

# MONITORING THE OCEANS AND CLIMATE CHANGE WITH ARGO

**MOCCA** PROJECT  
5 – YEAR ACHIEVEMENTS

**EUROARGO**

EUROPEAN RESEARCH  
INFRASTRUCTURE CONSORTIUM  
FOR OBSERVING THE OCEAN







## WHAT IS ARGO?

Argo is the first global real-time network for observing the ocean interior in history.

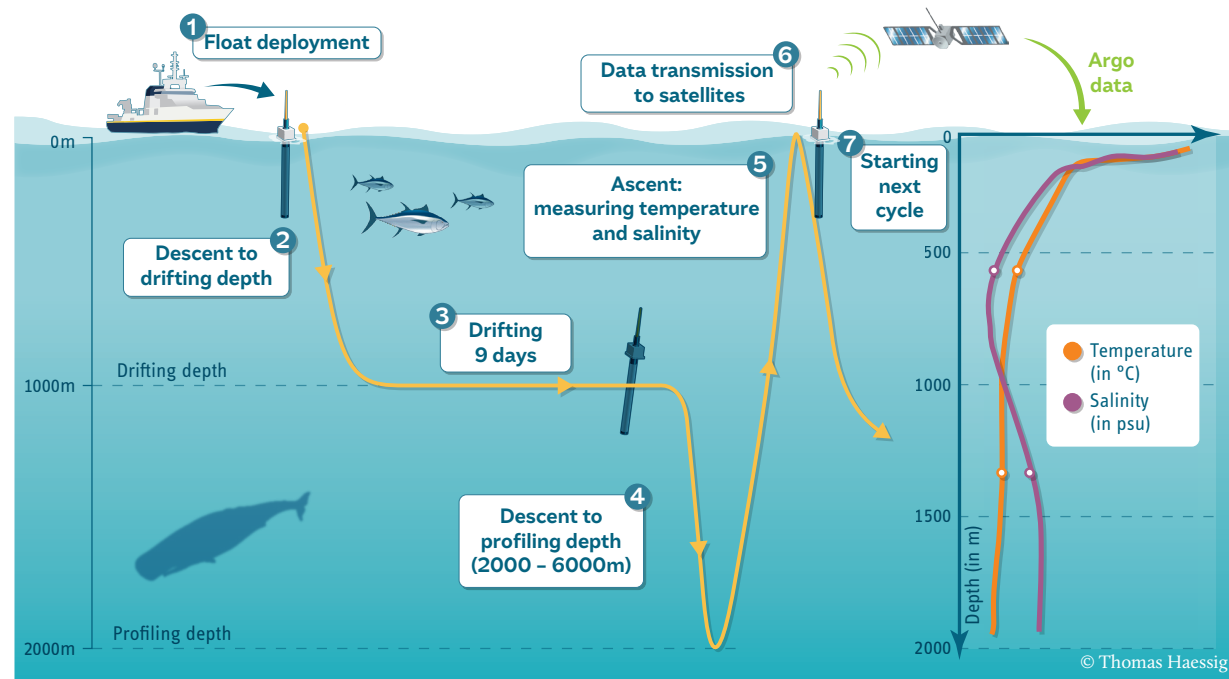
- Argo represents a fleet of about 4000 autonomous floats, deployed all over the world ocean.
- They carry sensors to report profiles of ocean properties (temperature, salinity and possibly up to 6 biogeochemical parameters).
- Argo floats perform measurements while actively going up and down the water column.
- They provide an unprecedented free and open quality-controlled dataset to a wide range of users.

### TEN DAYS CYCLE OF AN ARGO FLOAT

4 YEARS  
Argo float life expectancy

10 DAYS  
for a full cycle

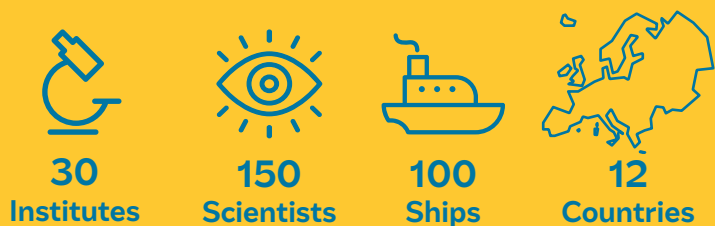
1-12 HOURS  
to share data



## WHAT IS EURO-ARGO?

Euro-Argo sustains, develops and optimises the European contribution to the international Argo programme, providing, deploying and operating nearly 25% of the float network.

- Established in 2014, the Euro-Argo European Research Infrastructure Consortium (ERIC) has matured to the stage that it is now able to initiate network upgrades in response to specific European research interests, especially towards high latitudes, biogeochemistry (BGC) measurements to study ecosystem parameters and down to deeper abyssal depths.
- The Euro-Argo ERIC is composed of 12 countries, and is coordinated by the Euro-Argo ERIC Office, hosted by Ifremer (France).
- Argo's success is mainly due to the high degree of international cooperation and European partners have played a crucial role in developing the Argo network since its inception in 1998.



### OBJECTIVES FROM 2014 - 2018

- 1 To maintain 25% of the global array
- 2 To provide additional coverage in the European regional seas
- 3 To develop further the infrastructure: enhancing float technology and adding new sensors, improving the data processing and distribution system
- 4 To provide quality-controlled data and products to the researchers in climate and oceanography fields, and to the operational communities - e.g. Copernicus Marine Environment Monitoring Service (CMEMS)

### MOCCA PROJECT in brief



150 Argo floats measuring temperature and salinity deployed in 3 years



5M€ co-funded by the European Maritime and Fisheries Fund (EMFF)



20% co-funded by Euro-Argo members

## WHAT IS MOCCA?

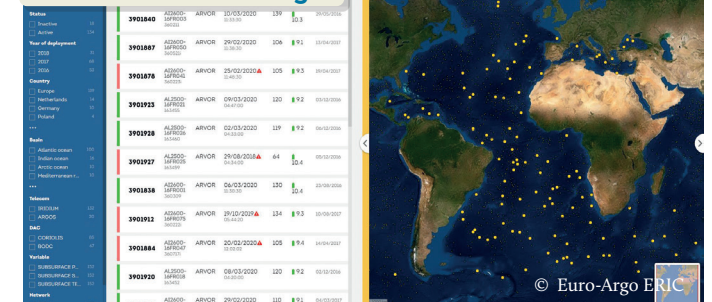
In 2015, the Executive Agency for Small and Medium-sized Enterprises (EASME) co-funded the Monitoring the Oceans and Climate Change with Argo (MOCCA) project for 5 years. With 5 M€, this project allowed Euro-Argo to procure and deploy 150 new floats measuring temperature and salinity. MOCCA made available more than 20 000 quality-controlled data to the oceanographic and scientific communities.

### MOCCA MANAGED 150 FLOATS, FROM PROCUREMENT TO SCIENCE READY DATA

#### Float procurement



#### «At-sea» monitoring



#### Coordination



#### Float deployment



#### Focus on data quality

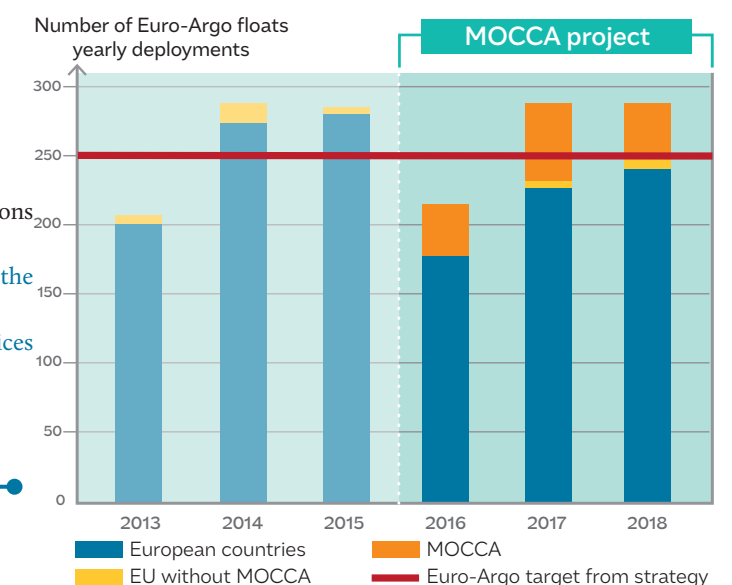


### MOCCA PROJECT: A CRUCIAL SUPPORT FOR EURO-ARGO ERIC DEVELOPMENT

MOCCA project enabled Euro-Argo to:

- Improve the coverage of available ocean observations in key regions with enhancement in European Seas.
- Further develop the Euro-Argo ERIC infrastructure, to reach 25% of the global network target.
- Demonstrate its operational capabilities and build value-added services for its members.

The European contribution to Argo, based on national funds only, would not have reached its target without MOCCA





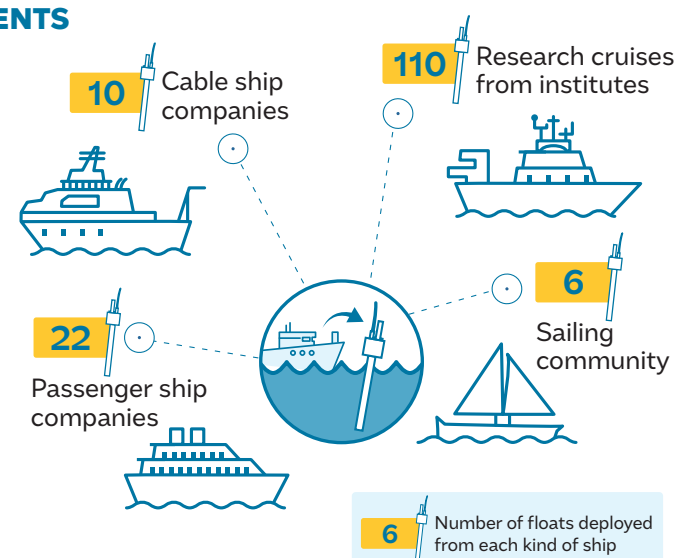
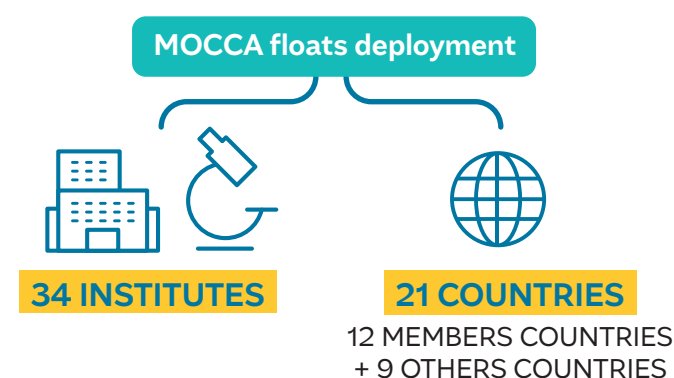


## COORDINATION

The ERIC Office coordinated deployment planning with Euro-Argo partners and the international community, in line with the Argo array design for ocean coverage. It also offered technical training and provided best practices deployment procedures to ship crews. It organized the monitoring of the floats and supported the processing of the data, federated user communities and promoted the project.

### A STRONG COORDINATION FOR FLOAT DEPLOYMENTS

The Euro-Argo ERIC strengthens collaboration between countries and with international and national programmes for the sharing of ship-time to deploy and recover floats.



### A DISTRIBUTED RESEARCH INFRASTRUCTURE

MOCCA demonstrated that Europe can significantly contribute in a coordinated way to the international Argo programme.



#### Linking with

ADMT  
Argo Data Management Team

AST  
Argo Steering Team

jcommops  
Joint IOC-UNESCO/  
WMO Centre for  
Oceanography and  
Marine Meteorology

### MOCCA STRENGTHENED USER COMMUNITY

MOCCA project activities widely communicated to the Argo community through different channels.



2

USERS MEETINGS



1

EURO-ARGO ERIC  
SCIENTIFIC WORKSHOP



1

WORKSHOP TO SHARE EXPERIENCES  
ON DATA QUALITY CONTROL



## FLOAT PROCUREMENT

Thanks to MOCCA project, the Euro-Argo Office elaborated the technical specifications and the necessary documents required for the call for tender. Acceptance tests were performed on procured floats to maximise their effective operation. This was done by the Euro-Argo Office technical team using Ifremer (host of the Euro-Argo ERIC Office) facilities.

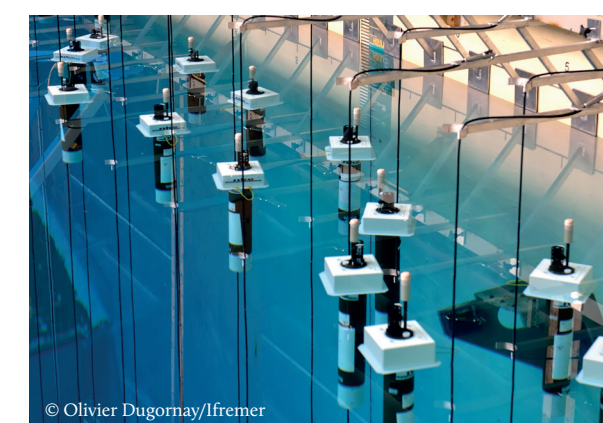
### FROM DETAILED SPECIFICATIONS TO SHIPMENTS

MOCCA made a major step in the development of Euro-Argo ERIC by setting up a reliable and reusable baseline for Euro-Argo float operations such as technical specifications and acceptance tests procedures.



#### BEFORE SHIPPING FLOATS

- ✓ 1/ Technical specifications
- ✓ 2/ Call for tender
- ✓ 3/ Contract with manufacturer
- ✓ 4/ Floats ordered
- ✓ 5/ Reception and acceptance tests
- ✓ 6/ Logistics and shipping floats



### BENEFITS FROM MOCCA PROJECT

- The MOCCA project demonstrated the operational capabilities of the ERIC to manage a large fleet and that centralizing procurement of this large fleet is beneficial for decreasing the overall costs.
- Acceptance tests helped to identify technical problems before deployment, these important tests contributed to reducing early at-sea failures and maximizing the return on investment.





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# FLOAT DEPLOYMENT: MOCCA IMPACT AND BENEFITS

Between 2016 and 2018, the MOCCA project supported the deployment of 150 Argo floats in key regions described in the Euro-Argo strategy for evolution of Argo in Europe. These deployments complemented the Euro-Argo contribution to the Argo network, focusing in filling identified gaps in the Atlantic Ocean, from North to South, and in the Southern Ocean.

## 150 DEPLOYMENTS RELYING ON A STRONG EUROPEAN COLLABORATION



© Joaquín Ignacio Salvador/ICM-CSIC

From Research Vessels



© Mocanu Marei

With the assistance of passenger ships

## ACHIEVEMENTS

**150 MOCCA floats deployed**  
by trained teams and engagement  
with a wide community

Involving the sailing community



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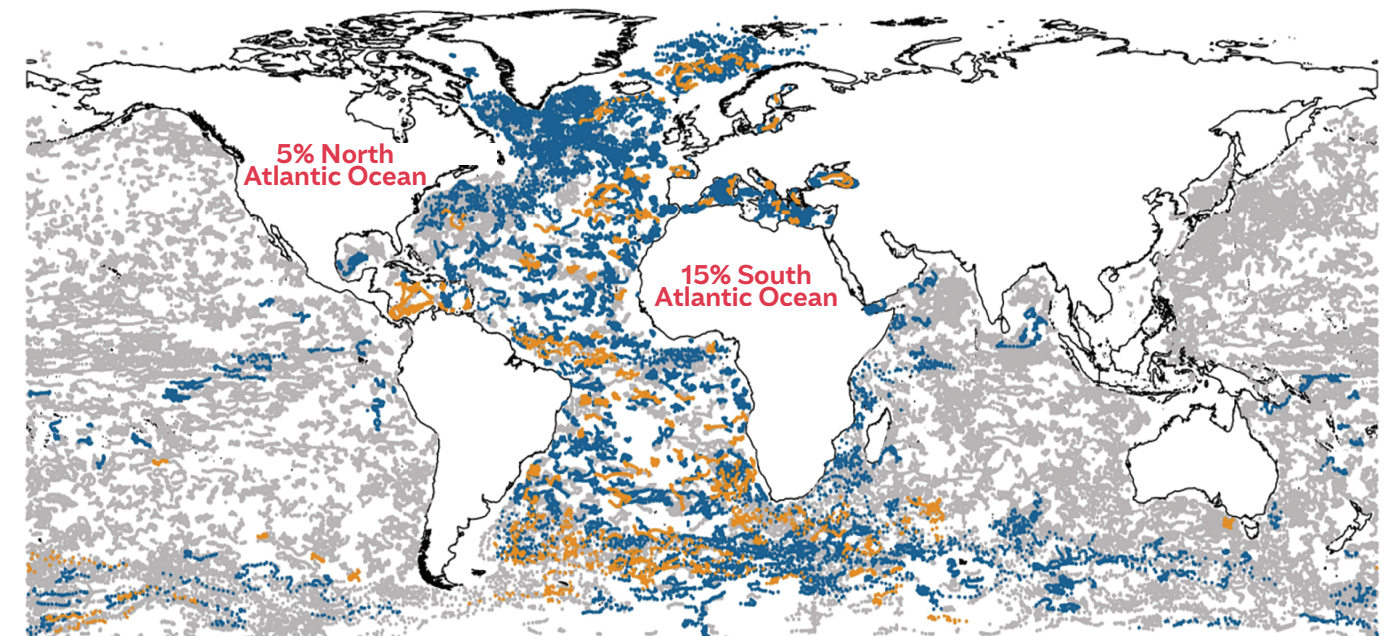
Partnership with cable-laying ships



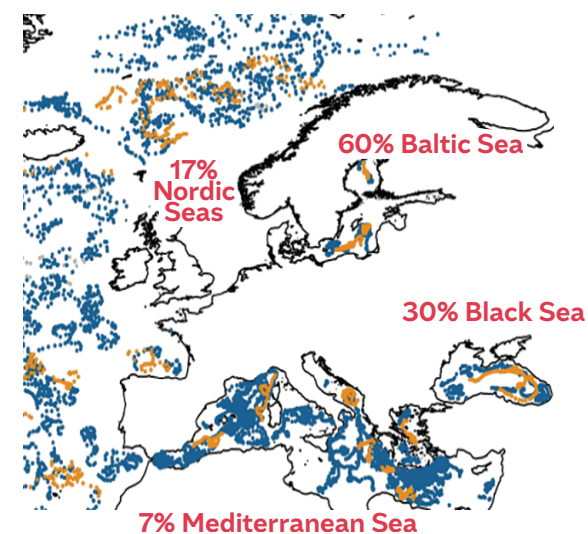
© Orange Marine

## INCREASED COVERAGE OF OBSERVATIONS FOR SCIENCE

This map shows all Argo CTD profiles collected in 2019. The Argo profiles collected thanks to MOCCA vs. all are represented with the %. E.g. 30% of the observations in 2019 in the Black Sea were collected from MOCCA floats.



Source: Coriolis GDAC & AIC



Data collected from:

- MOCCA
- EURO-ARGO
- ARGO INTERNATIONAL
- % MOCCA floats

## 5 TARGET DEPLOYMENT AREAS IN SUPPORT OF SCIENTIFIC QUESTIONS



**Nordic Seas:** "What are the key regions for the water mass transformation in the Nordic Seas? What are the key processes? What variability is observed? What is the impact of climate change on these processes?"



**Mediterranean Sea:** "How can MOCCA floats improve the data consistency in the whole Mediterranean Sea? What are the long-term changes in the mean intermediate circulation related to climate change in this key region?"



**Global ocean:** "What kind of new information can be derived from the deployment of MOCCA floats toward high latitudes (Nordic Seas) and Marginal Seas (Baltic, Mediterranean and Black Seas)?"

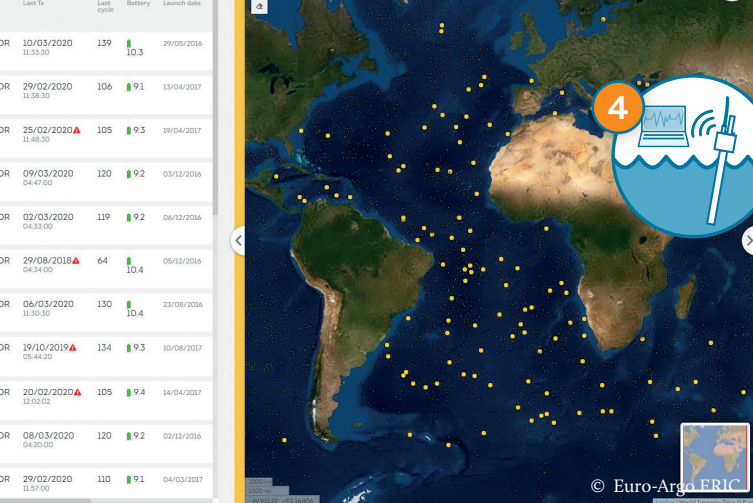


**North Atlantic:** "How are changes in the subpolar gyre connected to decadal variability in the subtropical gyre?"



**Off South Africa:** "What are the mechanisms among Agulhas rings? What are the processes of eddy transport or exchanges of heat and salt with other ocean basins? What are their role in the meridional overturning circulation (MOC) global circulation cell?"





## AT-SEA MONITORING: MOCCA IMPACT AND BENEFITS

Developed under the MOCCA project, the “at-sea monitoring” system allows visualization of key technical information of the floats along their trajectories. Several alerts and warnings regarding these parameters have been implemented and rapidly allow near real time problem detection, for a better assessment of the network’s health. This valued service is now available for the whole Argo community.

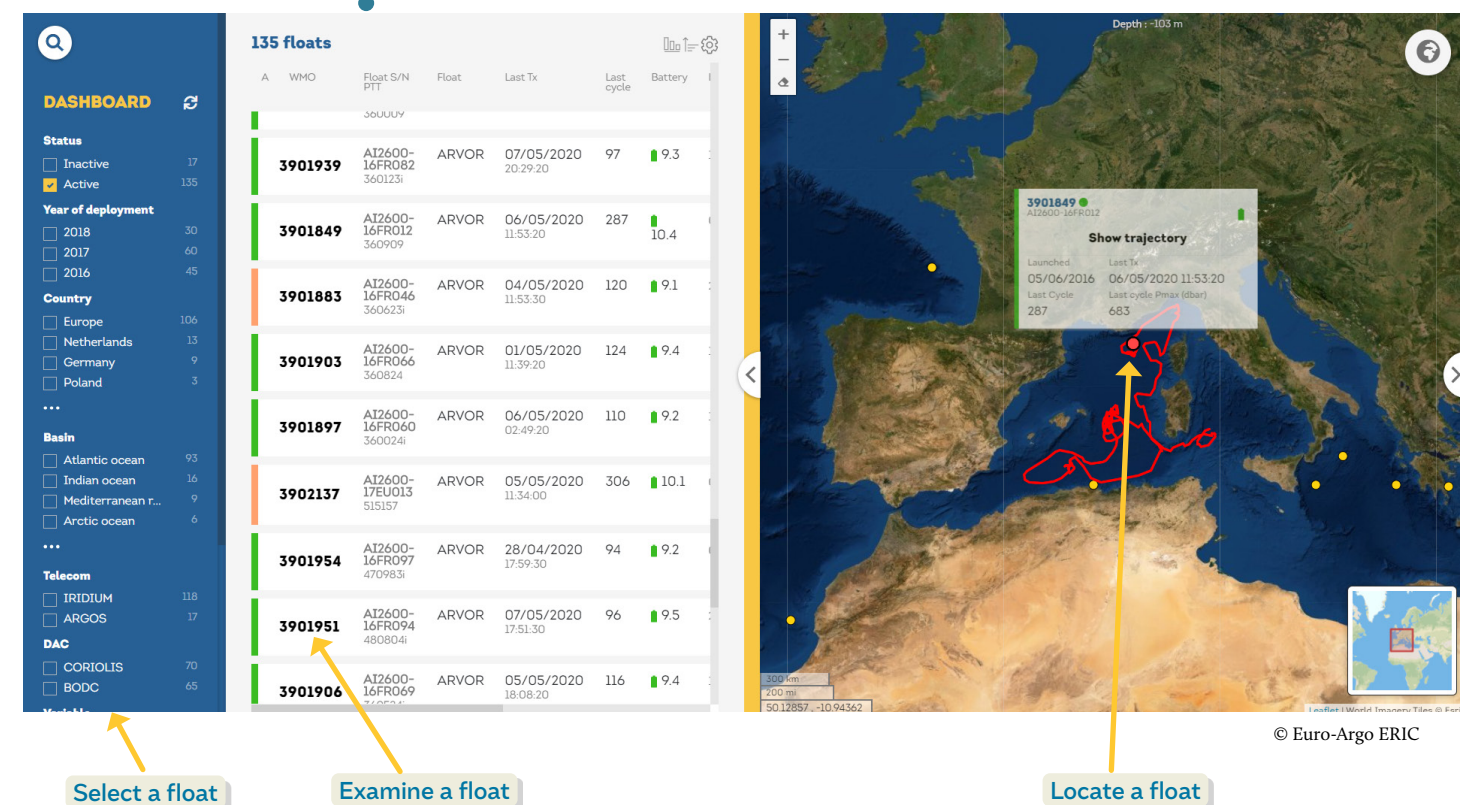
### AN UPDATED DEDICATED MONITORING TOOL

A new version of a dedicated monitoring tool (Argo dashboard) has been released in the framework of the MOCCA project:

<https://fleetmonitoring.euro-argo.eu>

It allows visualization of float metadata, ocean measurements, trajectories and technical parameters with specific alerts for the advanced users.

This website provides a lot of services to the community of Argo data users in a highly responsive and friendly webpage.



### THEMATIC STUDIES LAUNCHED THANKS TO MOCCA

In addition, the MOCCA project allowed thematic studies on specific technical or scientific topics:



Study of impact of waves on GPS/Iridium float performances.



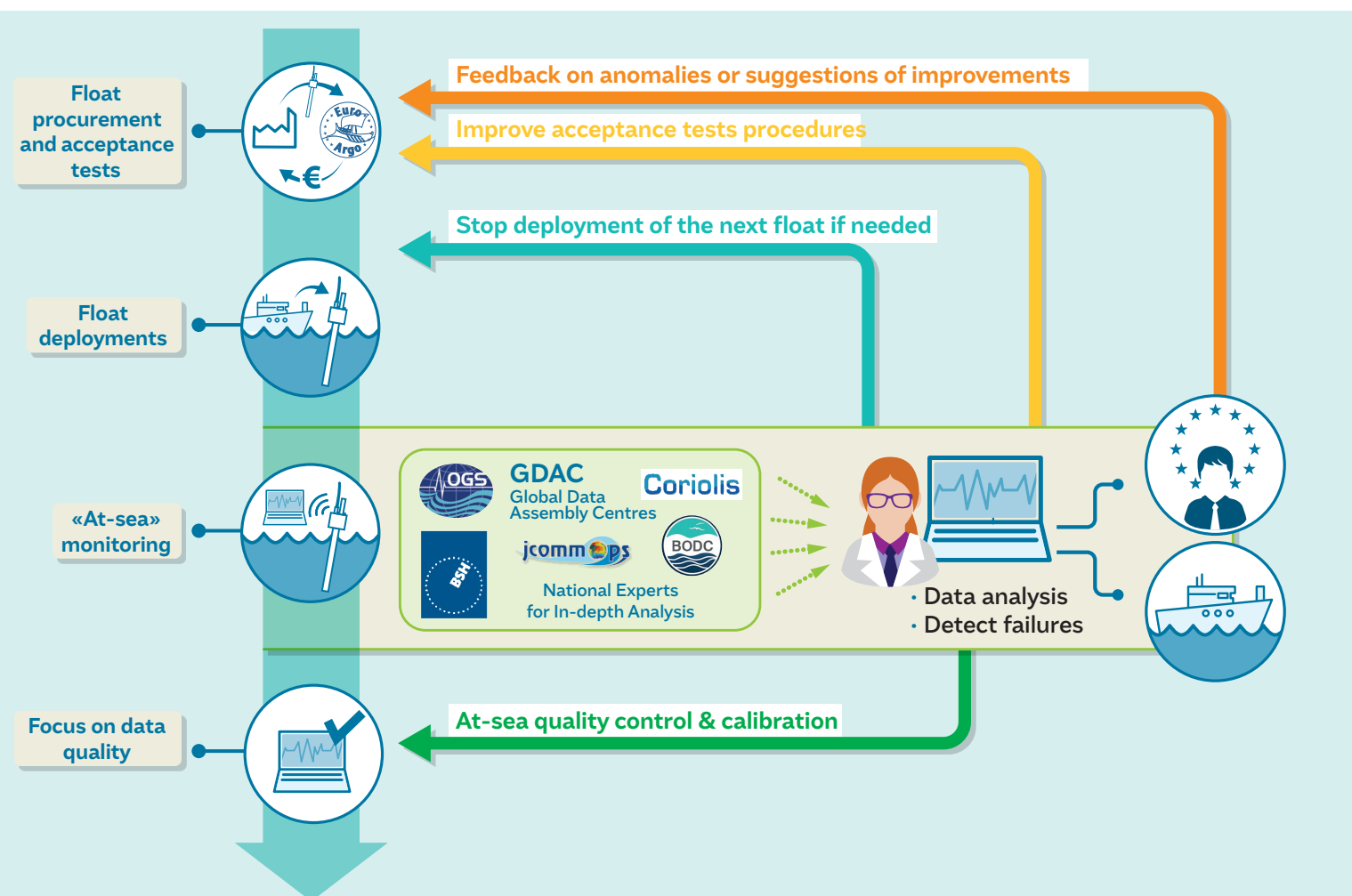
Study on float behavior in shallow waters, such as in Baltic Sea.



Analyses of floats that went under ice, checking technical data and improving ice-sensing algorithms in certain regions.



### A BETTER ASSESSMENT OF THE NETWORK



### MAIN ACHIEVEMENTS

#### GENERAL MOCCA STATISTICS IN JANUARY 2020:

**140** operational floats

**114** cycles per float  
(average number)

**1330** days lifetime ~3.6 years  
for the oldest platform

**95%** of the fleet  
achieved 50 cycles

**991** days lifetime ~2.7 years  
median age of the fleet

**89%** of the fleet  
achieved 100 cycles



**4** MOCCA floats recovered



5

## FOCUS ON DATA QUALITY: MOCCA IMPACT AND BENEFITS

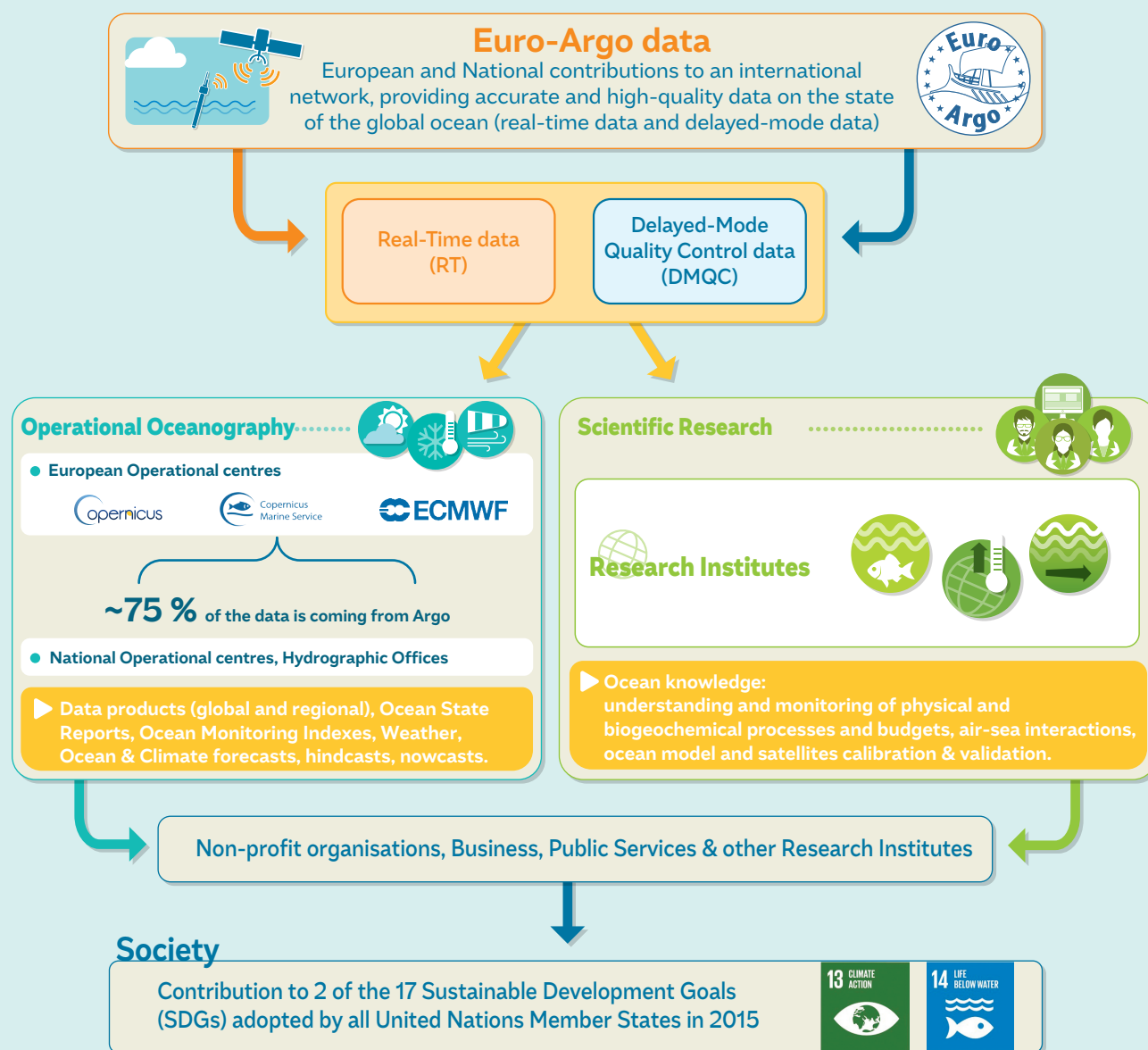
MOCCA float data are delivered to the Global Data Assembly Centre (GDAC) for the science community and to the Global Telecommunications System (GTS) used by Meteo Offices, in standardized data formats. Thanks to MOCCA project and partners, data was quality controlled to the best standards and many improvements of the real-time and delayed-mode procedures were carried out, resulting in an enhancement of the global Argo data management.

### INTEGRATION IN CURRENT ARGO DATA MANAGEMENT FLOW

There are two data processing modes:

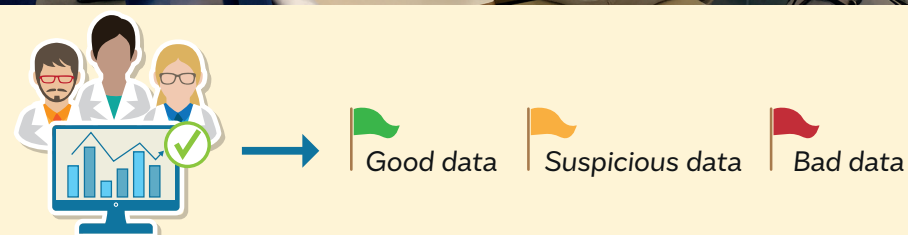
- The **Real-Time (RT)** data processing is applied according to the Argo standard procedures at European Data Assembly Centers (BODC, Ifremer). Initial automated QC tests are implemented to deliver data ready for operational users.
- The **Delayed-Mode Quality Control (DMQC)**, applied by specialists, makes the data research-ready. It is performed by

Euro-Argo MOCCA partners delayed-mode operators (BODC, Ifremer, OGS, BSH). It is based on statistical methods and comparison to a high-quality reference database of CTD profiles thanks to the scientific expertise from principal investigators (PIs). Malfunctioning sensors are identified and flagged and, if possible, issues are addressed in accordance with Argo guidelines. For instance, data could be calibrated for offset or drift.



### IMPROVEMENT OF DATA SERVICES EFFICIENCY

- The MOCCA project enabled the improvement of real-time data processing, including a new spike test and updating a list of malfunctioning sensors, known as the “grey list”.
- MOCCA partners updated reference datasets for the data quality controlled activity in Mediterranean, Black and Nordic Seas.
- Conversion of data software modules to open source language.



### MAIN ACHIEVEMENTS

#### STATUS OF MOCCA FLOAT DATA IN JANUARY 2020:

**20 000** temperature and salinity profiles (+500 each month)

**75%** of MOCCA observations have been quality controlled

**86%** of the MOCCA data is science ready (good data)

### TRAINING FOR DATA QUALITY CONTROL OFFERED TO EUROPEAN PARTNERS

As Euro-Argo extends to new countries, Members have identified a need to build capacity for Argo data quality control, in particular for the DMQC of temperature and salinity. MOCCA partners organised the **1st European Argo DMQC workshop in April 2018**, as part of the MOCCA project. This DMQC workshop allowed partners to:



Bring all Euro-Argo Member countries towards the same level of knowledge;



Make sure everybody has a common understanding of the Argo data system;



Start sharing DMQC procedures/tools/methods within EU.

MOCCA partners, at the first European Argo DMQC workshop, at Ifremer campus, Brest, 2018.





# MOCCA SUCCESS STORIES AND TESTIMONIALS



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**Tamaryn MORRIS**

Marine Coordinator at South African Weather Service

“Six MOCCA Argo floats were deployed in the Agulhas Current and were very successful in providing additional insight in to the dynamics of this fast-flowing Western Boundary Current. The floats captured inshore and offshore dynamics, as well as the stable fast-flowing core of the current, demonstrating its stability along the east coast of South Africa during this experiment. We look forward to continued collaborations with the MOCCA program on this and future endeavors.”



**Julie ZARADE**

Orange Marine, Quality, Safety, Environment Coordinator

“Thanks to MOCCA project, Orange Marine signed a partnership with Euro-Argo, making technical resources available to help deploy Euro-Argo floats, on transit routes of its cable ships. Since 2017, Orange Marine's ships have deployed about ten floats near Azores, in the Atlantic, in the South Pacific and even around the so-called “screaming fifties”! This partnership is a great opportunity for Orange Marine to take an active part in the international research on Climate Change.”



**Andreas STERL**

KNMI - Netherlands

“The availability of MOCCA floats made it possible to send some of them on short notice with a Dutch research cruise into the Caribbean Sea, where they now form the majority of active floats. Furthermore, we could increase our deployments in the Atlantic sector of the Southern Ocean.”



**Giulio NOTARSTEFANO**

OGS - Italy

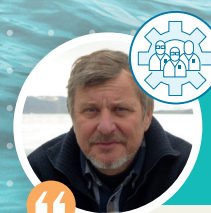
“One of the most substantial contributions of the MOCCA project to the Argo activity in the Mediterranean and Black Seas is related to the fleet monitoring tool designed by the Euro-Argo ERIC Office. Indeed, the new tool developed and provided in the framework of the project adds new features that significantly improved the monitoring of the fleet in difficult areas like these two Marginal Seas. Thus, it allows the operator to quickly act and modify the float mission configuration when needed.”



**Birgit KLEIN**

Euro-Argo Management Board Chair  
BSH - Germany

“The participation in the MOCCA project has contributed strongly to the sustainability of the German Argo program. Particularly the establishment of an ‘in situ-monitoring’ system has been a great achievement and had big impacts in our national programme. The easy access to technical data transmitted by the floats and the warning system has facilitated a much more efficient management of Argo Germany. Additionally, we have benefited from the shared expertise in the ERIC office and among members to advance the deployment of floats in the Arctic and the development of an Ice-Sensing-algorithm for the high northern latitudes.”



**Waldemar WALCZOWSKI**

IOPAN - Poland

“Poland deploys Argo floats in the Arctic, and since 2016 also in the Baltic Sea. The specific conditions of the Baltic Sea, especially the very strong pycnocline, made it difficult for ARGO profilers to reach the bottom. Cooperation with the MOCCA program, use of ARVOR floats and Euro-Argo technical support, allowed to overcome this difficulty. The DMQC of our Arctic floats and DMQC training is also very valuable to us.”



**Romain CANCOUËT**

Euro-Argo Office Operational Engineer

“MOCCA project also allowed the development of the Euro-Argo Office and of sustained services that were initiated within this project. MOCCA project included a very strong capacity building component: thanks to MOCCA, Bulgaria and Portugal deployed floats in 2016, and became Euro-Argo Member in 2018 and candidate Member in 2019 respectively. In addition, MOCCA project worked with some countries that are not Euro-Argo Members to deploy floats, such as Romania and Turkey in 2016, Croatia in 2017 and South Africa in 2017.”



**Susan WIJFFELS**

Senior Scientist, AST co-chair, Physical Oceanography Department WHOI - US

“MOCCA has greatly strengthened Europe's contribution to global Argo - by helping improve and sustain coverage in the Atlantic Ocean, through vital enhancements in Argo data management and quality control and through improving float reliability. Many of these developments have had very positive flow-on effects to the global array.”



**Matt DONNELLY**

NERC-BODC - UK

“MOCCA has enabled us to train a larger team of DMQC operators ensuring long-term sustainability of the team. This has involved the internal training of staff, training and knowledge sharing with European partners, a review of our internal procedures and tools, and liaising as an Argo Data Assembly Centre with DMQC operators external to BODC for the first time. The MOCCA project has supported us to contribute to the development of a new DMQC cookbook, undertake the DMQC of the MOCCA fleet and support the DMQC floats in national programmes.”



© Sabrina Speich/ENS



**Yves DEGRÉS**

nke Instrumentation Managing Director

“Orders related to the MOCCA project were very significant for nke in 2016. The proper functioning of the floats (observed through at-sea monitoring) has had a positive impact on the international image of nke. Thus for 2 years, nke became the manufacturer n°1 in terms of number of float deployments.”

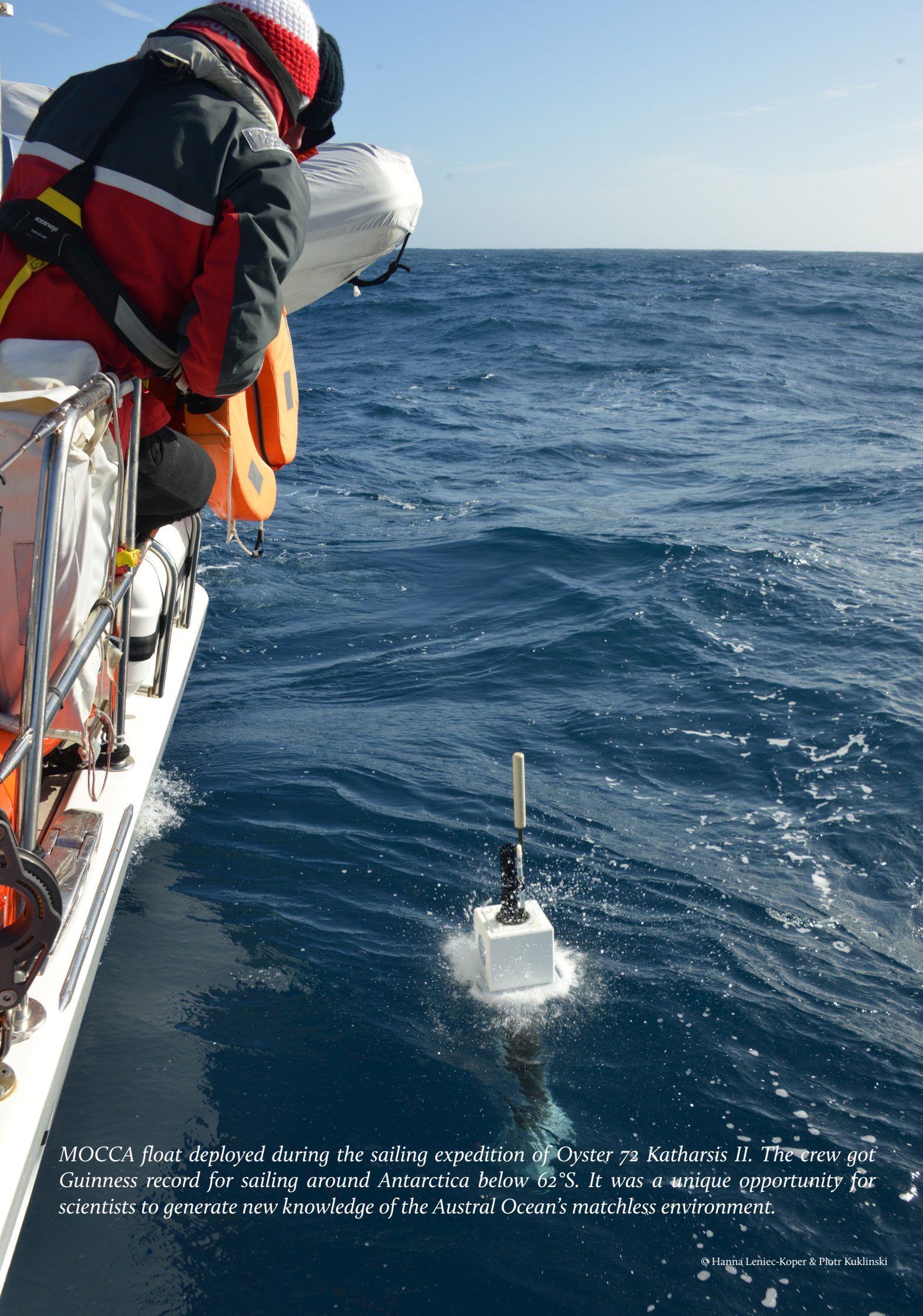


**Pierre-Yves LE TRAON**

Special Advisor to the Euro-Argo Council  
French representative

“From the very start of Euro-Argo, it was recognized that, given the global and international scope of Argo, European contributions to Argo should be shared between member states and the EU. Following numerous discussions between DG MARE, DG GROW and Euro-Argo ERIC, DG MARE took the lead in 2015 to contract the Euro-Argo ERIC so that the EU directly contributes to the core Argo array. This was the birth of the MOCCA project. The project has been highly successful and demonstrated that the procurement, deployment and processing of Argo floats can be very efficiently organized at European level. All MOCCA floats have been used and assimilated in real time in the Copernicus Marine Service (CMEMS) monitoring and forecasting centers. Data have also been integrated in the European Marine Observation and Data Network (EMODNET). Euro-Argo ERIC teams and Euro-Argo partners must be proud and congratulated for all these achievements. The challenge for the coming years will be to build on MOCCA to develop a sustained direct EU contribution to Argo and its deep ocean and biogeochemistry extensions.”





MOCCA float deployed during the sailing expedition of Oyster 72 Katharsis II. The crew got Guinness record for sailing around Antarctica below 62°S. It was a unique opportunity for scientists to generate new knowledge of the Austral Ocean's matchless environment.

© Hanna Leniec-Koper & Piotr Kuklinski

## THE MOCCA PROJECT'S 5-YEAR ACHIEVEMENTS



- Demonstration that Europe can significantly **contribute in a coordinated way** to the international Argo programme.



- **Central procurement service** through which Members can purchase floats for their national programmes.



- Implementation of the **Euro-Argo strategy** with **complementary EU funded float deployments**.



- **Better monitoring activities** and maximization of Argo float life expectancy.



- **Strengthening European Argo data efforts.**

### 6 Partners



### 2 Fundings



Co-funded by the EMFF programme of the European Union



Co-funded by Euro-Argo Members

### EURO-ARGO FUTURE SCIENTIFIC FOCUS

“**Better estimate the costs to society:** changes in Oceans dynamics that are not observed or well understood can result in significant societal impacts.”

“**Explore the deep Ocean:** half of the ocean's volume has yet to be observed by Argo.”

“**Understand the ocean ecosystems:** we are at a time where there is only rudimentary understanding of the ocean biological system.”

“**Quantify the oceanic CO<sub>2</sub> sink:** the North Atlantic is believed to represent the largest ocean sink for atmospheric carbon dioxide in the Northern Hemisphere, yet little is known about the temporal variability of this parameter.”

**165 standard Argo floats/year**  
As contribution to the global array



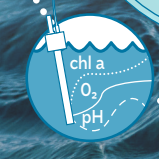
**60 floats/year**  
Monitoring Marginal Seas and extending to shallower waters



**EURO-ARGO 2030 TARGET**  
to contribute to the “global, full-depth and multidisciplinary Argo mission”



**50 DEEP floats/year**  
To understand deep ocean circulation



**50 BIOGEOCHEMICAL floats/year**  
To study ocean health, air/sea fluxes of CO<sub>2</sub>, primary production and acidification

**25 floats/year**  
Extending to high latitudes



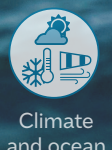
Climate Change



Global sea level rise



Ocean health, air/sea fluxes of CO<sub>2</sub> and acidification



Climate and ocean forecasts

### THE CHALLENGES FOR THE COMING YEARS

Build on **MOCCA success** to develop **Euro-Argo sustainability** through both **national partners contribution** and **direct European Union funding** for Argo and its deep ocean and biogeochemistry extensions.



Euro-Argo ERIC  
Campus Ifremer  
Technopôle Brest Iroise  
1625 Route de Sainte-Anne  
29280 Plouzané  
France



Tel.: +33 (0)2 98 22 44 83 | [www.euro-argo.eu](http://www.euro-argo.eu) | [euroargo@ifremer.fr](mailto:euroargo@ifremer.fr) | [🐦 @EuroArgoERIC](https://twitter.com/EuroArgoERIC)



This project has received financial support of the European Maritime and Fisheries Fund (EMFF)  
under grant agreement N° EASME/EMFF/2015/1.2.1.1/SI2.709624 Monitoring the Oceans