EURO-ARGO ERIC STRATEGIC PLAN FOR THE DECADE 2024-2033

EUROARGO

EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM FOR OBSERVING THE OCEAN

Foreword

The Euro-Argo European Research Infrastructure Consortium (Euro-Argo ERIC) supports the collective effort to design and implement the European share of the global Argo programme of automated *in situ* observation of the oceans. Both its original vector and the network deployed constitute prominent assets to provide a 4D synoptic observation of essential variables of the oceans, i.e., in depth, all over the globe and in a continuous manner. In a fast-changing context of serious concerns about the health of the oceans together with an acknowledgement of their role in the climate change and the carbon offsetting, and of striking progress in science and technology to monitor and forecast their natural and man-induced evolution, it is sound for Euro-Argo ERIC to rely on a ten-year Strategy and to share it openly. This statement should highlight the benefits it brings to society and allow all stakeholders to provide recommendations for steady further enhancement. The Strategy is set out in the following plan in order to clearly and concisely set out its motivations, goals and concrete objectives.

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A biogeochemical (BGC) float.

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1 EVOLVING CONTEXT ADDRESSED BY THE STRATEGY

The ocean and seas impact almost every aspect of daily life. Some of those impacts are direct, through their influence on the blue economy, leisure, and maritime transport. Some of the impacts are less direct but more widespread and profound through the oceans' influence on climate. The oceans have absorbed and store about 90% of all the excess heat absorbed by the earth as a result of anthropogenic increases in greenhouse gases in the atmosphere. Around 25% of all the excess carbon emitted to the atmosphere from fossil fuel burning has already been dissolved into the ocean, causing acidification of the ocean with consequences for ocean health and ecosystems.

Present ocean observing technology has enabled us to describe some of the changes and processes linked with global warming (e.g., ocean warming, sea-level rise), and emerging technology is enabling us to describe others such as the ocean response to increasing carbon and reductions in ocean oxygen concentration.

The Argo Programme is a major component of both the Global Ocean Observing System (GOOS) and the Global Climate Observing System (GCOS), providing near-real time data for ocean and atmospheric services and high-quality data for climate research. The Argo programme began its implementation in 1999 and has provided global coverage of the upper 2 000 m of the oceans since 2006.

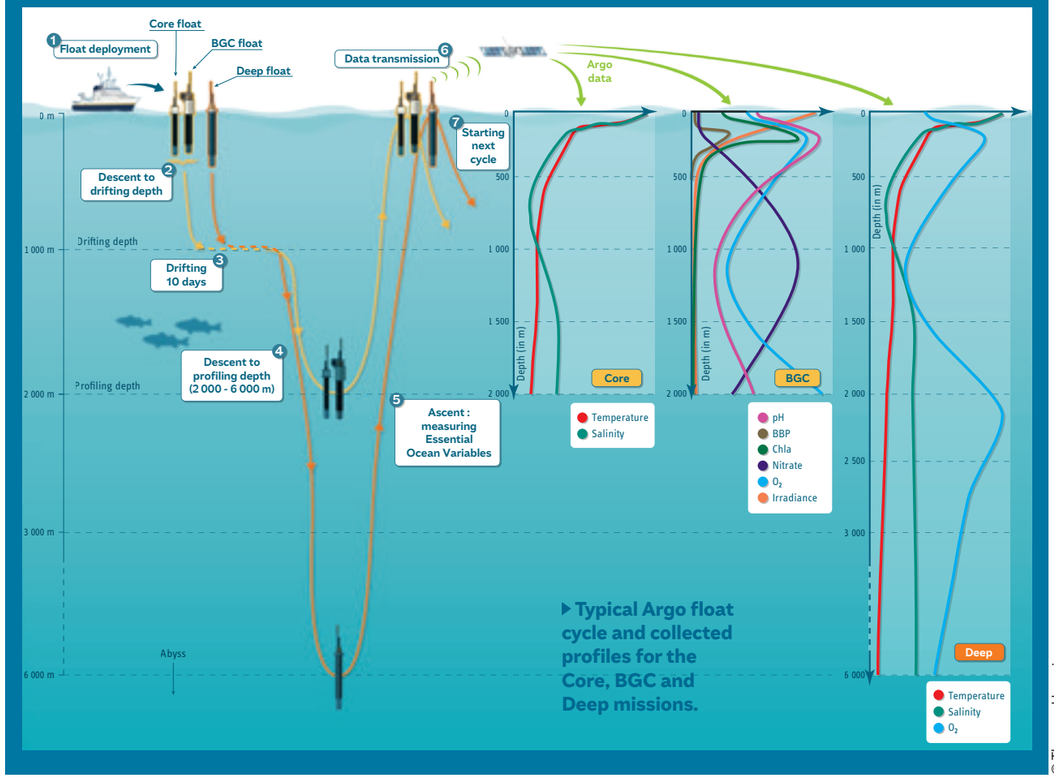
Although originally designed to provide temperature and salinity profiles in the upper 2 000 m of the ice-free ocean, the array has been expanded into seasonal ice zones. Argo profiling floats are also sampling in many marginal or enclosed seas. In addition, regional pilot programmes have demonstrated that some Argo floats can now measure biogeochemical parameters to address oceanic uptake of carbon, acidification, and deoxygenation (BioGeoChemical, BGC-Argo) and some floats are also able to make measurements throughout the water column to 6 000 m depth (Deep-Argo). These new BGC-Argo and Deep-Argo missions, together with the initial Core-Argo mission form the new global, full-depth and multidisciplinary OneArgo design → see Box 1.

Following this evolution, Argo's innovative data management system has set new standards, since emulated by many other ocean observing programmes, for the rapid and freely-available delivery of data within hours of measurements being made. These real-time data have become fundamental inputs to numerical weather prediction, weather forecasting, used by agencies and meteorological services the world over. Argo also produces a Delayed-Mode data stream, in which data have been carefully examined by experts. The Delayed-Mode data are used for climate research, and have been a fundamental part of assessments by the Intergovernmental Panel on Climate Change (IPCC). The availability of the two data streams enables society to understand the oceans' impact on weather and climate, to understand the impact of climate change on ocean health and ecosystems, and ultimately to take steps to mitigate changes to the global environment → see Box 2 p. 6.

Many questions about global change can only be addressed by means of global observations. The first observation method to achieve systematic global coverage with good horizontal resolution was by use of satellite-borne sensors. Sensing the ocean from space is limited in that it can only measure the properties of the ocean surface. Much greater knowledge and understanding can be acquired by making *in situ* measurements of the subsurface ocean. Prior to Argo the chief methods of doing this was from moored instruments at fixed points, which provide good temporal resolution but very limited spatial resolution, or from ships, which can provide good spatial resolution along the ship track, but sparse spatial resolution between ship tracks and very sparse temporal resolution. The global deployment of floats by Argo provides a balance of reasonable spatial resolution, measurements separated by few hundred kilometres, and temporal

BOX 1. ARGO FLOAT: **HOW IT WORKS**

The Argo network consists of a range of autonomous platforms (profiling floats) that are equipped with various sensors measuring ocean physics, biogeochemistry or biology. Data are collected while the float moves in the water column and sent to data centres regularly via satellites when it is at the surface.



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resolution of ten days, including observations in high latitude regions in winter, which was impossible with ships and moorings only.

Argo is the only observing network making systematic global *in situ* measurements, resolving signals of importance for short-term forecasting and longer-term climate change studies. It should be noted that Argo does not measure all Essential Ocean Variables in the global ocean. Argo is complementary to ship-borne measurements, and other parts of the Global Ocean Observing System. But the things that Argo does measure well, could not be measured with similar resolution with any other ocean observing technology presently available.

The development of the BGC and Deep-Argo missions present many new challenges to the Argo systems initially developed for the Core mission. The range of extra parameters and volume of data from BGC sensors requires a significant modification to the data system. New methods of data quality control are required for the BGC parameters, as well as for Deep measurements. These methods are presently being implemented by the Data Assembly Centres (BODC and Coriolis, in Europe). Over 20 years, Core-Argo has revolutionised knowledge of upper ocean physics. So long as resources for the BGC and Deep extensions to Core-Argo can be financially secured and sustained, which is one of the main challenges Argo is facing for the decade 2024-2033, the transformation that Argo has provided for temperature and salinity of the upper ocean is poised to be repeated for biogeochemical parameters and for the deep ocean below 2 000 m.

BOX 2. ONEARGO AND ITS SOCIETAL & ECONOMIC IMPACTS

Historically, the initial Argo programme has focused on two essential climate parameters, temperature and salinity, in the upper 2 000 metres. The Argo profiling data have been used to initialise ocean and ocean-atmosphere forecast models. Recent technological advances now allow floats to be deployed in ice-covered and coastal areas and to reach a profiling depth of 4 000 to 6 000 metres (Deep-Argo). Furthermore, biogeochemical sensors have been integrated to measure pH, oxygen, nitrate, Chlorophyll-A, suspended particles, and downwelling irradiance (BGC-Argo). These floats can monitor the seasonal, to decadal-scale variability in biological productivity, the supply of essential plant nutrients from deep-waters to the sunlit surface layer, ocean acidification, deoxygenation, and ocean uptake of carbon dioxide. They complement the remote sensing of ocean colour by providing information in the ocean interior and throughout the year in cloud covered areas.

OneArgo aims to implement these technological advances to expand from Core Argo to a global, full depth, interdisciplinary array. In doing so, it will revolutionise our 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, metabolism, carbon uptake, and marine resource modelling. Most importantly, it will dramatically 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, resource extraction and insurance). The OneArgo design now consists of three missions: Core-Argo, Deep-Argo and BGC-Argo.

▸ **On the Future of Argo: A Global, Full-Depth, Multi-Disciplinary Array. Front. Mar. Sci., 02 August 2019 https://doi.org/10.3389/fmars.2019.00439**

BOX 3. UN OCEAN DECADE

The United Nations Decade of Ocean Science for Sustainable Development (2021-2030), also known as 'the Ocean Decade', is a framework for stakeholders to co-design and co-deliver solution-oriented research needed for a well-functioning ocean (https://www.oceandecade.org/). The declared vision of the Ocean Decade is the "science we need for the ocean we want". Its goal is to help achieve by 2030 the 17 Sustainable Development Goals (SDGs) set up in 2015 by the United Nations General Assembly.

The Ocean Decade is coordinated by UNESCO's Intergovernmental Oceanographic Commission (IOC). Its Implementation Plan describes a series of ten Challenges and various actions that will unite partners around common ocean science priorities related to knowledge gaps, essential infrastructure, capacity development, and behaviour change. The Argo programme is a key contributor of three of the ten challenges, namely, Challenge 5, 'Unlock ocean-based solutions to climate change', Challenge 7, 'Expand the Global Ocean Observing System', and Challenge 8, 'Create a digital representation of the Ocean'.

On 5 December 2017, the United Nations proclaimed a Decade of Ocean Science for Sustainable Development, to be held from 2021 to 2030 → see Box 3. This Decade provides a common framework to ensure that ocean science can fully support countries' actions to sustainably manage the Ocean and to achieve the 2030 Agenda for Sustainable Development. At the heart of the Decade of Ocean Science are ocean observations. These observations are an integral part of assessing whether the UN's Sustainable Development Goals are being achieved (e.g., SDG 13, Climate Action). Since January 2021, OneArgo has been labelled as an action of the UN Ocean Decade, declared as "an integrated global, full depth and multidisciplinary ocean observing array for beyond 2020".

WHAT IS EURO-ARGO ERIC?

From the earliest stages of Argo, there has been cooperation and collaboration between European countries. The latest European cooperation has been formalised into the Euro-Argo European Research Infrastructure Consortium (ERIC). The Euro-Argo ERIC was signed into existence in 2014. The members of the ERIC are countries, signed into partnership by ministries or other government representatives. The aspiration of the Euro-Argo ERIC is for Euro-Argo to provide 25% of the global OneArgo array. This 25% share is to be achieved as the sum of floats deployed by national programmes of ERIC members, together with any floats procured and deployed with funds awarded to and directly managed by the ERIC. The Euro-Argo ERIC is managed by the ERIC Office, which provides central infrastructure that does not then need to be repeated in every member state. The ERIC Office can act on behalf of member states, providing expertise, and a chance to aggregate member states' activities to create a larger critical mass of activity, for instance to reach a better level of interaction with the supply-chain of float and sensor manufacturers. All of this raises governance issues that need to be addressed using best practice, and also with a view to closer integration into the landscape of European research infrastructures, especially those that also carry out environmental monitoring.

2 VISION AND MISSION IN A NUTSHELL

VISION

By 2033 Euro Argo ERIC will have revolutionised the European ability of observing the interior of the ocean from the surface to the abyss, inspiring the science we need for a sustainable ocean and contributing to society's wellbeing and resilience.

MISSION

Develop a long-term, sustainable European contribution to the OneArgo global ocean monitoring system, reaching one fourth of the fleet, in order to better understand and predict the ocean, its role in the climate system and its health.

Deployment of a Core float from the research vessel MV Plancius.

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3 SCIENCE & OPERATIONAL SERVICES, THE DRIVERS OF EURO-ARGO ERIC

The main drivers of the development of Euro-Argo are originating from two sectors: the European scientific community and operational forecast centres, from which derive various scientific applications based on several types of floats → see Box 4.

CLIMATE CHANGE

Climate change is one of the most pressing and universal challenges of humankind and the ocean plays a key part in it because of its central role in the climate system. About 90% of the heat excess absorbed by the Earth since the 1970's is stored in the ocean and changes in the hydrological cycle related to climate change are also strongly manifested in the ocean. Argo has transformed the way of ocean observing in the last decades already and is the most important source of *in situ* marine data.

Continuing to provide high quality oceanic data to the science community to better understand the role of the ocean in the Earth climate, to address issues of climate change and to expand their scope is at the centre of the Euro-Argo strategy. At European level, the goal is to maintain ¼ of the global array with a regional perspective and including on **European marginal seas** (Mediterranean, Black Sea and Baltic) and the **European Arctic Sea**.

Data delivered by Core-Argo floats to the scientific community will address scientific questions about regional and global changes in ocean **temperature and heat content** as well as **salinity and freshwater content** with associated societal impacts from heat waves to changes in the atmospheric hydrological cycle (droughts, flooding). Changes in the steric height of the sea surface – in relation to total **sea level** – derived from these data will be needed to address risks and mitigations for rising sea levels around Europe's coasts. Technological advances in measuring down to the ocean abyss will increase the quality of the sea level analysis and help estimate the contribution of deep layers in ocean heat storage. Changes in **the large-scale and regional ocean circulation** can be observed as well. There is demand to observe the melting ice cover in the **European Arctic Sea** since it is influencing the state and dynamic of the Arctic Ocean with strong feedbacks to climate and weather forecasting. In addition, the evolution of the ice coverage in the Arctic is also providing potential benefits for the blue economy as new transport routes are opening up. Data gathered in the European area support **climate and biodiversity policies** set up by the European Union.

A Deep float.

BOX 4. ARGO **FLOATS TYPES** AND THEIR MAIN **SCIENTIFIC APPLICATIONS**

Core-Argo floats make temperature and salinity measurements in the upper 2 000 m of the ocean, whereas Deep-Argo floats are able to measure down to 4 000m (or 6 000 m, depending on the float model). Some of the Core and Deep floats are also equipped with an oxygen sensor. The BGC-Argo floats can carry a series of sensors able to measure Dissolved Oxygen, pH, Nitrate, Chlorophyll-A, Suspended particles and Downwelling Irradiance in addition to Temperature and Salinity, down to 2 000 m depth.

Parameter	Scientific use	Float types
Salinity	Ocean circulation, heat and freshwater fluxes, Air-Sea exchanges, Water cycle	Core, Deep, BGC
Temperature	Ocean circulation, heat and freshwater fluxes, Air-Sea exchanges, Water cycle	Core, Deep, BGC
Oxygen	Decrease of oxygenation and increase of oxygen minimum zones, carbon cycle	Core (some), Deep (some), BGC
pH	Ocean acidification, CO_2-Uptake	BGC
Nitrate	Eutrophication, toxic algal blooms, biological productivity	BGC
Chlorophyll-A	Biological productivity, carbon cycle	BGC
Suspended particles	Biological productivity, carbon cycle	BGC
Downwelling irradiance	Underwater light field, biological productivity, carbon cycle	BGC

▸ **Official parameters measured by Argo and their main scientific applications.**

OCEAN HEALTH

Another sector of grand challenges is related to the health of the oceanic ecosystem and its impacts on society. The recent advance in **biogeochemical instrumentation** on Argo floats has greatly improved the ability to address ecosystem topics which have been difficult, if not impossible, to address with more traditional sampling methods.

Among these challenges are: coral bleaching caused by the continued **ocean warming** and exacerbated by **ocean acidification**, which threatens the bi odiversity of one of the most essential ecosystems and its ability to provide food for millions of people. **Deoxygenation** caused by increased nutrient loads and continued ocean warming is creating low oxygen zones (dead zones) with impacts on fishery. **Nutrient pollution** can also lead to harmful algal blooms (HABs) which devastate marine biodiversity and pose a significant risk to human health. In order to address these issues, assess their future impact and improve our understanding of the carbon cycle in the ocean, the BGC network → see Box 4 needs to be fully implemented and sustained in the long-term perspective as part of a multi-platform, interoperable *in situ* observation system which covers the entire open ocean to the coastal areas.

The emerging market of **blue economy** with sectors in marine food, coastal services, natural resources and energy and marine navigation/trade also drives a demand for data to support their business and adapt to challenges ahead.

OPERATIONAL SERVICES

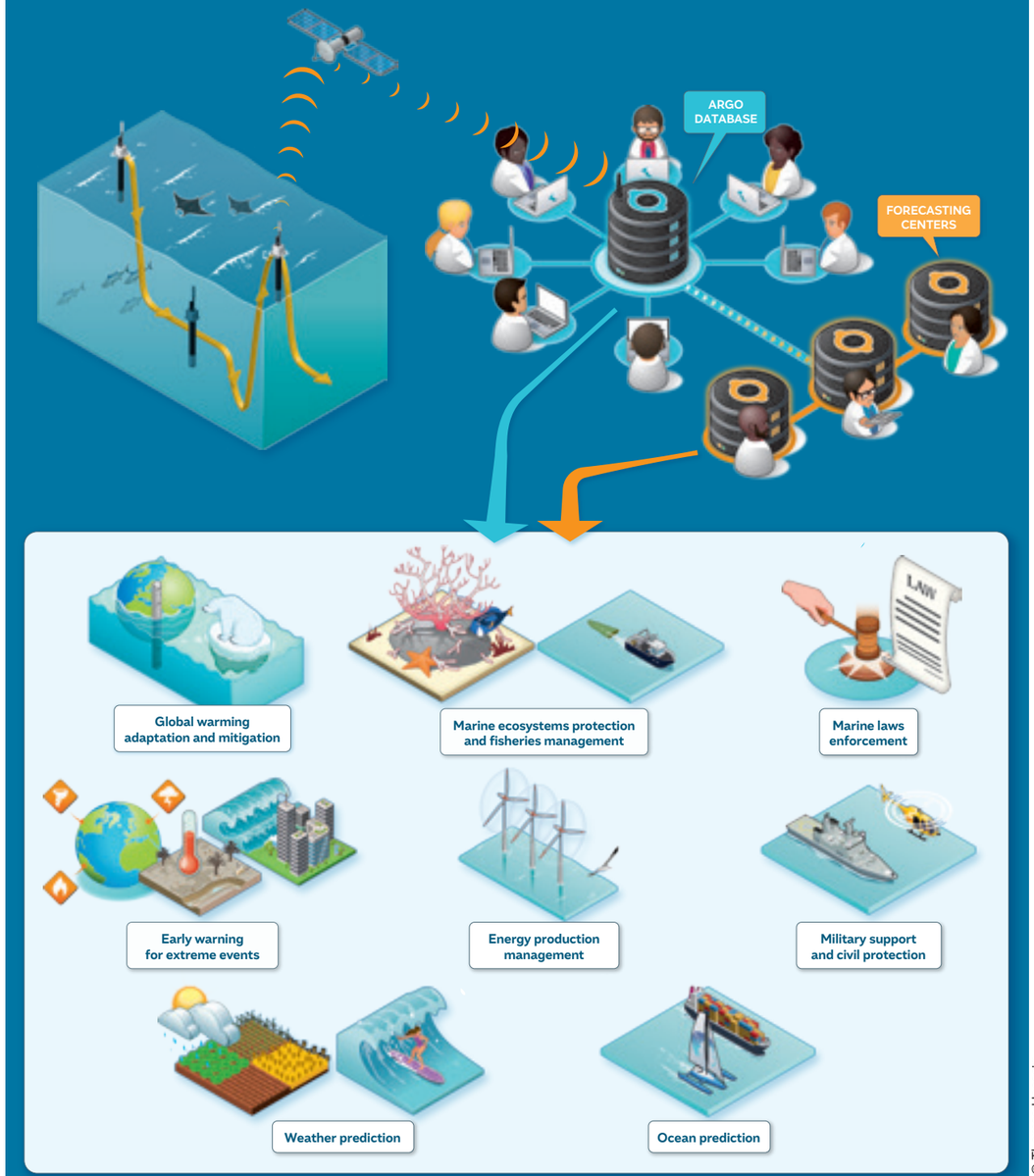
Operational centres integrate *in situ* and satellite-observation data in Real Time using numerical models producing products such as **ocean forecasts, weather forecasts** and **seasonal predictions** which are well ingrained into our daily lives → see Box 5 p. 12. These modelling services comprise different time scales from short range ocean forecasts (predictions over the next day to ten days) with applications in search and rescue, fisheries, shipping, oil and gas military support, civil protection and monthly to seasonal predictions with applications in tourism, agriculture and resource management.

Ocean reanalyses are another operational application of Argo data, among other data sources. This application consists in constructing **historical estimates of the state of the ocean**, based on models and observations. Reanalyses are building the bridge to many topics of scientific research as they produce **dynamically consistent data sets** that can be used to analyse heat budgets, freshwater exchanges, carbon budgets, and so on. State estimation is most commonly used for climate applications, from understanding ocean processes, ocean variability, teleconnections, and extremes.

In order to best serve Euro-Argo drivers, the future evolution of Euro-Argo needs to be shaped in respect to the European landscape of infrastructure/observation systems in the ocean and needs to seamlessly **integrate with complementary satellite observation systems monitoring** the ocean from above.

BOX 5. **ARGO DATA** AND ITS APPLICATIONS

The data collected at sea are sent to Data Assembly Centres where they are processed before being made freely available to everyone, including forecasting centres.



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▸ **The applications of Argo data**
https://argo.ucsd.edu/science/argo-and-the-modeling-community/

At European level, the main operational services are Copernicus (Marine and Climate Services) and the European Centre for Medium-Range Weather Forecasts (ECMWF), for which Argo is a major source of information. Euro-Argo assists with the enhancement of monitoring and observing systems at regional scales for **model-assimilation** and **model-validation** purposes, (i.e. in the Greek Poseidon system, the Western Mediterranean Operational forecasting system (SOCIB-WMOP), the Arctic Modelling and Forecasting Centre System (NERSC/METno) in the Nordic Seas and Fram Strait). In particular, the extensions of Argo into the deep ocean and ecosystem parameters offer new possibilities and will help to constrain and improve the models and resulting products.

Operational forecasting centres have recently taken on the challenge of biogeochemical and ecosystem forecasts by integrating these processes into their ocean analysis and forecasting systems, driven by ongoing environmental change and the growing awareness of the potential negative effects on marine ecosystem health and living marine resources. As a major source of *in situ* measurements for the global ocean, Argo will constitute an important component of the **Digital Twin of the Ocean** (DTO), → see Box 6.

BOX 6. THE **DIGITAL TWIN** OF THE OCEAN

The European Digital Twin Ocean (DTO) is an initiative of the European Union. It aims at setting up a consistent, high-resolution, multi-dimensional and near real-time virtual representation of the ocean, combining ocean observations, artificial intelligence, advanced modelling operating on high-performance computers and accessible to all users. The Digital Twin of the Ocean will integrate a wide range of existing and new data sources, to transform data into knowledge and to connect, engage, and empower citizens, governments and industries by providing them with the capacity to inform their decisions. Argo is a key data source for the Digital Twin of the Ocean providing Essential Ocean *in situ* observations, both for physics and biogeochemistry, at global scale and from the surface to the bottom of the oceans. Argo profiling floats provide critical and unique data sets to constrain ocean models through data assimilation. They are also essential to regularly re-calibrate and improve ocean models that will be used for the DTO to develop what if scenarios. Argo is and will continue to improve its data services to which it is essential that the Digital Twin of the Ocean connects, supporting the development of knowledge for a wider range of end-users.

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▸ **What is the Digital Twin of the Ocean (DTO)?**
https://www.eu4oceanobs.eu/wp-content/uploads/2022/06/the_digital_twin_ocean_20.04.2022.pdf

4 FIVE GOALS BROKEN DOWN INTO OBJECTIVES

GOAL 1

SUSTAINING THE COORDINATED EUROPEAN CONTRIBUTION TO THE GLOBAL ARGO PROGRAMME

Euro-Argo has succeeded in fulfilling its objectives to provide, deploy and operate ¼ of the global Argo programme, thanks to both national and EU contributions. For OneArgo, the international programme foresees to maintain in operation a fleet of 4 700 floats, including 1 000 floats equipped with biogeochemical sensors and 1 250 floats able to go deeper than 2 000 m. In this context, Euro-Argo's share would represent 1 175 operational floats. The balance of floats between Core-Argo, BGC-Argo and Deep-Argo as well as their geographic distribution would be defined according to Euro-Argo scientific objectives and European strategic interests, including specific focus on European marginal seas and partially ice-covered regions.

Moving from Argo to OneArgo will bring along potential new services, but also additional costs. OneArgo is estimated to be at least three times more expensive than the initial Argo network design. At the European level, this means raising an additional 9 M€ per year to fund floats alone, based on the present spend — in 2023 — of around 7.7 M€ per year (taking into account that the OneArgo implementation has already started). Given the additional parameters and float types, the implementation of OneArgo will rely on mutualisation of efforts, capacity building and expertise development in areas such as technology and data, and on improved coordination of deployments and related logistics.

OBJECTIVES OF **GOAL 1**

Objective 1.1	Define the Euro-Argo contribution to OneArgo (number of floats per Argo mission and spatial distribution), and estimate the number of floats to be deployed per year and the needed annual budget and human resources to implement it.
Objective 1.2	Secure the funding and human resources needed to implement Euro-Argo's contribution to OneArgo.
Objective 1.3	Implement the Euro-Argo contribution to OneArgo efficiently through well-defined procedures, costs optimization and shared workload, including the option of centralised float procurement for the Members.
Objective 1.4	Optimise data return and increase usefulness of each observation in complement with other ocean observation platforms through improved deployment strategy, array monitoring and piloting at sea.
Objective 1.5	Coordinate deployment plans and means (ships) with European and International countries.

GOAL 2

FOSTERING SCIENCE & TECHNOLOGY ADVANCEMENTS

Science and technology are closely intertwined. The availability of Argo platforms and sensors has allowed significant scientific advances which in turn lead to new questions driving innovation and technology development.

Euro-Argo seeks to operate reliable ocean observation platforms, equipped with high-quality sensors, enabling the implementation of OneArgo. Making use and contributing to new technological developments, Euro-Argo will expand its observations capabilities, with a cost-effective, coordinated and integrated approach.

The number of Argo platform and sensor manufacturers is limited, and competition, especially on the sensor market, is low. Euro-Argo aims at contributing to a more diverse market through an active and coordinated dialogue with potential, new and existing manufacturers. This can involve providing feedback on existing systems and offering technology transfer and licensing of techniques developed by R&D departments within some national Euro-Argo entities.

Strong connections between scientific experts and technologists across the private and public sector are required for continuous improvements and validations of sensor and float performance, and to reduce operational costs. These interactions also strengthen the development of European industry in the field of autonomous ocean observation equipment.

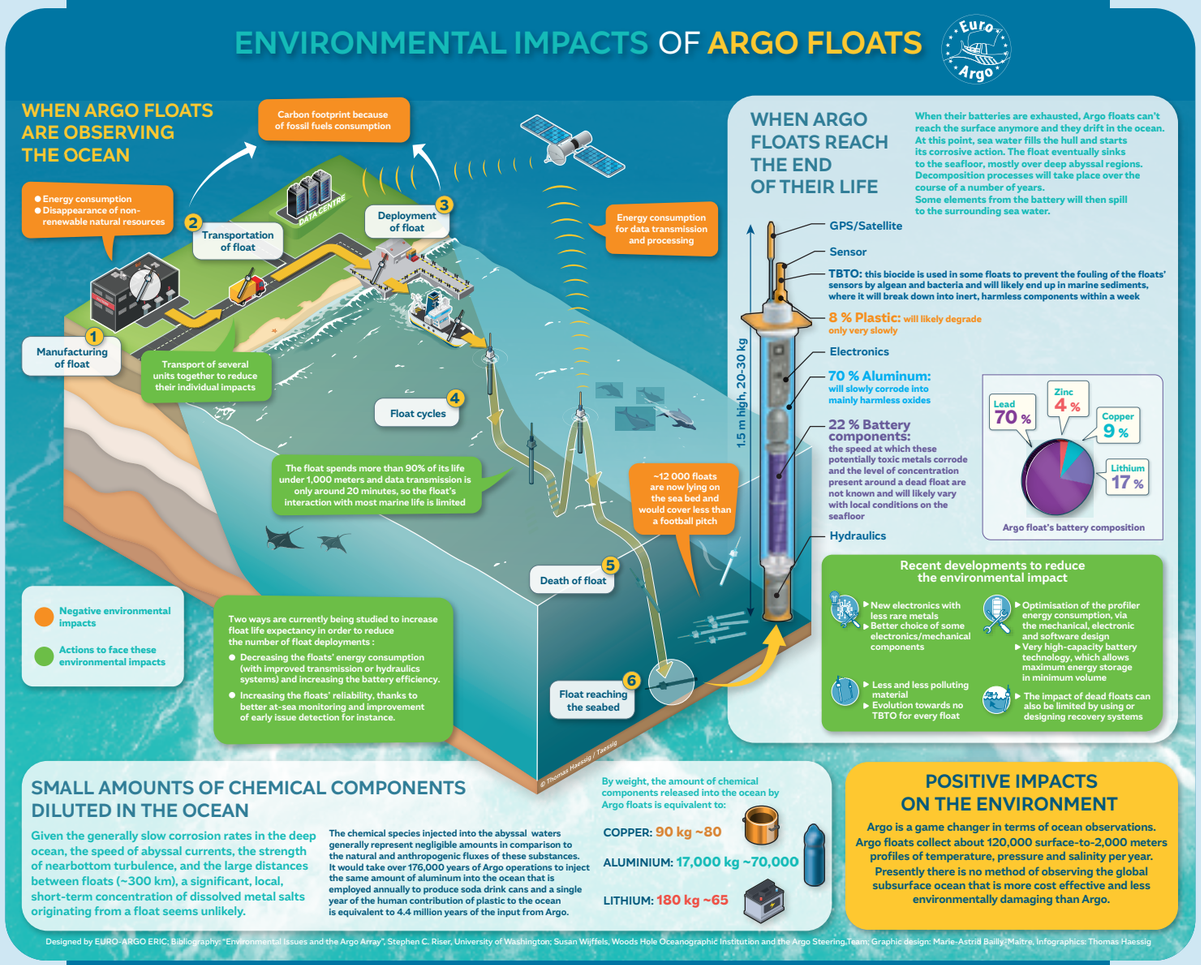
Euro-Argo also aspires for a (more) sustainable future → see Box 7 p. 16 and an enhanced coordination with other ocean observing networks, using similar technologies (e.g. moorings, gliders, etc.).

OBJECTIVES OF **GOAL 2**

Objective 2.1	Maintain and develop Euro-Argo technological capacity to procure, deploy and operate reliable and cost-effective platforms & sensors for OneArgo, capable of operating autonomously at sea for more than 5 years.
Objective 2.2	Support innovation for future scientific missions.
Objective 2.3	Facilitate testing and implementation of new sensors for enlarging the scope of OneArgo in response to the evolving demands from research and society.
Objective 2.4	Build a (more) sustainable future for Euro-Argo with a focus on efficient use and re-use of equipment.

BOX 7. **ENVIRONMENTAL IMPACT** OF ARGO FLOATS

Argo floats are game changers in terms of *in situ* ocean observations, although the fact that these autonomous instruments are predominantly left at sea raises concerns about their environmental impact. Presently, there is no method of observing the subsurface global ocean that is less environmentally damaging and more cost-effective than Argo. Euro-Argo aspires for a more sustainable future and started to explore ways to decrease the environmental impact of the floats. Relying on the collaboration framework existing in the European marginal seas, the recovery of Argo floats is one (promising) option.



▸ **The environmental impact of Argo floats leaflet, designed by Euro-Argo ERIC. Bibliography: "Environmental Issues and the Argo Array", Stephen C. Riser, University of Washington; Susan Wijffels, Woods Hole Oceanographic Institution and the Argo Steering Team.**

GOAL 3

DEVELOPING EURO-ARGO DATA SERVICES FOR SCIENCE AND SOCIETY

The Argo data system represents a major and often unseen achievement in open data processing and delivery to the public. The data is processed rapidly according to internationally agreed protocols developed in the Argo community and readily available to all. As part of the Argo international programme, Euro-Argo operates two of the data centres (DACs) and one of the two central portals (GDAC) to the Argo network data → see Box 8 p. 18.

The Argo data system continues to develop and must enhance its data handling capabilities to integrate data from the expanding variety of sensors implemented in OneArgo, in particular those linked to BGC-Argo and Deep-Argo. At the same time, the development, maintenance and evaluation of performance of existing sensors needs to continue.

Euro-Argo data activities also have to navigate and adapt to the evolving European data landscape and needs – for example within EOOS and GOOS – and the improvements needed to serve the European services such as the Copernicus Marine Service or the European Marine Observation and Data Network (EMODnet). Moreover, Euro-Argo, as a European Environmental Research Infrastructure, needs to enhance services from the European central portal GDAC to ensure Findable, Accessible, Interoperable and Reusable (FAIR) services on Argo data and deliver the information that end-users, including non-expert users and stakeholders, trust and value.

Data constitutes a massive resource, which has not yet been completely harnessed. Improving data access and delivery to meet research and operational needs, including the creation of a Digital Twin of the Ocean → see Box 6 p. 13, will expand the value of Argo data.

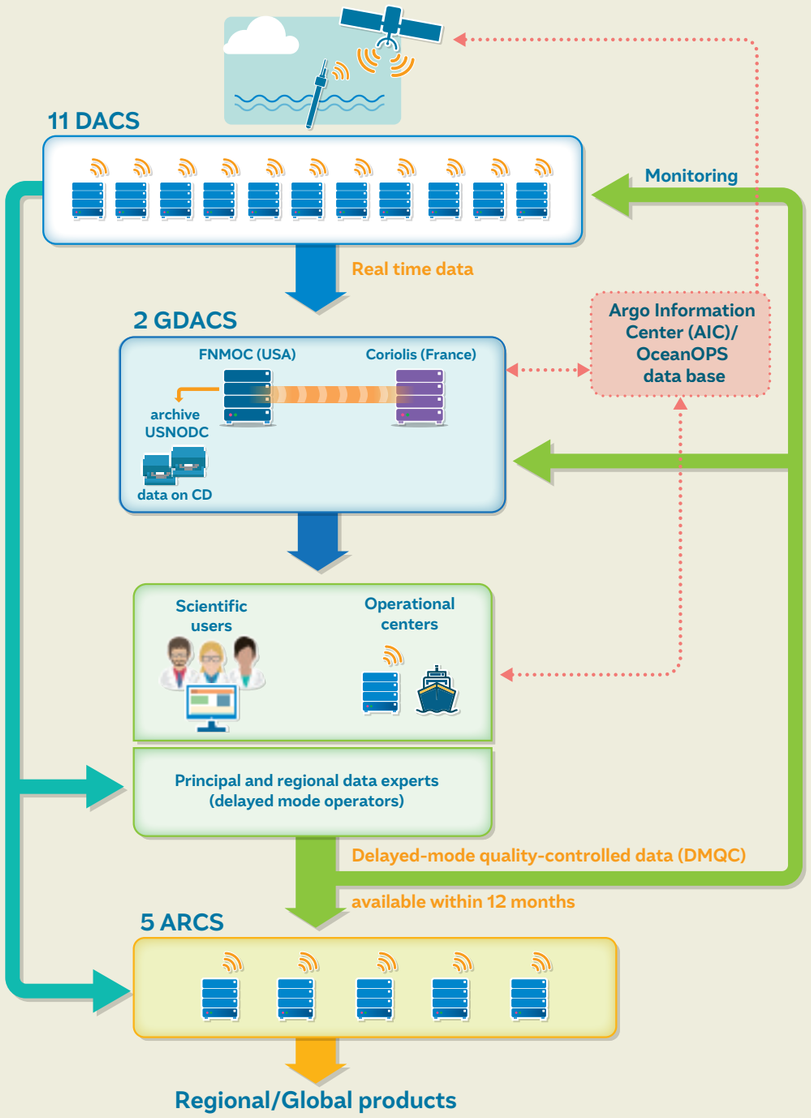
OBJECTIVES OF **GOAL 3**

Objective 3.1	Maintain and develop a reliable data system to process Euro-Argo data that is able to adapt and expand to handle technological enhancement in the network.
Objective 3.2	Organise the Euro-Argo data system to deliver interoperable, standardised, quality-ensured data within the landscape of European Research Infrastructures.
Objective 3.3	Enhance data services in collaboration with the scientific and operational users such as Copernicus and EMODnet to better fit their needs.
Objective 3.4	Develop further FAIR services in line with community best practices to facilitate data interoperability with a broad range of end user communities.
Objective 3.5	Enable engagement of non-expert users by providing tools to easily access and interact with Argo data.

BOX 8. DATA **ORGANISATION, MANAGEMENT & POLICIES**

The Argo data system provides Open and Free services on all the Argo data within a few hours from acquisition from two Global Data Centres (GDACs): one of them is operated by Ifremer/France as part of Euro-Argo.

Two Data Assembly Centres (DACs) operated by Ifremer/France and NOC-BODC/UK process data from all the Argo floats deployed by the Euro-Argo ERIC. These two centres need to evolve to be able to manage all the parameters that will be acquired in the coming years. The DACs will also have to evolve to manage the new types of Argo floats that will be developed. Euro-Argo also organises and coordinates the Delayed-Mode processing of all the variables acquired by the European fleet to provide data and products with the quality required for climate research and ocean reanalysis activities.



▸ **International Argo Data Management System.**

US NODC: US National Oceanographic Data Centre (now called NCEI: National Centre for Environmental Information);

OceanOPS: Argo Information Centre;

PIs: Principal Investigators;

RT: Real Time;

(G)DAC: (Global) Data Assembly Centre.

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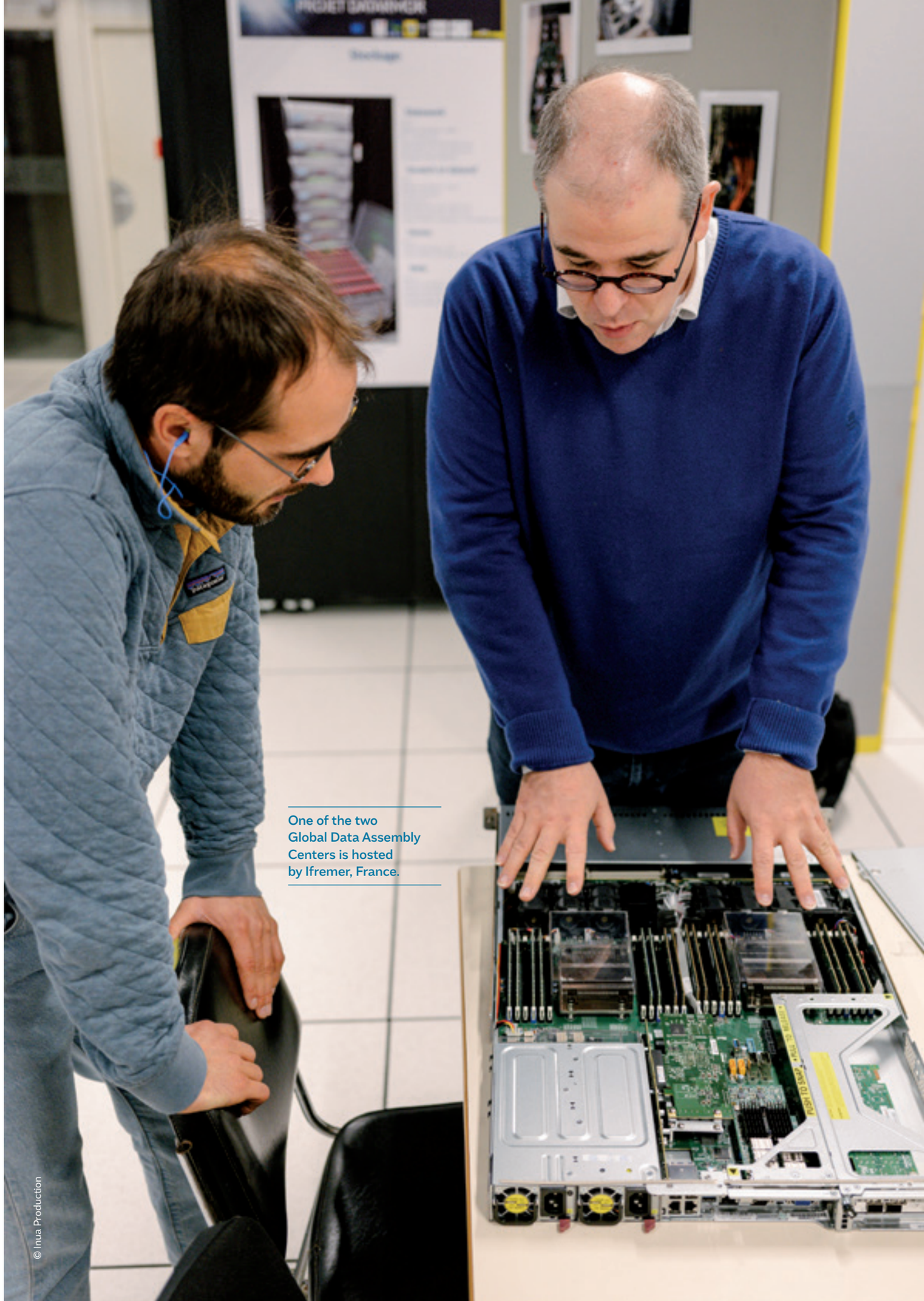

One of the two Global Data Assembly Centers is hosted by Ifremer, France.

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GOAL 4

ENGAGING USERS AND SOCIETY ACROSS SCIENCE, EDUCATION AND OUTREACH

The free and open access policy of Argo makes the data easily accessible to a wide range of users. At European level, Euro-Argo strengthens European integration into the global Argo network and provides links with institutional end-users such as Copernicus for operational services, or across climate and ocean health for research communities → see Box 9.

Euro-Argo also integrates into the wider and global ocean observing system GOOS and its European counterpart EOOS. Furthermore, it must evolve within a landscape of complementary marine Research Infrastructures (RIs) at the European level, working together to expand the European marine observing network. Increasing the synergies with other marine RIs is of paramount importance for the monitoring and understanding of the oceanic system under a multi-disciplinary approach. In this evolving landscape, Euro-Argo ERIC will strive to develop new connections with other research communities involved in ocean observations or in environmental monitoring, protection and preservation of the oceans.

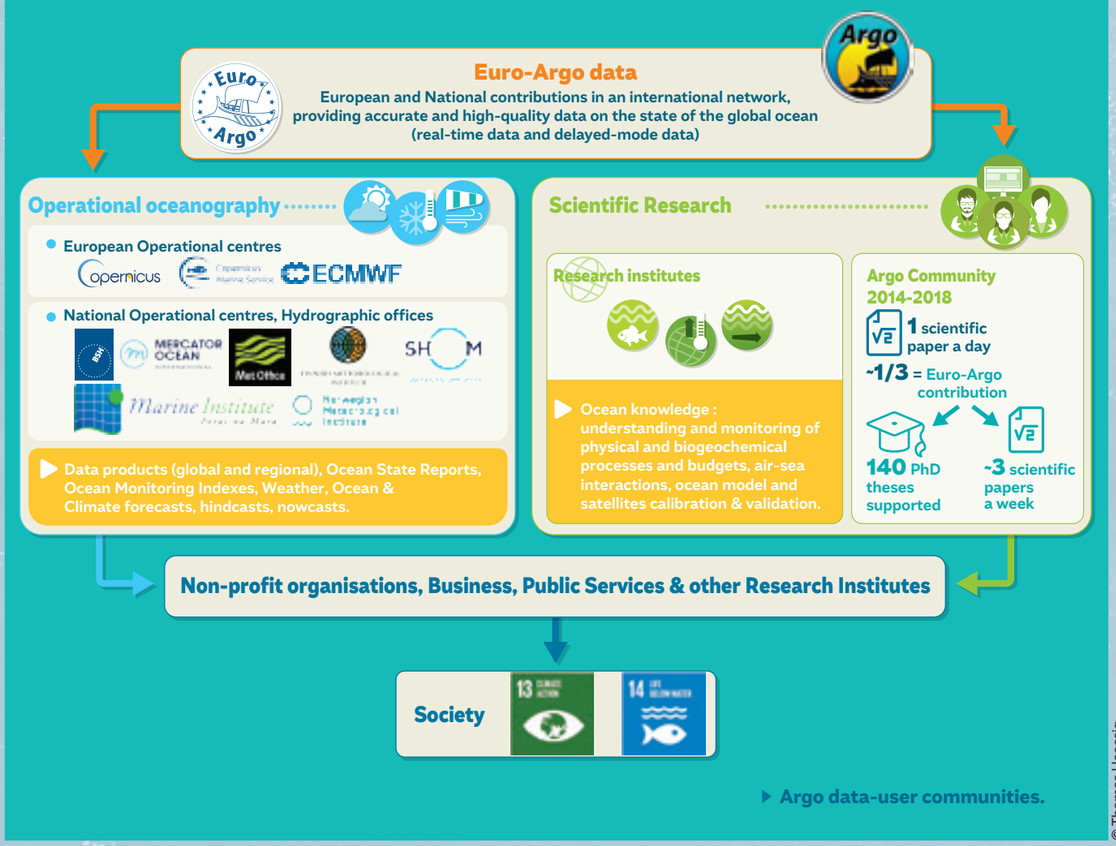
Euro-Argo advocates the role and importance of sustained ocean observations for socio-economic development and welfare. Through public engagement and educational activities at various levels, from local to international, Euro-Argo aims to increase its own visibility and actively raise public awareness about the benefits of Argo for the society. The Argo programme provides material serving the development of ocean literacy across several sectors. It can bring the ocean into the classroom and inspire Science, Technology, Engineering and Mathematics (STEM) education from primary school to university level. It can also be harnessed to inform the broader public on ocean conditions, local and regional climatic phenomena and climate change.

OBJECTIVES OF **GOAL 4**

Objective 4.1	Reinforce Euro-Argo capacity development, and strengthen coordination and communication actions with the European Argo data users.
Objective 4.2	Expand the Euro-Argo network to help achieving the European contribution to the Argo programme.
Objective 4.3	Widen the user community beyond the traditional one.
Objective 4.4	Advance efficient coordination and joint actions with other observing systems and Marine Research Infrastructures.
Objective 4.5	Expand the use of Argo into education and develop an active and popularised policy towards public awareness to strengthen Argo's visibility and benefits for the society.

BOX 9. ARGO **DATA-USER COMMUNITIES**

Argo is a global *in situ* observation network of crucial scientific importance, generating unprecedented datasets used in operational centres to produce standardised products. The scientific community relies on Argo data to understand the ocean's physical processes, as well as the marine ecosystem, and to make forecasts for the ocean.



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GOAL 5

CONSOLIDATING EURO-ARGO GOVERNANCE

Euro-Argo ERIC coordinates European activities of independent distributed national legal entities and facilities, whose activities are determined at national level. The contributions of the ERIC Member States, directly or via funding agencies, to their national entities constitutes the majority of resourcing for the European Argo programme's operational activities.

Good governance is fundamental to any effective organisation, and the governance arrangements of Euro-Argo ERIC play an important role in achieving the identified goals and objectives. Good governance means managing risks and performance through robust internal control systems and effective performance management practices. Increasing integration across the European Argo programme requires that Euro-Argo ERIC works to ensure coordination and accountability amongst its representing entities, nodes, and national programmes to ensure openness, effective communication and comprehensive engagement with Euro-Argo partners.

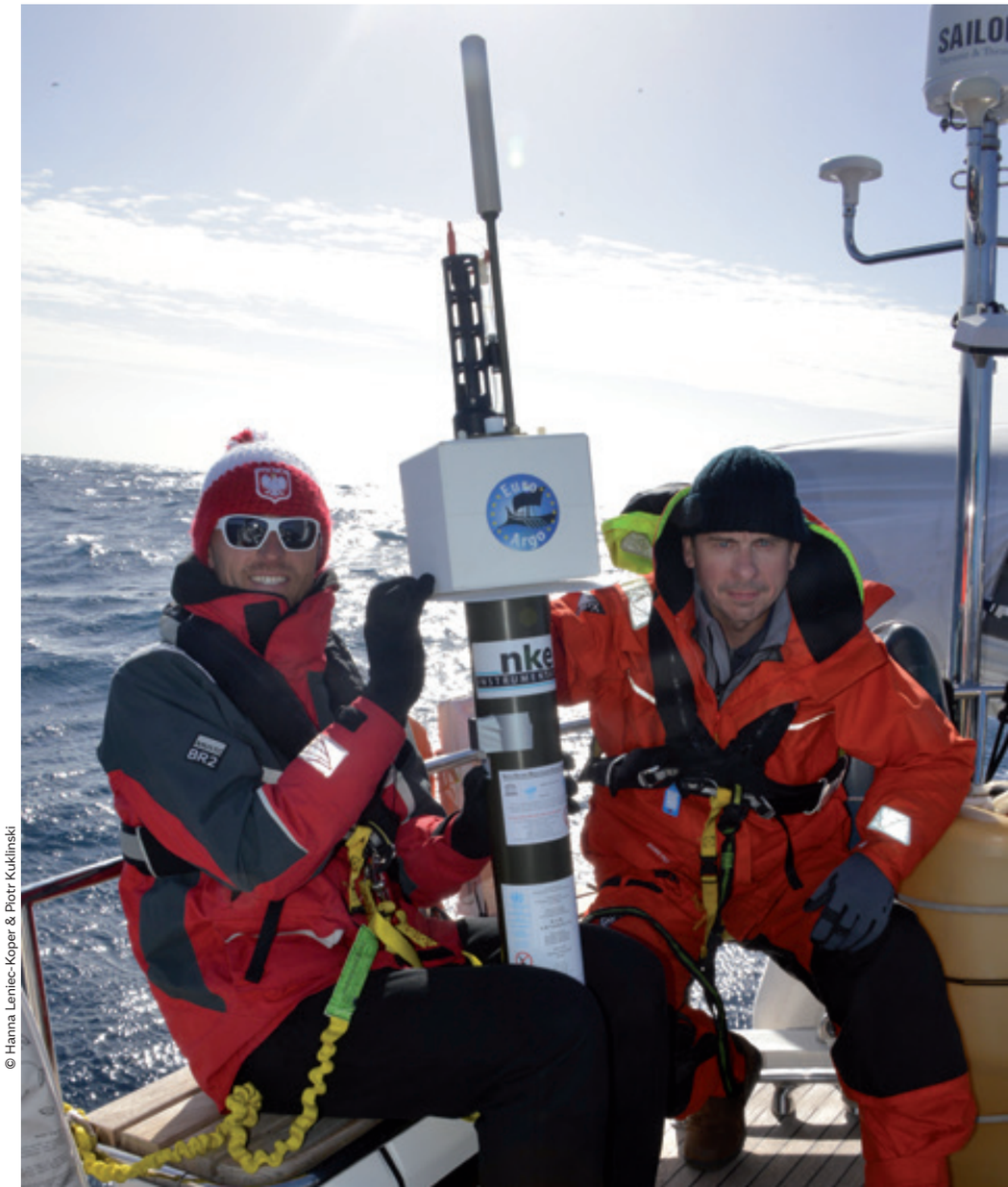
For the research community to experience a seamless pipeline of services and support, and for Member States to enjoy cost-effective infrastructure provision, it is of strategic importance to link up and synchronise marine and other environmental ERICs and RIs through the European Ocean Observing System (EOOS), the Community of European Environmental Research Infrastructures (ENVRI) and its Board (BEERI), and the Forum of European Research Infrastructure Consortia (ERIC Forum).

Fulfilling Euro-Argo ERIC's mission of maintaining ¼ of OneArgo while at the same time responding to specific European interests for marginal seas, high latitudes, deep ocean and biogeochemical measurements, presents a considerable sustainability challenge requiring engagement with European policy makers and funding programmes, Member States, and research institutions.

OBJECTIVES OF **GOAL 5**

Objective 5.1	Optimise Euro-Argo ERIC Office management & governance procedures through robust internal policies for recruitment, gender equality, procurement, finances, and human resources in line with best practice.
Objective 5.2	Strengthen integration between Euro-Argo ERIC Office, governing bodies, national programmes and representing entities to improve cohesion of the European Argo programme through the development of common policies, unified reporting & monitoring methods, application of performance indicators, integrated communications framework and collaboration on joint research & innovation projects.
Objective 5.3	Deepen interaction with European marine, environmental and other research infrastructures through EOOS, ENVRI, BEERI and ERIC Forum to develop the framework of long-term collaboration agreements and common policies for the development and implementation of European research infrastructure landscape and to respond to the European Research Area (ERA) Policy Agenda.
Objective 5.4	Develop outreach and advocacy activities for public funders, institutional stakeholders and policy makers at national and international level and to secure long term support for Euro-Argo ERIC operations and its associated financial sustainability.
Objective 5.5	Increase the visibility and input of Euro-Argo ERIC as coordinating infrastructure of the European Argo Programme in Argo International.

A Core float ready to be deployed in the Antarctic circle.



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GLOSSARY

BEERI
Board of Environmental European Research Infrastructures

BGC-Argo
Biogeochemical-Argo

(G)DAC
(Global) Data Assembly Centre

DTO
Digital Twin of the Ocean

EMODnet
European Marine Observation and Data network

ENVRI
ENVironmental Research Infrastructure

EOOS
European Ocean Observing System

ERA
European Research Area

ESFRI
European Strategy Forum on Research Infrastructures

FAIR
Findable, Accessible, Interoperable and Reusable

GCOS
Global Climate Observing System

GOOS
Global Ocean Observing System

OneArgo
Name of the new global, full-depth and multidisciplinary Argo programme, including the three BGC-Argo, Deep-Argo and Core-Argo missions.

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