EURO-ARGO:
BOOSTING EUROPE'S ABILITY TO MONITOR THE OCEAN

TO BETTER UNDERSTAND AND PREDICT THE OCEAN'S ROLE IN THE CLIMATE SYSTEM AND SCRUTINIZE ITS HEALTH

Why are Ocean Observations crucial for society?

How is Euro-Argo contributing to the Global Ocean Observing System?

What are Euro-Argo's future challenges?

EURO**ARGO**

EUROPEAN RESEARCH INFRASTRUCTURE CONSORTIUM

Foreword

Since 2014, Euro-Argo ERIC has taken the pulse of the ocean to better understand and predict its role in the climate system and its health. One of its main objectives is to develop a sustainable and long-term European contribution to the Argo international programme, monitoring the interior of the ocean, through a fleet of profiling robotic instruments, called “Argo floats” **(see article 1)**.

As you read on, you will discover why Ocean Observations and especially Argo data are crucial in many aspects of our daily life **(see article 7)**, from enhancing weather and climate forecasts to retrieving lost cargo or supporting the fishing industry. These Ocean Observations are also already viewed as essential, in a fast-changing context of serious concerns about the health of the oceans together with an acknowledgment of their role in climate change research and the carbon offsetting. For all these reasons, there is a growing demand for timely, reliable and accessible Ocean Observations, and the associated data systems and operational engineering **(see articles 5 & 6)**.

Historically, the initial Argo programme focused on two essential climate parameters, temperature and salinity, in the upper 2 000 metres of the ocean. Euro-Argo is now at a key turning point as it embraces the new OneArgo design, a United Nations endorsed set of actions to expand this initial Core Argo mission to a global, full-depth and multidisciplinary ocean observing system. Thus, recent technological advances now allow floats to reach a profiling depth of 4 000 to 6 000 metres (Deep-Argo, **see article 3**). Furthermore, biogeochemical sensors have been integrated to measure biogeochemical parameters such as oxygen concentration, pH or chlorophyll-a (BGC-Argo, **see article 2**). Henceforth, OneArgo aims to implement these technological advances to achieve the same data quality and scientific excellence for these two new Deep and BGC missions as for the initial Core mission.

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 (fisheries, aquaculture, energy, resource extraction and insurance). To provide a synoptic view of the ocean and rigorous answers to all these scientific concerns, Euro-Argo ERIC, is more than ever aiming to be fully embedded in the big picture of other *in situ* observation networks **(see article 4)** and to disseminate all this knowledge through a meticulous and appealing Ocean Literacy **(see article 8)**.

Making the OneArgo shift come true therefore requires a European policy of continuous support and incentives for data producers to ensure that *in situ* observation systems can fulfill their long-term potential, supporting the mission for sustainable ocean observation **(see article 9)**. Over the next few decisive years, the Argo programme can count on its unique community, transcending borders and generations **(see article 10)** and its collaborative spirit to meet such an ambitious challenge.

To go further and discover how Euro-Argo is transforming Global Ocean Observation, you can also watch and share those three videos:

- **Part 1** | https://youtu.be/im4HVlK4hVU – highlighting how Euro-Argo plays a major role in ocean observing through a series of interviews with European scientists and describing the revolutionary OneArgo design and its three missions.
- **Part 2** | https://www.youtube.com/watch?v=cd-Z-uY-394 – depicting Euro-Argo’s contribution to the European Global Ocean Observing System (EuroGOOS)
- **Part 3** | https://www.youtube.com/watch?v=NHFhMaHaUJQ – giving an overview of future needs and challenges faced by Euro-Argo ERIC and Europe’s strong engagement for *in situ* global Ocean Observing. **OneArgo is a revolution in ocean observation that requires commitment and support!**

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A biogeochemical (BGC) Argo float.

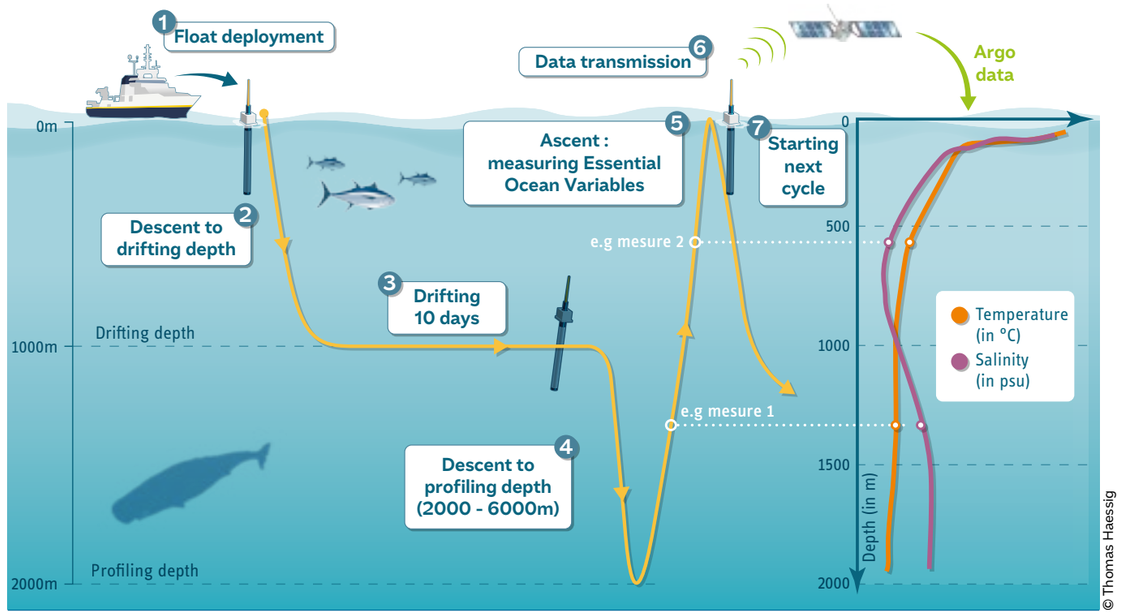
Argo float deployment.

1 EURO-ARGO ERIC: A LEADER IN THE ARGO FLOATS REVOLUTION

Since 2014, the Euro-Argo European Research Infrastructure Consortium (ERIC) has been cultivating the power of dozens of science institutes across Europe to grow and upgrade the Argo floats array, a game-changing Ocean Observation programme, transforming ocean research.

When Birgit Klein deployed her first Argo float at sea 18 years ago, it was an intense experience. "You have something worth the price of a car in your hands and you toss it in the ocean!" remembers this oceanographer from the Federal and Maritime and Hydrographic Agency in Hamburg, Germany. At first glance, these 2-metre-long steel cylinders with an antenna on top don't seem like much. But looks can be deceiving. The Argo floats cost indeed between 20 000 and 150 000 euros each. And more importantly, they have revolutionised the way we monitor the global ocean.

The floats are equipped with sensors that measure ocean properties, like its temperature, or salinity. Once they are deployed, they sink and rise autonomously. Following a 10-day cycle, they descend down to 1 000 metres where they save energy and drift with



A full 10-day cycle of an Argo float and the corresponding profile collected.

Euro-Argo float deployed thanks to an inflatable boat launched from a research vessel.

© Alberto González Santana/IEO

4 000 Argo floats
are deployed around the world ocean with the contribution of
30 countries
representing strong global cooperation and commitment.

WHAT IS ARGO?

Argo is an international programme that collects information from inside the ocean using a fleet of robotic instruments that drift with the ocean currents and move up and down between the surface and down to 6 000 metres deep. Each instrument, called float, spends almost all its lifetime below the surface.

WHAT IS AN ERIC?

The European Research Infrastructure Consortium (ERIC) is a specific legal form that facilitates the establishment and operation, on a non-economic basis, of Research Infrastructures with European interest. The ERIC membership is made up, on a voluntary base, of EU Member States and associated countries. By 2022, 24 research infrastructures have been established as ERIC in fields as various as Energy, Environment, Health & Food, Physical Sciences & Engineering, and Social & Cultural Innovation. Euro-Argo ERIC was created in 2014 to coordinate and foster the collaboration between national Argo programmes.

the currents, then in the final operational phase, they descend at the prescribed depth, set by the scientists who deployed them, before ascending.

Solely on their way up, their sensors analyse the temperature, the salinity, the oxygen content, the chlorophyl concentration and other environmental parameters of the sea water. They will measure what is called a profile, providing a set of data all along the water column. Once they reach the surface, the devices transmit their measurements via satellite. Argo floats also give precious information about deep ocean currents, deduced from two consecutive surfacings and crucial information for operational engineers who keep an eye on them, about their own functioning, such as the level of their battery.

THE POSITIVE IMPACTS OF ARGO FLOATS ON THE ENVIRONMENT AND SOCIETY

Argo floats produce free and open-sourced data in Near Real Time

For weather, climate and ocean prediction

The data are used by operational services:

Argo data improve the accuracy of the ocean forecasts and are critical for developing reliable seasonal to decadal climate predictions. Argo is a game changer in terms of Ocean Observations.

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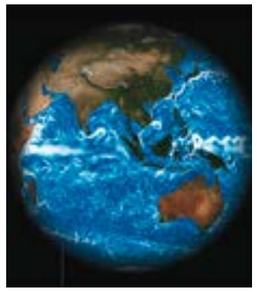

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For climate change mitigation

Scientists use these data for societal benefit:

One of Argo's most important scientific contribution is a huge improvement in the estimation of heat stored by the oceans – key for understanding global warming, rising sea levels and ocean health.

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Positive impacts on the environment and society
Contribution to 2 of the 17 Sustainable Development Goals (SDGs) adopted by all United Nations Member States in 2015.

Argo data are used by a wide range of scientific and operational oceanography teams.

The floats are deployed all over the planet in a global network of sentinels constantly surveying the global ocean. Their collected data are used for a plethora of applications, from predicting the weather and tracking currents to studying the role of the oceans in our changing climate.
The measurements collected become data that can be used by scientists and operational oceanography. Operational oceanography is like weather monitoring and forecasting for the ocean. It relies on powerful computers and numerical models that process *in situ* data, combined with satellite observations. The results of these models can be used, for example, to deduce warnings of coastal floods or ice and storm damage, optimum routes for ships, ocean currents, ocean climate variability, etc. And what has also made the Argo programme a game-changer since its inception in 1999 is that all the data gathered are free, open, quality-controlled and almost instantly available to everybody: scientists, businesses and private individuals alike. And with a tally of about 4 000 floats deployed all around the planet and made up of 30 different countries' contribution, the programme represents strong international scientific cooperation of unique scale, transcending borders but also generations.

One quarter of the Argo floats in the world is managed by the Euro-Argo European Research Infrastructure Consortium (ERIC). "To deploy and maintain the floats, we need continuous funding, that's why we came up with the idea of the ERIC in 2008," recalls Sylvie Pouliquen, co-founder and former Programme Manager of the Euro-Argo ERIC.

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Deployment in Antarctic waters.

WHAT IS ONEARGO?

OneArgo is the new “global, full-depth and multidisciplinary” Argo programme design, including the three missions: Core Argo (measuring temperature and salinity), BGC Argo (able to report up to six biogeochemical additional variables, such as pH and Deep Argo (able to dive till the abyss).
It revolutionises 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 increases end-user value and the benefits for society at large, for instance through more accurate climate projections enabling better societal adaptation.

Euro-Argo makes up 25% of the Argo international floats network

In 2014, the infrastructure was finalised and hosted in France, harnessing the political and financial commitment of nine countries. Today, the consortium is composed of 13 European countries and represents a joint effort of about 30 science institutes. “We are involved at all levels: floats purchase and deployment, new technology development, data management or research strategy,” says Sylvie Pouliquen. “With our partners, we define what this network of floats should be and how it should evolve, keeping in mind to target the new OneArgo global, full-depth and multidisciplinary design.” Proof that joining forces with the ERIC works: according to Sylvie Pouliquen, about one fourth of the Argo-related research papers recently produced in the world are authored by European teams. And this European contribution should be consolidated in the coming years, to face the new challenges related to the implementation of the ambitious OneArgo.

Besides strengthening the role of Europe within the international Argo programme, the Euro-Argo ERIC addresses European specific priorities. One component of the 2019-2022 EU-funded project called Euro-Argo-RISE* (Research Infrastructure Sustainability and Enhancement) was to develop techniques and technologies that will help improve the Argo coverage in regional seas where floats are scarce: shallower waters, marginal seas and icy areas such as the European polar seas. The latter is the field of expertise of Birgit Klein, whose agency is part of the Euro-Argo ERIC. “On the European side of the Arctic Ocean, we decided to monitor a large area that is seasonally ice-free,” explains the German researcher. “But you really don’t want the floats to hit some ice at the surface or they could be damaged”. With her colleagues, she’s now studying techniques and tools that could protect the floats against sea ice. Acquiring then much more measurements in the high latitudes is indeed a timely challenge with respect to global warming.

* This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement n° 824131

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Deployment by the Greek member of Euro-Argo ERIC.

FIND OUT MORE

- **Video “Euro-Argo: Transforming Global Ocean Observation”:** https://youtu.be/im4HVIK4hVU
- **International Argo Programme:** argo.ucsd.edu
- **Euro-Argo:** www.euro-argo.eu
- **OneArgo: 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

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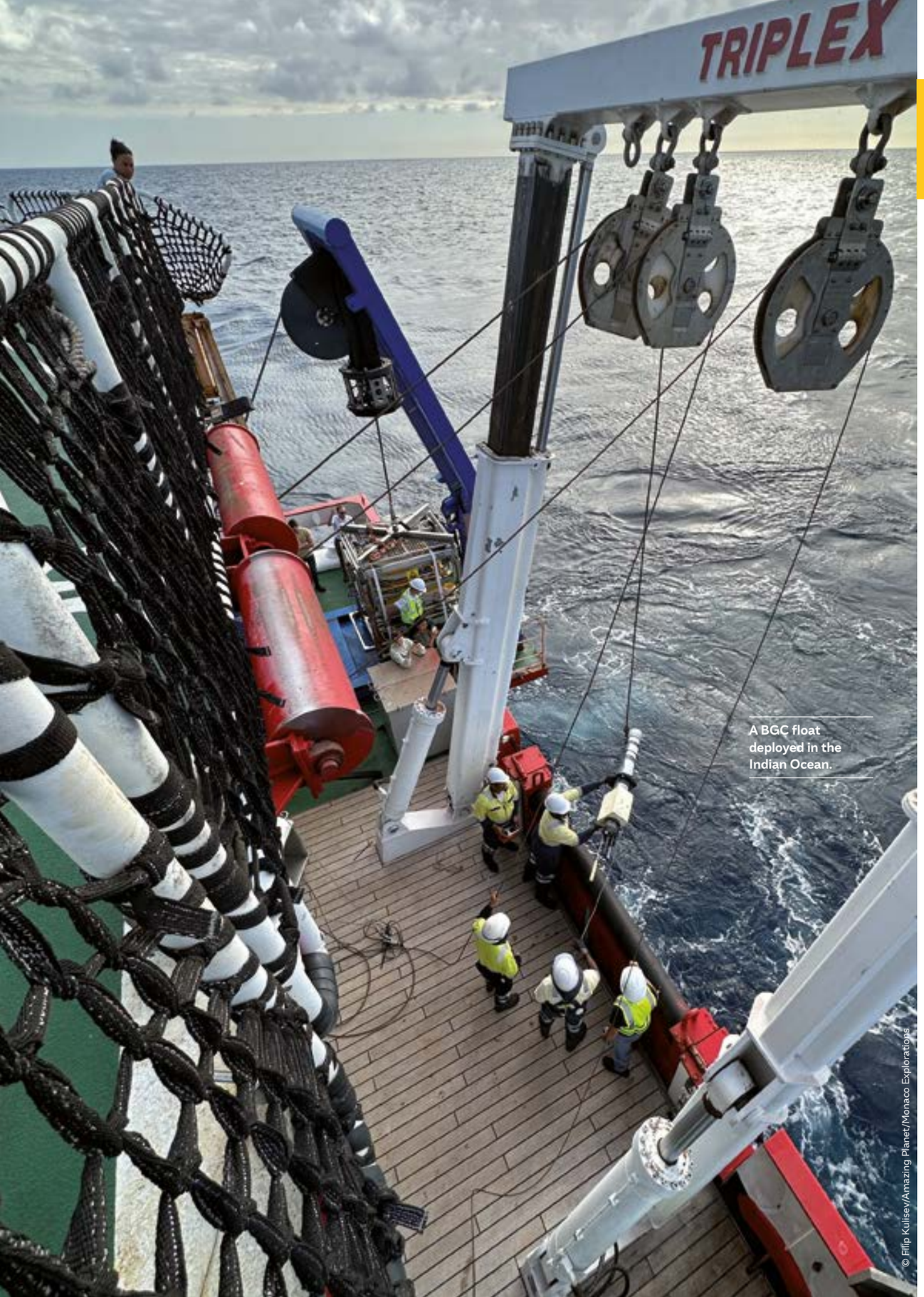

A BGC float deployed in the Indian Ocean.

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2 BGC ARGO: A FULL-SIZE LAB INSIDE A TINY FLOAT

The Argo floats have already revolutionised physical oceanography. Now, a new wave of floats equipped with biogeochemical sensors will do the same for marine ecology.

In 2004, Hervé Claustre helped deploy several Argo floats in the Pacific Ocean. When this research director at the French National Center for Scientific Research (CNRS) saw the data collected by these autonomous instruments, he had an epiphany. "What if we could add optical or oxygen sensors on these floats to study marine life?," thought Hervé Claustre, who's now part of Argo France and an expert of the Euro-Argo ERIC Scientific and Technical Advisory Group (STAG). As soon as he got back to France, he started developing projects to implement biogeochemical – or BGC – sensors on Argo floats. Since then, Hervé Claustre has co-pioneered a new wave of Argo floats called BGC Argo. Today, deploying around 1 000 BGC Argo floats by 2030 is one of the main ambitions of OneArgo, a United Nations endorsed set of actions to create a global and multidisciplinary Ocean Observing array.

© Euro-Argo ERIC

Emanuele Organelli trained the students on how to deploy, operate and recover a BGC float.

BGC Argo floats carry 6 additional sensors

"One single BGC float is like a tiny research vessel that will operate autonomously for five to six years and send its data every 10 days," Hervé Claustre says. A float also costs a lot less than the simplest and shortest research vessel campaign. On top of the temperature and salinity sensors already found on Core Argo floats, a BGC Argo float carries six additional sensors for sampling oxygen, pH, nitrates, chlorophyll, suspended particles, and light.

"The idea is to understand how climate change impacts on marine ecosystems, their biodiversity and functioning," explains Emanuele Organelli, a marine ecology researcher from the Italian National Research Council (CNR), working today for Argo Italy, a member of the Euro-Argo consortium. Dramatic changes in the marine ecosystems have repercussions on living marine resources, such as fisheries all around the world. By better understanding global marine ecosystems, scientists can better advise policy makers on the urgent actions needed to anticipate and mitigate these potentially dramatic effects on marine resources.

A BGC float at the Ifremer facility, in the unique 20-metre depth pool tank where Argo floats are tested.

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A BGC float with its six additional biogeochemical sensors.

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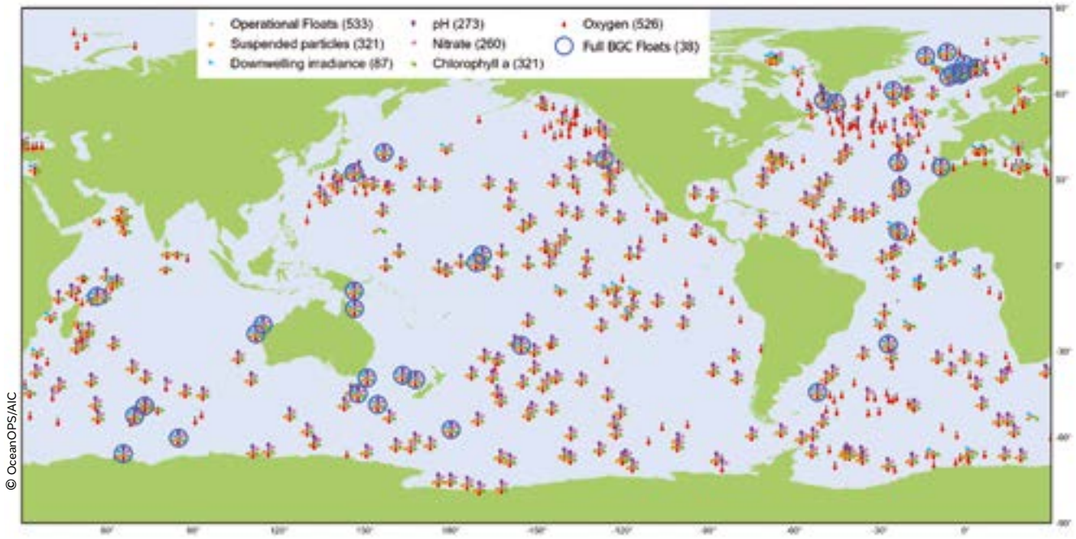
Tests of BGC floats.



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Latest locations of the 533 operational BGC floats in May 2023 and the sensor types they are equipped with.

The BGC floats provide the tools to collect a wide array of key data for marine ecology: oxygen sensors can detect regions where oxygen is scarce. As the oceans are getting warmer, their circulation is getting weaker. Consequently, there are less exchanges between oceans and the atmosphere, and less oxygen entering oceans in certain areas. pH sensors can measure ocean acidification. The excess carbon dioxide from human activity is absorbed by the oceans and then transformed into acid via a chemical reaction in the water. This phenomenon has dire consequences for marine life.

Nitrates, chlorophyll and light sensors are used to monitor phytoplankton, microscopic marine algae. It is an essential component of the food chain, being its first link: phytoplankton is consumed by zooplankton, microscopic drifting animals, and zooplankton is the main food source of small fish and other marine animals. Moreover, the quantity and types of phytoplankton thriving in one region give a lot of information about the local ecosystem. Each type, or community, of phytoplankton modifies the intensity and color of marine lightscapes. With light sensors, scientists can identify these colors and study the diversity of such communities. Scientists can also assess phytoplankton biomass in a particular area by measuring chlorophyll and suspended particles in the water. In the long run, they should be able to deduce the distribution of phytoplankton communities all around the planet. That, in turn, will help them assess how healthy marine ecosystems are and how sustainable harvest of living marine resources is in different regions around the planet.

If the Core Argo floats have shaken up the world of physical oceanographers, the BGC Argo mission represents an even bigger leap for marine biologists. For Emanuele Organelli, the fact that he and his European colleagues can get data all year long is a game-changer as it will help scientists better understand life cycle through seasons. “Though it remains essential, sampling from research vessels may be biased towards calm seasons for sailing,” the Italian researcher notes. Free and instant access to *in situ* data is also unprecedented for marine biologists who usually expect 2-or-more-years embargos on research data. “Sharing all this information this way with colleagues in Europe and around the world makes science more accessible than ever,” Hervé Claustre says. “It is the beauty of Argo and one of the reasons why this international programme succeeds more than any other.”
The French senior scientist feels like he’s been doing a totally different job since he started working with BGC Argo. “I spent the first half of my career filtering cube metres of water in a lab,” he recalls. “Today, I’m a ‘couch sea explorer’: I get tons of *in situ* data from Tahiti or the Arctic from the comfort of my living room, and I sometimes make discoveries I really didn’t expect.”

FIND OUT MORE

- **Video “Euro-Argo: Transforming Global Ocean Observation”:** https://youtu.be/im4HVIK4hVU
- **Biogeochemical (BGC) Argo:** biogeochemical-argo.org
- **BGC Argo Mission:** https://argo.ucsd.edu/expansion/biogeochemical-argo-mission/ **“Observing the Global Ocean with Biogeochemical-Argo”, H. Claustre et al., 2020,** https://doi.org/10.1146/annurev-marine-010419-010956
- **OneArgo: 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

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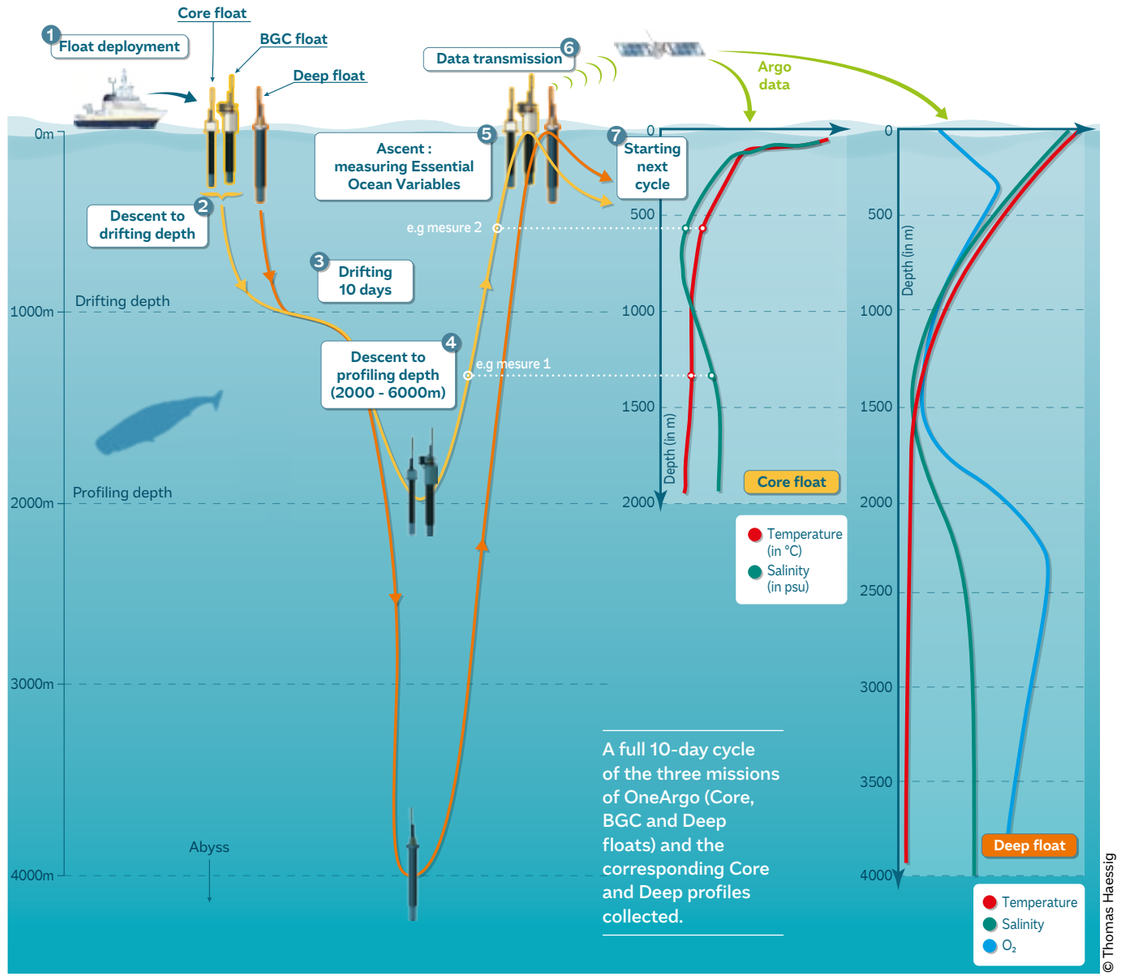
3 DELVING INTO THE ABYSS WITH DEEP ARGO

With a new generation of floats that can reach the bottom of the sea, scientists could soon close the global ocean's heat budget.

With more than 4 000 Argo floats patrolling around the globe, we are getting a clearer than-ever picture of the state of our seas. Until recently though, these floats could not descend below 2 000 metres. As a result, they've managed to monitor only about half of the ocean volume. Today, a new generation of floats named Deep Argo floats can delve where no other autonomous Ocean Observation instruments have been on a global scale: the abyss. As they descend to 4 000 or 6 000 metres and then ascend, the Deep Argo floats sample groundbreaking data with a focus on climate change.

Romain Cancouët, operational engineer at Euro-Argo ERIC, testing a Deep Argo float at the Ifremer facility, in the unique 20-metre depth pool tank.

© Stéphane Lesbats/Ifremer



A full 10-day cycle of the three missions of OneArgo (Core, BGC and Deep floats) and the corresponding Core and Deep profiles collected.

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A Deep Argo float tested at the hyperbaric chamber of Ifremer facility, to reproduce the extremely high pressures of the abyssal zone.

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Deep Argo floats at Ifremer facility.

© Olivier Dugornay/Ifremer

90% percent of the excess heat produced by human activity is stored in the oceans and we estimate that 10–15% of this heat is stored below 2 000 metres.

"More than 90% percent of the excess heat produced by human activity is stored in the oceans and we estimate that 10 – 15% of this heat is stored below 2 000 metres," explains Virginie Thierry, a physical oceanographer for Argo France, one of the 13 members of Euro-Argo ERIC (the European Research Infrastructure Consortium coordinating European contributions to the international Argo programme). With Deep Argo floats, researchers will be able to accurately measure the global ocean's average temperature and its variations.

They will also have the opportunity to study which regions or which ocean layers are more impacted by global warming. Furthermore, when the oceans get warmer, their volume increases, inducing a sea level rise. "It is vital that we quantify the role of the deep sea in sea level rise," Virginie Thierry says. Deep Argo floats will also be invaluable assets for ocean modeling. Ocean models are computer simulations of the perpetuous motion and circulation of the water masses of the oceans. They are essential to study our oceans and their influence on our global climate. According to Damien Desbruyères, another physical oceanographer collaborating with Euro-Argo, "these floats will bring a new source of data, and help evaluate, thus improve our current models and how they represent deep ocean currents in particular."

When they ascend above 2 000 metres depth, the Deep Argo floats observe the same physical parameters as traditional Argo floats, also called Core Argo floats, making Deep Argo a natural extension to the international Argo programme. Scientists like Damien Desbruyères, Virginie Thierry and their European and international peers are working together to extend the Core Argo floats with their Deep Argo counterparts. They have their work cut out for them though. Pressure at a 4 000 metres depth is 400 times higher than at the surface. By overcoming the challenge of very accurately correcting the impact of the high pressure on the sensors, we can track the signals of climate change at these depths, since the variations of temperature is of the range of 1/1 000th of degree Celcius there.
By 2030, the Deep Argo researchers and engineers' community hope to maintain 1 200 operational Deep Argo floats around the globe. That would represent one fourth of the whole Argo floats tally. This is one of the priorities of OneArgo, a United Nations Decade of Ocean Science for Sustainable Development endorsed set of actions to create a global and multidisciplinary Ocean Observing array. Its goal is to upgrade the Argo array into a truly global network that could study the polar and marginal seas, include biogeochemical measurements as well as, in the case of Deep Argo, explore the full ocean depth.

FIND OUT MORE

- **Video "Euro-Argo: Transforming Global Ocean Observation":** https://youtu.be/im4HVIK4hVU
- **Deep Argo:** argo.ucsd.edu/expansion/deep-argo-mission
- **OneArgo: 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

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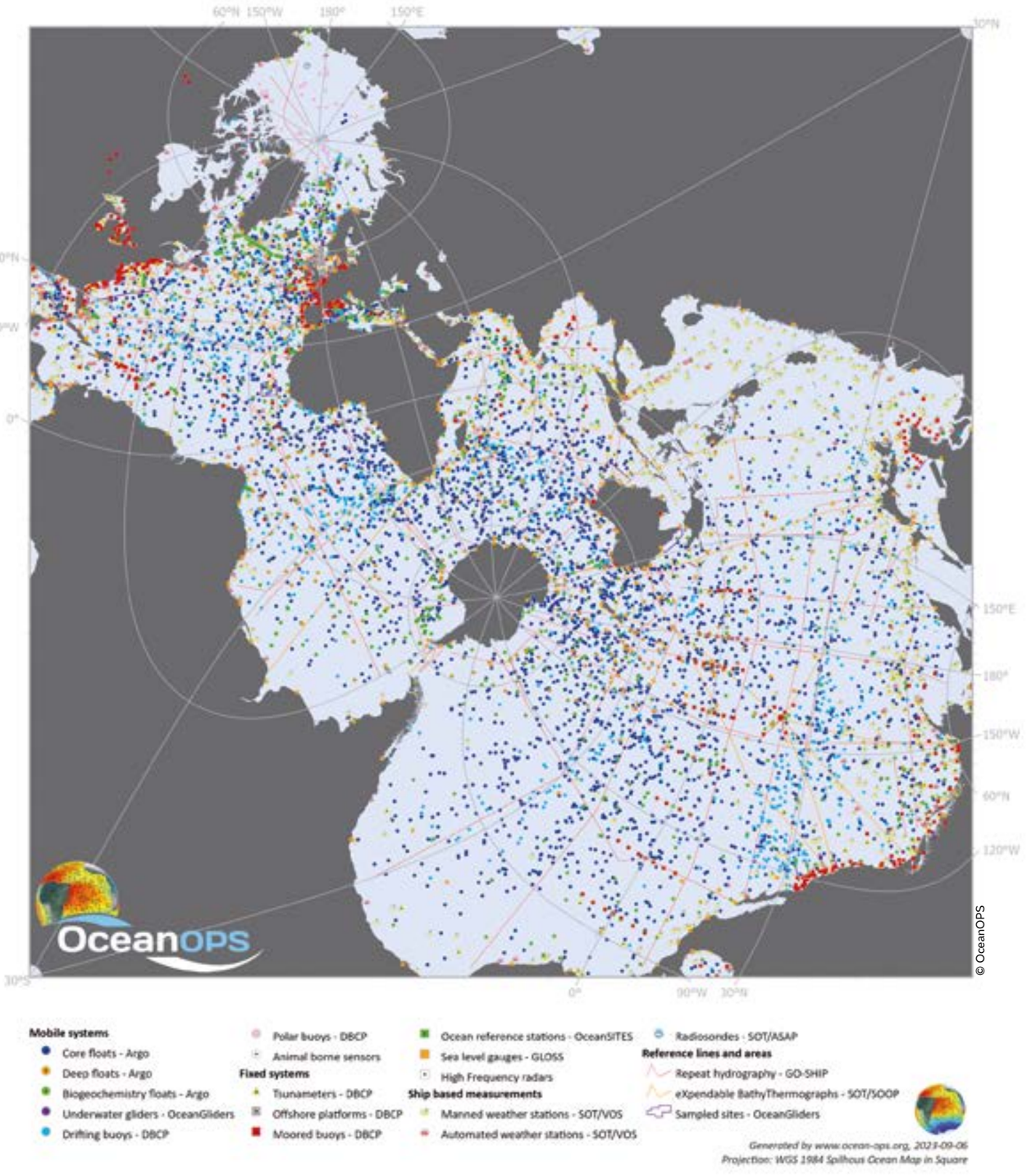

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The Global Ocean Observing system in August 2023 with all the *in situ* operational platforms monitored by OceanOPS.

4 EURO-ARGO, A KEY ASSET FOR **THE GLOBAL OCEAN OBSERVING LANDSCAPE**

By unifying their Argo Ocean Observation capacities within Euro-Argo ERIC, European countries have a real impact on the international scene.


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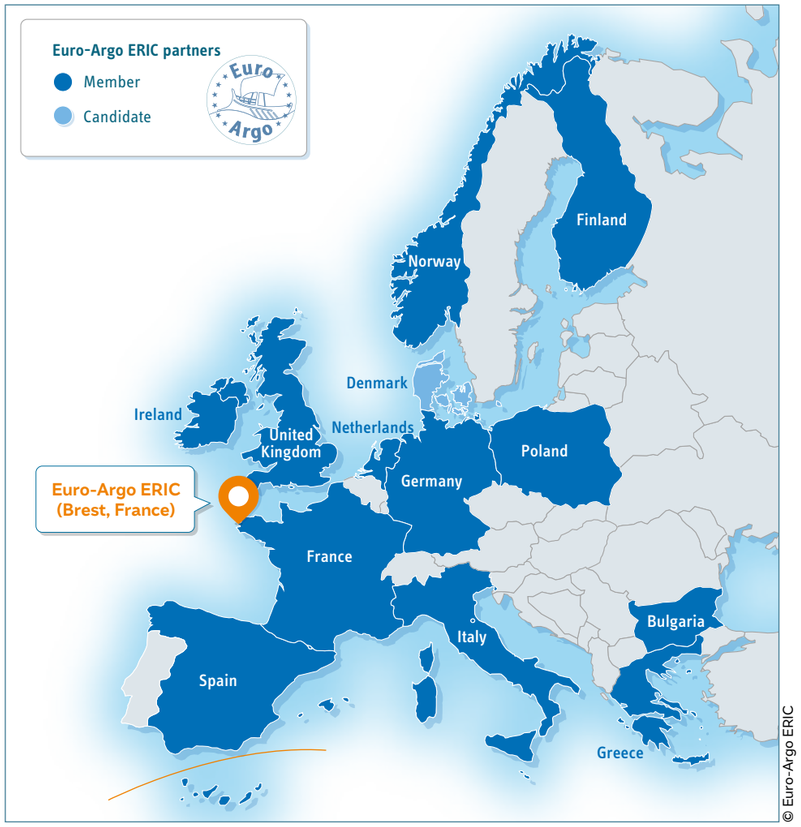
Victor Turpin, Technical Coordinator, and Emanuela Rusciano, Science and Communications Officer at OceanOPS.

With approximately 4 000 floats deployed around the world, Argo is the most prominent *in situ* Ocean Observation programme on Earth. But it is not the only one. The Global Ocean Observing System, or GOOS, comprises approximately 10 000 *in situ* observational platforms as various as Argo floats, research vessels, mooring buoys, gliders and others. Euro-Argo, the European contribution to the international Argo programme, is a major asset for GOOS, as it supports research and development on Argo instruments and sensors as well as floats deployment in European and international seas, and quality control of the data collected. To fulfill this task, Euro-Argo ERIC – the infrastructure which coordinates Euro-Argo – collaborates with OceanOPS, a joint centre of the World Meteorological Organisation and the Intergovernmental Oceanographic Commission of UNESCO, which itself provides operational coordination for GOOS.

The European Global Ocean Observing System (EuroGOOS) is one of Euro-Argo ERIC's main partners. The European component of GOOS gathers 46 organisations from 19 different countries which are specialised in operational observation systems and numerical modelling. EuroGOOS's mission is to lead the development and implementation of sustained and coordinated operational oceanography across Europe so that everyone, from the fishing and tourism industries to citizens, can benefit from high quality data about sea level, coastal pollution, ocean currents, etc. It also hosts an Argo task team.



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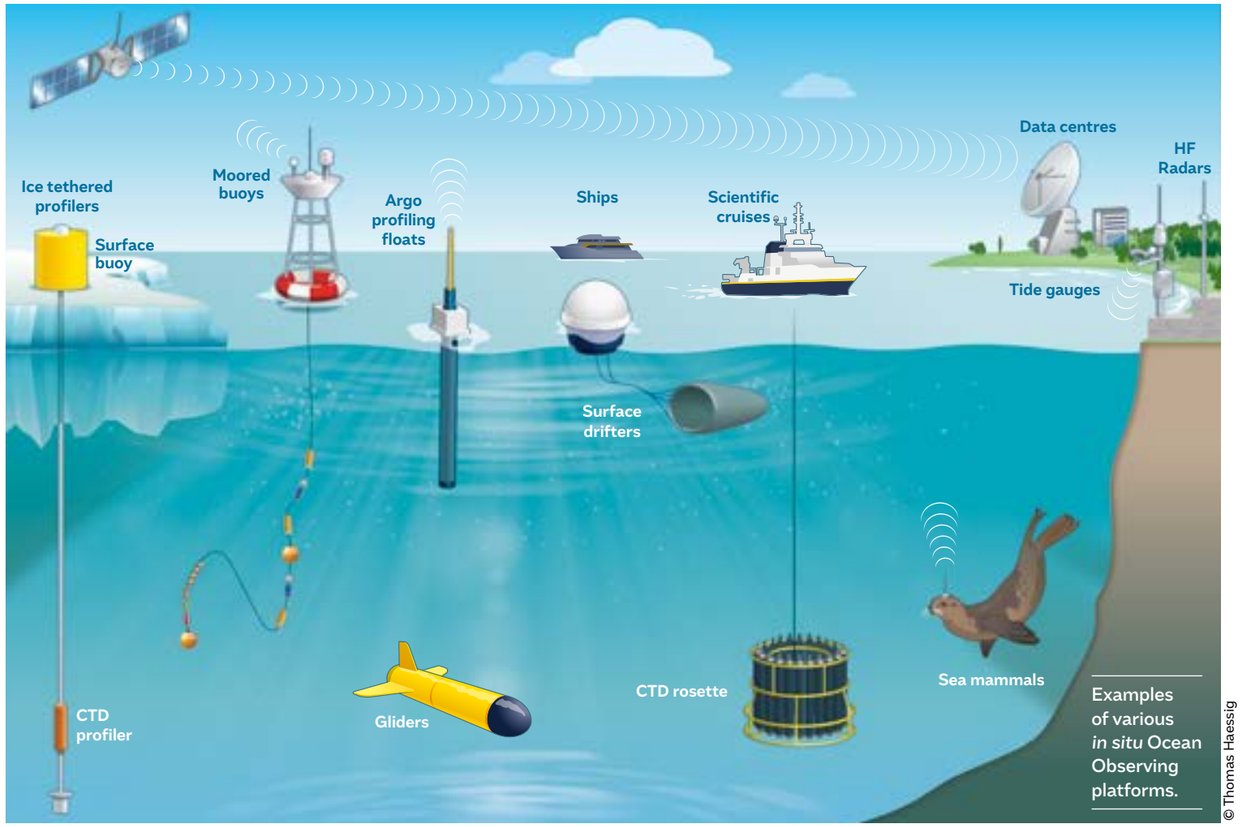
The Euro Argo consortium includes 12 members and Denmark is a candidate member.

EuroGOOS
46 organisations
19 European countries



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Examples of various *in situ* Ocean Observing platforms.

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A moored buoy.

© Ifremer

A CTD rosette on board a research vessel.

© Teledyne

A glider.

"With this task team, we act as facilitators and we prepare new countries to join the Euro-Argo ERIC," says Inga Lips, Secretary General of EuroGOOS. Five new countries are currently interested in joining the existing membership of the consortium.
"At a global scale, the United States provides most of GOOS' firepower," states Mathieu Belbéoch, OceanOPS Manager. "But by joining forces via structures like Euro-Argo ERIC, European countries can have a real impact on the international scene." Among its missions, Euro-Argo ERIC harmonises the work of all its members, so organisations like OceanOPS only have to speak with one entity instead of thirteen. "Euro-Argo concerts deployment plans, for instance, and this kind of coordination is very helpful for us. Euro-Argo ERIC sets an example as a collaborative European infrastructure with shared services and strong coordination of its members, and this ambition tends to bring the European Ocean Observation community together."
According to Mathieu Belbéoch, "the next step for Euro-Argo ERIC would be to become a more operational infrastructure for Argo in Europe, by extending its capacities to order instruments, perform checkups and clearances for members and, possibly also, deployments towards global and European goals, scale economy and efficiency." OceanOPS and Euro-Argo ERIC collaborated on the 2019-2022 EU-funded project called Euro-Argo-RISE* (Research Infrastructure Sustainability and Enhancement) by co-developing tools and indicators to monitor floats' life expectancy, performance and data flow, documenting best practices for deployments in Exclusive Economic Zones (EEZs), and tailoring these tools to European needs.

At the international level, even if Argo provides the majority of GOOS' *in situ* data, the floats can't suffice by themselves. All the existing *in situ* Ocean Observation systems complement each other: gliders are very mobile and useful to study extreme events but they lack autonomy, research vessels can't cover the whole world but they can measure a large array of various parameters, etc. To advance GOOS further, "we should advance scientific and technological coordination with all Ocean Observing infrastructures and networks, for a better knowledge about the processes and changes in the ocean" states Inga Lips.

* This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement n° 824131

WHAT IS GOOS?

GOOS provides countries and end-users with critical information on physical, chemical, and biological essential ocean variables, aimed at delivery for climate, operational services, and ocean health. The GOOS mission is to lead the Ocean Observing community and create the partnerships to grow an integrated, responsive and sustained observing system.

FIND OUT MORE

- **Video "Euro-Argo's contribution to the European Global Ocean Observing System":** https://www.youtube.com/watch?v=cd-Z-uY-394
- **Global Ocean Observing System (GOOS):** www.goosocean.org
- **European Global Ocean Observing System (EuroGOOS):** eurogoos.eu
- **OceanOPS:** https://www.ocean-ops.org/board

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

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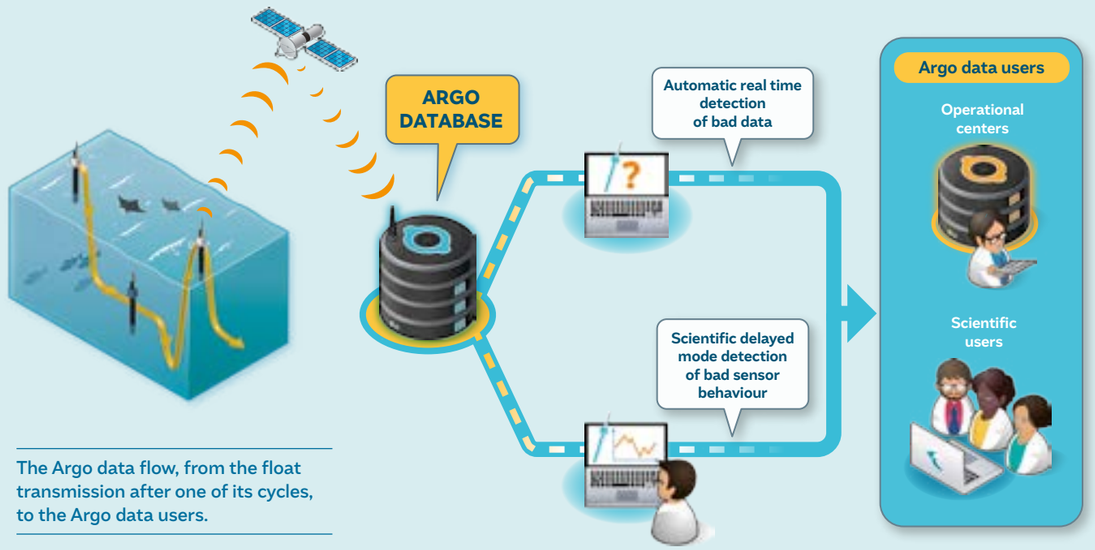
5 A POWERFUL SOURCE OF DATA TO **ADVANCE OCEAN SCIENCE**

Argo floats' data passes through a sophisticated flow of processing and management systems that certify its quality and make it easily accessible.

The Argo floats' data is intended to be quickly and easily used by researchers around the world for a wide range of applications. Each time an Argo float completes one of its observation cycles, it transmits its measurements via satellite to Data Assembly Centers, or DACs. Two synchronised Global Data Center provide access to the same Argo data: one in the United States, and one in France near Euro-Argo's headquarters. The Argo community has developed and maintains a data system capable of processing and managing data in real time. A second Argo data stream enables detecting and correcting fine sensor drift in delayed mode.

"We have privileged access to the data and can scrutinise the measurements to detect potential problems," explains Claire Gourcuff, Science Officer at Euro-Argo, who is in charge of data monitoring. Argo data experts recently noticed drifting issues with certain salinity sensors for instance, a common problem for this kind of sensors. This is where Claire Gourcuff and her international colleagues' expertise as oceanographers comes in handy. "If the float shows a weird reading, this means that either the sensor is malfunctioning or, on the contrary, the sensor works perfectly and has sampled an exceptional phenomenon," she says. "In these cases, it's really important to know the ocean's properties in the regions where the float is traveling."



The Argo data flow, from the float transmission after one of its cycles, to the Argo data users.

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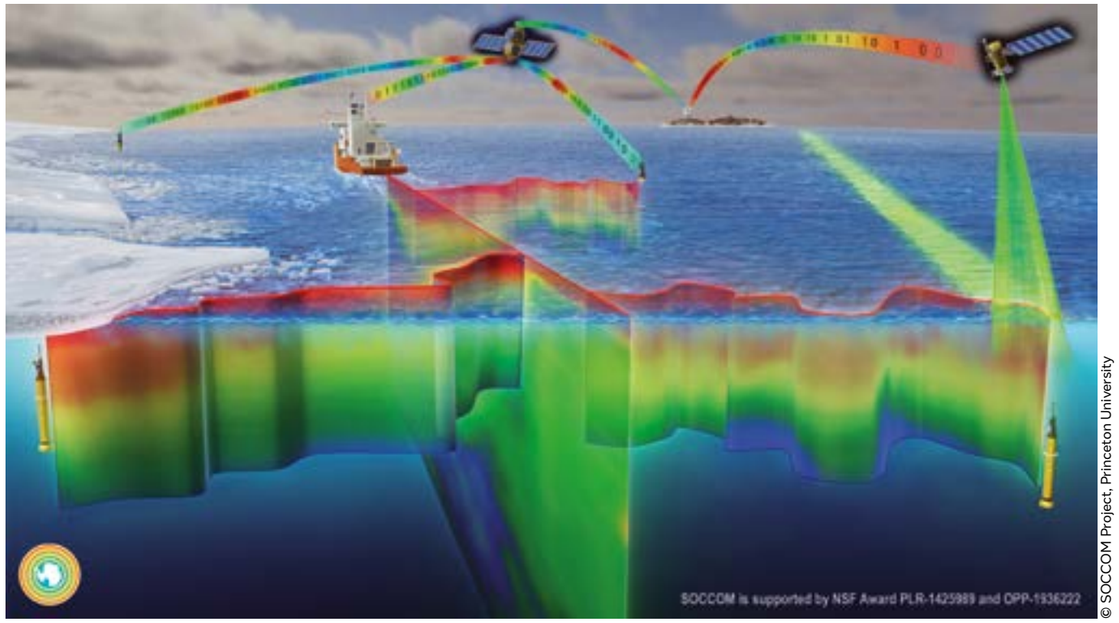

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Euro-Argo delivers critical data complementary to satellite observations for assimilation in ocean analysis and forecasting models, as well as in weather and climate forecasting.

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The international Argo Data Management Team comes together once a year. The photo above is from the meeting in October 2019, in Villefranche-sur-mer, France.

"Since the beginning, Euro-Argo and the international Argo community have been using standards recommended by the International Oceanographic Data and Information Exchange (IODE)," says Sylvie Pouliquen, Euro-Argo former Programme Manager. "Euro-Argo has been a leader in designing and implementing the Argo data system, and is operating two of the main data access portal services that facilitate free and open access to all the Argo data." Euro-Argo has also been a pioneer in integrating FAIR (for Findable, Accessible, Interoperable and Reusable) data services in the Argo data system. "In four years, with the support of the European Commission, Argo data system has gone from FAIR for humans, to FAIR for machines, with the creation of the Argo Vocabulary Server and new machine-to-machine services," Sylvie Pouliquen states.

Euro-Argo is one of the most important *in situ* infrastructure delivering required data for the Copernicus Marine Service (CMS), one of the six services of the European Union Copernicus Earth Observation programme. Mercator Ocean International has been entrusted by the European Commission to implement the CMS, which provides an operational monitoring and forecasting of the global ocean and European regional seas.

At a global scale, the Copernicus Marine Service, through its *in situ* Thematic Assembly Centre (TAC), receives observations from infrastructures such as Euro-Argo. Thanks to this data, the *in situ* TAC produces some new value-added data, called "data products" that have been validated and harmonised with the observations from other networks". Those data products are needed to improve various applications of operational oceanography, such as ocean forecasting models, but also to validate satellite observations or carry out climate research. "We now have outstanding examples that show how combining satellite data with Argo data substantially improves our ability to describe the inner layers of the ocean and to predict how the state of the oceans might evolve," says Pierre-Yves Le Traon, the Scientific Director of Mercator Ocean International. "Argo by itself is already a huge success, but combined with satellite data – such as altimetry – and models, it is even more compelling."

In order to make its data even more accessible, Euro-Argo also collaborates with partners such as the European Marine Observation and Data Network, or EMODnet, an initiative funded by the European Union, under the oversight of the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE). "EMODnet is a key public service for *in situ* marine data," states Kate Larkin, Deputy Head of the EMODnet Secretariat. "It gathers all conceivable marine environmental variables: from the surface to the sea floor, from chemistry, biology, bathymetry, geology, physics, seabeds, habitats and human activities." EMODnet relies on a network of 120 expert organisations across Europe specialising in data management and marine data products and services. EMODnet assembles, harmonizes and standardizes the data so that they can be interoperable, that is, universally usable.

"Ocean science infrastructures like Euro-Argo are important data providers for EMODnet," explains Kate Larkin. EMODnet uses European and international data standards to ensure that this data is usable by a wider community, especially those using Global Information system (GIS) tools to map it in combination with other information such as ice-covered areas.

"Euro-Argo works with EMODnet on data accessibility, sharing information about improvements made in the Argo data System and about new available services," explains Sylvie Pouliquen, who adds: "Euro-Argo also collaborates with EMODnet Chemistry on biogeochemical variables data quality to contribute to the monitoring of the impacts of global warming and in particular to better assess the capacity of the ocean to be a carbon sink."

FIND OUT MORE

- **Video "Euro-Argo: Transforming Global Ocean Observation":** https://youtu.be/im4HVlK4hVU
- **Euro-Argo data access:** https://www.euro-argo.eu/Argo-Data-access
- **Argo data management:** http://www.argodatamgt.org/
- **EMODnet:** https://emodnet.ec.europa.eu/en
- **EMODnet Chemistry:** https://emodnet.ec.europa.eu/en/chemistry
- **Copernicus Marine Service:** https://marine.copernicus.eu/
- **Dashboard - Copernicus Marine In Situ TAC:** http://marineinsitu.eu/dashboard/
- **International oceanographic data and information exchange (IODE):** https://www.iode.org/

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6 OPERATIONAL ENGINEERS: THE BACKBONE OF THE ARGO REVOLUTION

As they organise procurement, test, coordinate deployment and monitor floats, operational engineers play an essential role in the Argo programme.

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A Deep Argo float tested at the Ifremer facility.

© Euro-Argo ERIC

Argo float tested at the Ifremer facility by Romain Cancouët, who is in charge of all operational tasks at Euro-Argo ERIC, and Delphine Dobler, data scientist at Euro-Argo ERIC.

One thing that makes Argo floats such unique Ocean Observation assets is that they are totally autonomous. Once they are deployed and during their typical five-year lifetime, these instruments are programmed to go through diving cycles and will seldomly require human intervention. This also means that if one of these floats is launched while not functioning correctly, this 20 000 to 150 000 euros piece of equipment could be lost for good. Making sure that floats are working smoothly before, during and after their deployment, is part of the job of operational engineers.

"We first set contracts with the manufacturers to procure platforms and sensors that will fulfill technical specificities required by the scientists and their research," explains Romain Cancouët who is in charge of all operational tasks close to the Euro-Argo ERIC (European Research Infrastructure Consortium). "There are many benefits for being a Euro-Argo member: reduced prices as we purchase floats in bulk, centralised purchase and after-sales management, access to storage in our facility and stock management," he notes.

The floats undergo a series of tests in a unique facility: a 20-metre deep basin at the Euro-Argo headquarters located on the French Research Institute for Exploitation of the Sea (Ifremer) campus in France. "We check if they dive and ascend correctly, if they transmit their data via satellite and also test if the sensors are working properly," Romain Cancouët says. For Deep Argo floats that can dive to a depth of 4 000 metres, engineers use a hyperbaric chamber available at the Ifremer premises to simulate the

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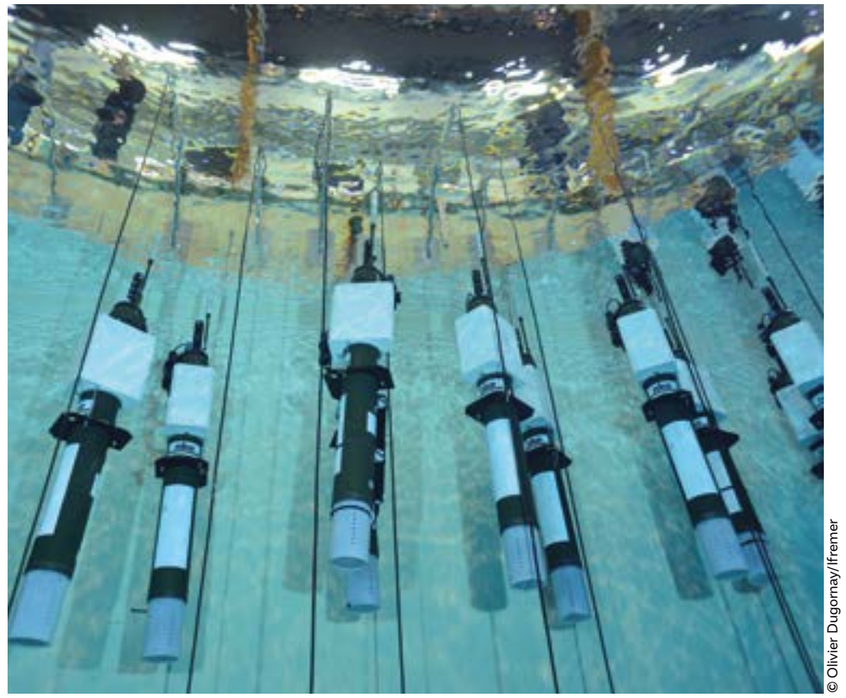
Argo float ready to be deployed.

© Euro-Argo ERIC

Tests of floats.



© Olivier Dugornay/Ifremer

Biogeochemical Argo floats tested at the Ifremer facility.

© Olivier Dugornay/Ifremer

Argo floats ready to be tested at the Ifremer facility.

extremely high pressures of the abyssal zone. If there are any defects, returning a float is also made easy for Euro-Argo members since the current equipment provider is located near the consortium headquarters.

Once the floats have been tested, they are shipped to seaports all around Europe and the world. Argo floats can be deployed from a diverse array of ships: public or private science vessels, opportunity ships such as merchant ships, sailing boats, tourism vessels, cable-ships, etc. These vessels are either regular or on-and-off partners of Euro-Argo. "We have created tutorials and simple guides to train the ships' crew how to deploy an Argo float," explains Noé Poffa, an Instrumentation Engineer at Argo France, the country launching the most instruments among the Euro-Argo 13 members. He sometimes supervises deployments at sea himself. "The procedure depends on the type of boat we boarded: we drop the float in the water either manually or by using a quick-release hook or a crane," Noé Poffa describes.

The operational engineers check the floats' diagnostics every week. If problems occur, for instance if a float is caught in an eddy or close to enter ice-covered areas, they can communicate with the float via satellite and control them remotely.

They can modify its parameters so that it will dive and drift at different depths. If a float is defective or if its battery is empty, it is usually left to sink. But when a vessel's trajectory happens to get close to a malfunctioning or depleted float, operational engineers will at times pilot a retrieval operation from land since they have access to the float's coordinates in real time. "A successful retrieval depends on the know-how of the ship's crew and also on pure luck: how agitated the sea is on that day, or how clear communications between us and the boat are," explains Noé Poffa. "It can be nerve-wracking." To recover and refurbish more and more floats when it's possible or cost-effective is one of Euro-Argo's long-term objectives.

Via workshops and meetings, Romain Cancouët is getting feedback from the community of Euro-Argo users. "We want to know more about how they operate or would like to operate the floats and what their needs are," says Romain Cancouët. "We then report back to the manufacturers so that they can implement this feedback in the next generation of floats." Now, with new generations of Argo floats such as Deep Argo floats which can dive till the abyss and Biogeochemical Argo floats, able to measure up to six biogeochemical variables such as oxygen concentration, Romain Cancouët is working on testing new types of sensors. As part of an Horizon Europe project, he's connecting with the communities of scientists and engineers who work with different Ocean Observation platforms that use the same sensors as these new floats, such as gliders and moorings. According to Romain Cancouët, "we are building synergies and we are getting insightful feedback about sensors' failures and data quality control to keep improving our next floats."

FIND OUT MORE

- **Video "Euro-Argo: Transforming Global Ocean Observation":** https://youtu.be/im4HVIK4hVU
- **International Argo Programme:** argo.ucsd.edu
- **Euro-Argo:** www.euro-argo.eu

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7 ARGO: AN ESSENTIAL **PUBLIC SERVICE**

Argo floats benefit our societies in multiple ways: from enhancing weather and climate forecasts to retrieving lost cargo or helping the fishing industry.

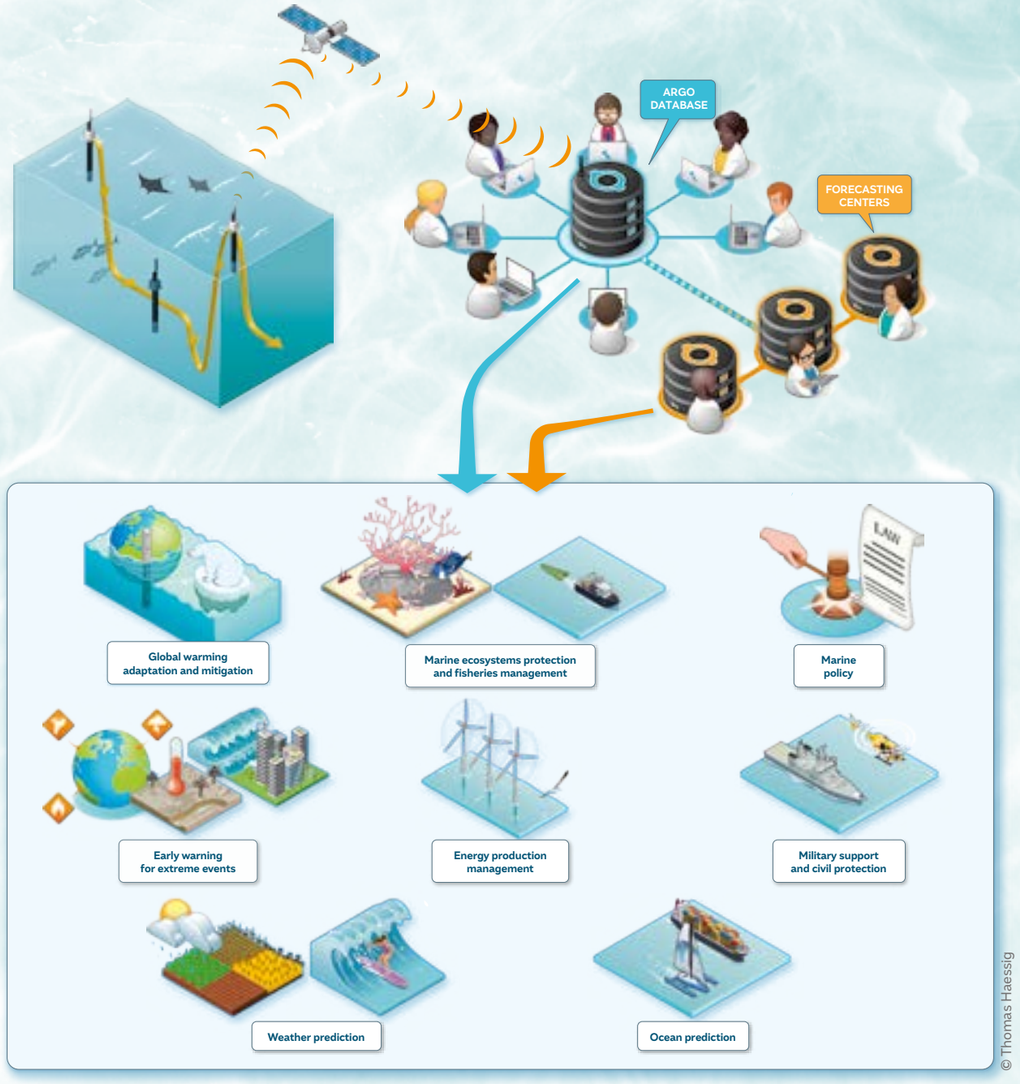
© Unsplash

Beyond being a revolutionary tool for scientists all around the world, the Argo floats have a tremendous, albeit mostly unrecognised, impact on our societies, and its importance is bound to grow in the near future. "Most of the global population lives near the seashore and will be impacted by sea level rise, coastal flooding and other phenomena caused by climate change," explains Virginie Thierry, a physical oceanographer at Argo France, a member of Euro-Argo ERIC – the European contribution to the international Argo programme.

The traditional Argo floats measuring temperature and salinity, or Core floats, help better assess climate change. "With its extensions Deep Argo and Biogeochemical Argo, we'll be able to go further and accurately diagnose climate change," she adds. "As a result, we will be able to show people how real climate change is." With Argo's dataset, scientists can also initiate accurate climate forecast models. "We'll know exactly how our oceans moderate global warming and we'll be able to inform policy makers on the decisions they have to make," says Virginie Thierry.

"Argo is now essential for all kinds of forecasts, such as seasonal climate forecasting and weather forecasting," says Susan Wijffels, a physical oceanographer at the Woods Hole Oceanographic Institution (WHOI), USA, and expert of the Euro-Argo Scientific and Technical Advisory Group (STAG). Historically, weather forecasts were based on satellite data and on pressure or wind measurements from land and ships stations and used only atmospheric models. Today, these models are starting to include an accurate simulation of the active global ocean thanks to the addition of *in situ* observations, and Argo's data-set makes the vast bulk of these observations. Argo data is transmitted within a few hours to the World Meteorological Organization (Global Telecommunication System) to be used routinely by Numerical Weather Prediction centers. This data is critical, for example, to improve their ability to forecast the intensity of extreme weather events such as hurricanes, which draw the energy from the ocean heat content. "One of the ways we're going to manage climate change is by getting people out of the way of these extreme events as their frequency will get higher and higher," Susan Wijffels says.

For the senior scientist, Ocean Observation programmes like Argo and their data constitute an enormous wealth. "Better observation means better coastal protection and better protection at sea," she notes. "This is potentially transferable in savings for insurances of human life and properties."



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The various fields of applications of Argo data.

In situ observations, such as those provided by Argo, highly improve ocean models' accuracy by grounding them to reality.

Audrey Hasson
Mercator Ocean International

Of course, Argo also plays an essential role in oceanography and particularly operational oceanography, that is, the equivalent for the ocean of weather monitoring and forecasting. Operational oceanography is centered around ocean models that help predict the state of our seas. The data they provide are essential for millions of users around the world, such as fishermen, cargo captains looking for the best route, tourism ships or individuals looking for day-to-day information about their favourite beaches or sailing spots. "*In situ* observations, such as those provided by Argo, highly improve ocean models' accuracy by grounding them to reality," explains Audrey Hasson, Head of the GEO Blue Planet European Office at Mercator Ocean International.

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Argo's data on ocean currents for instance are particularly useful to study how things drift at sea. "If you're trying to manage an oil spill, you want to have a detailed forecast of what the currents are going to do in the next two to three weeks," she says. "Or if you're looking for a lost container at sea, you want to be able to backtrack or predict where it might go, and Argo floats help reach this high level of detail."
In situ Ocean Observations like Argo, satellite observations and ocean models constitute substantial assets for the fishing industry as well. For instance, they can help guide fishing vessels to productive zones. This is particularly useful for artisanal fisheries in countries like Bangladesh or Vietnam. "Fishermen consume less fuel as their time at sea can be counted in days instead of weeks," says Audrey Hasson. "For this profession, less time at sea also means a lesser risk of mortality."

Argo's data is getting even more precious thanks to the rise of BGC Argo, a new generation of floats equipped with biogeochemical sensors. These floats help scientists and seafarers better understand our world marine ecosystems, how they are shifting because of climate change, and how dire the impacts are on the resources exploited by the fishing industry.

FIND OUT MORE

- **Video "Euro-Argo: Transforming Global Ocean Observation »:** https://youtu.be/im4HVIK4hVU
- **International Argo Programme:** argo.ucsd.edu
- **Euro-Argo:** www.euro-argo.eu
- **Biogeochemical (BGC) Argo:** biogeochemical-argo.org
- **Deep Argo:** argo.ucsd.edu/expansion/deep-argo-mission

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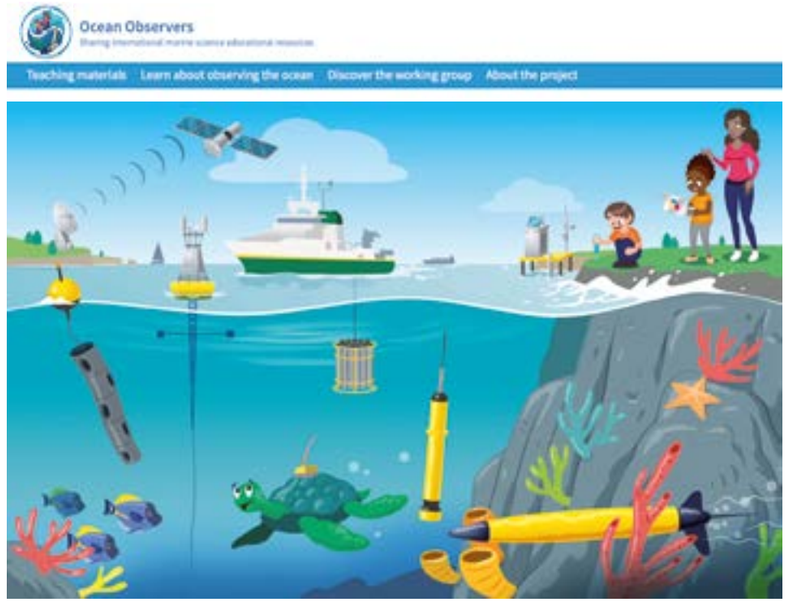
8 OCEAN LITERACY: EMPOWERING PEOPLE TO TAKE DIRECT AND SUSTAINABLE ACTION

The Argo floats and the ocean observing system provide an unprecedented opportunity to raise public awareness about our seas and the crises they endure.



The Ocean Observers website is enriched with educational resources about *in situ* Ocean Observing networks by the international working group launched in 2017: www.oceanobservers.org

As Deputy Head of the EMODnet secretariat, the European Marine Observation and Data Network, Kate Larkin knows too well how our ocean has been changing in recent years. Last year though, one particular map caught Kate Larkin's attention. "When our network compared data before and during the Covid-19 pandemic, we were shocked: we really saw how much human activities like fishing or other vessel traffic had stopped or slowed," says Kate Larkin. "If a pandemic can reduce human activities and their negative impact on our seas, we, as a society, should be able to find sustainable ways to reduce these activities." Ocean Literacy, i.e., empowering people to better understand how the ocean influences our life and how we influence the ocean, is one pillar of the United Nations (UN) Decade of Ocean Science for Sustainable Development and the UN Sustainable Development Goals (SDG). Joint initiatives such as the EU4Ocean Coalition for Ocean Literacy connect diverse organisations, projects and people contributing to foster Ocean Literacy and the sustainable management of the ocean. The initiative is funded by the European Union and includes three communities representing professional stakeholders (Platform), Youth (Forum) and Blue Schools (European Educational Network).

Claire Gourcuff, Euro-Argo Scientific Officer, explaining the float cycle to a classroom who joined the "Adopt a float" initiative.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Young students adopted and signed floats on board research vessel SA Agulhas II in Saint Denis (La Réunion) (above) and in Victoria (Seychelles) (on the right). The latter has been signed by H.S.H. Prince Albert II of Monaco and ministers of the Seychelles in order to attest their support to ocean education.

Since 2017, Euro-Argo, the European contribution to the international Argo programme, and OceanOPS, an international organisation of the UN that coordinates, monitors and helps the implementation of the Global Ocean Observing System, have been working together on the Ocean Observers Initiative.

We bring together stakeholders, scientists, and communicators involved in marine sciences and science-based outreach activities, as well as teachers from all around the world to share experiences on educational activities related to *in situ* Ocean Observations, and thus federate them in an international educational network around a well-coordinated programme," explains Emanuela Rusciano, OceanOPS' Science and Communication Officer. Together with the Euro-Argo officers Marine Bollard and Claire Gourcuff, Emanuela Rusciano has organised workshops and created a website to assemble educational materials and activities on a global Ocean Observation learning platform oceanobservers.org.

According to Emanuela Rusciano, *in situ* observing instruments like Argo floats are ideal education tools helping to humanise Ocean Observations. "Speaking to the public at large and raising awareness about physical oceanography is still a complicated matter and requires experience and expertise," she notes. "Bringing actual instruments into classrooms allows us to more easily explain to students the importance of these tools and why they should care about ocean data, which supports scientific knowledge and essential services needed by all sectors of society."

Introducing floats to classrooms is exactly what the adopt a float programme is about. "As a researcher, I've always thought that it is important to reach out to the young public and, in this way, give something directly back to the taxpayers who pay for my salary," says Hervé Claustre, a senior scientist member of Euro-Argo.

When he's not doing research with Argo, he and his colleague Carolyn Scheurle are fully invested in the international adopt a float programme. With the help of a science mediation team and accompanied by science mentors, classrooms of all school levels literally adopt profiling floats. The students give a name to it, draw a logo and can familiarise themselves with Argo technology and science. Moreover, they are able to track it in real time on an interactive map. Thanks to interactions with scientists, working with these


© Euro-Argo ERIC

A classroom adopted a float in Brittany, France. Two scientists from Euro-Argo ERIC presented the float and explained some scientific concepts to the kids.

observational tools then opens to complementary ocean topics and ocean sciences. And, sometimes, the sailor and/or the scientific team in charge of the float deployment also shares onboard experiences with the students. "As scientists, and as one of our missions, we need to prepare society for the long-term future," says Hervé Claustre. "Informing kids and teens, training them on scientific approaches and raising awareness among these future voters who will decide political directions is just as important as doing good quality research." Carolyn Scheurle won a French National Centre for Scientific Research (CNRS) medal in 2022, an award in science communication, for her work leading the adopt a float educational programme.

A key communication tool for the ocean is the European Atlas of the Seas. "We select the most societally relevant maps from EMODnet, Copernicus, Eurostat, etc., and we provide stories and abstracts explaining why this data is important," explains Kate Larkin. Recently, she and her colleagues have also worked with professional educators to create teaching resources, such as quizzes and activities for different age groups. For Kate Larkin, it's crucial to find positive ways to engage and inspire people. "If you offer a map where, for instance, they can check the status of either a beach where they like to go surfing or a coast where they like to sail, they may realise how much they depend on it and value it," she says. "And if they value it, they will take steps to make some significant changes."

FIND OUT MORE

- **Ocean Observers:** https://www.oceanobservers.org/
- **Adopt a float:** https://adoptafloat.com/
- **EU4Ocean Coalition for Ocean Literacy:** https://www.marineboard.eu/eu4ocean-coalition-ocean-literacy
- **Copernicus:** https://www.copernicus.eu/en
- **Eurostat:** https://ec.europa.eu/eurostat

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9 ARGO'S FUTURE: **A QUEST FOR SUSTAINABILITY**

Although the international Argo programme has become an indispensable instrument for ocean and climate monitoring, forecasting and study, it often lacks clear political commitment, notably on the European level, as well as an appropriate funding system allowing to sustain operations in the long term.

A BGC Argo float ready to be deployed.

© GEOMAR

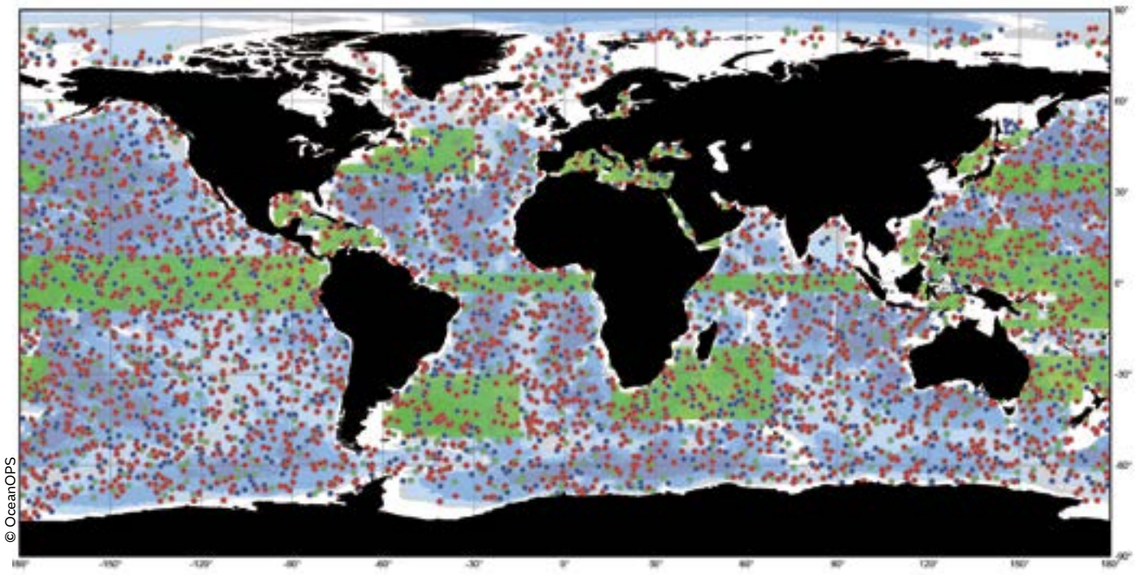
Deployment of a Core Argo float in the Arctic.

© Nicolas Kolodziejczyk

The international Argo programme has gone a long way since 1998, when a scientific team presented the idea of an international array of floats to take the pulse of our seas and our climate. "Argo has become the dominant data stream for many state estimates of the ocean and it plays a prominent role in forecasting systems," notes Susan Wijffels, a senior scientist at the Woods Hole Oceanographic Institution (WHOI), USA, and one of the co-founders of the international Argo programme. Today, the programme has an ambitious new design called OneArgo, a United Nations Decade of Ocean Science for Sustainable Development endorsed set of actions to create a global and multidisciplinary Ocean Observing array.

OneArgo aims at reaching 4 700 floats by 2030 – 2 500 Core Argo floats (measuring temperature and salinity), 1 000 Biogeochemical (BGC) floats (able to report up to six additional biogeochemical variables, such as pH) and 1 200 Deep floats (able to dive till the abyss) – and expanding Argo presence into the polar and marginal seas. But despite its success, the Argo project faces its share of challenges.

Some of them are immediate. "With the Covid-19 pandemic, we have had big supply chain issues," says Susan Wijffels, who is also an expert of Euro-Argo ERIC Scientific and Technical Advisory Group (STAG). "Argo equipment suppliers have been caught with chip shortage and shipping impediments, the latter also bringing mayhem to research vessels that deploy floats. Consequently, some float deployments have been delayed and the Argo community is still in the process of catching up.



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OneArgo and its targeted network of 4 700 floats by 2030.

- Core Floats, 2500
- Deep Floats, 1200
- BGC Floats, 1000

OneArgo aims to double the observations coverage in these areas.

What is G7 Future of Seas and Oceans Initiative?

The G7 initiative is an intergovernmental group working on enhancing financial support and implementation for the Global Ocean Observing System (GOOS). It unites marine scientists and representatives from government agencies and ministries accross the G7 nations and the European Union to enhance the global Ocean Observing system that provides ocean data required for the health of our seas and oceans, for weather and climate forecasting, and for the development of a sustainable Blue Economy.

Another issue: there are only a few sensor manufacturers able to satisfy Argo floats requirements. This monopoly could hinder the deployment of the BGC Argo floats that require even more sensors. "We need to initiate a dialogue with private-sector sensor developers and encourage multiple sources of sensors to reduce cost and time of development," says Susan Wijffels.
On another matter, expanding the array in the marginal seas sometimes leads to political hurdles, especially around the exclusive economic zone (EEZ) of some countries. For Susan Wijffels, "it's a long-term diplomatic challenge to convince these nations that allowing Argo to operate within their EEZ is actually to their benefit."

But the biggest obstacle on Argo's path is the lack of sustainable funding. OneArgo is indeed characterised by the progressive deployment of Deep and BGC Argo floats, whose individual costs are respectively two and five times higher than Core floats. The current estimate for the OneArgo design therefore at least triples the annual expenditure allocated to it. "We are in a difficult situation where we are trying to build capacity to operate these Deep and BGC new missions while getting flat or declining funding," explains Susan Wijffels. Since floats have a four-year lifespan, even maintaining the existing Core Argo array with current funding is problematic, chiefly because of float and sensor price inflation. With such financial stress weighing on the Argo members, it can be difficult for them to coordinate at the international levels and to overcome certain situations, for instance, when some areas lack floats. As a result, there are gaps in the Argo global network, most noticeably in the Indian Ocean.
"Because the programme has been existing for 20 years, policy makers and even some members of the Argo community think that its long-term future is guaranteed," notes Sylvie Pouliquen, former Programme Manager of Euro-Argo ERIC. "One of the reasons why we built Euro-Argo was to mobilize European governments' commitment to the international Argo programme and to bring our members' voices to decision makers."

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G7 Future of the Seas and Oceans Initiative Working Group meeting in Berlin in November 2022. One of its activities is working to support the implementation of a full-1000 biogeochemical float array by 2030.

"Although Ocean Observation is a fundamental need, this scientific field has always faced precarious fundings in Europe," says Zoi Konstantinou, Policy Officer at the European Commission Directorate-General for Maritime Affairs and Fisheries (DG MARE). Thus, Argo funding schemes are varying from one country to another. There is, for instance, a major disparity between Europe and the USA, two of the biggest Argo contributors: in Europe, the high proportion of grants and research programmes in funding reduces the visibility of support. "The challenge is to convince the European Union (EU) Members that this should be a standardized and shared responsibility, and that a secure funding for this continuous need should be set through collective (EU) funds. As they are based on European research projects, todays' EU support cannot be considered as sustainable."

"A lot of the work on Argo is carried on the back of a handful of champions: individual scientists who work together, endlessly write proposals and get very short term – four or five years – funding," also regrets Maria Hood, the G7 Future of the Seas and Oceans Initiative (FSOI) Action Coordinator for the EU4OceanObs project. She collaborates with Euro-Argo ERIC to bring up European priorities such as the monitoring of marginal seas on the international scene. "What happens when those dedicated champions retire or decide to change focus? Do we lose the array?" For Maria Hood, the Argo network of floats has become too important for its continuation to depend on a few champions. "It is time to transition Argo to operational funding and it is essential to build a bridge to the next generation of scientists," she concludes. "Scientific and operational users make a daily use of our data, and the new parameters in OneArgo are essential for monitoring the health of the marine ecosystems in threat of the global change. Being the only network that provides a 4D (in depth and over time) synoptic view of the oceans in constant motion, there is drastic need to provide a sustainable financial support to the Argo programme", concludes Yann-Hervé De Roeck, programme manager of Euro-Argo ERIC.

FIND OUT MORE

- **"Euro-Argo: Future Needs and Challenges":** https://www.youtube.com/watch?v=NHFhMaHaUJQ
- **European Global Ocean Observing System (EuroGOOS):** eurogoos.eu
- **Global Ocean Observing System (GOOS):** www.goosocean.org
- **G7 Future of the Seas and Oceans Initiative:** www.g7fsoi.org
- **OneArgo: 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

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10 A UNIQUE COMMUNITY **TRANSCENDING BORDERS AND GENERATIONS**

The Argo programme has been built on a unique collaborative and problem-solving culture. These values are being passed on to young experts joining the programme today.

© Blue Observer

A Euro-Argo float deployed by the Blue Observer crew.

An Argo float being deployed from a light boat.

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The Argo programme was born from the impassioned will of a handful of scientists to promote climate forecasting and to provide prediction services for people all around the world. To reach this goal, the scientists were convinced that the data produced by the Argo floats had to be shared freely and as fast as possible. In the world of science research where competition and hoarded information are the dominant norms, it was and it still is a paradigm shift. “There was a culture of collaboration and problem-solving established right from the beginning,” recalls Susan Wijffels, a senior scientist at the Woods Hole Oceanographic Institution and one of the co-founders who launched Argo 24 years ago. “And we have been able to maintain this culture as new people come on board today.”

For Susan Wijffels, this culture of global collaboration is at the roots of Argo’s success. “One of the best things about working in the Argo world is this wonderful international peer group of very dedicated people that are determined to see Argo succeed,” she says. Different countries or groups of scientists do their share in different ways. “Euro-Argo, for instance has done incredible work investing in the Argo data management system, while other members have lent their expertise in improving other components, from deployments to technologies,” Susan Wijffels explains.

At a European level, Euro-Argo has been cultivating the Argo spirit since 2014. “There is a very strong mindset in the Euro-Argo community to share all

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The international Argo community gathered in Brussels at the 7th Argo Science Workshop to discuss the latest scientific achievements, October 2022.

the information we have so we can build upon each other's work instead of redoing the same things or making the same mistakes," says Ingrid Angel-Benavides, an ocean scientist for Argo Germany – a member of Euro-Argo, who has worked on Argo for four years. "Collaboration has always been an implied rule, but through the Euro-Argo RISE* (Research Infrastructure Sustainability and Enhancement) project which aimed at further developing the Euro-Argo infrastructure, putting our efforts together has officially become one of the main objectives."

Collaboration has always been an implied rule.

Ingrid Angel-Benavides
Argo Germany/Euro-Argo ERIC

The international Argo programme was created more than 20 years ago and many of the researchers from that time are now retiring, and they are all ready to pass the torch to the new generation," says Sylvie Pouliquen, Euro-Argo former Programme Manager. "When a newcomer starts working on Argo, it can be a bit overwhelming," shares Ingrid Angel-Benavides. "There are so many places to seek out information about the programme and you have to understand all the different structures involved."

Fortunately, the collaborative mindset embedded in Argo's community means that knowledge and experience are smoothly shared between veteran scientists and young experts. Since Ingrid Angel-Benavides entered the Argo programme, she has been

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Deployment of a Core float.

There was a culture of collaboration and problem-solving established right from the beginning.

Susan Wijffels
WHOI/member of Euro-Argo Scientific and Technical Advisory Group

working with Birgit Klein, an oceanographer operating in the same German institute (BSH) and who has been part of the Argo world for 18 years. "Birgit insists that I take part in all the major international Argo meetings – such as the steering team meetings or the Euro-Argo board meetings – and that I observe the personal dynamics in these gatherings," Ingrid Angel-Benavides says. "Beyond transferring knowledge, there's also a focus on transferring the way we do things in Argo, how we collaborate within an international community and how we manage our relationships with other members."

With the Covid-19 pandemic, most of the meetings were virtual. As a benefit, a lot more people could participate. Young scientists from all around the world that might be interested in getting into an Argo group can attend the meetings and get all the information they need. "We also encourage each national group to bring along a young expert and to partner them with a more senior scientist," tells Susan Wijffels.

With OneArgo, a United Nations endorsed set of actions to create a global and multidisciplinary Ocean Observing array, the Argo programme is now at a turning point. And these new objectives will be undertaken by a new generation of scientists. With this in mind, Euro-Argo organises every two years science meetings to share the state-of-the art knowledge about Argo and to connect veteran and young researchers.

FIND OUT MORE

- **Video "Euro-Argo: Transforming Global Ocean Observation »:** https://youtu.be/im4HVIK4hVU
- **International Argo Programme:** argo.ucsd.edu
- **Euro-Argo:** www.euro-argo.eu
- **Euro-Argo RISE project:** https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022
- **OneArgo: 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

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Funded by the EU via the EU4OceanObs project and Euro-Argo ERIC, these articles aim to showcase how the European Union (EU) is responding to global ocean and coastal data needs, with a specific focus on the EU contribution to in situ ocean observing.

This campaign raises awareness on the need for sustained and comprehensive in situ observations, which combined with satellite observations and predictive models, are critical for generating knowledge required for sustainable development, management and protection of ocean resources and coastal resilience.

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