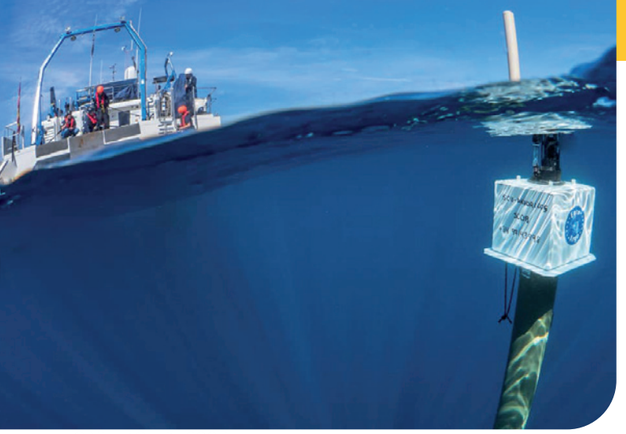
EURO-ARGO RISE
FINAL RESULTS

EUROARGO

EUROPEAN RESEARCH
INFRASTRUCTURE CONSORTIUM
FOR OBSERVING THE OCEAN



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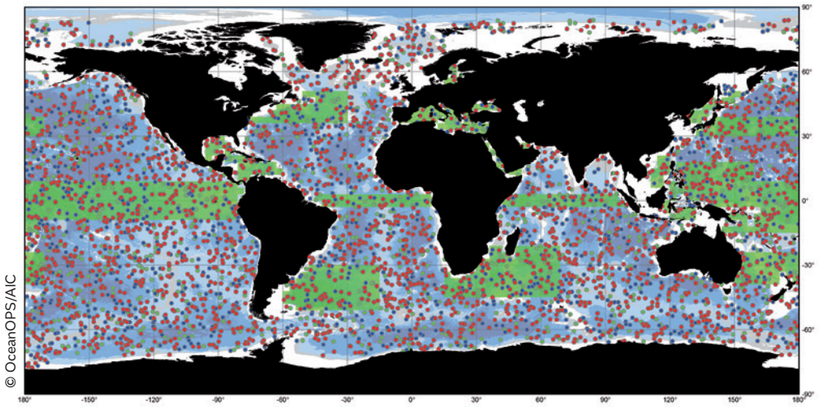
EURO-ARGO RISE: ALIGNING EURO-ARGO WITH THE OBJECTIVES OF ONEARGO

Argo's design needs to adapt as requirements change and new technologies become available. A new global design "OneArgo" relying on technological innovations and international coordination has been launched. One Euro-Argo RISE objective was to match the Euro-Argo ERIC missions with those of OneArgo.

ARGO'S DESIGN AFTER 2019: ONEARGO

The new global design OneArgo includes:

- Strengthening the original mission to improve spatial coverage and include Polar regions and Marginal Seas, while also increasing resolution in key areas of interest.
- Enhancing and expanding major new Biogeochemical (BGC) and Deep Argo missions.
- Ensuring data management teams are ready and able to handle the new data streams.
- Strengthening national and international partnerships.
- Enhancing strong community support and advocacy.



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Central to OneArgo is that BGC and Deep floats now contribute to the core float data stream.

- Core Floats, 2500
- Deep Floats, 1200
- BGC Floats, 1000
- Target density doubled

EURO-ARGO ERIC MISSION

- Euro-Argo ERIC is the European Research Infrastructure Consortium (ERIC) dedicated to the development of a long-term Argo global ocean monitoring system in Europe with the aim to better understand the ocean, its role in the climate system and its health.
- Euro-Argo sustains, develops and optimises the European contribution to the international Argo program, providing, deploying and operating nearly 25% of the float network.
- Euro-Argo is now able to initiate network upgrades in response to specific European research interests, especially towards high latitudes, Marginal Seas, biogeochemistry (BGC) measurements to study ecosystem parameters and sample deeper into the abyss.

OBJECTIVES FROM 2014 - 2018

1. Sustain the existing Core Argo mission.
2. Develop the extension of Euro-Argo contribution to Argo according to OneArgo.
3. Develop scientific and technological coordination with other ocean observing networks (GOOS and EOOS).
4. Develop the engagement with European Argo user communities and stakeholders.
5. Operate the Euro-Argo ERIC Office under good governance.

2019-2022

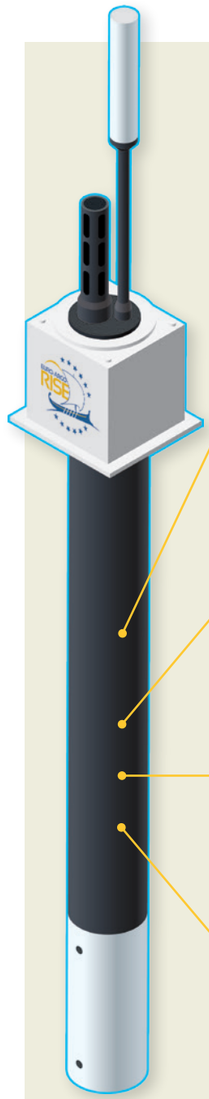
COORDINATION BY EURO-ARGO ERIC

- **Funding:** 3.95M€ European Union's Horizon 2020 research and innovation program
- **Grant agreement ID:** 824131
- **Call for proposal:** H2020-INFRADEV-2018-1

WHAT IS EURO-ARGO RISE PROJECT?

Euro-Argo Research Infrastructure Sustainability and Enhancement (RISE)

Euro-Argo ERIC aims to provide essential ocean observations for a better understanding of ocean health and of the global warming consequences on the ocean. To reach this goal, the Euro-Argo RISE project pooled together the effort of 19 European partners to further develop Euro-Argo contribution towards biogeochemistry, greater depth, ice-covered and shallower water regions.



EURO-ARGO RISE: BOOSTING THE EUROPEAN ARGO CONTRIBUTION

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

Technological progress

- Test new sensors to assess their accuracies and performances, with the objective to diversify sensor provision
- Assess EU fleet performances
- Test and recommendations on how to operate floats in high-latitudes and shallower water

Data Management

- Improve and share quality control procedures and materials for core & Deep Argo
- Improve the BGC data processing workflow at the European level
- Enhance the quality of Essential Ocean Variables

Services to users

- Ease access to Argo data and increase their usage
- Enhance services for operational and expert users
- Create awareness about the services/products provided by Euro-Argo and attract new users

Euro-Argo Community enhancement

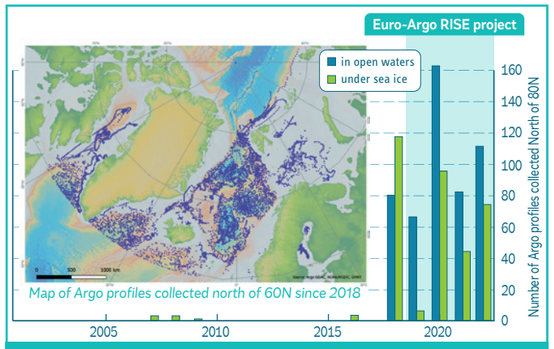
- Engage with new countries to develop and coordinate national programs while reaching more oceanic zones
- Reinforce the links and partnership with other ERICs and networks (within and outside Europe)

TECHNOLOGICAL DEVELOPMENTS IN SUPPORT OF ONEARGO IMPLEMENTATION

Euro-Argo RISE project has been a key enabler to diversify sensor manufacturers and strove to secure the best sensor performance at a competitive cost while matching the required scientific data quality. It also assessed Euro-Argo fleet performance to provide configuration recommendations, increased Argo floats survival in high latitudes and encouraged to test Argo floats in shallower waters.

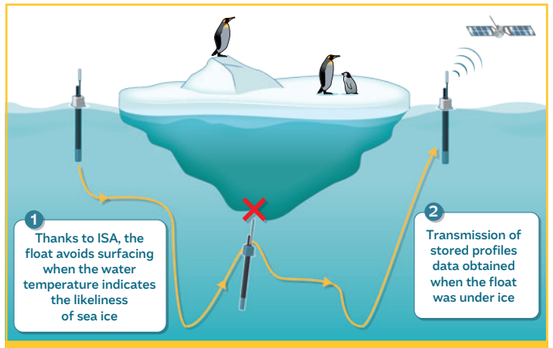
TECHNOLOGY HELPED EXPAND EUROPEAN GEOGRAPHICAL COVERAGE

The Euro-Argo RISE project has provided guidance for the expansion of the Argo monitoring system in targeted missions close to the coast of European Marginal Seas and in partially ice-covered areas.



Argo expansion in high latitudes

Argo profile positions collected north of 60N. A clear increase in the number of available profiles in recent years reflects Argo deployments in higher latitudes and improved reliability and capabilities of floats operating in these regions.



Deployments in partially ice-covered areas

Euro-Argo improved Argo observations coverage of annual observations in these regions by using the Ice Sensing Algorithm (ISA) software with locally adapted configuration parameters that allow more floats to operate under seasonally ice-covered areas.

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Deployments in shallower waters of European Marginal Seas

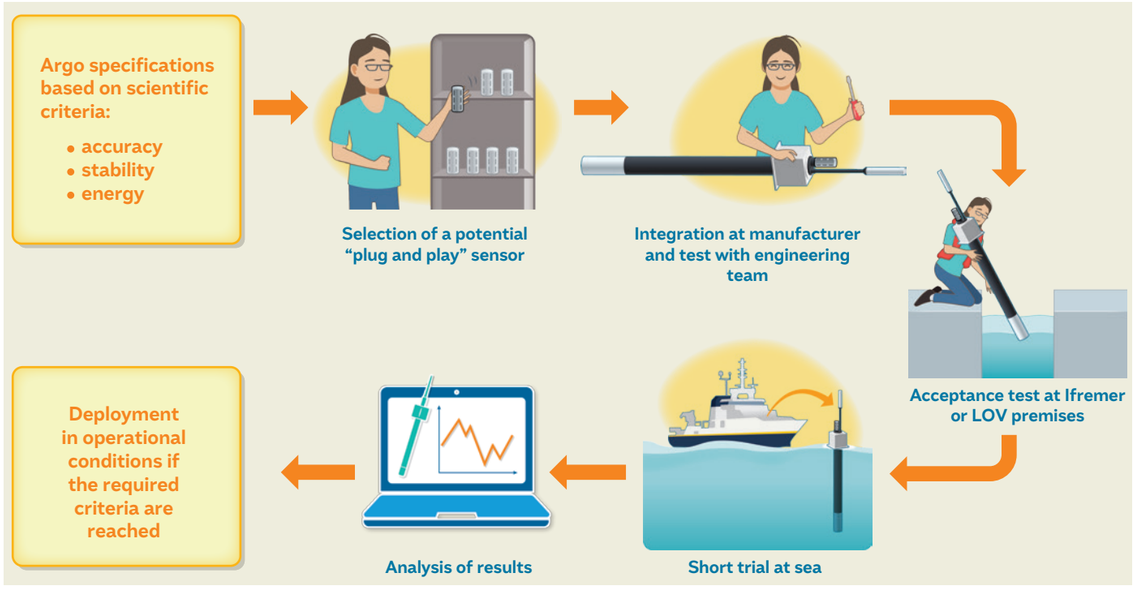
Thanks to specific float configurations tuned for shallower waters, combined with a higher level of interactive communication with the floats, the potential use of Argo was demonstrated in selected sites of the Baltic, Mediterranean and Black Seas.

IN-DEPTH ASSESSMENT OF EURO-ARGO FLEET PERFORMANCE

- Float lifetimes and performance have been extensively investigated, through comparisons between models, deployment basins, Euro-Argo and international arrays.
- The European technology exhibits the top survival rates for the core and BGC missions.
- Methodologies and routines have been developed to track and compare float lifetimes and configurations.

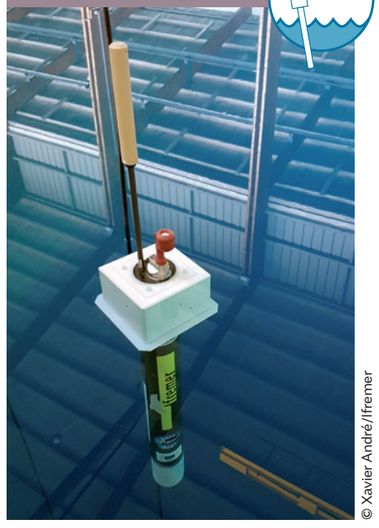
TESTING NEW SENSORS ON ARGO FLOATS

So far, the vast majority of sensors are supplied by a single manufacturer. Euro-Argo has made it possible to test sensors produced by new manufacturers by integrating them on floats according to the steps presented below. If successful, this will strengthen the European market and secure sensor provision at a competitive cost with the required scientific data quality.



The various stages of sensor testing prior to operational deployments.

Core float



© Xavier André/Ifremer

Euro-Argo RISE allowed the specification, integration and testing of the RBRArgo3 sensor on the nke Arvor float. Through European and international deployments, this contributed to the endorsement of the sensor by the Argo Program in 2022, offering an alternative sensor for the core mission.

Deep float

© Patrick Rousseau/Ifremer

A 2-headed float about to be tested at Ifremer facility to compare the two new sensors (SBE61 on the right, RBR concerto new sensor on the left). This new generation of sensors has been developed in collaboration with Argo international and the manufacturers to provide data accurate down to 6000m.

BGC float

© Edouard Leymarie/LOV-OMTAB

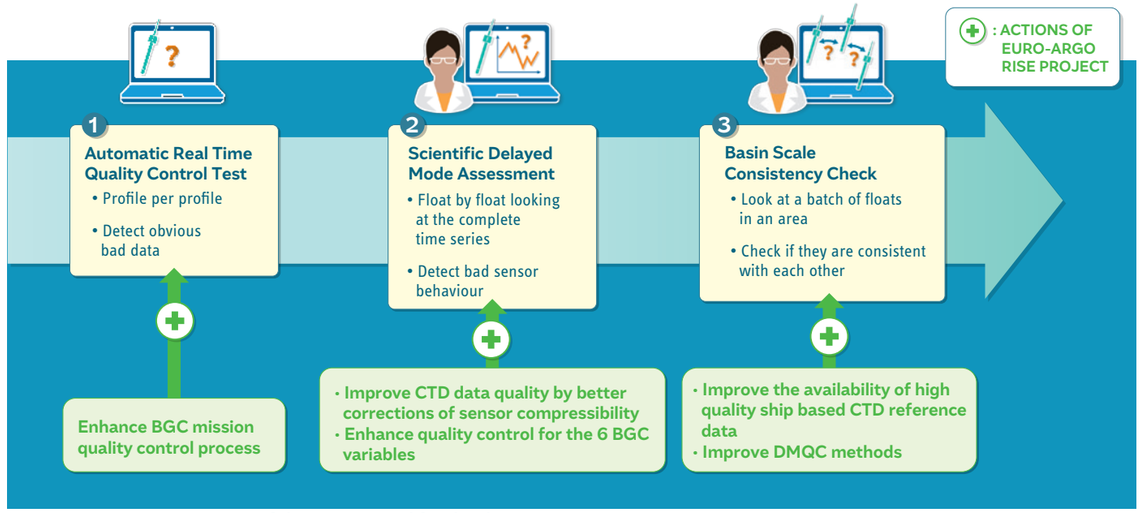
A BGC float was deployed offshore Villefranche, France, to compare two irradiance sensors: the RAMSES hyperspectral sensor from TRIOS and the standard OCR sensor from Seabird. Euro-Argo RISE reinforced the leadership of EU teams in BGC Argo activity.

IMPROVING THE EUROPEAN CONTRIBUTION TO THE ARGO DATA SYSTEM

Euro-Argo RISE contributed to enhancing the existing Argo data system in order to handle new float types tested. New delayed mode quality control (DMQC) methods were developed to cover the OneArgo quality requirements. Euro-Argo RISE has been central to enhancing the European component to the OneArgo data system through efficient collaborative developments.

ENHANCEMENT OF THE DATA QUALITY FOR ONEARGO

Euro-Argo RISE facilitated the improvement of data quality for operational and scientific purposes, providing and further developing the required quality control procedures both in near real time and in delayed mode.



Improvements at every stage of the process and for the three missions.

IMPROVED DATA QUALITY CONTROL

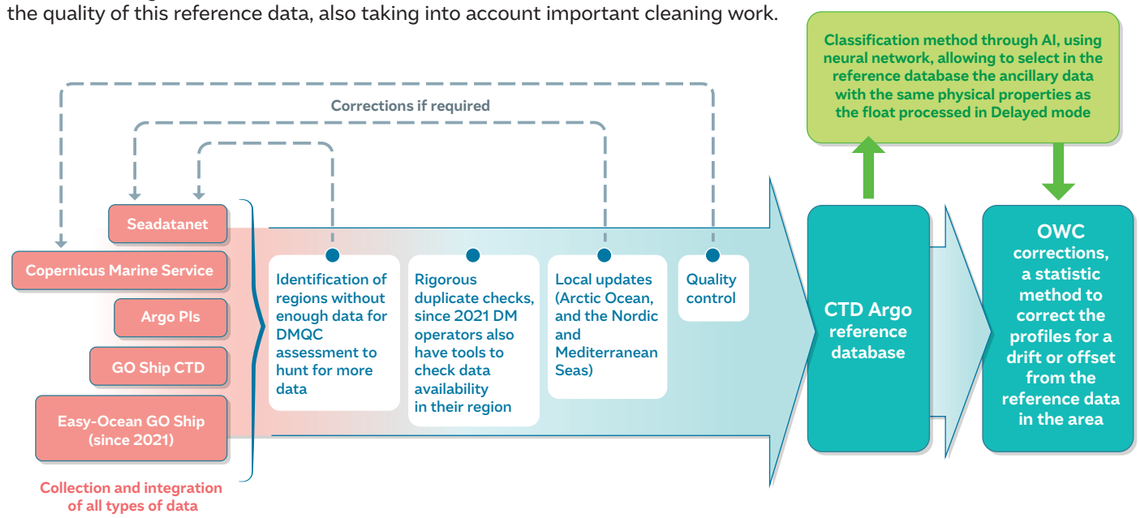
Euro-Argo RISE allowed to enhance quality control processes, improving algorithms and methods for the three missions, and transferring them into operational mode for the Research Infrastructure.

Endorsed by Argo community (ADMT)

MISSIONS AND ARGO VARIABLE		PARAMETERS MEASURED AND PROXYS	REAL TIME QUALITY CONTROL STATUS OF PROGRESS	DELAYED MODE QUALITY CONTROL STATUS OF PROGRESS
Core	Temperature and Salinity	Climate change, exchange of energy between atmosphere and ocean, climate and ocean forecasts	Update for RBR QC ✓	Recommendation for DMQC in Baltic shallower waters
Deep	Temperature and Salinity below 2000m	Sea level rise, earth energy budget, deep ocean circulation	Definition of procedures ✓	Definition of Deep DMQC procedures ✓
BCG	6 biogeochemical parameters	Ocean ecosystem health	Robust procedures have been enhanced or developed ✓	Enhanced DMQC procedures developed, tested and for some of the parameters discussed at international level

IMPROVEMENT OF REFERENCE DATABASES

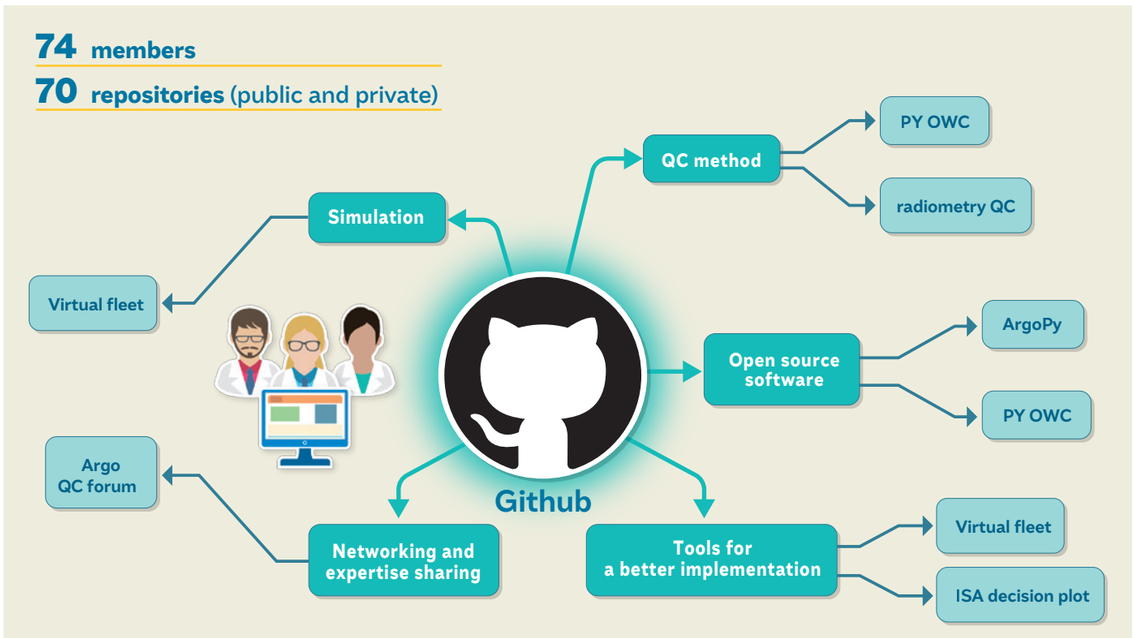
Quality assurance of Argo data was improved by comparing Argo data to high quality observation of similar water masses, assembled in Argo reference databases.
Within Euro-Argo RISE, activities were carried out to enhance the amount and the quality of this reference data, also taking into account important cleaning work.

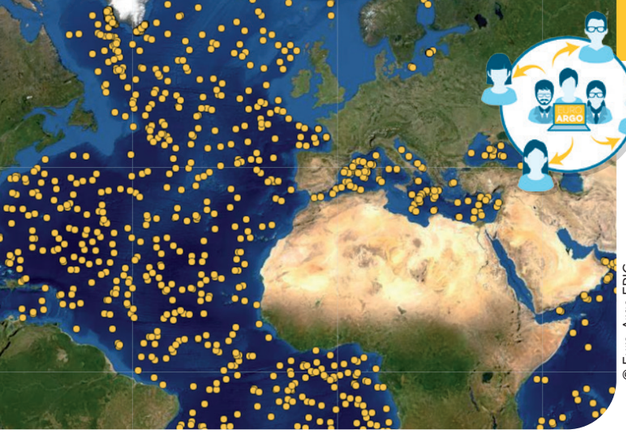


A COLLABORATIVE FRAMEWORK FOR EURO-ARGO

To strengthen R&D in all quality control related activities among European partners, the Euroargodev collaborative framework hosted on Github was set up in December 2019 to foster collaboration along three themes:
- Software (e.g. development, performance, usage, access, QC methods) either distributing or co-development;
- Reference datasets (e.g. content, access, availability);
- Data & Expertise (e.g. training, sharing, educating users).

The platform currently hosts tools and materials related to Argo in general.





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ENHANCEMENT OF SERVICES TO USERS

To facilitate the use of Argo scientific and technical data by users, Euro-Argo RISE has improved and created various tools and services and made them accessible to the Argo community and beyond. In addition, interoperability with other RIs has been improved to ease joint use of the data.

NEW TOOLS TO EASE ACCESS TO ARGO DATA AND INCREASE THEIR USAGE

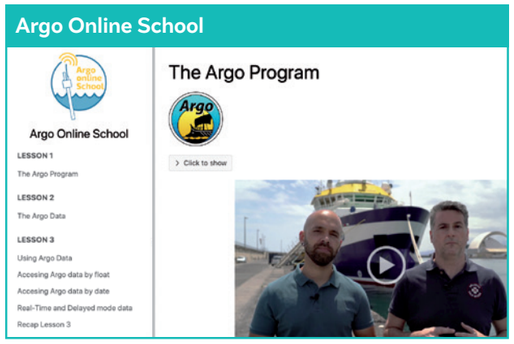
This online tool allows to display, select sub-sets and download Argo data in several formats.
Its efficiency has been improved.
It became the European GDAC data selection tool and is well received by various audiences (Argo Steering Team, regional workshops, etc.).

Argo data selection tool

Argopy

Argopy has been developed to help Argo data users accessing and manipulating Argo data easily. Non-experts can access Argo curated data in two lines of code while Argo experts have access to more detailed data and benefit from a library developed jointly by the community.

Argo Online School



The Argo Online School is a new educational tool which aims to teach the basic foundations together with some advanced features to understand, promote and improve access and use of the Argo data.

ENHANCEMENT OF SERVICES AND PRODUCTS

For the scientific community
- Simplified BGC-Argo synthetic profiles for end users.
- Launched in early 2021, the "Argo Floats" app allows users to explore the Argo network on their smartphone.

For floats operators
- Argo floats recovery web service to facilitate float recoveries at sea.
- Some currents forecast models were used as a tool to better pilot floats in coastal areas.

For operational services
- Links were strengthened with Copernicus, ECMWF and EMODnet, key operational users at European level.
- Argo currents product, processed at Coriolis GDAC every day, is now integrated in Copernicus Marine Service product portfolio.

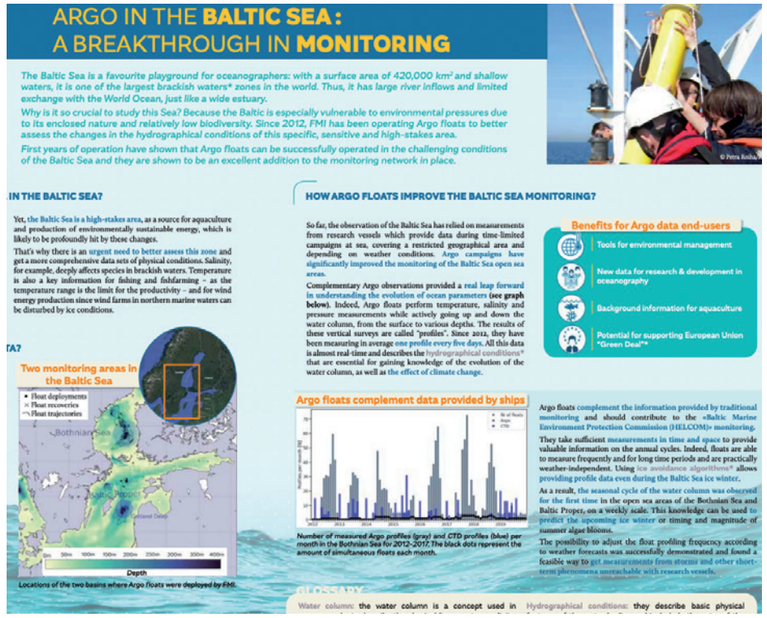
CREATE AWARENESS ABOUT THE SERVICES AND PRODUCTS

The project has enhanced a range of tools based on users' needs and disseminated the services developed in a popular way.

KEY FINDINGS OF THE USERS SURVEY

- Current Argo file formats and outputs are satisfactory.
- Training about data formats, quality control, and data are required.
- Ocean Best Practices and Cookbooks are recommended as training materials to support Euro-Argo outreach and dissemination activities.

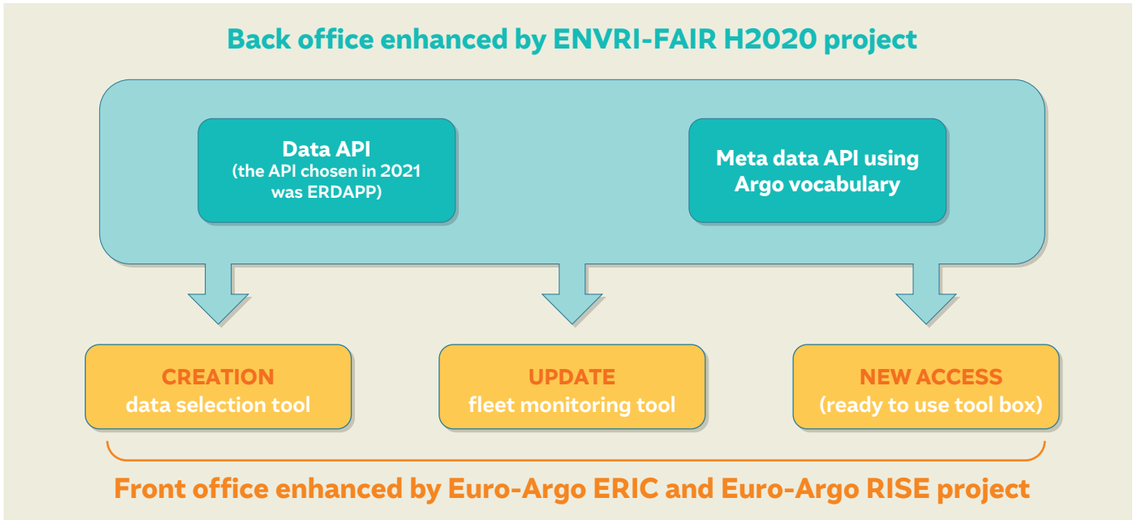
"European Argo Users Communities Specific Requirements" were highlighted through a survey conducted in 2019.



"Argo use cases" highlight various applications of Argo data as well as the technical and scientific advances Argo enables.

BUILD SYNERGIES TOWARDS INTEGRATION INTO THE NETWORK OF GLOBAL OCEAN OBSERVATIONS

Closer collaboration with other Marine RIs is needed to close the gaps in the observing network and monitor its implementation through OceanOPS. Addressing that aim, Euro-Argo RISE and ENVRI-FAIR projects collaborated to provide Euro-Argo user community with tools facilitating Findable Accessible Interoperable and Re-usable (FAIR) data access with other Marine RI's data.



*API: Application Program Interface

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STRONG COMMUNITY ENHANCEMENT

Euro-Argo RISE project has been an efficient accelerator to enhance the Euro-Argo community and reinforce its integration in European and international landscape. Concrete progress was achieved downstream linking with Argo user community, but also upstream with funders and manufacturers.

KEY EVENTS TO DEVELOP NEW PARTNERSHIPS

Thanks to the project, engagement with new countries was accelerated, national programs were developed and links with other ERICs and networks were reinforced, ultimately increasing Euro-Argo ERIC membership.

Strenghten the scientific Argo community in Europe

The 7th Euro-Argo Science meeting, held by Euro-Argo in Athens in 2019, brought together 69 scientists from 17 countries and provided an opportunity for high-level science interactions linking with Argo.

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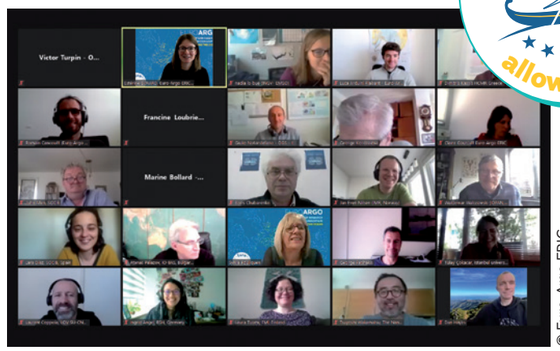
Engage with high-level stakeholders, politicians and decision makers

The first Euro-Argo Political event was held in 2021, demonstrating to high-level stakeholders the importance of Argo for environment and society. The marine Research Infrastructures side event, organised during the 9th EuroGOOS international conference brought together scientists and officers from the various European marine Research Infrastructures.

EURO-ARGO RISE allowed to...



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The Euro-Argo regional workshops were held in 2021 and connected the communities sharing an interest for European Marginal Seas. It set up the basis for new collaborations into regional spheres and led to Denmark's application as a candidate Member of Euro-Argo ERIC.

Engage with new users and new countries

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The 23rd AST meeting was organised in Monaco in March 2022 and many discussions were held about the challenges faced in the implementation of OneArgo.

Reinforce Euro-Argo's links with Argo international

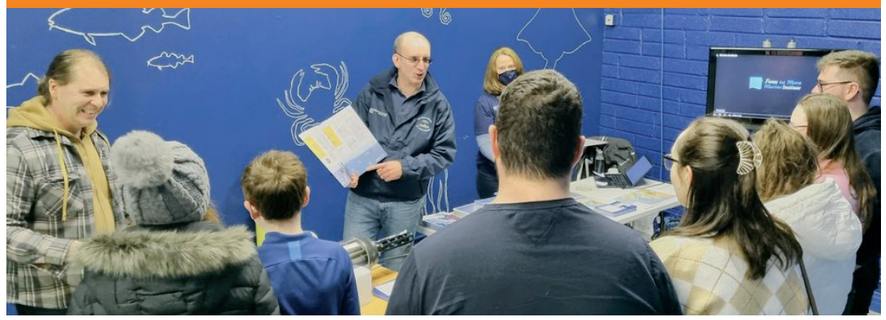
A PROJECT INCREASING AWARENESS AMONG YOUNG PEOPLE

The Ocean Observers initiative was successfully pursued

© Thomas Haessig

The international Ocean Observers Working Group organised the 2nd Ocean Observers workshop in November 2021. With 70 participants – including communicators and scientists – from 22 countries, this unique opportunity led to improvements to the Ocean Observers website.

Euro-Argo Members hold outreach activities



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The Marine Institute and Galway Atlantaquaria celebrated Engineers Week "An ocean journey with the Argo float", showcasing the importance of marine engineering to the next generation of scientists.

A WIDE RANGE OF COLLABORATIONS IDENTIFIED

Throughout the project, many collaborations have been built up step by step, to better implement the Argo network, to facilitate access to users and to strengthen the links with the European community and ensure coherence with the different European projects.

- Publication of a white paper on the role and value of marine RIs and identification of project deliverables for adoption across marine RIs, through transnational / trans-RI research projects.
- Reinforcement of links with EOOS towards integrated observing strategies.
- Reinforcement of collaborations to facilitate the development of common funding proposals.
- Collaboration on technology development and sensor integration.
- Implementation of FAIR data principles to foster new partnerships with environmental RIs aiming at integrated services for user communities.
- Creation of joint education and common communications messages.

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EURO-ARGO RISE
SUCCESS STORIES AND TESTIMONIALS

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Susan WIJFFELS
Senior Scientist at WHOI and AST co-chair, USA

It is vital that the great work EuroArgo ERIC has done in the past in supporting and implementing the global Argo program continues. With the Euro-Argo RISE project, this goes well beyond deploying a significant component of the array itself, but many key activities that improve Argo technology and information management, which benefit the entire global effort. The future planned activities are well targeted to help drive forward the implementation of the new ambitious OneArgo array. I congratulate the Euro-Argo Team on their successes and look forward to their next achievements.

Arne KÖRTZINGER
Professor at GEOMAR and Euro-Argo ERIC Scientific and Technical Advisory Group (STAG) chair, Germany

It is a long way from raw measurements delivered by a BGC sensor on a float to finally processed and quality-controlled data. In this context, Euro-Argo RISE has enabled us to add a significant process to the delayed-mode quality control for dissolved oxygen. It has also allowed us to gain a better understanding of the status of float-based pH measurements which calls for the need of an independent quality control mechanism in the surface ocean.

Annie WONG
Research Scientist at University of Washington, USA

Contributions from several Euro-Argo RISE partners have been vital in the progress of the global Argo RBR pilot effort. The pilot effort aims to introduce RBR CTDs into the Argo array. Several initiatives from Euro-Argo RISE, including the RAPROCAN cruise and the "tritete" prototype floats from IFREMER, provided crucial field data that enabled international partners to characterise and validate RBR CTD data against the traditional Sea-Bird CTD data. These have helped improve the calibration of RBR CTDs, making them more compatible with the existing Argo array. Thanks to these efforts from Euro-Argo RISE, it is now possible for Argo to have an alternative CTD supplier, thus mitigating the risk of a single point of failure in the global program.

Catherine SCHMECHTIG
Research Engineer at CNRS, BGC-ADMT task team co-chair, France

Euro-Argo RISE has allowed us to focus on the development and improvement of data management of the BGC-Argo parameters, with an emphasis on the Delayed Mode quality control. Starting from "ongoing work" and dispersed procedures, the project has offered the opportunity to share at the European level a robust workflow for BGC-Argo and lay the foundations of an organised European data management system.

Inga LIPS
EuroGOOS Secretary General and Euro-Argo ERIC STAG member, Belgium

With the extension of Argo observations towards biogeochemistry, as well as to partially ice-covered and shallower water regions, the Euro-Argo RISE project makes a significant contribution to the development of an integrated European Ocean Observing System (EOOS) and advancement of seasonal and climate change studies in the coastal regions and higher latitudes.

Megan SCANDERBEG
Argo Research Associate at Scripps Institution of Oceanography and ADMT co-chair, USA

The Euro-Argo RISE project set up one of the first Argo focused GitHub repositories to publicly share a collection of tools for the entire Argo community. Some of these tools are dedicated to applying quality control methods to Argo data and for accessing Argo data using freely available software. It can be challenging for students, post-docs and researchers to get started with Argo netCDF data and the online school developed uses videos and interactive web pages to effectively explain Argo data, its format, and how to access it using the Python toolbox shared on the GitHub repository.

Miguel SANTOS
Senior Research Scientist at IPMA, Portugal

Since Portugal is not yet a Member of Euro-Argo ERIC, its participation in the Euro-Argo RISE project was very valuable. Thus, it allowed us to be included in an experienced team involved in every aspect of the international Argo program and this will greatly contribute to our future membership. Furthermore, Euro-Argo RISE also allowed to initiate the monitoring of the Gulf of Cadiz using Argo floats, to better understand the Canary Current System where the Mediterranean Water outflow starts to spread in the North Atlantic Ocean.

George PETIHAKIS
Research Director at HCMR, Greece

EuroSea project aims to significantly improve the European ocean observing system as an integrated entity within a global context while targeting innovations towards higher technology readiness level and efficient data delivery. By expanding operational capacity of the Argo network to greater depths and to biogeochemistry, Euro-Argo RISE project efficiently contributes to multi network approach with new essential observations towards global challenges such as the climate change.

SUMMARY OF WHAT EURO-ARGO RISE HAS ACHIEVED

- **TECHNOLOGY**
  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**
  Quality control procedures have been improved, but also have become more accessible (open source software), transparent and reproducible (code and expertise sharing).
- **SERVICES**
  Services and tools were improved and made known to the Argo community and beyond.
- **COMMUNITY**
  The Euro-Argo community is better structured and collaboration with other Research Infrastructures and between members is strengthened.

63 deliverables gathering all the knowledge of the Euro-Argo community on these 4 pillars

19 partners

13 countries

DISCOVER THE WHOLE PROJECT IN THE ENHANCED DIGITAL VERSION

BEYOND THE PROJECT

The development of OneArgo will probably take a decade to be fully implemented at global scale. At European level the Euro-Argo ERIC will build on Euro-Argo RISE achievements to further develop its strategy for the next decade and associated implementation plan with the Member states and European Commission.

FUTURE CHALLENGES FOR EURO-ARGO ERIC

- **Secure sustained operational funding** for the implementation of OneArgo at European level.
- **Optimise the implementation efficiency of OneArgo** at European level to preserve and improve the data and products' quality.
- **Support the development of greener technologies** and reduce the environmental impact through recovery of the floats.
- **Strengthen the data quality assessment procedures** for all parameters to maintain the high-level quality required for the monitoring of climate change and ocean health.
- **Develop new products** adapted to the evolving needs of end users.
- **Address the technological and scientific challenges** related to the measurement of new biogeochemical and biological variables, as well as the technological stakes for the monitoring of coastal areas.
- **Further develop joint activities and field applications with partners** of the European and Global Ocean Observing Systems, in the framework of the UN Ocean Decade.

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