at European and international level, to demonstrate that the investment produced concrete results and to provide arguments to fund other projects. The print version targeted the Argo community and the project partners, summarising the project in a technical manner and giving an overview of the tools developed. The digital one targeted high-level stakeholders and decision makers, through an immersive and "mobile first" experience, with various videos and reading levels so that the reader can click directly on the sections of interest while having an overall synthetic view.

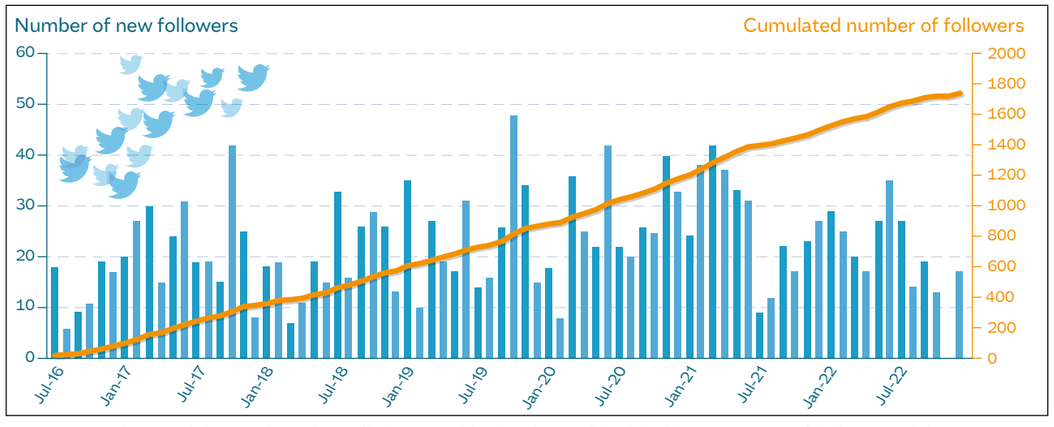


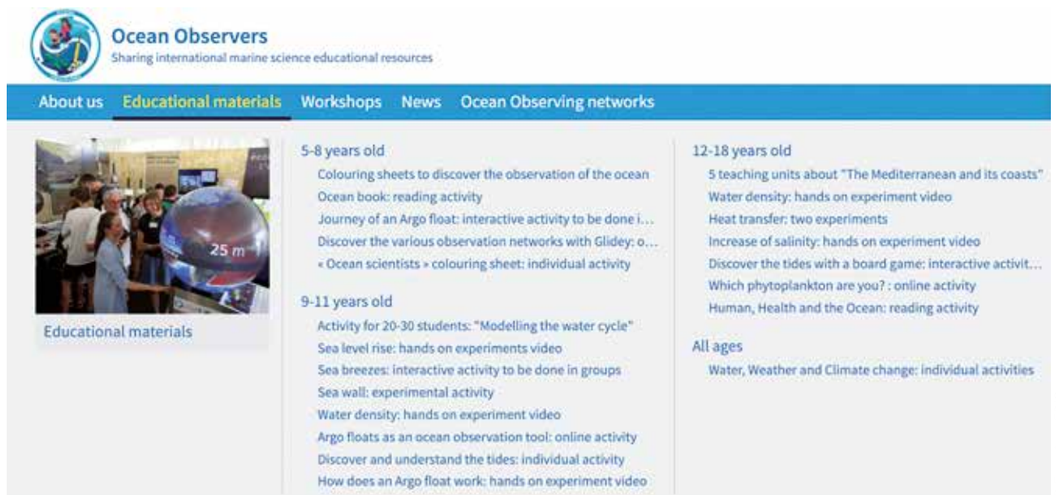
Figure 15: Evolution of the number of new (left axis, in blue) and cumulated (right axis, in orange) followers of the Euro-Argo Twitter account.

→ Ocean Observers website and visibility reinforced

Euro-Argo continued its activities with the Ocean Observers community, initiated in collaboration with OceanOPS in 2017. The Ocean Observers website **(see oceanobservers.org)** was enriched with more than 20 freely accessible and ready to use educational resources and activities related to *in situ* ocean observations and 10 thematic sheets about ocean observing networks. The Ocean Observers initiative and those last updates were then presented at the 5th International Marine Science Communication Conference "CommOCEAN 2022" in collaboration with OceanOPS and resulting in additional funding to enhance the Ocean Observers platform.

© Euro-Argo ERIC

CommOCEAN 2022 was the occasion for four members of the Ocean Observers initiative to meet.



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List of the educational resources published on Ocean Observers website (activities to be done in class, colouring sheets, books, hands on experiments videos, etc.), classified by age and scientific topics.

© Euro-Argo ERIC /Mercator Ocean International/ EU4OceanObs

The first video of the "European Ocean Observing Awareness" campaign.

→ "European Ocean Observing Awareness" campaign

A communication campaign was elaborated in collaboration with Mercator Ocean international and EU4OceanObs to raise awareness of the European ocean observation capacity and the importance of *in situ* ocean observations for society. It aims at presenting the scientific missions and challenges of Argo, OneArgo **(see p. 11)** and Euro-Argo to the general public, politicians and the Argo community. This campaign consists of three videos and 10 articles and relies on many interviews of European scientists and EC representatives.

The EMD is the place where "Ocean Leaders Meet".

→ Submission of a joint workshop at EMD 2023

A proposal for a workshop was submitted at the end of the year for the European Maritime Days (EMD) event 2023, the annual two-day event during which Europe's maritime community meet to network, discuss and outline joint action on maritime affairs and sustainable blue economy. The workshop "Sustainable ocean observation, from open sea to coast: shared responsibilities" is the result of a collaboration between six European RIs or in the process of being so (EuroGO-SHIP, EMBRC, EMSO, Euro-Argo ERIC, JERICO and ICOS) and OceanOPS.
A common statement suggesting a public-private involvement is expected, addressing the blue economy and European environmental coherence.

© Euro-Argo ERIC

The Euro-Argo ERIC Council gathered in Brest in November.

Objective 5

OPERATE THE EURO-ARGO ERIC OFFICE UNDER GOOD GOVERNANCE

Main operational outcomes

In 2022, three Management Board meetings and two Council meetings were held → Table 4, thereby contributing to an effective management of the ERIC.

The Euro-Argo ERIC Office and the Management Board worked on three documents that will be crucial for the mid- to long-term development of Euro-Argo ERIC, namely, the 2024-2033 Euro-Argo Strategic Plan and the associated Implementation Plan and Sustainability Plan. The latters will both cover the period 2024-2028. The draft versions of these documents were delivered at the end of the year in the framework of the Euro-Argo RISE project.

The Management Board continued to act as an advisory board for the Euro-Argo RISE project, focusing more specifically on the work packages elaborating recommendations on the development of the Euro-Argo ERIC after the completion of the project.

Yann-Hervé De Roeck was appointed as the new Euro-Argo Program Manager at the 17th Council meeting and Birgit Klein (BSH) was re-elected as the chair of the Management Board during the 23rd Management Board meeting.

At the 24th Management Board meeting, the position of Euro-Argo ERIC for future calls was discussed, the Gender Equality Plan was presented and Laura Tuomi (FMI) was elected vice chair of the Management Board.

On this occasion, Denmark, who joined as a candidate member through DTU-Aqua, also presented its Argo activities. It was also suggested to set up a Euro-Argo Task Team, separated from the Management Board, that would allow engagement with more countries and institutes among EuroGOOS and Regional Operational Oceanographic Systems (ROOS) members.

At its 18th meeting, the Council highlighted that on November, 18% of the European fleet (177) is composed of floats that are five years or older. Thus, in the past, EU contributions to the fleet (through MOCCA project) have advanced the Argo network, but these floats are getting close to their lifetime and similar contributions are needed in future, especially to achieve OneArgo. At this time, the international goal for OneArgo is not reached, neither globally (3,880 instead of 4,700) nor at the European level, and the lag is especially large for the BGC and Deep floats. For these, the European contribution may appear satisfactory, providing respectively 43% and 33% of the international fleet, however many of these floats have degraded capacity or performance: many O_2 only BGC floats instead of 4 to 6 sensors, and 4000m instead of 6000m diving depth for Deep floats.

The Council also noticed that 2022 has been an intense activity period for the ERIC Office with reduced personnel and a lot of deliverables to submit within the Euro-Argo RISE project. In addition, the Program Manager presented the new method that has been conducted in order to establish the work plan for the year 2023 and Jean-Marie Flaud and Elena Mauri were reelected and elected Chair and vice-Chair of the Council, respectively.

Euro-Argo ERIC Office team

2022 was marked by the arrival of Yann-Hervé De Roeck as the new Program Manager of the Euro-Argo ERIC Office. At this time, there is strong evidence of the need for a sustainable *in situ* monitoring of the ocean, on both its physical and biogeochemical properties and in its open-sea, polar and coastal dimensions, Yann-Hervé De Roeck is taking up the challenge of the sustainability and expansion of Euro-Argo ERIC. The Euro-Argo ERIC Office team was also pleased to welcome Delphine Dobler, its new data scientist. Delphine has been working in the field of marine science for five years and has an expertise in physical oceanography, data science, and quality control processes. She will be involved in the management of Argo metadata (within the framework of the ENVRI-FAIR project), the improvement and operational implementation of Key Performance Indicators (KPIs) and the follow-up of data-related issues.

Euro-Argo ERIC Office team welcomed its new data scientist, Delphine Dobler.

© Stéphane Lesbats/Ifremer

© Euro-Argo ERIC

Sylvie Pouliquen passed the torch to Yann-Hervé De Roeck, as the new Program Manager of Euro-Argo ERIC at Council meeting in Brest, in November.

New framework for central procurement adopted by the Council

A clear and common framework for central procurement was settled during the 18th Council meeting. It consists of three statements based on the collaborative spirit that binds the ERIC Office and the members:

– a Framework Agreement is agreed with any Participating Entity that would like to support through the Office the EU engagement to manage 1/4th of the OneArgo fleet;

– once a year, the Participating Entity provides in a lumpsum that covers the purchase and the operational costs of N floats of X types (Core, BGC, Deep). The ERIC Office is then the sole owner of these additional floats, the "float owner" in the metadata;

– in turn, the Euro-Argo ERIC Office will entrust an operational profiler to a Participating Entity just for the deployment, which is performed as an in-kind collaboration. Once a Deployment Agreement signed, a logo on the float and the "operating institution" in the metadata recognize the eminent role of the Participating Entity.

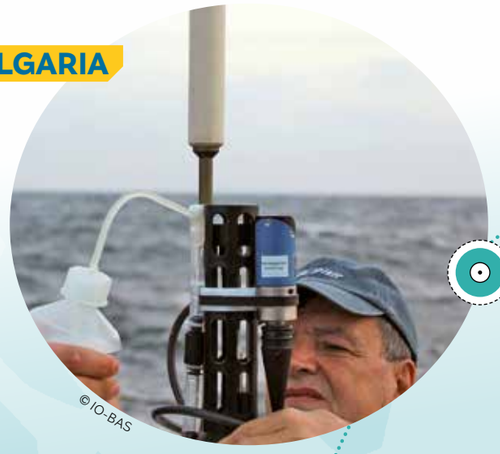
These new simple rules are meant to facilitate the central procurement by the Office, which avoids the burden of many preparatory and operational tasks for the Participating Entities.

Event	Date
22nd Management Board	February online
17th Council	May online
23rd Management Board	June online
24th Management Board	September in Copenhagen
18th Council	November in Brest

Table 4: Euro-Argo Management Board and Council meetings in 2022.

3 EURO-ARGO MEMBERS MAIN ACHIEVEMENTS IN 2022

ARGO BULGARIA


© IO-BAS

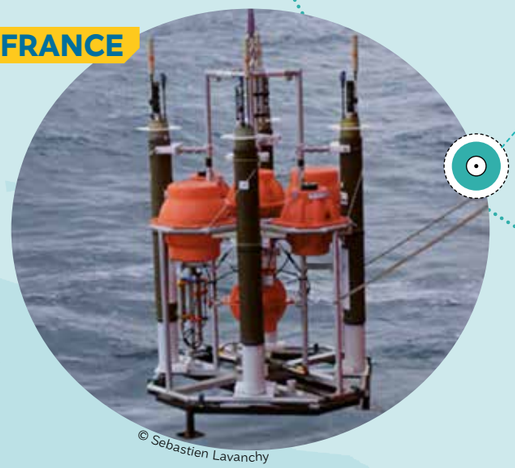
- Deployed **2 ARVOR floats** equipped with an **oxygen sensor**.
- Launched its new BulArgo website (https://bulargo.io-bas.bg/) with the support of the MASRI project – Infrastructure for Sustainable Development of Marine Research, including the participation of Bulgaria in the European infrastructure Euro-Argo.
- Reached in November its **highest number of operational floats**: 8 (2 Core floats and 6 with an oxygen sensor).
- Achieved BulArgo data to be routinely assimilated into the Black Sea forecasting system of the Copernicus Marine Environment Monitoring Service.

ARGO FINLAND


© Silvie Lainela

- Deployed **3 floats in high latitudes ice-covered areas**, **2 in the Barents Sea** in cooperation with Norwegian colleagues and **1 in the Bothnian Bay**, including the development of ice sensing algorithms (ISA) work.
- Proved **Argo operations can be conducted in the Northern Baltic Proper**. One of the floats drifted away from the target area and had to be recovered. Estonian colleagues recovered it within a week, demonstrating the good cooperation of the Baltic Operational Oceanographic System (BOOS) community.

ARGO FRANCE


© Sebastien Lavanchy

- Deployed **78 floats**, including **6 under ice**.
- Successfully deployed 4 Deep floats with an Autonomous System For Argo floats Release (ASFAR).
- Also deployed **8 REFINE BGC floats**.
- Published an **update of the ANDRO** – Argo Trajectory Atlas – products for the period 2010-2020 including AOML DAC floats (https://doi.org/10.17882/47077).
- Developed a **high-level python library** that provides simplified access to all Argo data (Argopy, https://argopy.readthedocs.io) and **Argo fleet simulation software**, (VirtualFleet, https://github.com/euroargodev/VirtualFleet).

ARGO GERMANY


© Aleksandra Mazur/Voice of the Ocean Foundation

- Deployed **22 floats in the southern Weddell gyre**, 15 of which have already surfaced after spending the winter under ice (AWI).
- Successfully **recovered 2 hyperspectral and 1 multispectral float** after 1 year deployment – about 170 cycles – in collaboration with "Voice of the Ocean Foundation" and "Taltech University" Estonia (ICBM).
- Successfully deployed 1 float with a CO_2 sensor in the Baltic Sea (IOW).
- Showed potential offset in the surface ocean through a crossover analysis of pH data measured by BGC floats and an ICOS Ship-of-Opportunity line (GEOMAR).
- And BSH received good news: the Federal Ministry for Digital and Transport is providing additional operational funds to transition to a full implementation of OneArgo until 2027.

ARGO GREECE


© HCMR

- Deployed **3 Arvor floats** in the framework of the HIMIOFOTS program.
- Deployed **3 Italian floats** in the Ionian Sea in the context of field activities cooperation.
- Published the **"Cooperation Framework between Marine RI - Meeting Report"** following the meeting organised by HCMR in collaboration with the Euro-Argo Office (https://doi.org/10.5281/zenodo.6810214).
- Organised a special session entitled "Argo floats contribution to the marine research and operational monitoring of the Mediterranean Sea – Evolution, Achievements, and Future Needs" within the framework of the **"Marine and Inland Waters Research Symposium"** event.
- Got involved in various **educational events** and presented Greek Argo activities on the occasion of school interventions.

ARGO IRELAND


© Garry Kendellen/Galway Atlantaquaria 2022

- Reached **17 active floats**.
- Teamed up with Galway Atlantaquaria to celebrate and support **STEPS Engineers Week**, through "The Argo Adventure", in March. The entire weekend was dedicated to the Argo float and showcased the importance of marine engineering to the next generation of marine scientists.

ARGO ITALY

- Deployed **20 floats** – including **3 Bio/BGC floats**, **3 floats** equipped with the **DO sensor**, **1 Deep float** and **13 Core floats** – in the framework of the COLLAPS projects (OGS).
- Deployed and recovered floats in the Ross Ice Shelf (OGS).
- Deployed **1 float in shallow waters** of the North Adriatic as part of the extension of Argo in shallow/coastal waters (OGS).
- **Updated the ship-based CTD reference dataset** to perform the delayed quality control of float physical parameters, in the frame of a new collaboration with Croatia (OGS).
- Participated to an Awareness Rising Event in Trieste and to the **"Marine and Inland Waters Research Symposium"** event (OGS).
- Participated in one of the Eurofleets+ Floating Universities, in collaboration with Euro-Argo ERIC Office (CNR ISMAR).
- Launched the ITINERIS project in November (OGS and CNR ISMAR). This project aims to deploy BGC floats mainly in the Mediterranean Sea.


© Luca Triggiani

ARGO POLAND

- Signed an **agreement with the Ministry of Education and Science** on financing the purchase and deployments of floats, as well as innovative works on better adapting floats to measurements in shallow waters for a period of 5 years.
- Deployed **1 float** equipped with the DO sensor in the Greenland Sea During the s/y Oceania cruise.
- Deployed 1 float in the Bornholm Basin, **with the option of parking on the bottom**.
- Collected two time series in the Puck Bay, **using a float anchored to the bottom** with an **acoustic release and a thin line**.
- Continued works to reduce floats drifting in the Baltic Sea.


©Waldemar Walczowski/IO PAN

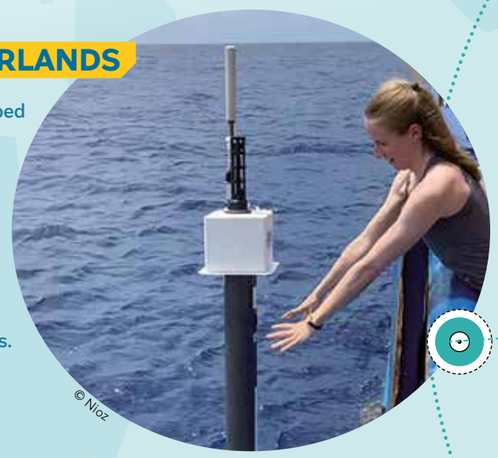
ARGO SPAIN

- Reached a number of **20 operational floats**.
- Carried out the DMQC of 4 Deep floats AtlantOS and E-AIMS projects for the 1st time, following the standards of the Deep Argo community (IEO-CSIC).
- **Recovered 1 float** thanks to the Spanish Army (SOCIB and IEO-CSIC).
- Deployed **2 Arvor floats** in the Western Mediterranean Sea.
- Developed analysis of "encounters" between ships of opportunity and Argo floats through the use of Argo data and Automatic Identification System (AIS) data (IEO-CSIC).
- Launched a **new collaboration agreement** with the Cartagena Ocean Research Institute (CORI) in the field of ocean literacy.


© Armada Española - Ministerio de Defensa

ARGO NETHERLANDS

- Deployed **4 floats** equipped with **RBR sensor** along with four French floats with SBE sensor in the Caribbean Sea to compare the sensors.
- Published a **web-magazine** about Argo for the Dutch large public (https://magazines.rijksoverheid.nl/knmi/knmispecials/2022/06).


© Nioz

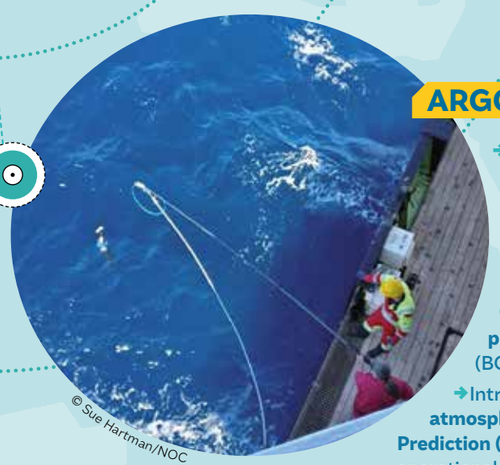
ARGO NORWAY

- Deployed **14 floats** in the Nordic and Arctic Seas, including **6 BGC** and **3 Deep** floats.
- Deployed **1 float** equipped with the **DO sensor** north of Svalbard.
- **Recovered 1 BGC** float in the Norwegian Sea after more than 3 years operation and 230 cycles.
- Reached its highest number of **operational floats: 47**.


© Henrik Søiland

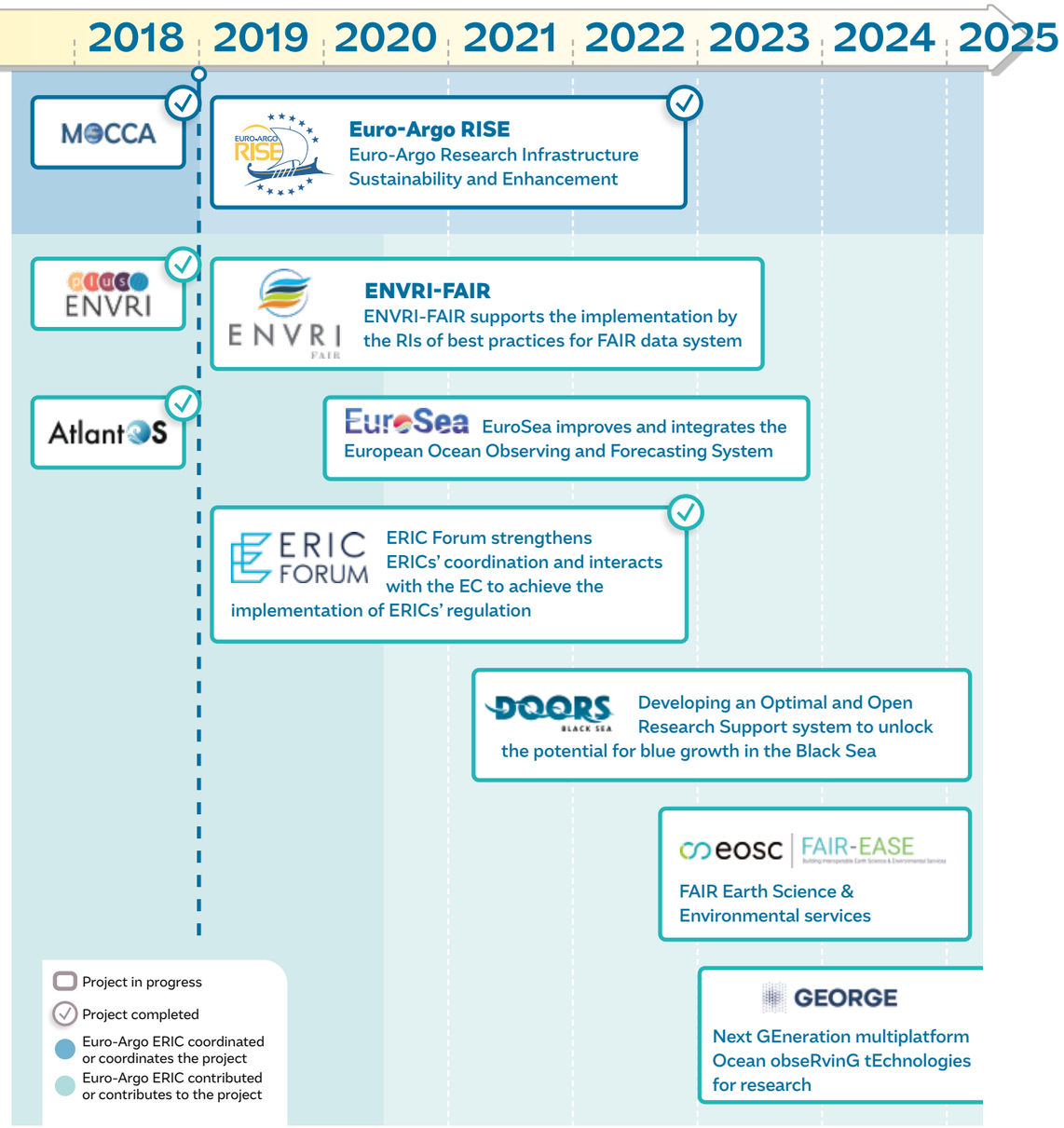
ARGO UK

- Deployed **32 floats**, including 25 Core, **6 BGC** and **1 SOLO II Deep float** (Met Office & NOC).
- Led the **Atlantic Deployment Planning group**, which was created after AST 23. This has already led to more efficient deployment planning of BGC floats in the North Atlantic (Met Office).
- Analysed and submitted **around 3452 core profiles** between March 2022 and February 2023 (BODC).
- Introduced an **operational coupled ocean/atmosphere/sea-ice/land Numerical Weather Prediction (NWP) system** in June, which takes full operational benefit of the assimilation of Argo data.


© Sue Hartman/NOC

4 PROJECTS INVOLVING EURO-ARGO IN 2022

2022 was marked by the end of two H2020 projects: Euro-Argo RISE (coordinated by Euro-Argo ERIC) and ERIC Forum. Meanwhile, Euro-Argo ERIC joined two new Horizon Europe projects: FAIR-EASE and GEORGE.



Deployment of a Deep float.

©Yingjie Liu

EURO-ARGO RISE

EURO-ARGO **R**ESEARCH **I**NFRASTRUCTURE **S**USTAINABILITY AND **E**NHANCEMENT

The Euro-Argo RISE project enhanced and extended the European capacity of the Argo network to provide essential ocean observations to better answer societal and scientific challenges. To reach this goal, it enhanced and organised the new EU Argo observations towards biogeochemistry, greater depth, ice-covered and shallower water regions. Euro-Argo RISE enabled Europe to fulfil its international commitments to the revamped Argo programme and preserve its key international position.

2019-2022
Coordination by Euro-Argo ERIC

- **Funding:** 3.95M€, 536K€ for Euro-Argo ERIC
  European Union's Horizon 2020 research and innovation action
- **Grant agreement ID:** 824131
- **Call for proposal:** H2020-INFRADEV-2018-1

WORK PACKAGES

The Euro-Argo RISE project is organised in eight work packages that allow the project to progress towards Euro-Argo five-year plan objectives.

WP1 PROJECT MANAGEMENT

WP2 IMPROVEMENT OF THE CORE ARGO MISSION

WP3 EXTENSION TO DEEP OCEAN

WP4 EXTENSION TO BIOGEOCHEMICAL PARAMETERS

WP5 EXTENSION TO HIGH LATITUDE REGIONS

WP6 EXTENSION TO MARGINAL SEAS

WP7 EURO-ARGO RISE VISIBILITY: COMMUNICATION AND DISSEMINATION TOWARDS USER'S COMMUNITY

WP8 INTEGRATION OF EURO-ARGO ACTIVITIES IN THE GENERAL CONTEXT OF GLOBAL OCEAN OBSERVATIONS

© Alan Berry/Marine Institute

https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022 to discover the whole project

MAIN ACHIEVEMENTS IN 2022

© Euro-Argo ERIC

The 19 partners gathered in Brest in November for the final meeting.

Euro-Argo RISE project ended in 2022. The synthesis and outcomes were presented at the final meeting in Brest, at the end of November. The 19 partners were all present: relying on this opportunity to finally gather since the Covid-19 pandemia, they summarised the main results and achievements along the four main pillars (see on the right). This was also an important moment to propose the legacy of the project through the implementation of the results at the level of the Research Infrastructure.
To that aim, a dedicated discussion session was organised with the Euro-Argo ERIC Management Board to define the future priorities.

The project allowed the European scientific community to produce 63 official deliverables, representing the state of the art of the European Argo community and the natural follow-up of the work started since the beginning of the Euro-Argo ERIC. Besides some technical documents, the deliverables also included first versions of three key documents in the life cycle of the ERIC: the new Euro-Argo strategy for the next decade, as well as the implementation and long-term sustainability plans for the next 5 years. These documents resulted from a strategic thinking built-up with the Euro-Argo ERIC Management Board.

To describe and disseminate the results of this four-year project, two communication supports were elaborated: a print leaflet and its digital version. These documents were published early 2023 and widely shared through an efficient communication strategy.

SCAN ME

SUMMARY OF EURO-ARGO RISE ACHIEVEMENTS

Through 4 key topics, Euro-Argo RISE enabled Europe to fulfil its international commitments to the further development of OneArgo.

Technological progress

Euro-Argo RISE progressed the development of new sensors in support of OneArgo. New sensors and sampling techniques in shallow/coastal and ice-covered areas have been made available to the community.

Data Management

Quality control procedures have been improved, but also have become more accessible (open source software), transparent and reproducible (code and expertise sharing).

Services to users

Services and tools were improved and made known to the Argo community and beyond.

Euro-Argo Community enhancement

The Euro-Argo community is better structured and collaboration with other Research Infrastructures and between members is strengthened.

PARTNERS

ENVRI-FAIR

FINDABLE, ACCESSIBLE, INTEROPERABLE AND REUSABLE SERVICES

ENVRI-FAIR aims at enhancing the connection of the Cluster of ENVRI to the European Open Science Cloud (EOSC). It supports all participating Research Infrastructures to build a set of FAIR data services to increase efficiency and productivity of researchers and enable data and knowledge-based decisions.

2019-2023

Coordination by FZJ

- **Funding:** 18.99M€, 105,5K€ for Euro-Argo ERIC
- European Union's Horizon 2020 research and innovation action
- **Grant agreement ID:** 824068
- **Call for proposal:** H2020-INFRAEOSC-2018-2

EURO-ARGO CONTRIBUTION

Built on ENVRIplus achievements, ENVRI-FAIR enhances access to environmental Research Infrastructure data and products. It is first driven by individual RI user needs, then by marine domain user needs for integrated services. These services will be in the future available through the European Open Science Cloud (EOSC). These two themes allow the project to progress towards the Euro-Argo Five-Year plan objective n°3 (see p. 18). Euro-Argo and EMSO Research Infrastructures coordinate the WP9 about the improvement of the FAIRness of the Research Infrastructures for the Marine subdomain.

EURO-ARGO MAIN ACHIEVEMENTS IN 2022

Thanks to the time, resources and expertise made available along the year, the FAIRness evolution of the five marine RIs (Euro-Argo, EMSO, SeaDataNet, ICOS and Lifewatch) was assessed and analysed. During the 2022–ENVRI-week meeting, a workshop dedicated to collecting information was organised. At this occasion, each Marine RI could list the resources (i.e. technologies) they use to meet FAIR requirements. Later on, their answers were processed and interpreted. This was summarised in the ENVRI-FAIR deliverable D9.9 Marine subdomain FAIRness Assessment. It is noteworthy that Euro-Argo has associated resources to all FAIR principles, and this completeness of FAIRness was achieved thanks to the last upgrade, i.e. the creation of the NERC Vocabulary Server (NVS) which is an online server with tables describing the vocabulary used by Argo community. The deliverable also includes recommendations to improve the FAIRness assessment towards transversal questions.

At the RI level, the NERC vocabulary server was maintained with the update of seven of these Argo tables. The governance was also improved by the creation of a dashboard to follow the requests for curation and evolution on the NVS tables. The web access to Argo data was improved in two ways: first, evolution needs of Argo ontology (description of the links between metadata exposed on the web), which is used in web queries, were accounted for, and second, the EOV broker architecture was enhanced to circumvent some limitations.

At the project level, a demonstrator linking all Research Infrastructures datasets and called "ENVRI-hub" was published. This offers extended abilities to access Argo data for a wide range of users that would not have directly accessed our portal.

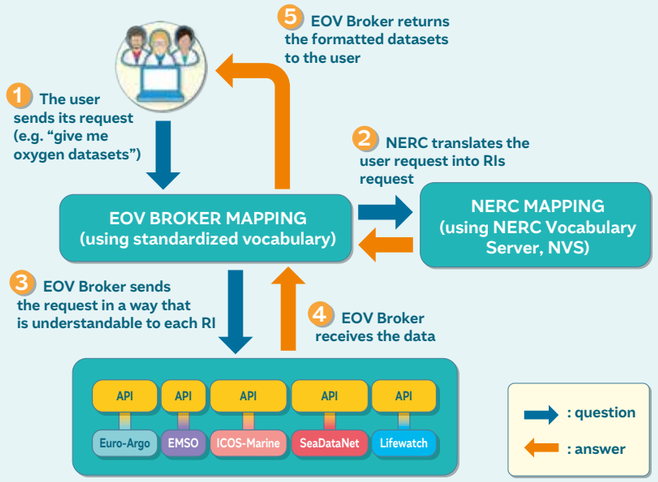


Figure 17: The Marine Use case full steps achieved in 2022 for a FAIR data management system. The enhanced API developed in 2022 both used ERDAPP and SPARQL to circumvent performance issues.

PARTNERS

EUROSEA

EUROPEAN OCEAN OBSERVING AND FORECASTING SYSTEMS

In the continuation of the AtlantOS project achievements, the EuroSea international consortium aims at advancing research and innovation towards a user-focused, truly interdisciplinary, and responsive European ocean observing and forecasting system for a sustainable use of the ocean.

2019-2023

Coordination by GEOMAR

- **Funding:** 12.642M€, 796K€ for Euro-Argo ERIC
- European Union's Horizon 2020 innovation action
- **Grant agreement ID:** 862626
- **Call for proposal:** H2020-BG-2019-1

EURO-ARGO CONTRIBUTION

The Euro-Argo ERIC is involved in two work packages: WP3 "Network Integration and Improvements" and WP7 "Ocean Climate Indicators Demonstrator", with the following objectives:
– WP3 will improve and strengthen ocean observing networks, foster networks innovations and oversee key aspects of technological integration;
– WP7 will assess the ocean role in climate through new ocean climate indicators with decreased uncertainty and will evaluate the economic value of the ocean carbon sink.

MAIN ACHIEVEMENTS IN 2022

As part of EuroSea WP3, Euro-Argo participated in improving harmonisation between ocean observing networks in terms of data management. The objective of the work performed was to reach a common basis of metadata and information (using the FAIR principles, see p. 44) for any *in situ* network that will ease the interoperability and their integration in the various European data integrators, such as Copernicus Marine, EMODnet or SeaDataNet, while being in line with what has been done at international level. The recommendations are provided in deliverable D3.7 Network harmonisation recommendations.

Data collected from Euro-Argo floats, funded and deployed within the project but also from previous experiments, were scientifically processed for the demonstrator on Ocean climate indicators where Ifremer, Sorbonne/CNRS and GEOMAR are major contributors. Three major deliverables relying on these data were published this year:
– deliverables D7.1 Report on demo mission and dissemination pathways of obtained data and D7.2 Development of BGC Argo data quality validation based on an integrative multi-platform approach.

© Euro-Argo ERIC

Claire Gourcuff and Estérine Evrard, Science Officer and Project Manager of Euro-Argo ERIC Office, introduced the 7th international Argo Science Workshop meeting.

Mooring installations, BGC float deployments, and Autonomous Surface Vehicle (ASV) missions were successfully performed during 2021, completed by intercomparisons and data quality assessments carried out this year by Sorbonne/CNRS and GEOMAR.
– deliverable D7.3 Estimate of magnitude and drivers of regional carbon variability. The analysis was based on operational carbon assessments using a combined observing and modelling approach. Regional high-resolution model simulations of EuroSea partners have been used to test different observational network strategies in the Mediterranean Sea and Labrador Sea. Finally, techniques to estimate the time-integrated ocean uptake of excess carbon using different parameter combinations and observation platforms have been further investigated.

The 7th international Argo Science Workshop meeting was organised by Euro-Argo ERIC Office in October, with essential support by the EuroSea project. Euro-Argo ERIC also participated remotely in the EuroSea General Assembly in May.

PARTNERS

ERIC-FORUM

EUROPEAN **R**ESEARCH
INFRASTRUCTURES **C**ONSORTIUM

The ERIC Forum was established in 2017 in order to strengthen the coordination among ERICs and interact effectively with the European Commission to achieve the full implementation of the ERIC regulation. The forum speaks with one voice on issues of common interest for the ERICs and interacts with all stakeholders much more efficiently than individual ERICs.

2019-2022

Coordination by BBMRI ERIC

- **Funding:** 1.5M€
  14K€ for Euro-Argo ERIC
  European Union's Horizon 2020 coordination and support action
- **Grant agreement ID:** 823798
- **Call for proposal:**
  H2020-INFRASUPP-2018-1

PROJECTS OBJECTIVES AND EURO-ARGO CONTRIBUTION

The ERIC Forum Implementation Project brings together the ERIC community to strengthen its coordination and enhance collaborations between the partners. The major objectives of the project are to: (a) support the organisation of specific meetings, targeted thematic workshops focusing on shared challenges such as the development of internal procurement rules, harmonized reporting, VAT exemption practices, insurances and pensions policies and training of governance bodies representatives; (b) support ERICs in preparation, based on best practices; and (c) support common communication and outreach activities and strengthen external representation of ERICs' as a stakeholder in consultations and other policy actions that could affect them.

MAIN HIGHLIGHTS IN 2022

© ERIC Forum

The ERIC Forum General Assembly and Final Meeting of the ERIC Forum Implementation Project brought together 61 articipants from 35 different organisations (the ERIC community, policy makers and key stakeholders).

The Final Meeting of the ERIC Forum Implementation Project was held in Brussels on 11th-12th October. The project, to which Euro-Argo ERIC contributed in various ways, delivered a series of policy papers and resources that are helpful to ERICs in different stages of their lifecycle. One example is the ERIC Forum Policy Brief on "Assessing the socio-economic impact (SEI) of ERICs: Paving the way towards evaluating the full value and contribution of RIs to resilient knowledge-based economies" published in October. SEI is a key element of the advocacy strategy Euro-Argo ERIC will implement to ensure the sustainability of its operations.

One of the most noticeable deliverables of the project is the ERIC Forum Toolkit, an online platform released in December. It provides answers to most practical questions relevant to ERICs, including financing, administration, human resources, communication, impact and evaluation. It also includes various documents and templates that can be used as inspiration or examples of best practices.
A second ERIC Forum Implementation Project will be submitted in January 2023 in response to a targeted Horizon Europe call.
Euro-Argo ERIC will be leading two work packages dedicated to the "sustainability of ERIC services, including transnational and virtual access", and "addressing the challenges of the implementation of the ERIC Regulation, including the VAT exemption", respectively.

PARTNERS

DOORS

DEVELOPING AN **O**PTIMAL AND **O**PEN **R**ESEARCH **S**UPPORT SYSTEM TO UNLOCK THE POTENTIAL FOR BLUE GROWTH IN THE BLACK SEA (DOORS)

The overall objective of DOORS is to work with stakeholders to implement the Strategic Research Innovation Agenda (SRIA) for the Black Sea, to support the successful implementation of Blue Growth and to contribute to a healthy, productive and resilient Black Sea.

2021-2025

Coordination by National Institute of Marine Geology and Geoecology - GeoEcoMar

- **Funding:** 19.25M€,
  180k€ for Euro-Argo ERIC
  European Union's Horizon 2020 research and innovation action
- **Grant agreement ID:** 101000518
- **Call for proposal:** H2020-EU.3.2.3.3

PROJECTS OBJECTIVES AND EURO ARGO CONTRIBUTION

Euro-Argo goal is to demonstrate the potential of BGC Argo, as part of the integrated multiplatform observing system for the Black Sea. The Euro-Argo ERIC is involved in two work packages: WP4 "Deep knowledge" and WP8 "Stakeholders engagement".

MAIN ACHIEVEMENTS IN 2022

Euro-Argo ERIC procured two suites of biogeochemical sensors to equip two BGC floats provided by the Euro-Argo ERIC and IO-BAS, in the framework of the task 4.2 "Establish innovative/smart observations in the Black Sea for sustained biogeochemical monitoring (novel sensor technologies and multi-sensor platforms)". This will allow measuring Dissolved Oxygen, Nitrate, Chl-a/CDOM/Backscattering and Radiometry parameters, in addition to the CTD head, a first insight of the biogeochemical properties in the Black Sea.

Upon reception of the equipment, the ERIC technical team has performed intensive acceptance tests at Ifremer premises (at the 20 meters deep pool tank) to check several float components (hydraulic, communications, etc.) as well as sensors behaviour. These testing procedures are commonly in place at Euro-Argo ERIC to try to detect any potential faults and maximise chances of successful deployments at sea. After in-depth analysis of acceptance test data, floats and sensors have been deemed ready for deployment. Floats configuration and mission parameters were set up in accordance to the scientific needs of the project, and shipment organised to IO-BAS premises. Due to the political situation in the Black Sea region, the cruises and deployments were postponed to 2023.

© Euro-Argo ERIC

Acceptance tests for the H2020 DOORS BGC sensors mounted on BGC Argo floats in August.

PARTNERS

LAUNCH OF TWO NEW PROJECTS

Euro-Argo ERIC joined two new Horizon Europe projects: "FAIR EArth Science & Environmental services" (FAIR-EASE, 24 partners) and "next GEneration multiplatform Ocean obseRvinG tEchnologies for Research Infrastructures" (GEORGE, 23 partners), launched respectively in September 2022 and January 2023.

FAIR-EASE

FAIR-EARTH SCIENCE & ENVIRONMENTAL SERVICES

The overall objective of FAIR-EASE is to customise and operate distributed and integrated services for observation and modelling of the Earth system, environment and biodiversity, by improving their different components implemented in close cooperation with user-communities, the European Open Science Cloud (EOSC) and Research Infrastructures in their design and sustainable availability.

2022-2025 (36 MONTHS)
Coordination by CNRS

- **Funding:** 4.7M€
  61.2k€ for Euro-Argo ERIC
  European Union's Horizon Europe research and innovation action
- **Grant agreement ID:** 101058785
- **Call for proposal:**
  HORIZON-INFRA-2021-EOSC-01

eosc | FAIR-EASE

EURO-ARGO CONTRIBUTION

Euro-Argo Office will be involved in a use-case where new tools and external datasets for the calibration, validation and correction of ocean BGC data will be developed. These new services will be made available to BGC data scientists through a massive, high-performance, distributed data infrastructure able to combine in situ, satellite and model data **(see Figure 19)**.

GEORGE

NEXT GENERATION MULTIPLATFORM OCEAN OBSERVING TECHNOLOGIES FOR RESEARCH INFRASTRUCTURES

The overall objective of GEORGE is to advance the global technological competitiveness of European ocean observing Research Infrastructures (EMSO, ICOS, Euro-Argo ERICs) in the characterisation of the ocean carbon system, through the development and demonstration of a state-of-the-art biogeochemical, multi-platform observing system from sensor to data repositories.

2023-2027 (54 MONTHS)
Coordination by ICOS

- **Funding:** 7.7M€
  690k€ for Euro-Argo ERIC
  European Union's Horizon Europe research and innovation action
- **Grant agreement ID:** 101094716
- **Call for proposal:**
  HORIZON-INFRA-2022-TECH-01

GEORGE

EURO-ARGO CONTRIBUTION

As part of the Horizon Europe INFRA-2022-TECH call "Next generation of scientific instrumentation, tools and methods" Euro-Argo ERIC and its partners (SU, Ifremer, IOW, SOCIB and GEOMAR) were deeply committed in the GEORGE proposal coordinated by ICOS. Euro-Argo ERIC will be involved in WP1, WP3, WP4, WP5, WP6 and WP7 **(see Figure 20)**.

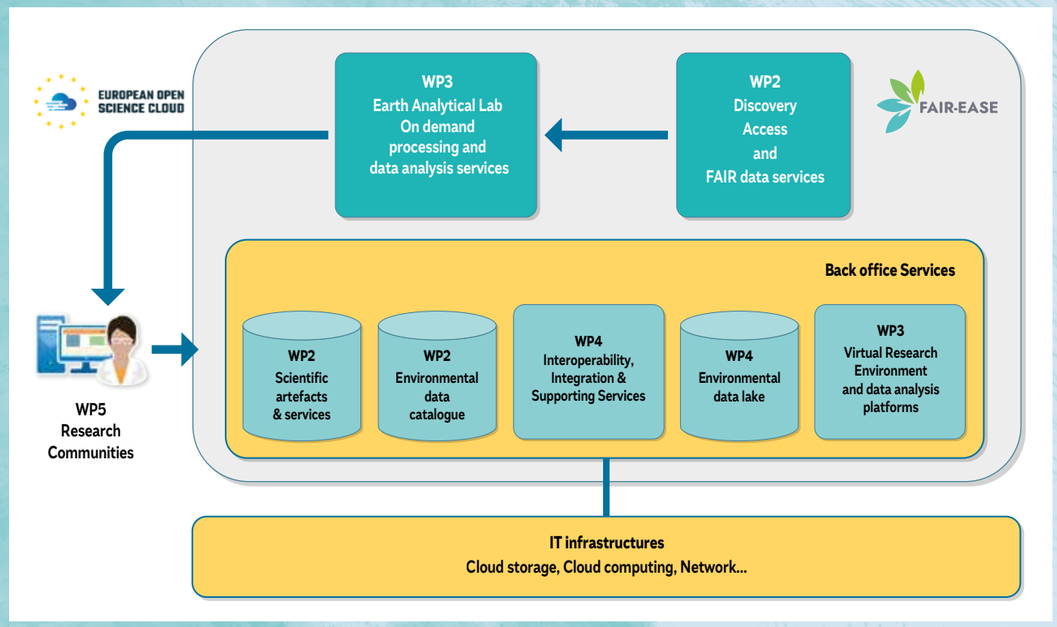


Figure 19: FAIR-EASE workpackages.

OBJECTIVES

- GEORGE will advance the technology readiness level of novel sensors enabling for the first time systematic autonomous, *in situ* seawater CO_2 system characterisation, and CO_2 fluxes on moving and fixed platforms. These sensors will be integrated on state-of-the-art platforms augmented with the latest in autonomous technology enabling new observing capability.
- Technologies, methods and SOPs for carbon observing will be harmonised across a framework for multi-platform, cross-ERIC ocean observing, from sensor to data repositories.
- GEORGE will build capacity in ERICs through the provision of training in the use of new technologies and SOPs on data handling and reporting to staff and member organisations.
- Technology will be co-developed between industry and ERICs ensuring direct route to market and potential for scalability.

WORKPACKAGES

- WP1 Project Management
- WP2 Innovations in autonomous sensor and sampler Technologies
- WP3 Innovation on Ocean Platform Technologies
- WP4 Integration and Interoperability
- WP5 Implementation and Demonstration
- WP6 Training and Education
- WP7 Exploitation, Communication, Sustainability and Impact
- WP8 Ethics requirements

Figure 20: Main objectives and the eight workpackages of GEORGE project.

5 SCIENTIFIC HIGHLIGHTS

"The Synergy of Data From Profiling Floats, Machine Learning and Numerical Modeling: Case of the Black Sea Euphotic Zone"

Authors: Emil. V. Stanev et al.
First published: 21 July 2022
https://doi.org/10.1029/2021JC018012

Abstract

How to reconstruct biogeochemical (BGC) dynamics with few BGC floats? Relying on machine learning (ML) and picking the Black Sea, being an enclosed body of water from which floats do not enter or leave, for a feasibility study, answered a team of German and Bulgarian scientists led by Emil V. Stanev. As a matter of fact, they succeeded in reconstructing the 4D dynamics of the euphotic layer of the Black Sea at basin scale and for the period 2013-2020. To reach this result, they used a newly proposed method, combining data from Argo floats, physical properties from numerical models and ML.

Thus, they relied on seven BGC Argo floats only and the central question was therefore whether the currently available BGC data were sufficient to reliably describe basin-wide variability of the BGC parameters. As expected, data analysis showed complex temporal and spatial relationships between physical and biogeochemical variables and some limits in understanding the details of biogeochemical dynamics.

To account for the intricacy in the interrelationships between those physical and BGC properties, they investigated the usefulness of a newly developed ML technique using physical measurements only: a feedforward backpropagation neural network (NN). It can be considered as an input–output mapping in which the neurons combine the input data (temperature and salinity) to derive output data (Chl-a, bbp and O2), in such a way signal processing can "capture" the nonlinear interactions between processes with different time scales.

The performance was very high, particularly for oxygen. NNs were trained from a relatively short time, so they appeared to be less successful when applied to historical data, revealing substantial recent changes in the ocean system.

But is the reconstruction skill using NNs really more powerful than a traditional coupled physics-BGC model? To answer that question, the scientists made a comparison with simulations from an operational biogeochemical model from the Copernicus Marine Environment Monitoring Service (CMEMS). The conclusion was cristal clear: for all floats and parameters, the NN reconstructions outperform the results of the numerical model simulation. This finding reveals the potential to enhance the quality of BGC numerical simulations by using ML.

Authors took advantage of this synergy of different data sources: they computed the 4D BGC dynamics of the euphotic layer during 2013–2020 using 4D temperature and salinity data from the CMEMS model as inputs → **Figures 21 & 22** (example of Chl-a, a proxy for phytoplankton biomass).

Large values of Chl-a along the western coast were known from the early days of satellite oceanography*. These values are explained by the inflow from the large rivers bringing more nutrients into the system. The estimations show that, overall, Chl-a concentrations along all coasts are higher than those in the interior of the basin → **Figure 21**. Furthermore, it was demonstrated that this ML fed by physical data from numerical models appears to be a useful tool to replicate both the mean and eddy states of the Black Sea BGC → **Figure 22**.

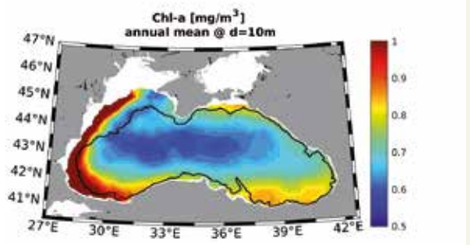


Figure 21: Reconstructed Chl-a at 10-m mean for 2015-2020.

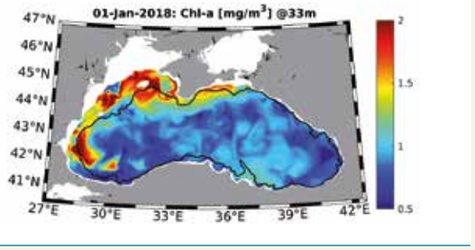


Figure 22: Reconstructed Chl-a at 33-m mean – January 1st 2018 snapshot.

*Barale & Murray, 1995

"A shift in the ocean circulation has warmed the subpolar North Atlantic Ocean since 2016"

Authors: Damien Desbruyères et al.
First published: 26 February 2021
https://doi.org/10.1038/s43247-021-00120-y

Abstract

Since 2016, the subpolar North Atlantic Ocean (SPNA), a key region in the global ocean and climate system, likely entered a new warming phase. Here, scientists combined datasets derived from satellites and Argo floats, idealized observation-based modelling, and a machine learning technique to explain this most-recent warming trend.

An ocean analysis product called In Situ Analysis System-15 (ISAS-15) and covering the period 2002–2019 was used to show the evolution of temperature anomalies in the eastern SPNA. This ISAS-15 was developed to produce gridded fields of temperature and salinity that preserve as much as possible the time and space sampling capabilities of the Argo network of profiling floats. It showed that the ocean heat content (OHC) of the 0 – 2000 m layer increased by about 8.5 X10^{21} J between April 2016 and December 2019, with 80% of this heat gain found above 700m depth. Anomalous air-sea heat fluxes potentially contributed to about a quarter of that value, making the ocean heat transport as a dominant contributor, as predicted by previous study*.

To evidence the dynamical mechanism underlying this specific contribution of ocean currents to the 2016-to-present warming of the SPNA, authors relied on altimetry data and an advection-diffusion model for a passive tracer. They focused on the relative proportion of the two source waters transported towards the SPNA by the large-scale circulation: cold subpolar waters (CSPG) and warm subtropical waters (CSTG) → **Figure 23**. This proportion (PSTG) was found significantly correlated to temperature changes in the eastern SPNA, both in terms of temporal evolution – not shown – and horizontal distribution → **Figures 24 & 25**.

Is this result confirmed by Argo floats? To answer that question and assess the evolution of ocean interior properties scientists applied a machine learning algorithm – namely a profile classification model (PCM) – to their three-dimensional observational dataset. Once trained, the PCM can be used to assign any given profile to its most probable class. This resulted in a statistical clustering of profiles into a cold and fresh subpolar class and a warm and salty subtropical class, which remarkably concurred with the tracer-based monitoring of P_{STG}.

The ongoing SPNA warming and the long ocean memory of this region makes it likely to persist over the coming years, with possible consequences on regional and coastal sea-level rise, heat transport to the Arctic and ice responses, as well as on marine ecosystems.

*Surface predictor of overturning circulation and heat content change in the subpolar North Atlantic. D. Desbruyères et al. Ocean Sci 15, 809–817 (2019).

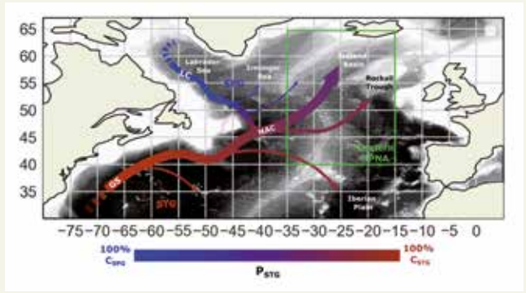


Figure 23: **Schematic of the northern North Atlantic circulation.** The Labrador Current (LC) of the Subpolar Gyre (SPG) and the Gulf Stream (GS) of the Subtropical Gyre (STG) connect within the North Atlantic Current (NAC) that feeds the eastern SPNA (green box) with a mixture of cold subpolar waters (blue, CSPG) and warm subtropical waters (red, CSTG).

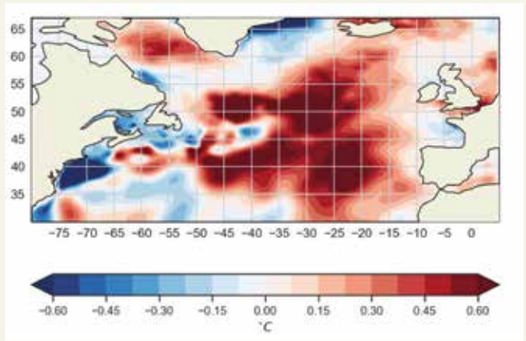


Figure 24: **Spatial patterns of recent changes.** Horizontal pattern of observed temperature anomalies in the upper 0–100m layer computed as 2017–2019 minus 2014–2016.

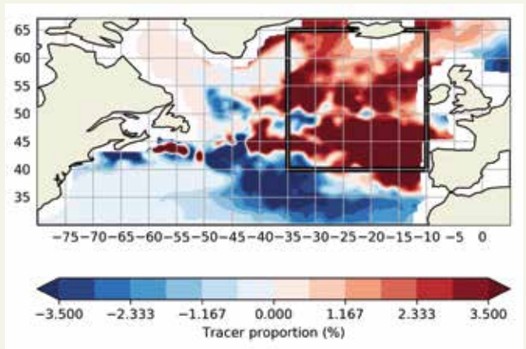


Figure 25: **Spatial distributions of passive tracers.** Horizontal pattern of PSTG change from 2014–2016 to 2017–2019.

6 FINANCIAL STATUS

The Euro-Argo ERIC 2022 accountings show a strong balance sheet and a first loss, which both deserve explanations. Being still prepared by a chartered accountant, the method has changed. As a legacy of its inception, the accounting method used to be on a (EU-) project by project basis in the previous exercises. However, to be able to monitor how the ERIC is performing on a long term, it appears to be wiser to adopt a more business-like approach. The loss is structural but manageable while a new and sustainable business model is put in place.

The amount of the overall balance sheet is 1.7 times higher than last year: 3,476 k€ versus 2,006 k€. Two factors explain this growth. Primarily, the high variation in the number of floats purchased through the central procurement procedure, namely due to the time lag between order, purchase and, once tested, resell of the floats. The share of this activity remains high: the turnover on floats reaches 1,345 k€ while the operating expenses (i.e., without the central procurement activity) are limited to 867 k€. The second factor is related to the fact that, from the signing of a grant agreement on, project expenses and incomes (including the corresponding overheads) are now accounted for year after year, as they are justified. According to the contract set at grant agreement, other receivables and other debts are generated that correspond to the work that will be performed during the following years in the framework of the project. From a business-oriented point of view, the induced growth of the balance sheet can be considered as an assessment of secured future activities.

EURO-ARGO 2022 FINANCIAL STATUS

TYPE	DEBIT	CREDIT
OPERATING INCOME		**794**
Subscription members/observer		350
Operating grants		444
OPERATING EXPENSES	**866**	
Wages and social contributions	**399**	
Salaries	272	
External personnel	127	
Amortization on fixed assets	**244**	
Other external expenses	**235**	
Telecommunication (satellite)	55	
Travels-receptions-seminars	68	
Public relations	39	
Legal fees	16	
Rental	16	
Insurance	7	
Others expenses	34	
Others income	**-6**	
Global balance of central procurement	**-6**	
LOSS	**-72**	

Table 5: Simplified income statement in k€, central procurement of floats excluded.

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Euro-Argo Office team testing Core floats at Ifremer facility.

The income statement shows a moderate loss (–72 k€) in 2022 where 2021 had generated a slight profit (42 k€). Indeed, the activity on EU-funded projects is decreasing, especially for projects on which profilers could be purchased; then, the charge of the depreciation of the floats has been growing. In these conditions, the Euro-Argo ERIC Office has not bought any floats outside the projects on its own resources, hence it was not in a position to "fill the gaps" to complement the contribution of the member countries to reach 1/4th of the global Argo fleet. Regarding risk management, it should also be considered that the currently available treasury is equal to 1.94 times the present yearly level of wages and social contributions (400 k€, for 7 full-time equivalents, FTEs). The evaluated net treasury, assuming all debts, liabilities and residual value of floats have vanished, can sustain several years should the current loss level continues. This finding calls for looking for complementary sources of funding and asking for a reevaluation of the membership fees, unchanged since 2014. Meanwhile, the Program Manager wishes to go on investing in human resources to strengthen the Office in order to provide the expected support towards the implementation of the ambitious OneArgo.

EURO-ARGO MEMBERS AND OBSERVER 2022 BUDGET

COUNTRY	FLOATS PURCHASED	FLOATS DEPLOYED	FULL TIME EMPLOYEE	CONSOLIDATED BUDGET OF NATIONAL ARGO PROGRAMMES
Bulgaria	3	2	0,03	84,5
Finland	0	3	0,5	183
France	43	78	13	5,782
Germany	59	59	5,0	2,307
Greece	0	1	0,3	40
Ireland	0	0	0,1	50
Italy	16	21	3,5	780
Netherlands	12	12	0,08	230
Norway	10	14	2,9	850
Poland	0	1	0,66	99
Spain	3	2	2	173
UK	17	32	3,91	1,080
Total	146	116	26,98	2497,589

Table 6: Euro-Argo members and observer 2022 budget.

ANNEX 2 - GLOSSARY

ADMT
Argo Data Management Team

AIC
Argo Information Centre

API
Application Programming Interfaces

ASD/FSD
Abrupt/Fast Salinity Drift

AST
Argo Steering Team

ASW7
7th Argo Science Workshop

AtlantOS
All-Atlantic Ocean Observing System

BEERi
Board of European Environmental Research Infrastructures

BGC
Biogeochemical

Bio
Biogeochemical floats with only one to five variables

BODC, NOC
British Oceanographic Data Centre, National Oceanography Centre

BOOS
Baltic Operational Oceanographic System

BSH
Bundesamt für Seeschifffahrt und Hydrographie

CDOM
Colored dissolved organic matter

Chl-a
Chlorophyll a

CMEMS
Copernicus Marine Environment Monitoring System

CNRS
Centre national de la recherche scientifique

Core
Standard Argo float measuring temperature and salinity (T/S)

CSIC
Consejo Superior de Investigaciones Científicas

CTD
Conductivity, Temperature, Depth

DAC / GDAC
Data Assembly Centre/ Global Data Assembly Centre

Deep
Argo floats diving to greater depths than 2000 meters

DO
Dissolved Oxygen

DOORS
Developing an Optimal and Open Research Support

DMQC
Delayed Mode Quality Control

DTU-Aqua
National Institute of Aquatic Resources

ECMWF
European Centre for Medium-Range Weather Forecasts

EMD
European Maritime Days

EMODnet
European Marine Observation and Data Network

EMSO
European Multidisciplinary Seafloor and water column Observatory

ENVRI
Environmental and Earth System Research Infrastructures

ENVRI-FAIR
ENVRI- Findable, Accessible, Interoperable and Reusable services

ENVRIplus
ENVRI- Providing Shared Solutions for Science and Society

EOOS
European Ocean Observing System

EOSC
European Open Science Cloud

EOV
Essential Ocean Variables

ERIC
European Research Infrastructure Consortium

ERIC Forum
Network of ERICs to strengthen their coordination and interact effectively with the EC

ESFRI
European Strategy Forum on Research Infrastructures

EU
European Union

Euro-Argo RISE
Euro-Argo Research Infrastructure Sustainability and Enhancement

EuroGOOS
European Global Ocean Observing System

EuroSea
European Ocean Observing and forecasting systems

FMI
Finnish Meteorological Institute

FZJ
Forschungszentrum Jülich

GDAC
Global Data Assembly Centre

GeoEcoMar
The national Institute for Research and Development of Marine Geology and Geoecology of Romania

Geomar
Helmholtz-Zentrum für Ozeanforschung Kiel

GO-BGC
Global Ocean Biogeochemistry Array

GOOS
Global Ocean Observing System

GO-SHIP
Global Ocean Ship based

HCMR
Hellenic Centre for Marine Research

ICOS
Integrated Carbon Observation System

IEO
Instituto Español de Oceanografía

Ifremer
Institut Français de Recherche pour l'Exploitation de la Mer

IMR
Institute of Marine Research

IO PAN
Institute of Oceanology of the Polish Academy of Sciences

IO-BAS
Institute of Oceanology – Bulgarian Academy of Sciences

IOC
Intergovernmental Oceanographic Commission

ISA
Ice Sensing Algorithm

KNMI
Koninklijk Nederlands Meteorologisch Instituut

LOV
Laboratoire d'Océanographie de Villefranche

MB
Management Board

MI
Marine Institute

MOCCA
Monitoring the Oceans and Climate Change with Argo

NERSC
Nansen Environmental and Remote Sensing Center

NOAA
National Oceanic and Atmospheric Administration

NVS
NERC Vocabulary Server

OceanOPS
The WMO-IOC Joint Technical Commission for Oceanography and Marine

OGS
Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (National Institute of Oceanography and Applied Geophysics)

OneArgo
The United Nations endorsed set of actions to reach a global and multidisciplinary ocean observing array

RTQC
Real Time Quality Control

R/V
Research Vessel

SOCIB
Sistema d'observació i predicció costaner de les Illes Balears (Balearic Islands Coastal Observing and Forecasting System)

SOOS
Southern Ocean Observing System

SOP
Standard Operating Procedures

SRIA
Strategic Research Innovation Agenda

STAG
Scientific and Technical Advisory GroupT/S Temperature/Salinity

SU
Sorbonne Université

UVP
Underwater Vision Profiler

WHOI
Woods Hole Oceanographic Institution

WMO
World Meteorological Organisation

ANNEX 3 - PARTNERS OF EURO-ARGO ERIC

Country	Statute	Representing Organisation
Bulgaria	member	IO-BAS
Denmark	candidate	DTU-Aqua
Finland	member	FMI
France	member	Ifremer
Germany	member	BSH
Greece	member	HCMR
Ireland	member	MI
Italy	member	OGS
Netherlands	member	KNMI
Norway	member	IMR
Spain	member	SOCIB, IEO-CSIC
United Kingdom	member	Met Office
Poland	observer	IO PAN

*** The listed institutes represent the Member States, but other institutes in the country can also participate to the Euro-Argo activities.**

ANNEX 4 - EURO-ARGO ERIC GOVERNANCE BODIES

	Profession / Position
Council Members	
Jean-Marie Flaud	*Chair* - MESR France
Elena Mauri	*Vice-Chair* - OGS - Italy
Jon Turton	Met Office – UK
Aristomenis Karageorgis	HCMR – Greece
Sybren Drijfhout	KNMI – Netherlands
Mikko Strahlendorff	FMI – Finland
Kerstin Jochumsen	BSH – Germany
Marta Stawicka	Ministry of Education & Science – Poland
Odd Ivar Eriksen	Research Council of Norway - Norway
Joaquin Tintoré	SOCIB – Spain
Glenn Nolan	Marine Institute - Ireland
Atanas Palazov	IO-BAS - Bulgarian Academy of Sciences Bulgaria
Pierre-Yves Le Traon	Special Advisor to the French representative - France
Karen Edelvang	DTU-Aqua - Denmark
Management Board Members	
Birgit Klein	*Chair* – BSH – Germany
Laura Tuomi	*Vice-Chair* – FMI – Finland
Alan Berry	Marine Institute – Ireland
Dimitris Kassis	HCMR – Greece
Pedro Vélez-Belchi	IEO-CSIC – Spain
Virginie Thierry	Ifremer – France
Kjell Arne Mork	IMR – Norway
Waldemar Walczowski	IO PAN – Poland
Andreas Sterl	KNMI – Netherlands
Fiona Carse	Met Office – United Kingdom
Giulio Notarstefano	OGS – Italy
Violeta Slabakova	IO-BAS – Bulgaria
Colin Stedmon	DTU-Aqua – Denmark

	Profession / Position
Euro-Argo ERIC Central Research Infrastructure	
Sylvie Pouliquen Yann-Hervé de Roeck	Programme Manager Ifremer France
Francine Loubrieu	Administrative Assistant Ifremer France
Romain Cancouët	Operational Engineer Euro-Argo ERIC
Claire Gourcuff	Science Officer Euro-Argo ERIC
Estérine Evrard	Project Manager Euro-Argo ERIC
Marine Bollard	Communication Officer Euro-Argo ERIC
Delphine Dobler	Data scientist Euro-Argo ERIC
Luc van Dyck	Advisor for policy and partnership relations Euro-Argo ERIC
Scientific & Technological Advisory Group (STAG)	
Arne Körtzinger	*Chair* – GEOMAR Germany Research
Inga Lips	EuroGOOS Secretary General EOOS
Susan Wijffels	WHOI USA – Argo International
Johnny Johannessen	NERSC Norway Copernicus Marine Service
Philip Browne	ECMWF UK – Weather forecasting and Coupled Data Assimilation
One Euro-Argo ERIC expert assists the STAG	
Hervé Claustre	LOV France – Bio-Argo

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