24th meeting of the International Argo Steering Team

Hosts: Department of Fisheries and Oceans Canada

Halifax, Canada

20 – 24 March, 2023

Link to google drive for AST-24 with presentations and reports

Link to google spreadsheet for AST-24 Action Items

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BGC Session

Introduction

In many respects, 2022 was a record year for BGC-Argo. Over 200 BGC floats were deployed, the most ever in one year. This continues an upward trend in BGC-Argo deployments. The number of multi-sensor floats also continues to increase. Data quality for all parameters continues to improve with better uniformity and accessibility. This is reflected in an increasing number of influential science publications. Despite the improvements, there continues to be a number of areas where additional work can be done. This includes additional data system improvements, platform and sensor improvements, organization of the Mission Team, and an update to the Science and Implementation Plan. Challenges include a proliferation of new sensor models for approved variables and a need to improve existing sensors and platforms.

Action 1: Write a letter of thanks to Blair Greenan and DFO for hosting the AST-24 meeting.
Who: *AST co-chairs*

BGC Argo mission status

By the end of 2022, the array was composed of 506 active floats provided by 17 nations. This is an annual record. Over the past 2 years, the BGC-Argo array increased by 10%. The goal of 1000 floats is still far from being reached but for the first time it is over 50%. After three years of few deployments, the trend has risen again, which is a very good signal. In 2022, 183 BGC-Argo floats were deployed to reach 80% of the target. A large contribution of US (100 BGC floats deployed over the past year) still maintains the network at a good level. With respect to the array design requirement, the coverage did not significantly change. In particular, the Indian Ocean, the Pacific Ocean and the Southern Ocean are still largely under-sampled. Still a limited number of BGC-Argo floats have the complete suite of sensors (40% of them carry only oxygen as extra sensor). Little progress has been achieved in 2022, with about 45% of the floats deployed with 5 or 6 BGC sensors. This will benefit the multi-disciplinary aspect and should encourage the community to continue its efforts. Outreach efforts to improve recognition for the program and public understanding is improving with programs such as Adopt-A-Float and involvement with the MATE ROV competition.

National Reports

Australia

Since March 2022, Argo Australia deployed 62 floats, including 56 core floats and 6 BGC floats. All 6 BGC floats include all six BGC sensors, and one included a UVP. We plan to deploy 47 floats in the next year, including 43 core clots and 4 BGC floats. Contracts with our major funder are ending, but we expect funding to continue. We expect to attract new funding for Deep Argo, and we're exploring new avenues with new partners. Over the past two years, we purchased 30 Alto floats with RBR CTDs as a contribution to the RBR Pilot array. We deployed 22 of these floats, with 14 early failures. Problems included loss of communication with the CTD, early battery depletion due to hardware fault (with Bluetooth constantly running), a hydraulic valve fault, and four unexplained failures. We've maintained high productivity in DMQC, including processing of floats with RBR CTDs, and we're making progress on data from BGC floats, which have posed some additional challenges. Our team members continue to show leadership in the Argo technicians community of practice and the Argo DMQC discussion series. These activities have helped us stay engaged with international colleagues, despite travel restrictions.

Canada

In 2022, Canadian researchers deployed 17 core floats with oxygen sensors and 8 BGC floats with different configurations of additional sensors (2 full-parameter floats with a high-sensitivity light sensor, one of them with an additional UVP; 2 floats with oxygen, chlorophyll, backscatter, and pH; 4 floats with oxygen, chlorophyll, and backscatter). A number of additional floats are either in store or have been ordered for deployment over the coming years: 9 core floats with oxygen; 5 full-parameter floats with a high-sensitivity light sensor, one of them with an additional UVP; 2 floats with oxygen, chlorophyll, backscatter, and pH; 5 floats with oxygen, chlorophyll, backscatter, and radiometry; 16 floats with oxygen, chlorophyll, and backscatter. Funding is in place for 27 additional BGC floats to be ordered in the coming year. The Canadian DAC expanded their processing system to handle data from NKE CTS4 floats (operational since fall of 2022) and is actively working on the capability for NKE's CTS5 floats for upcoming deployments. A Canadian adopt-a-float program was launched in March (https://adopt-a-float.ocean.dal.ca/).

China

In 2022, China Argo deployed three BGC floats; Now, China Argo is arranging 20 active BGC floats, including 7 in Northwest Pacific, 2 in Indian Ocean, 11 in Southwest Atlantic. In particular, there are 3 Chinese-made BGC floats (HM2000 Argo float with Aanderaa 4330 Oxygen sensor). In the next two years, China will deploy at least 10 BGC floats in the Northwest Pacific & North Indian Ocean, including: 2 Provor CTS-5 floats (observing all 6 core variables) from Ocean University of China (OUC), 4 Navis floats (observing 4 or 5 core variables) with SeaTrec rechargeable batteries from CSIO, 1 Provor-CTS 4 with an ECO sensor from CSIO, 3 Provor-CTS4 observing 4 or 5 core variables from Hainan Tropical Ocean University (HTOU) and from South China Sea Institute of Oceanography (SCSIO). In 2022, China researchers published 11 peer-reviewed papers using BGC-Argo floats, including 1 published in Communications Earth & Environment and 3 in Journal of Geophysical Research: Oceans.

UK

During the period from 2022 through March 2023, the UK deployed 12 BGC Argo floats. Nine of these were full (6-parameter) PROVOR floats as part of the ASBAN programme, including the first 6-parameter floats in the South Atlantic. One float was a 5-parameter PROVOR CTS-5, and two were 4-parameter NAVIS. An additional two floats experienced failures during deployment and were recovered (one NAVIS and one CTS-5). The UK currently plans 18 more deployments through 2025 (16 of these being 6-parameter floats through the ASBAN project). All UK float deployment efforts are concentrated in the Atlantic. The UK DAC, BODC, has commenced processing of 6-parameter ASBAN floats. All floats are now reporting data in near-real time. There are additionally 6 active and 35 inactive BGC floats for which BODC is processing core data only. There are 3 active floats still not yet processing data to the GDAC. BODC received training in 2022 and early 2023 for BGC DMQC and has commenced DMQC of oxygen data. As of March 2023, DOXY DMQC has been completed for 13 floats (4505 profiles).

EuroArgo

Euro-Argo aims to contribute to ¼ of the global OneArgo network, with a current target to deploy 50 full BGC floats per year and equip half of its fleet with oxygen sensors. However, Euro-Argo Members are currently updating their BGC-Argo implementation strategy and new targets should be defined in 2023, including regional refinements. In 2022, European partners have deployed 70 BGC floats with at least one BGC parameter in 2022, including 38 measuring at least 2 parameters, and 16 full BGC floats. As of March 17th, Europe had 197 active BGC floats, similar to last year, including 71 with more than 2 parameters. The plans for 2023 are encouraging, with a total of 105 floats, including 40 full 6 variables floats. In addition to European national activities, activities currently being carried out at European level include the organization of BGC-Argo data management, pCO2 sensor development and integration in collaboration with other RIs (GEORGE project), enhancement of BGC-Argo in the Black Sea (DOORS project) and lobbying for additional funds to sustain the European contribution to BGC-Argo.

France

Over the next 5 years and thanks to diverse funding sources, the annual French contribution to the global BGC-Argo array is expected to be ~15 floats with 5/6 variables and 20 floats with O2 only. All the BGC-Argo floats are based on the new Jumbo CTS5 from NKE. In the context of the EU ERC REFINE project, 22 of these floats additionally carry an underwater vision profiler (UVP) sensor and a transmissometer to better study the biological carbon pump. Ten of these floats are also equipped with a sensor combo measuring hyperspectral downwelling irradiance (Ed) and upwelling (Lu) radiance. As part of the PIANO project an active acoustic sensor is developed to be later deployed on the floats acquired by the Argo2030 project. During the Indian Ocean Cruise in fall 2022 onboard RV Agulhas II and funded by Monaco Explorations, the LOV team has deployed a total of 29 floats (Core, Deep and BGC) in the tropical Indian Ocean characterized by severe observation gaps. In 2022, seven research articles have been published with French scientists as co-authors and four in 2023 so far. Orens Pasqueron de Fomervault has been hired at OceanOPS thanks to a position funded by Monaco Explorations and hosted by Sorbonne University at LOV. It will help coordinate and promote BGC-Argo. In 2022 a new and more interactive version of Adopt a Float was released by LOV and more than 70 classes are presently involved in the adventure.

Germany

During the period 2020-2022, Germany has deployed a total of 24 BGC Argo floats (2 in 2020, 18 in 2021, 4 in 2022). The floats featured different float platforms (APEX, PROVOR III/IV/V) and a rather variable sensor setting (24 x O2, 12 x pH, 3 x NO3-, 17 x Chl a, 13 x CDOM, 17 x bbp, 9 x radiometry) depending on the scientific purpose and project funding background. Regional foci were the subpolar

North Atlantic/Labrador Sea, Baltic Sea, Mediterranean Sea, eastern tropical North Atlantic (Canary Current EBUS) and eastern subtropical South Atlantic (Benguela Current EBUS). For the period 2023/2024, we are planning deployment of 18 further BGC Argo floats. Both, the diverse sensor settings, as well as regional foci, will remain very similar to the recent deployment period. In recent years, a strong focus has been placed on BGC sensor evaluation and validation (e.g., pH, CO2 partial pressure, nitrate/bisulfide, radiometry). Evidence for pH from the subpolar North Atlantic points at significant uncertainties associated with the current best practice procedures for delayed mode quality control resulting in accuracy issues that were identified by comparison with independent in-situ pH observations. The work on sensor cal/val will be continued in the coming years.

India

In the Indian Ocean, the deployment of BGC floats started with oxygen sensors along with the core CTD sensors since 2006 (16 DOXY, 66 DOXY + CHLA + BBP700, 1 DOXY + CHLA + BBP700 + Nitrate). Four floats are deployed in collaboration with NIO, Goa. The majority of these floats are deployed in the Northern Indian Ocean and 13 are deployed in the Southern Indian Ocean south of 30 S. Unfortunately, no new floats could be deployed in the last one year and the total floats including core Argo contributed by India stands at 494 floats. DMQC of Doxy floats are being done using the SAGE tool and BD files are being pushed to GDAC. A method for correcting the Chlorophyll data is developed using the remote sensing data from MODIS satellite and the same was published in Deep Sea Research II. As per the suggestion of the ADMT, this method is still not implemented in generating the BD files and will wait for go ahead nod. Indian has initiated procurement of 50 floats (BGC and Core Argo floats) and will plan to deploy based on the ship time availability. All researchers and students are encouraged to use the available data in their scientific publications by enhancing our outreach activities.

Italy

Argo Italy has deployed a total of 20 BGC-Argo floats (16 DOXY, 2 DOXY + CHLA + BBBP700 + IRRADIANCE, and 2 DOXY + CHLA + BBBP700 + IRRADIANCE + NITRATE). Most of these are in the Mediterranean Sea, but we also have 3 DOXY floats in the Southern Ocean. BGC data management is currently handled by the Coriolis DAC, but we do have experts (for DOXY, BBP and IRRADIANCE) and have started discussing how members of the Italian BGC-Argo team could contribute to managing our data. The activities related to RTQC of BBP have moved to Italy and we are also currently seeking funding to develop DMQC methods for BBP. At OGS we also have a strong BGC modelling group that routinely uses BGC-Argo data for model development, validation and for data assimilation into the operational BGC model of the Med Sea distributed by Copernicus. For their activities, OGS modelers have developed additional QC of BGC-Argo data that could be integrated into the BGC-Argo data management.

Currently a large Italian project (ITINERIS) is providing funds for ~25 BGC-Argo floats (between OGS and CNR). These floats will mount most BGC-Argo sensors (except for pH) plus additional new sensors for hyperspectral irradiance and the UVP6. We are also considering testing new sensors (e.g., RBR Tridente) for existing BGC-Argo variables. Argo Italy have also decided to mount DOXY sensors on all core floats, which will support modelling and experimental studies in the Mediterranean Sea. Planned deployments for 2023 include 2 BGC + 2 DOXY floats in the western Med Sea, 1 DOXY float in the east Med Sea and 1 or 2 Deep floats with DOXY.

One important concern that we would like to raise with the AST is: How do we ensure that new sensors for existing BGC variables generate intercomparable data with the existing BGC-Argo dataset? This is an important issue for sensors that are not calibrated with certified reference materials.

Japan

In Japan, since 2005, more than 100 BGC floats have been deployed in the North Pacific, Indian Ocean and Southern Ocean. In 2022, two BGC floats have been deployed in the North Pacific. In 2023, five BGC floats will be deployed in the North Pacific and Southern Ocean. For ongoing programs, in the Hotspot2 project, 14 BGC floats were deployed in 2021 and 2022 to examine the mechanisms on formation and dissipation of O_2 maximum and minimum layers in the subtropical western North Pacific. Additionally, JAMSTEC, T.S.K, and TUMSAT are developing BGC NINJA floats with a fast repetition rate fluorometer and pH/CO_2 sensor. For the current status of data processing, JMA has been developing a program for RTQC of each parameter and conducted RTQC for O_2 with adjustments based on WOA in August 2022. JAMSTEC is currently developing a program for DMQC of O_2 and plans to submit BD files with O_2-adjusted values. Additionally, JAMSTEC is testing whether NO_3 and pH observed by BGC floats in the North Pacific can be effectively corrected by the SAGE.

Norway

Since 2019, Norway has deployed a total of 38 BGC-floats, 8 in 2019, 10 in 2020, 9 in 2021, and 11 in 2022. The floats were equipped with different number of sensors. 9 PROVOR floats were full BGC-floats (DO, chla, bbp, Irradiance, nitrate, pH), 13 PROVOR floats had 4 BGC-variables (DO, chla, bbp, Irradiance) while the other 16 floats (Arvor) had only oxygen as additional sensor (10 of these were deep floats). At present, Norway has 24 operative BGC-floats that include 6 floats with 6 BGC-variables. In 2023, Norway plans to deploy 10 BGC-floats. Two of these floats are full BGC-floats (PROVOR) including CROVER transmissometer and Underwater Vision Profiler (UVP6). Two other floats are also full BGC-floats (PROVOR). 4 other floats (PROVOR) are equipped with 4 BGC-variables and two floats (Arvor) have only oxygen. Norway does DMQC of oxygen, nitrate, and pH. DMQC of Chl-a is in progress and will be done during this spring.

US

The primary institutions in the US deploying BGC-Argo floats are the University of Washington, WHOI, Scripps, and the NOAA PMEL and AOML laboratories. In 2022, these groups deployed 107 BGC-Argo floats, most of which were 5 or 6 sensor floats. 120 floats were funded for deployment but the effects of COVID-19, supply chain issues, and cruise availability reduced the target. 139 floats are funded for deployment in 2023, with 25 already deployed. These will all be 5 or 6 sensor floats. Close coordination is made with the GO-SHIP program and floats will be deployed on A16, P14, and I05 cruises in 2023. Most of the data processing is done at MBARI. AOML is also developing the capability to process BGC data. Considerable work is being done to refine and improve sensors and platforms. This includes validation of the new SBS-83 oxygen sensor, adaptation of the Apex float to carry all 6 BGC sensors, and development of the new BGC SOLO-II float, which carries 6 BGC sensors.

Saudi Arabia

In 2021-2022, we purchased 2 NKE PROVOR BGC-ARGO to be deployed in the Red Sea. The first one has been deployed in the Northern Red Sea but after a month we lost communication with the float. When analyzing the data, we noticed that the sensor was not working for waters having high salinity values (> 40 PSU). We tried to solve this issue with the sensor's supplier and NKE but have not yet had success.

The second float was damaged during transport in our building and has been sent back to NKE for repair. We are hoping for a next deployment in 2023 or 2024 depending on NKE.

In parallel, a 5 year proposal has been submitted to purchase an array of BGC-Argo to be deployed in the Red Sea and Arabian Sea.

Data Management

ADMT23 report

The data quality has improved dramatically over the last few years as the data quantity continues to grow, and downloading the full dataset is now easier than ever thanks to the implementation of the standalone synthetic profiles DOI in 2022.

During the ADMT meeting, an action has been taken with the MET Office to specify vocabulary and units for some new parameters to be pushed (e.g. CHLA, NITRATE) in the BUFR format to the GTS. Some specifications have been written and have been added to the BGC QC cover document with an updated list of the Argo parameters.

There are also many upcoming challenges facing BGC Argo data managers. Modified and new sensors and floats will continue to be developed and become operational once approved by IOC. These could be FLBBFL Sea-Bird, RBR BGC sensors, Pyroscience Pico pH optode, LioniX ISFET pH sensor, Trios OPUS nitrate, Trios RAMSES hyperspectral radiometers, New oxygen foils from Aanderaa, SBE83 Sea-Bird and new MRV BGC SOLO II float. Pushing these improvements also requires resources both for development and implementation. There is still a need to foster the support between DACS, by providing codes, outputs and guidance on sensor performance, monitoring and quality control, particularly as data management procedures continue to develop and be refined. AST feedback is required to define rules to prepare the acceptance of a new sensor measuring an already approved parameter (comparisons with previous sensors, amount of sensors at sea, processing and QC procedures …)

Since the ADMT, a drive has been set to share the documentation (processing and QC) to foster the collaboration and speed the updates : the BGC QC cover document (Bad PSAL recovery), the pH updates : processing and QC, the nitrate temperature correction in the processing documentation, and the BBP QC document, as examples. All these documentations have already been updated on the drive and are under review by the task team. All people interested in participating in writing the documentation should volunteer with Tanya or Catherine to get the rights to edit.

The first BGC DMQC workshop has been organized in Villefranche from the 23 january to the 26 january 2023. The first two days were focused on DOXY (background, softwares, and use cases), the third day on NITRATE and pH and the last day on biooptics (Radiometry, BBP, CHLA). All the feedbacks from the participants were extremely positive.

We are all fortunate that Orens Pasqueron de Fommervault has recently taken a position heading the BGC Argo project office hosted by Sorbonne University, operated at IMEV-LOV, and sponsored by Explorations of Monaco.

Regarding discussions on specific BGC PARAMETERS, the following list highlights key status points from the recent meeting:

-DOXY : time response implementation in DM has been endorsed

-NITRATE : new temperature correction is now endorsed for processing, paper submitted, documentation is under review in the drive

-pH : Honeywell will continue the production of ISFET chips, documentation is under review in the drive

-BBP : paper presenting the RTQC procedure has been submitted, documentation is under review in the drive

-CHLA : a single way to provide CHLA scale factor estimates is presented and during the BGC DMQC workshop new possible ways to help DACs to process CHLA consistently rose and the work is on-going

-Radiometry: working group recommendations include 4 bands – 380, 443, 490, and 555 nm (PAR removed), PRES > 250dbars, vertical sampling < 1m.

BGC DMQC report

This year, the BGC-Argo community held the first BGC-Argo delayed-mode quality control (DMQC) workshop in Villefranche, France (January 23-27), hosted by the Laboratoire d'Océanographie de Villefranche (LOV). Over fifty participants attended (24 in-person). The main objectives of this hybrid workshop included training participants on DMQC methods currently in use for BGC parameters, facilitating international use of available QC software tools, and promoting collaboration and communication among Argo data centers. These objectives support the broader community goal of maintaining a unified, standardized global Argo dataset. The workshop incorporated a mix of presentations on BGC sensor operation and quality control, as well as a practical component where DMQC was reviewed collectively by the group for select case studies. Different software tools were also compared and discussed. Throughout the week, key processes and areas of the DMQC approach that require further refinement for various parameters were also identified. For example, these included discrepancies seen in DMQC results using the LOCODOX software for DOXY, how to handle large animal spikes in select BBP signals, and new methods proposed for improving the fluorescence-to-Chla slope factor. Some of these issues were brought to AST for further discussion and planning. There was lots of positive feedback from participants at the workshop, and the community plans to continue with this framework into the future.

DAC status, issues

One question from the DMQC workshop came back to the BGC Mission Team to address. This is, how should we flag bio-optical data in the mesopelagic that are detecting mid-water organisms? After much discussion it was agreed that the Data Team should:

Retain the automated QC signal of bad or questionable/probably bad that are applied in R mode files for the “extensive” mid-water excursions due to organisms in the A and D mode files

DM QC operators should provide an Index File of profiles/data segments that they believe contain the signal of mesopelagic organisms.

Product

The development and delivery of BGC-Argo products (e.g. gridded products for some variable) has been discussed as part of ADMT and DMQC meetings or workshops. While such products are needed and requested by the end-user (modeling) community, their production and delivery might put additional workload on data managers at a time when production of high-quality BGC-Argo data remains the priority of the mission. On certain occasions, the development of BGC-Argo products might nevertheless be key for the delivery of the best quality BGC-Argo data for some variables. This is the case for Chla, where the production of synthetic products of profiles of Chla and radiometry, through neural network method initially developed for backscattering (SOCA: Sauzède et al., 2016), might allow the development of globally interoperable DM procedure for this variable. Additionally, this procedure would allow a better evaluation of the DM-Chla estimate against the extensive Chla HPLC database, the key reference for such measurements.

Implementation

Radiometry WG report

Here was presented a summary of the activities carried out by the WG on BGC-Argo radiometry during 2022. The group was established in 2021 and met once during the last year. The WG has four main goals: 1) to select a common set of bands for radiometers to be installed on BGC-Argo; 2) to recommend the optimal vertical resolution of radiometry; 3) to perform a cost-benefits analysis between multi-spectral and hyper-spectral radiometry; 4) to recommend the optimal sampling depth for a radiometric profile. The analysis carried out by the WG yielded the following results:

1) The following bands 380, 443, 490 and 555 nm are the best candidates for BGC-Argo as they provide useful (not redundant) biogeochemical information and links with current satellite measurements. The channel dedicated to PAR will thus be replaced. Radiative-Transfer (RT) simulations have shown that PAR can be estimated from the four selected bands very accurately.

2) ≤1-m resolution is the recommended vertical resolution for radiometry as it allows to reproduce the optical properties of phytoplankton communities and to better characterize the FChl signal for calibration purposes. The recommended resolution will not produce any significant changes in energy consumption with respect to degraded resolutions (e.g., 2m, 5m).

3) Hyper-spectral radiometry will allow to increase the number of EOV/ECV/EBV acquired by BGC-Argo by helping definition of phytoplankton abundance and community structure. Hyper-spectral radiometry will also help to better understand Mixed Layer Dynamics. However, hyper-spectral radiometry is more expensive than multi-spectral solutions in terms of price of the sensors, data transmission costs and energy consumption. WG final recommendation is, for who has the capacity, to move to hyperspectral radiometry.

4) Radiometry must always be sampled between 0 and 250 dbar, unless the float is sampling very clear environments (e.g., subtropical gyres). In these cases, we recommend that the float PI allows the float to start sampling radiometry deeper (e.g., at 300-500 dbar).

WG activities are almost completed, only a few additional tests must be done on PAR estimations. PAR RT model will be open, but probably we need to distribute via Argo channels the PAR estimated values to guarantee our legacy. After main goals have been fully accomplished, the WG will still meet once a year to discuss any BGC-Argo radiometry issues.

BGC Argo float timing and scientific objectives

Steve Riser updated the AST on the final recommendations from the ad hoc Argo Sampling committee. He showed histograms of local surfacing times by DAC for floats deployed in 2021-2022 and 2022-2023 and they times are not uniformly distributed which leads to bias in estimating ocean temperature, upper ocean heat content and surface heat flux. To prevent this, the working group had four recommendations:

1) All Argo floats should be set to sample at approximately, but not exactly, 10-day intervals (an example is the use of a 10.08 day interval), with a park depth of 1000m and a profile depth of 2000m, whenever possible. The goal should be to obtain an even distribution of surfacing time.
2) This approximate 10-day sampling should be implemented on all core- and BGC-Argo floats to be deployed in the future, with users changing the manufacturer's default settings to this protocol prior to deployment when necessary.
3) Present floats using some other protocol yielding non-uniform sampling should be changed to the 10-day protocol as soon as it is feasible, using two-way communication.
4) Float users and manufacturers should work together to ensure that these changes are implemented in the proper manner.

Steve Riser then presented information about when the preferred sampling time is for the various core and BGC Argo sensors. To accommodate the desire for the radiometer to sample at noon, the group suggested the following strategies:

1) Add one full 0-2000m noon profile at 1 or 2 month intervals.
2) Flag these in the database, so they can be removed if not wanted (no timing interruptions).
3) Set the radiometer to sample at the maximum practical rate near the surface during ascent.

Finally, park sampling recommendations were shared:

1) All BGC-Argo floats should sample temperature, pressure, FLBB and radiometer hourly during the park phase.
2) Salinity and nitrates would be useful, but the energy cost is too high. Note that O2, pH and NO3 all require salinity measurements.

Action 2: Ask for a report at ADMT-24 & AST-25 on the time of day of profiles in the past year and if the extra noon profiles have been added. ***Who**: Steve Riser*

Action 3: Ask ADMT to find a way to flag noon time profiles in the data system for those who want to remove them from their analyses. ***Who**: John Gilson, Megan Scanderbeg, ?*

Deployment planning tools

It has been recalled that submitting a deployment plan to OceanOPS is a requirement under the law of the sea. In addition, it is also beneficial for the Argo community as it helps with network monitoring, projections, basin-scale coordination, etc. Unfortunately, only a few operators submit their plans, at least for BGC-Argo which is a significant issue. During the presentation, the 4 different methods for submitting data to OceanOPS were presented (with the first compulsory step being to create an account to gain write access to one or more programs). It was also noted that this process can be done machine-to-machine. Discussions are ongoing to improve the tools and encourage the community to submit their plans. In particular, a way to ingest deployment plans from the US GO-BGC program (half of the BGC-Argo fleet) must be found.

Sensor and float updates

BGC SOLO updates

The BGC SOLO is a recently developed 6 sensor BGC Argo float model based on the energy efficient SOLO-II core model. The BGC SOLO carries all SBE sensors and measures Dissolved Oxygen, Nitrate, pH, backscatter, chlorophyll fluorescents, and downwelling irradiance in addition to the core parameters. The BGC SOLO was developed in 2022 by SIOs IDG lab who has since deployed 4 floats. Three are still active (deployed between March 2022 and Feb 2023) with float 001 cycling at 3 day intervals, having already reached over 180 cycles. The float model has performed well overall, with some sensor failures unrelated to the platform. A commercial license was finalized in Fall of 2022 and SIO has been working this year with MRV systems to transfer the design and production to them. MRV engineers visited SIO to observe the assembly of a float and are in the process of ordering parts and transitioning the design to be production ready. First deliveries from MRV are expected in December of 2023.

Jumbo CTS5 NKE

The CTS5 JUMBO from NKE is a new float with additional capabilities. It can manage the acquisition of the six BGC-Argo variables with a tunable vertical sampling resolution. Additionally, it can carry new sensors (or sensor in particular configuration) including (1) the Hydroptics underwater vision profiler (UVP6) with embedded AI-based animal recognition sensor (2) the SBE C-Rover transmissometer mounted in vertical position and that can be flushed during parking depth through a SBE pump when it is in the so-called optical sediment trap mode (3) a combo of hyperspectral downwelling irradiance (Ed) and upwelling (Lu) radiance from Trios (4) the OPUS Nitrate sensor from Trios. The extended (20 cm) hull allows for more batteries to increase the available energy by 65%. Hence, this float has the potential not only to acquire the 6 BGC-Argo variables but also additional variables in the OneArgo standard acquisition mode and over extended periods expected to be greater than 5 years. A GUI allows optimizing the sampling strategy and to accommodate for specific schemes like data acquisition as part multi-parking depth, in the same time it provides an energy budget for the planned mission.

NAVIS/APEX floats

Steve Riser reported on the status of Navis and Apex floats as part of the Argo fleet and noted that Apex has been 24% of floats of floats deployed in the past five years and Navis has been 16%. He reported on the performance of UW Apex floats and noted that while floats that encounter ice have a shorter life expectancy, about 70% still make 200 profiles. BGC Apex floats were also looking quite good, except for a sharp drop off around 150 cycles which has been identified as a battery issue which is being addressed. UW and MBARI worked to modify a BGC Apex float to accept all six sensors to be compliant with the BGC Argo Mission and one will be deployed soon. He then reported on some issues with Apex floats including the ongoing air bladder problem and supply chain issues for the BGC Apex hull.

In terms of the Navis, delivery of the BGC Navis is behind schedule and require a great deal of in-house testing at the moment which has added to delays. SeaBird is developing an updated BGC Navis which will hold more batteries and have an improving pumping mechanism. Testing will take place throughout 2023 with possible delivery in late 2023 of the first floats.

pH sensor

The pH sensor has presented a number of challenges in the past 2 years. Excessive failure rates in SBS pH sensor were found. Laboratory investigation pointed to failures at an o-ring sealing the reference sensor caused by improper o-ring selection and excessive mechanical tolerances. These issues have been rectified and we believe the problem is solved. In June, we were informed that Honeywell would stop production of the ISFET semiconductor at the heart of the sensor. However, it now appears that Honeywell has restarted production and this problem may be resolved. A new version of the DuraFET pH sensor, termed the Gasket DuraFET (GDF) has been developed. The sensing components are identical to existing components, but mechanical seals are improved or eliminated altogether. 14 GDF sensors have been deployed with no failures. To mitigate this sole-source supply issue for ISFET die, several groups have approached a new semiconductor supplier to produce an alternative solution. This project is underway, but the first semiconductors will not arrive until June. A pH optode has also been tested extensively for use on floats. The response time found on glider deployments is probably too slow for profiling floats, but the manufacturer has indicated that they have options to improve response time and that work is underway.

Mini ISUS

A new version of the ISUS nitrate sensor is in development, termed the mini-ISUS. It is designed to be attached externally to a float. Design goals were a positively buoyant instrument that was more easily manufactured than existing instruments. It was also required to be small enough to fit in the wetted instrument bay of a Spray-II glider, to enable 6 sensor gliders. Due to supply chain issues, work has been delayed and final assembly and testing won't occur until summer 2023.

Opus sensor

The TRIOS OPUS nitrate sensor is a potential, less expensive alternative to the SBE SUNA. Basically, it relies on the same measurement principle, and is rated to 6000m. As part of the 2025 DArgo program, two NKE CTS5 floats have been equipped with both sensors. They have been deployed in the Baltic Sea to evaluate their respective performances and compare sensor measurements to reference profiles (acquired over the deployment period). Both floats have acquired, down to a maximal depth of 250m, more than 200 profiles each in waters where concentrations are low (maximum < 12 uM). Overall OPUS data are a bit more scattered, but not biased when compared to SUNA ones. OPUS displays a faster response thanks to a better flushed path. Overall OPUS and SUNA give equivalent and accurate data after DMQC. The first results are therefore encouraging but more field deployments (especially with standard missions : 0–2000 dbar) are required to confirm the potential of OPUS.

UVP sensor

Described in Picheral et al. 2023 (Doi: 10.1002/lom3.10475), the Underwater Vision Profiler (UVP6) is a low power image-based sensor with a sensing volume of 0.7 L that allows to see particles in the size range 100 mm-2.5 cm and that has an embedded AI-based taxonomic identification for 20 classes of plankton. UVP6 sensors address new variables that might have the potential to interest a wider and new community by providing observations relevant to the Biological Carbon pump as well as Ecology / fisheries. Available from Hydroptics, this instrument is presently implemented on the PROVOR CTS5. Close to ~ 25 units have been (will be soon) deployed by Argo-France and other countries (Norway, Australia) by the end of this year. The implementation of the "data pipeline" is ongoing at Coriolis.

Hyperspectral radiometry

Radiometer sensor diversification is starting. Beside the OC4 from SBE, Biospherical Instruments is providing a high-dynamic range sensor (MPE-PAR) while TRIOS proposes the RAMSES, a downwelling irradiance (Ed) hyperspectral sensor. All three sensors have been intercompared onto a PROVOR and surprisingly the RAMSES appears more sensitive than the OC4. A new supplier (RBR) has announced that it will soon release a multi-spectral sensor. For all these sensors, the interoperability should be facilitated by NIST traceability. The hyperspectral dowelling RAMSES sensor has also been implemented onto the APEX float. With the data acquisition mode being different according to float (e.g. 70 wavelengths for PROVOR; 255 wavelengths for APEX) this imposes a different processing scheme. On-going work is undertaken to establish specifications (available on the BGC Documentation drive). Once done, reprocessing will start at Coriolis. Finally, a combo of two RAMSES hyperspectral sensors, Ed together with upwelling (Lu) radiance. This combination has begun to be tested onto NKE CTS5 Jumbo in view of contributing to Cal/Val activities of Ocean Color sensor, especially NASA-hyperspectral PACE sensor which will likely be launched by early 2024.

New RBR BGC sensors

A review of the released RBR BGC sensors was presented. That included:

The optode RBR*coda*[3] T.ODO: with a review of its specs and calibration procedure

The optical sensor RBR*tridente*: focusing on the three channels backscatter, Chl-a, and fDOM. The carefully considered geometry of the sensor, its calibration procedures, and its power consumption were presented.

The radiometric instrument RBR*quadrante*: Both PAR and single wavelength radiometers were introduced, focusing on the cosine and spectral response of the PAR sensor and the calibration laboratory RBR has installed at RBR.

New SBE BGC sensors

Eric Rehm from Sea-Bird presented information on BGC sensors including the dual-wave fluorometer and the eco v2 as well as work done to make metadata machine readable. He presented information on the relationship between chlorophyll fluorescence and total chlorophyll a pigment concentration, with the Southern Ocean showing the highest anomaly. Sea-Bird has investigated this variability and suggests that somewhere in the 426-441nm range would be the best balance. So, they are testing a new chlorophyll a sensor with excitation at 435nm which should be more widely available soon. He then showed work done at Sea-Bird to make the CTD metadata machine readable in a JSON format using the Argo vocabulary and asked for feedback. Sea-Bird has not yet allocated resources to deliver this, but will likely begin with NAVIS floats which they produce.

ARO-FT sensor

ARO-FT is an optical DOXY sensor, developed by JFE Advantech in collaboration with JAMSTEC in 2011. Its features are higher accuracy (± 2 **μ**mol/kg or ± 2%) and faster response time (< 1 sec) than other sensors. JAMSTEC has deployed 16 floats with ARO-FT since 2014 in the North Pacific. Three items were examined for ARO-FT; (1) Storage drift of ARO-FT in laboratory, (2) Comparison ARO-FT with bottle data at float's deployment, and (3) Time drift of ARO-FT. (1) was examined by JFE Advantech in their laboratory. It is within - 1% for the first 100 days, at oxygen concentration of 100% air saturation and T=20°C. Due to (2), we found that the difference between DOXY of most ARO-FTs and bottle data has a clear linear relationship with bottle data at floats' deployment, according to their fast response time. DOXY of ARO-FTs were able to be corrected with the range of initial accuracy by using slope and offset of their linear relation for each floats. When (3) was examined by using DOXY measured in air at each cycle, we found that ARO-FTs have small time drift and are very stable. But, floats are not likely to measure DOXY in air well. Although floats are not likely to measure DOXY in air well, JAMSTEC developed the correction equation for ARO-FT's DOXY, which is a linear equation similar to other sensors. When the corrected DOXY profiles at more than 200 days after floats deployment were compared with the nearest bottle data within 25 days and 35 km for them, the difference between the two were within ± 4 **μ**mol/kg at the layer deeper than 1200 dbar. JAMSTEC continues to monitor ARO-FT's time drift and try to explore the cause of slightly large offsets and slope of the first DOXY profile.

Diversification of sensors (for the same variable): impact on DAC dataset

Since the beginning of BGC-Argo, and except for O2, our community has relied on a single sensor for each of the five other BGC-variables. For these variables, there are now several types of sensors (with different maturity), some of them presenting differences in measurement principles (as for the CTD Seabird vs RBR). This diversity can be a strength as competition between companies to deliver the best sensors for the community should be a priori beneficial both in terms of price and sensor performance. This diversity can nevertheless be an issue: if not properly a priori evaluated, the inclusion of low performance sensors in the array would be detrimental. Additionally, new (and sometimes complex) sensors mean new decoders, workload on data managers and developers (more code, more documentation) in a context where DAC are already understaffed to deliver QC data. With the complexification of sensors (e.g. hyperspectral radiometry), documentation could become more sensor- than parameter-driven and QC methods might be more linked to the sensor rather than to the parameter. Therefore, in the integration phase of a new sensor by a DAC a tight collaboration between data managers involved in the documentation together with specialists of the measurements / developers of the sensor has to be ensured.

The need to set up a technological TT ?

The BGC-Argo mission faces issues for securing the supply of sensors while maintaining interoperability of measurements for standard variables. In parallel, the diversification of sensors for the same variables offer potential interesting opportunities but requires a priori proper evaluation of their performance before their integration in the array. Within the BGC-Argo community, the technological expertise on variables (and sensors to measure them) is scattered among various groups who do not have a good forum to share this expertise for the benefit of the greatest number. The BGC-Argo AST meetings cannot allocate enough time to review and address in detail the technological aspects that are becoming increasingly important for the cost-effective development the BGC-Argo array. The establishment of a BGC-Argo Technological Task Team is encouraged as it should be the place for technological experts to discuss and develop recommendations ensuring the best technology be use by the BGC-Argo mission. The necessary interaction of this Task Team together with BGC AST and BGC-ADMT is obvious.

Action 4: AST suggests the formation of a Technology Task Team for BGC Argo sensors. **Who**: *Edouard Leymarie, Orens* de Fommervault, ?

Long term sensor performance assessment

A key to the success of core Argo has been continuous assessment of platform and sensor performance. Similar assessments of BGC sensor and platform performance should be an integral part of BGC-Argo. Sensor performance is regularly assessed in the SOCCOM and GO-BGC projects and examples of performance for different sensor models, such as ISUS and SUNA nitrate sensors or Aanderaa and SBS oxygen sensors, were shown. It is clear that there have been periodic drops in performance of various sensor types that can be traced back to specific manufacturing issues. While this is done in the SOCCOM and GO-BGC projects, it would be more powerful to be able to routinely do such comparisons across the entire BGC-Argo array. That will require new monitoring tools from OceanOps and careful attention to metadata by the float deployers.

How OceanOps can help in setting BGC-Argo monitoring tools

Over the past several years, it has been discussed in AST and ADMT meetings the need for direct collaboration between OceanOPS and BGC-Argo volunteers to develop and improve the tools and metrics available on the web interface. Although the number of products is significant and constantly evolving, it seems insufficient to meet the expectations of the BGC-Argo community. Specifically, "hot topics" are emerging that would merit priority attention, such as monitoring sensor performances and providing KPIs as a function of the cycle number. It was noted that the lack of manpower at OceanOPS is hindering developments. To address these issues efficiently, a formal working group will be established. Orens de Fommervault will send an email to identified volunteers to work on a technical document specifying their needs.

BECI and BGC Argo

Tetjana Ross presented on behalf of the Basin-scale Events to Coastal Impacts (BECI) UN Ocean Decade Project. Their objective is to implement an international ocean intelligence system of monitoring, research and analytical approaches that provide timely advice to decision makers about the impact of current and future climate conditions on socio-ecological systems. Work needs to be done to identify users and scientific partners, such as BGC Argo, as well as finding potential funding. The plan is to assemble a BECI Science Plan writing team drawing from existing PICES experts and to obtain full plan approval at PICES 2023.

Revising the Implementation Plan

The BGC-Argo Science and Implementation plan was written in 2016. Various changes in the past 7 years require that it be updated. Areas that need revision include:

The role of 5 vs. 6 sensor floats

The role of oxygen only floats

This topic led to a discussion that suggested a workshop on adding more oxygen is needed. The workshop preparation should include OSSE’s that define the desired number of oxygen only floats.

The effect of increasing costs on BGC-Argo floats.

Website / newsletters / outreach

During the meeting, updates on ongoing BGC-Argo communication efforts were presented and are listed below.

The BGC-Argo website (https://biogeochemical-argo.org/) is currently being redesigned to improve its functionality. In particular, the bibliography is being monitored more regularly, and partners were asked to send in any newly published papers.

The newsletter system is being relaunched with a new release planned for April (5-6 article almost finalized). The template is short (200-1000 characters) and flexible. Anyone is welcome to contribute.

The BGC-Argo social media account is being revitalized through regular tweets (+150 followers in 4 months).

The Adopt a Float and Ocean Observers international outreach activities were discussed, and the community was encouraged to get involved. In 2022, 80 classrooms were involved in Adopt of Float and the program was awarded by the CNRS (mediation medal).

OceanOPS is contributing to the communication of BGC-Argo through various projects targeting policy makers and civil society, such as the report card and the Odyssey project. It was suggested to launch a communication campaign, such as a One-Argo brochure, which OceanOPS would be happy to support.

It was recalled that the contribution of the community is essential to maintain all the different initiatives, so do not hesitate to contact Orens de Fommervault.

Deep Argo Session

Deep Argo implementation

Status of the Deep Argo array

National Reports

France

France deployed 13 Deep-Arvor floats in 2022. Four floats of those were deployed at the same location at a 3 month interval through a frame moored in the Wedell Sea (ASFAR frame). Six floats are currently under ice and two floats deep died prematurely. There are currently 42 actives Deep-Arvor floats, which represent about 70% of the European fleet and 24% of the Deep-Argo fleet. 13 Deep-Arvor-O2 floats were purchased in 2022 and 9 Deep-Arvor should be deployed in 2023: 5 in the North-Atlantic and 4 in the Southern Ocean

Funding is secured to buy 10-15 Deep-Arvor floats per year until 2027 (ObsOCean project + IR* Argo-France) and to develop and buy Deep-6k floats after 2025 (PIANO and Argo-2030 projects).

US

Zilberman presented a summary of the U.S Deep Argo float deployments and technology development. 22 of the U.S. Deep Argo floats deployed between 03-15-2022 and 03-15-2023 are operational. 18 U.S. Deep Argo float deployments are planned between 03-15-2023 and 03-15-2024. Ongoing technological development of Deep Argo sensors and Deep SOLO floats includes:

1. Continued studying the Keller pressure sensor performances and development of a method to define individual CPcor values on SBE-61 CTDs (NOPP, Scripps and SeaBird)
2. Assessing temperature, salinity, and pressure accuracies of the RBR CTD to 6000-m based on shipboard comparisons (Tangaroa cruise May 2023, NIWA and Scripps)
3. Assessing dissolved oxygen accuracies of SeaBird, RBR, Aanderaa, and JAC dissolved oxygen sensors based on shipboard comparisons (Tangaroa cruise May 2023, NIWA and Scripps)
4. Developing a vertical sampling software on ascent compatible with sampling on descent on Deep SOLO floats (Scripps)
5. Strengthening the Deep SOLO float antenna (Scripps).

Japan

Japan has deployed 60 Deep Argo floats, mainly in the Pacific and Southern Ocean. As of February 2023, a total of 15 floats, consisting of 12 Deep APEXs and 3 Deep NINJAs, are in operation. One Deep NINJA was deployed in FY2022, and up to two Deep NINJAs will be in FY2023. Among the SBE41cp and SBE61 sensors on deep Argo floats, the evaluation of Cpcor coefficient is required to obtain accurate salinity values. JAMSTEC estimates optimized Cpcor after deployment with ship CTD casts, and validates the salinity negative biases for better adjustment for SBE41cp (Deep NINJA) and SBE61 (APEX-Deep). Regarding the dissolved oxygen sensor for deep Argo, JAMSTEC is evaluating RINKO AROD-FT's time drift, exploring the causes of slight large offsets and slope (Presented in AST24 by K. Sato). Development of a correction method that suits AROD-FT is still working with JFE Advantech. Regarding the float deployment coordination and research collaboration in recent years, Deep and Core Argo floats are deployed by CSIRO vessel (PI: S.Rintoul). Also, collaborative research of water mass and under ice conditions is started between JAMSTEC and CSIRO in the Southern Ocean and Antarctic Ocean. Currently, in collaboration with French manufacturers "OSEAN" and the international academic geoscience consortium "Earth Scope Oceans", MOBY float is being tested as an improved version of the Mermaid float with hydrophone sensors to detect seismic events and CTD down to 4000 m depth. It is expected to establish itself as an option for Deep Argo floats and as a multi-platform float linked to other observation systems. As TWR has already ceased production of Deep APEX and will not be launching in the future, the results of JAMSTEC's Deep APEX to date are summarized. As of February 2023, the number of active deep APEX, presumably dead, and terminated are 12/30, 4/30, and 14/30, respectively. Experienced trouble (including duplicates) are profile error (10), emergency mode(1), missing profile and technical data (2), buoyancy error(4), oil Leak (2), Graylist for SBE61 sensors (7). Although variable kinds of errors have suffered until now, the number of longer lifetime floats (profile >130) are 15, which looks not bad performance on float body and potentially improved if further development were carried out. JAMSTEC is investigating alternative deep Argo floats to contribute to the deep Argo mission (e.g., Deep NINJA, deep SOLO, deep Arvor, MOBY).

UK

Brian King reported on the status of the UK Deep Argo floats. Currently, there are six active floats in the Argentine basin; five are Deep APEX and one is a Deep SOLO. All carry an SBE61 which is functioning properly. Presently, there is no budget for implementing a significant Deep Argo program in the UK. One deep float is still funded and procurement will begin soon.

Australia

Australia has deployed five MRV Deep SOLO floats, three in January/February 2019 and two in December 2021, all in the southern part of the Australian-Antarctic Basin. One of the floats deployed in 2019 (WMO# 7900636) experienced an abrupt failure of the salinity sensor after cycle 85, when values dropped from ~34.5 to ~29.5 along the deep 0.5degC isotherm. This float reported 2 years and 2 months of profiles. One of the floats deployed in 2021 (WMO# 7900923) experienced CTD fouling and the float leaked and aborted mission after 40 cycles (no deep dives with good data; more details in Australia's annual report). The remaining three floats are working well, with no drifts in salinity after 120-170 cycles, and continue to profile on 10-day cycles. Australia plans to deploy 12 more MRV Deep SOLO floats in the southern part of the Australian-Antarctic Basin in early 2024 (voyage from mid-January to mid-March).

Europe

Euro-Argo aims to contribute to ¼ of the global OneArgo network, with a current target to deploy 50 Deep floats per year, mainly in the North Atlantic and Southern Ocean. Euro-Argo Members are currently updating their Deep-Argo implementation strategy and new targets should be defined in 2023, including regional refinements. As of March 20th, Europe had 60 Deep active floats, which represents 1/3 of the international array. 90% of them are also measuring oxygen. European partners plan to deploy 12 Deep-floats in 2023 in total. This represents a decrease compared to previous years, this number should increase again in the future, thanks to the involvement of new countries (e.g. Germany). European partners are strongly involved in Deep-Argo DMQC, and in testing Deep CTDs (e.g. intercomparison study with several prototypes floats equipped with several (two and three) CTDs).

Norway

Since 2019, Norway has deployed 10 Arvor Deep floats, two in 2019, four in 2020, one in 2021, and three in 2022. All floats were deployed in the deep basins of the Nordic Seas and include oxygen sensors. The floats deployed in 2019 are no longer active, while the others are. Thus, at present, there are eight operative deep floats. Norway has no deep floats to deploy in 2023. Norway does DMQC of deep floats and make new estimates of the CPcor parameter. Two of the ten deep floats that are deployed have been identified with abrupt salinity drift (ASD).

Italy

Italy has deployed seven Deep-Argo floats in the Hellenic Trench area in the Mediterranean Sea from 2016 to 2022. The typical configuration adopted is a cycle time of 5 days and a deep park pressure (3500-3800 dbar) to try to keep the float in the deepest area for a longer time. As of March 2023, one Italian Deep-Argo is active. In total, the Italian fleet has acquired about 360 deep profiles. Two out of seven Deep-Argo missions were completely successful: three floats were lost at the beginning of their mission, one after the deployment, and one after less than 1.5 years at sea. The potential of the deep extension in the Mediterranean Sea is good, since there are several areas with depths between 2000 and 5000 meters. The Italian goal is to deploy about one or two platforms per year in the Ionian Sea and the Cretan-Levantine region with the available public funds. In 2023, 1 or 2 deployments are planned in the Ionian Sea. OGS collects (about on a yearly basis) deep CTD reference data from various sources to try to build a robust data set for quality control.

China

In 2022, China deployed three floats in the Philippine basin, two XUANWU and one HM4000 in the Philippine basin. For XUANWU #1, we lost it after it dived into the ocean. For Xuanwu #2, which profiles two days for a cycle and parks at 2000m, it is currently still alive and has collected over 120 profiles. The HM4000 with RBR CTD died after it finished 109 cycles with sampling frequency of one day.

For XUANWU #2, it has finished 127 profiles as of early April, 2023. Two profiles have reached 6000m and most of the profiles are greater than 5000m. CSIO conducted the salinity correction using the new CPcor and it seems that the correction is quite good compared with the climatology in the deep waters.

In 2023, there are two cruises in the western pacific and 8 XUANWU floats will be deployed. There will be 2 floats in the Kuroshio Extension region and 2 floats in the Philippine basin by RV DFH. Another 4 floats will be deployed in the Philippine basin by RV KEXUE in November and December this year.

Canada

Tetjana Ross gave an update on the Deep Argo program in Canada which is actual run by Kohen W. Bauer of Ocean Networks Canada (ONC). ONC plans to procure 18 Deep Arvor floats with oxygen sensors and MEDS has been preparing to handle the data in both real time and delayed mode. Currently, Bauer is planning for two deployments in the NE Pacific near Line P, but seeks advice on where else to deploy the floats to maximize this contribution to both the Deep and BGC Argo arrays.

Discussion

In the discussion, there were several comments about how best to monitor float lifetimes, including tracking particular batches of floats with the same engineering. Two actions resulted from this discussion.

Action 5: AST suggests the formation of a task team to work with manufacturers to find a way to well document big changes and track this through the appropriate metadata. ***Who**: Brian King will lead the task team*.

Data Management

Recommendations from ADMT

Nominal conductivity cell compressibility value (Cpcor) value from SBE (CpcorSBE), -9.57e-8 is too small, resulting in a substantial fresh salinity bias at high pressure. The optimized CPCor values obtained for 161 Deep float are recorded in a spreadsheet to monitor the CPcor values and their variations as function of sensor batch or sensor type:

https://docs.google.com/spreadsheets/d/1ai1I0gzyHHRv_n6t2M3BMWVBp1F9XO4L2XB1YhBni9U/edit#gid=278821204

The analysis of the Cpcor values from the spreadsheet reveals that there is a quite large variability of optimized Cpcor values even in the same batch (from about -10e-8 to -13e-8 for SBE61 & recent SBE41) and that the current recommended Cpcor values (-12.5e-8 and -13.5e-8) are no longer representative of the fleet average (~ -11.6e-8). Due to the observed Cpcor variability between individual CTDs, using the ADMT-recommended Cpcor value of -12.5e-8 for the SBE-61, and -13.5e-8 for the SBE-41 instead of an optimal value, would lead to salinity bias as big as (and potentially larger than) 0.004 PSS-78 outside Deep Argo's target of salinity accuracy. Using SeaBird's recommended value of Cpcor (-11.6e-8) instead of an optimal value would lead to similar bias.

As a consequence, here are the 3 ADMT recommendations:

ADMT Recommendations #1 : Given that using a nominal value for all SBE-61s and SBE-41s is not applicable, the ADMT strongly recommends that SeaBird provides a Cpcor value for each CTD. This is the more sustainable solution BUT might be long to get this done by Seabird and therefore might delay DM adjustments.

ADMT Recommendations #2 on Real-Time adjustment: A new Cpcor value, Cpcor_new, should be used in real-time, 'A' mode, to adjust salinity from Deep-Argo floats with Sea-Bird CTDs. The ADMT recommended standard Cpcor_new values (-12.5e-8 for SBE61 and -13.5e-8 for SBE41) should be used in A-mode. An optimized Cpcor value can be used instead if provided by the DM operator soon after deployment. This real-time adjustment is high priority for the DACs.

ADMT Recommendations #3 on delayed-mode adjustment: An optimized Cpcor value (or a batch average) should be used in delayed-mode whenever it is is available (reference CTD cast available) and robust. Otherwise, the current recommended Cpcor values should be used. If possible, delayed-mode operators should estimate an optimized Cpcor asap after deployment, and provide this value to the DAC for better A-mode adjustment.

A deep Argo DMQC workshop will be organized 5-6 June 2023.

Discussion: SBE and Cpcor

In the discussion with SeaBird, Dave Murphy stated that he had been working on this problem for some time and has been trying to develop an operational method to make cells with a consistent Cpcor value. Work is ongoing and Nathalie Zilberman will also be helping.

Technology

Deep Argo floats

Deep Arvor

Xavier ANDRE from Ifremer summarized the main deployment, status and R&D information for the Deep-Arvor profiling float. 57 Deep-Arvor are currently in operation at sea. For the 2020-2021-2022 period, 84% operate normally, 10% died in their very first cycles, and three other met technological problems (one DO leakage, one Bluetooth problem, one unidentified). Ifremer recommend to make hyperbaric test to check hydraulic performance, and a pool test, before deployment.

Statistics: users need to pay attention to the hardware configuration (particularly, one should clearly identify batches that integrate problem corrections throughout the life of the product, etc.), software configuration (cycling period, etc.), sensor configuration (continuous pumping/spot sampling, DO measurement, etc.) before doing statistics. The difference in terms of “survival rate 1” between Deep-Arvor deployed after 1st Jan 2017 and those deployed after 1st Jan 2019 shows a clear increase in performance at sea over time, due to various evolutions. Now, 80% of Deep-Arvor floats live longer than four years (operating in continuous pumping and mainly with a DO optode, with a complete profile from the very bottom during ascent).

2-headed and 3-headed Deep-Arvor to cross-compare Seabird and RBR CTDs: see Virginie THIERRY presentation: “Updates 2-head, 3-head and 6000m RBR”.

Deep-Arvor with both Aanderaa 4330 and JAC Rinko AROD-FT: both sensors are integrated on the same Deep-Arvor to be cross-compared in situ at sea. R&D is finished, qualification is at its end, and deployment should occur soon, depending on the conclusions on the sensor drifts (see Rinko paragraph).

Autonomous System For Argo floats Release (ASFAR): this metallic structure, designed by the Laboratoire d'Océanographie Physique et Spatiale (LOPS), embeds 4 deep-Arvor floats. It is deployed and sits on the bottom of the ocean, and then releases floats on predetermined dates. On 2022’s deployment, 4 Deep-Arvor floats were released under ice. 3 of them survived and are still cycling. The cage has been recovered for future other deployments.

Deep SOLO

Zilberman presented an update of the Deep SOLO float performances. 78% Deep SOLO floats are active 4 years after deployment. The survival rates of Deep SOLOs from Scripps and MRV are approaching S2As and SOLO-IIs. Deep SOLO float profiling on descent and ascent is feasible and compatible with the Deep Argo mission and operational user needs. Estimated Deep SOLO float longevity is 6.4 years using 2-dbar binning between 0-2000m and 10-dbar spot sampling between 2000-6000m on descent, and 2-dbar binning in the upper 1000m on ascent. The vertical sampling software on descen t+ ascent will be finalized by IDG in July 2023. A collaborative work between IDG and Maxtena is underway to develop a new antenna design on Deep SOLO floats.

MOBY

The MOBY float developed by OSEAN S.A.S. (manufacturer in France) is improved based on the hydrophone-equipped Mermaid float, which can measure CTD (SBE61) down to 4000m depth. To develop MOBY, we started to discuss with OSEAN in April 2021, just after the AST-22 meeting. Then the Argo Sub-committee kick off meeting was held remotely with Earth Scope Oceans, which is the international academic geoscience consortium, during AST-23 meeting in March 2022. Now OSEAN assembles the MOBYs and tests in the Mediterranean Sea. The MOBY float uses a glass sphere body, which is the same as Deep SOLO and Deep APEX. The float size (LxWxH) is 630x630x1310mm, weight is 65kg. All elements are already compatible with pressures at 4000 dbar, and some parts adapt below 6000 dbar, which indicates a potential to extend to the full depth Deep Argo float. All data are transferred in a raw format by iridium (RUDICS). The software, written in Python, converts data to CTD and seismic format, generates dive and profiles graphs. JAMSTEC is planning to deploy two MOBYs during a cruise of Shinsei-maru (JAMSTEC) in June 2023. A CTD cast (~4000m) will be conducted at the launching point to calibrate SBE61 CTDs. The obtained data through the Iridium RUDICS will be shared with ESO and not be delivered via GDAC in real time. Regarding the float mission, we need to consider sharing observation procedures in both the missions of Argo and ESO. For Argo, CTD measurements are required during upcast every 10 days and drifting 1000 dbar, while for ESO hydrophone measures seismic wave during near bottom parking, promptly surfacing when seismic signal detected. Application to the deep Argo mission and future multi-observation platform are expected.

Deep XUANWU

XUANWU is an updated version of HM4000, which profiles to 6000m depth. XUANWU is named after one of China's Four Sacred Creatures of the Heaven in ancient mythology and is seen as a symbol of longevity.

For the lost XUANWU #1, we suspect that the communication between CTD and float fails after the first descent, which may be due to the interface faults.

For the lost XUANWU #2, the parking depth changes greatly, roughly 200m at around the prescribed parking depth. This problem may be fixed in the future but may consume more power to make the parking depth more stable.

In 2023, we plan to update the design and configuration of XUANWU. We redesigned the shell and planned to use a flexible antenna instead of the rigid one. We will use a new battery and expect to increase the battery capacity by 30%. For the Buoyancy drive system, we replaced the driving system with reduced bladder volume, and a set of buoyancy compensation modules will be considered. The buoyancy compensation module can save nearly 20% consumption of power for each cycle. As for the power, we will adopt the thionyl chloride cells with high energy density and super capacitor scheme.

CTD sensors

Updates 2-head, 3-head and 6000m RBR

An update on the intercomparison of the SB41CP, SBE61 and RBR*argo*^{3}|6k CTDs was given. The intercomparison shows that the pressure and temperature sensor differences are within sensors accuracy. Ship-based reference casts are mandatory to get accurate salinity data for the two SBS sensors. A pressure signal is present in the salinity of the RBR*argo*^{3}|6k sensor. Investigations are ongoing to further understand this signal and to correct it.

Updates on RBR*argo*^{3}|6k

An update on the characterization of the RBR*argo*^{3}|6k CTD was provided. I included the validation of pressure, temperature, and salinity measurements from two separate deployments: one in the Pacific on line P, and one in the Southern Ocean, both to ~ 45000 dbar.

Pressure and temperature measurements show an accuracy within the target accuracy of the Deep Argo program, and no sign of a compressibility error. Salinity residuals demonstrate a trend with pressure, that is consistent with the data collected from bi- and tri-headed floats. The stability analysis of the salinity measurements using an OWC analysis supports stable behavior over the length of the record (<= 1 year). Finally, dynamic errors of the RBR*argo*^{3}|6k were characterized in the lab and validated in the field.

A short introduction to the work done in a flume to characterize optodes time response of three major optode manufacturers was also provided.

BGC sensors

Rinko

AROD-FT is an optical DOXY sensor developed by JFE Advantech in collaboration with JAMSTEC in 2011 which can be added to Argo floats and can measure DOXY until 6,800 dbar. Its features are high accuracy (± 2 **µ**mol/kg or ± 2%) and faster response time (< 1 sec) than other sensors, same as ARO-FT. JAMSTEC has deployed nine floats with AROD-FT in the North Pacific and the Southern Ocean since 2014. The two items were examined for AROD-FT; (1) Comparison AROD-FT with bottle data at float's deployment and (2) its time drift at deep layers. Due to (1), we found that AROD-FT's DOXY were able to be corrected within the initial accuracy range at the layers near sea surface and deeper than about 400 dbar except at the strong oxycline at about 300 dbar, by using the linear relation between bottle data at float's deployment and the difference of AROD-FT's DOXY from it for each float. Mean offset of them are comparable to ARO-FT. Then, AROD-FT's time drift at deep layers was examined for 3 floats deployed in the North Pacific where TEMP, PSAL and DOXY are relatively stable at layers deeper than 3,000 dbar. DOXY of two floats on each isobaric layer at deeper than 3,000 dbar got lower significantly until cycle 3 by 4~6 **µ**mol/kg, and then drifted lower slightly. This feature is the same as time dependent hysteresis induced by pressure of RINKO mounted on the mooring observing system. Because the amount of drift for each cycle is similar despite the different cycle of two floats, it suggests that the amount of drift is dependent on the number of times for the float to dive the deeper layer, not period under high pressure. JAMSTEC continues to monitor ARO-FT's time drift and try to explore the cause of slightly large offsets and slope of the first DOXY profile.

Backscattering sensors

Optical (back-)scattering data on Deep Argo are needed to improve our understanding of the fate of sinking particles produced at the surface and their role in burying organic carbon in sediments, to quantify sediment resuspension and transport near the ocean bottom, and to measure the transport and redistribution of trace metals. Towards these aims, a prototype RBR Tridente was tested on a ship's rosette deployed across the Drake's Passage down to 4800 dbar and demonstrated to generate data that were of similar or superior quality to existing optical instruments. The low power consumption of the Tridente would allow Deep-Solo floats to collect and transmit optical backscattering data with minimal impact on the energy budget.

Upcoming Tangaroa cruise

Zilberman presented plans from NIWA and Scripps to conduct a Deep Argo survey northeast of New Zealand on NIWA's Tangaroa vessel. This cruise is motivated by two objectives: (i) Study the variability of the volume transport and water mass characteristics in the deep western boundary current along the Wishbone ridge, and (ii) Improve the performances of the 6000m Deep Argo CTDs and DO sensors. Shipboard measurements will be collected from full-depth CTD casts to define individual CPcor values on SBE-61 CTDs, and to assess temperature, salinity, and pressure accuracies on RBR CTDs to 6000-m for the first time in the field. The performances of 15 DO sensors (4 x SBE-83, 2 x SBE-63, 4 x Aanderaa, 3 x Rinko, and 2 x RBR) will be demonstrated based on bottle data comparisons between 0-6000m.

AST-24 Plenary Welcome & Introductory session

Toshio Suga welcomed everyone to the meeting for his first in-person AST since before Covid.

Objectives of the meeting

The main goal is to assess our progress towards the implementation of OneArgo. Maintaining progress has been particularly tough over the past three years and the post COVID world is not the same as before. It has made what we do harder for all of us – the national Argo programs and our commercial partners. Regardless, we continue to make progress by improving sensors and platforms. We are also growing our user community through data from the new missions and spatial expansions. Based on our interactions at science community meetings, Argo remains a highly valued part of the larger GOOS. We have strong support from the salinity mission community, the BGC modeling community, Global Climate Observing System 2020 conference, the ocean surface topography science mission team and climate assessment teams. All are reliant on Argo and are eagerly anticipating the data from the new missions. Our primary challenge is also to convert this strong support into real investment across more Argo national programs. As we continue to improve our technical readiness levels on the new mission activities, the case becomes increasingly compelling. We look forward to hearing more about this progress this week.

Status of actions from AST-23

Megan Scanderbeg went through the status of the action items from AST-23. Many were in progress and would be reported on at the AST-24 meeting. Action 5 was postponed until next year after feedback from EuroArgo that the Boundary Current study was not yet ready for presentation. There was a brief discussion on Action 7 which asked a group of people to explore creating a product with only good Argo data on standard depth levels with error bars. Ultimately, it was put on hold until interactions can occur with the different groups that create collections of profile data to see if they can be improved to include delayed mode Argo data with the application of the appropriate qc flags. If this does not look like it will be successful, Argo will reconsider creating its own set of curated profiles.

The two actions related to ice-detection on floats (9 & 10) were carried over to this year as they were not implemented, but are still desired by the AST. Action 18 asking Mathieu Belbeoch to request a new circular letter be sent by the IOC asking for new national focal points was requested again. Action 25 centered around the RBR data Task Team (TT) gathering information on how to set up floats prior to purchasing was deemed no longer necessary as changes have been implemented on the RBRargo3 CTD that remove this need. The other actions were either completed or will be addressed elsewhere in this meeting report.

Action 6: Ask EA Rise to report back to AST on Boundary Current study. **Who***: Guillaume Maze*

Update commitments table

Victor Turpin presented the commitments table which was filled in initially by EuroArgo and National Reports, but all countries were given a chance to confirm or adjust their commitments. Commitments are approximately 20% to 30% higher than the real number of annual float deployments which is partly due to the misalignment between AST and regular Argo National funding. Also the National report can be optimistic about finding deployment opportunities for all the floats.

In 2023, 952 floats are committed to be deployed which is wonderful and likely partly a result of a backlog of floats and a lack of deployment opportunities over the past couple of years. Amongst them, 629 are core floats and equivalent (while the target is 610 floats), 268 are BGC floats, including oxygen only (while the target is 220 floats) and 55 are deep floats (While the target is 260). It is crucial that these deployments continue to help the implementation of OneArgo. It was encouraging to hear of more Deep float deployments during the meeting and the AST recognizes the efforts of several countries to try and expand the OneArgo design in their nation.

WMO update

Mathieu Belbeoch reported on updates at WMO including the elevation of the ocean as an essential component of the Earth System. There will be a WMO workshop in May 2024 entitled "8th Workshop on the Impact of Various Observing Systems on NWP and Earth System Prediction: Contribution from the Designers of the Ocean Observing Networks". Currently, there are 8 questions that they are looking for experts to address and present on at the meeting.

In the ensuing discussion, it was agreed that the AST should identify individuals to both develop content for the workshop as well as to attend the workshop. It is suspected that outcomes of this workshop may give suggestions on how the Earth observing system might evolve and Argo is very interested in taking part in the workshop and providing impact on the design of the observing system.

Action 7: Form a task team to interact with the organizers of the 8th WMO Workshop on the Impact of Various Observing Systems on NWP and Earth System Prediction : Contribution from the designers of the Ocean observing networks in May 2024. Find people to attend. Contact Mary Laure Gregoire. **Who**: *Breck Owens, Mathieu Belbeoch, Susan Wijffels, Peter Oke, Ken/Herve/BGC, Molly Baringer, Annie Wong*

OneArgo status update

Argo's status report

National support

North America and the EU increased their contributions to the OneArgo program by about 80 floats a year (8% of the OneArgo array). This is compensating the reduced contribution of some countries (-80 floats for Asia partners) in key regions (Indian Ocean). This low level of investment is impacting a lot of the coverage in the Indian Ocean.

New Argo programs are about to start. Indonesia plans to deploy Argo floats in the coming years while Portugal has already planned four Argo deployments in its Atlantic EEZ.

Implementation

As previously said, implementation of OneArgo is stable around 770 floats/year for the past three years. The decrease due to the transfer from Core to BGC float at the same level of investment seems to be damped now. Still, considering the current performance of the OneArgo fleet, this is not enough to maintain the current array.

Also, distribution of the float deployment locations should continue to improve by deploying more floats in regions under stress.

- Good activity, density and coverage indicators
- BGC and SO reaching targets

Improved Performance

- Deep float converging to Core float performance
- Core float reliability continues to improve
- BGC Survival Rate improved

Regional coordination effort bear fruits

- Southern Ocean
- IO and SE-PO
- Key operations in 2022 (Kaharoa, Blue Observer)

Cruise opportunities are increased.

Blair thanked Victor and the basin planning coordinators for their work which has been very beneficial to Argo. There was some discussion on how best to set the lifetime expectations for both BGC and Deep floats. It was suggested to carefully follow the actual float lifetimes for BGC and Deep to better understand the deficit of core Argo profiles and to guide float purchasing and deployment over the next few years. There were also some questions about how float recovery impacts float lifetimes. Finally, it was noted that Argo relies on many of these ships to make deployments for free and we need to ensure that the communication between us and ship operators is clear and not overwhelming.

BGC Argo Mission status and challenges

The status and challenges facing the BGC-Argo Mission were discussed in a presentation by Johnson and Claustre. It is clear from a number of metrics that 2022 was a very successful year. A record number of floats carrying one or more BGC sensors were deployed (211) in 2022 with many carrying 5 or 6 BGC sensors. 268 floats with one or more BGC sensor are committed for 2023. The fraction of data in A or D mode is also rapidly increasing. This is enabling many new papers utilizing BGC-Argo data to be written. The data teams continue to improve the fraction of data moved from R mode to the scientifically useful A and D modes. A BGC DMQC workshop was held in Villefranche to teach users new techniques for QC and to improve the uniformity of the data. Various tools for DMQC were intercompared. The participants at the workshop also generated several questions that were passed back to the Mission Team for decisions. In the case of signals in optical sensors caused by mesopelagic organisms being attracted to the sensor light, it was decided to retain the automated flagging that assigns these signals as questionable or bad in the A and D mode data files. A proliferation of new sensor models for approved variables will present a challenge to data teams. Supply chain issues during COVID have been a particular problem. Finally, the Mission Team must work with manufacturers to address problems of affordability.

Action 8: AST suggests that we write an opinion piece about the urgent need to measure the status of BGC parameters in the ocean now, specifically carbon and pH, at minimum. Target publications could include New York Times, Nature, etc. **Who**: *Ken Johnson, Katia Fennel, Susan Wijffels, Tetjana Ross*

Deep Argo Mission status and challenges

Zilberman presented on behalf of the Deep Argo Mission team the status and challenges of the Deep Argo mission. 182 Deep Argo floats are currently active. 68% (123) are 6000-m capable, and 32% (59) are 4000-m models. 31% (57) of active Deep Argo floats equipped with DO sensors. 2 Deep Arvors with dual DO sensors will be tested in 2023. Three new regional Deep Argo pilot arrays were implemented in the Indian, Southern Pacific and Southern Atlantic oceans between 2022 and early-2023. 34 Deep Argo float deployments are planned March-December 2023, and 24 Deep Argo floats will be deployed early-2024. The annual Deep Argo float deployment rates of 2022 and 2023 are smaller than 2021. Based on the deployment rate of ~30 floats/year in 2022-2023 and averaged Deep Argo float longevity of ~3-year, at least half of the Deep Argo array will disappear in the next 2 years if added funds are not provided.

Breck remarked that one of the successes in core Argo is the availability of fantail ready floats and wondered if any Deep Argo float models were fantail ready. Greg Johnson and Brian King both offered that the Deep SOLO from MRV is fantail ready and easy to implement. Virginie Thierry stated that the Deep Arvor is also easy to deploy and working well. The Deep Xuanwu and the MERMAID floats are also looking promising, so it looks like industry is responding to the need for fantail ready floats.

Action 9: Ask ADMT to find the best way to indicate deep Argo profiles in the index lists. ***Who**: John Gilson, ADMT co-chairs, Deep Argo co-chairs, GDACs*

Polar Argo Mission status and challenges

In February 2023, 75 floats are active in the Arctic basin (north of 60°N) and 252 floats in the Southern Ocean (south of 60°S). In 2023, south of 60°S, 79 deployments (including core and BGC) have been operated by 7 countries. North of 60°N, in 2022, 33 floats (including core and BGC) have been operated by 8 countries. The intensity of deployment is stable in the Arctic for last 5 years (~32 ,4±6 floats/years) and has increased in the Southern Ocean in 2022-2023 (+40%). In February 2023, in the Arctic, the target density ocean is still not reached north of the Svalbard, but no statistics are provided by OceanObs in the major part of the Arctic Ocean (Canadian basin, Eurasian Shelf, …). In Feburary 2023, in the Southern Ocean, only 1/3 of the area reaches the Argo Target design. It is worth noticing that life expectancy for Arctic floats is currently 3.65 years and 4.29 years for the Southern Ocean.

The Arctic and Southern Ocean Argo float operations are challenging due to sea ice coverage during winter. The Ice Sensing Algorithm (ISA) prevents floats from attempting to surface in sea ice conditions using a mixed layer temperature criteria. This helps preserve floats from being damaged in the sea ice and increases the life expectancy of the floats. The floats can send their data when surfacing in an free ice region. This has allowed an increase the profile collection during winter. Nevertheless, no GPS fix –

i.e. no position - can be retrieved from under ice profiles. Post-processing data algorithms are used to estimates more realistic under ice profile positions (than linear interpolation of the positions). ISA setting tools and terrain following algorithm for under ice positioning has been proved operationally in the framework of EA-rise project (finished in 2022), along with recommendations for under-ice operations. Research is currently under way to improve ISA algorithm and under ice positioning.

An Argo Polar mission team has been formed to address implementation topics (deployment coordination, QC, reference database) and challenges (improve under ice operation, ice avoidance, acquisition ...).

Action 10: AST strongly supports the acceleration of the formation of the Polar Argo Mission to consider tasks such as deployment coordination, improving ice avoidance and acquisition, and perhaps qc, of reference data. ***Who:*** *If interested, please contact Nicolas Kolodziejczyk or Esmee van Wijk*

Action 11: Ask ADMT to consider how to store information floats send back about ice avoidance ***Who****: Esmee van Wijk, John Gilson, Annie Wong, Steve Riser, Matt Alkire, Robert Drucker, Megan Scanderbeg, Niolas Kolodziejczyk*

OneArgo status discussion

Indian Ocean deployments

The discussion first centered around deployments in the Indian Ocean and the ongoing need for deployments in that region. Virginie noted that France has made deployment plans in the region and felt that the Indian Ocean deployment planning meetings have been helpful. Blair noted that he would be happy to have floats deployed in the Indian Ocean, but that shipping the floats to Cape Town was very expensive. Susan noted that the icebreaker that loads in Trieste might be a good option for loading floats. Tammy noted that some of challenges for Indian Ocean are getting floats into Kenya or Tanzania and this is likely to continue in the short term. Peter Oke offered a deployment opportunity in Townsville in June this year. Greg Johnson from PMEL also noted that sometimes they are able to load a small number of floats to go to partners for the RAMA cruises. Sometimes, they do not have enough floats (4-6) to supply for this opportunity and could work to load other program's floats if they were shipped to Seattle. Brian King noted that sometimes it can be challenging for delayed mode operators when floats are deployed in new regions that they are unfamiliar with. Susan noted that in the past, countries have had partnerships with other countries that deploy floats in different regions. Peter Oke offered to help groups with DMQC of floats in the Indian Ocean.

Deep Argo efforts

Susan asked for each National Program to report on any large impediments to expanding into the Deep Argo mission beyond the cost. Emily Smith noted that operational centers are not using the data because its not in real time and that we need to work to advertise the data availability. Megan Scanderbeg reiterated that it is a high priority for the ADMT to produce Deep Argo profiles with corrected Cpcor values in real time to make it available to operational centers. Blair noted that the OneArgo array can be confusing to funding agencies and that we should work on making this clearer.

Mathieu noted that a great number of operational users access their data via the GTS and unless the Deep SOLO sends a profile upon ascent, they are not meeting the timeliness window for some operational users. Breck said that there are a variety of timeliness needs for operational centers and that this should be part of the one on one discussions that are planned. Perhaps if the time window was expanded to 11 days, this problem will be addressed.

Action 12: AST suggests the formation of a task team to develop and tune indicators on OceanOPS to better define targets, missions, float monitoring, coverage, density, etc. ***Who:*** *Chris Gordon, Claire, Gourcuff, Catherine Schmechtig, Romain Cancouet, Ken Johnson, Hervé Claustre, Katja Fennel, OceanOPS, Susan Wijffels*

Implementation issues

OceanOPS update

M. Belbeoch reported on the status of OceanOPS, including its goals and services to networks which include technical coordination, web-based dashboard and API, publication of a yearly GOOS report card and development of partnerships with civil society and private companies for instrument deployments. Details were presented about goals in the 2021- 2025 strategic plan, including one on monitoring, one on metadata, one on operations, one on new networks, and the last one on infrastructure. Argo is doing quite well in many categories, but discussion is ongoing.

He reported on the success of using the Blue Observer to deploy roughly 100 floats from a sailboat funded by NOAA, WHOI, Argo Canada and EuroArgo ERIC. While it was great for the environment, it was difficult to coordinate and OceanOPS is learning from this. He ended by showing tools available on OceanOPS to find cruises.

Action 13: Ask Matheiu Belbeoch to ask IOC to send a new circular letter asking for new national focal points. ***Who****:* *Mathieu Belbeoch*

EEZ guidelines and strategies

Mathieu Belbeoch updated the AST on recent efforts with respect to EEZ notifications. He first noted that EEZs represent one third of the ocean and with the need to deploy 800 floats per year in targeted areas to implement the OneArgo array, MSR notifications can have a chilling effect on Argo's status. He suggests a solution should be found at a regional or international level, possibly through an operational application of UNCLOS. He presented a table showing the clear differences between notifications for Argo and non-Argo floats and said that OceanOPS will pilot UNCLOS article 247 this year.

Action 14: Add EEZ deployment table to the new Float Deployment page on AST website as well as the Argo one pager explaining what an Argo float is and is not. **Who***:* *Megan Scanderbeg*

Action 15: Work to inform the research community of legal issues surrounding EEZs and that Argo floats have special permissions and obligations regarding EEZs. Consider adding information to websites as well as to manufacturers to clearly identify what an Argo float is. Ask Emily to raise with OCG. ***Who**: Emily Smith, Megan Scanderbeg, Victor Turpin, Nathalie Zilberman*

AIC, OceanOPS funding

M. Belbeoch reported on the status of OceanOPS funding for the eight person team. He noted that web development was stopped due to budget cuts, but Orens de Fommervault was added as a BGC Argo coordinator. He noted that some countries in Argo have been unable to make a contribution to OceanOPS in the past year and that Emanuela has sent requests to all donating countries for 2023 contributions. Argo has a large involvement in OceanOPS and WMO is strongly supporting OceanOPS. While the budget looks ok for now, Mathieu requested increased and diversified funding from countries involved in Argo and other networks supported by OceanOPS.

Action 16: AST asks National Programs to consider either making a new contribution to OceanOPS (a small one is welcome) or to increase their current contribution to account for inflation (perhaps 10% more). ***Who**: all countries contributing to Argo.*

EuroArgo Status

Since 2014, Euro-Argo has the status of European Research Infrastructure Consortium. By coordinating the efforts of the European member countries of the Argo program, its goal is to have the European contribution reach 1/4 of the global network. In addition to the core funding from members, Euro-Argo participates in and even leads some EU-funded research projects, which are key catalysts for the evolution of many facets of the network. Euro-Argo RISE is such a key-enabler project, which has been quoted several times during the meetings since Monday, whose main outcomes are on the technological developments, data management, service to users and Argo community building. These results are summarized in a *Euro-Argo RISE Final leaflet* and, for decision makers, an easy to access ***Digital version***.

This success does not preclude listing sustainability challenges and finding ways for the European Commission to indirectly support Euro-Argo through the operational community, which would benefit from a specific budget, or volunteer member countries that would receive incentives from the EU.

Exploring the OMZ in the Atlantic

Low oxygen levels found in the tropical Northeast Atlantic have potential implications for coastal socio-ecosystems offshore of West Africa. This is because hypoxia does not just concern deep central water layers but also the shallower water mass that feeds coastal upwellings. Being able to monitor long-term regional O2 trends in this oxygen minimum zone (OMZ) and attribute the changes to specific processes is currently not feasible given the paucity of past observations. An increasing number of Argo floats is present in the OMZ which will allow the monitoring of the O2 trend. But several key terms of the O2 budget will remain poorly constrained, including mean and eddy advection. Having Argo floats drift inside the OM while in parking would alleviate this.

In my talk, I am thus arguing that there would be major scientific and social benefits to using Argo parking depth shallower than 1000 m in this region. I am also questioning the utility of continuing an unlimited accumulation of flow information at 1000 m depth in a sector where typical flow speeds are a fraction of a cm/s and are already fairly well known.

In the discussion that followed, the general consensus was that the 1000db drifting pressure needs to be maintained and is a critical part of the OneArgo implementation. The depth of 1000db was chosen because the eddy to mean flow ratio is the smallest and we need to continue to park floats at this depth to help resolve long term trends. Nathalie Zilberman noted that while Deep Argo floats are often parking at pressures deeper than 1000db, this is during the pilot phase to help keep floats in certain regions to learn the most from the pilot arrays. When the Deep array is more mature, the drifting pressure will be switched to 1000db.

Tammy Morris suggested investigating the SynObs project being run by Yosuke Fuji to help with estimating shallow currents and Breck suggested using satellite altimetry.

Deployment coordination across missions

Dedicated meetings to try coordinate Argo float deployment opportunities and available Argo floats have taken place for three ocean basins - Atlantic, Indian and Pacific Oceans.

Atlantic Ocean:

This group is chaired by Fiona Carse of UK MetOffice and four meetings have been held since the last AST meeting in 2022. The North Atlantic is fairly well covered currently, and the focus has been on the South Atlantic, specifically the Amazon outflow, around the Cape Verde islands, the Gulf Stream (southern section) and the Iberian-Biscay-Canary Islands section. Some Argo floats are still required in the Fram Strait. An example of where collaboration has worked well is the instrumenting of A16N (Go-Ship Cruise) and the Atlantic Meridional Transect cruises onboard the RV Ronald Brown and RRS Discovery respectively. Through the Atlantic discussions, no overlapping of BGC and Core Argo float deployments will take place, instead of both cruises targeting similar gaps in the Atlantic Ocean.

Indian Ocean:

This group is chaired by Tamaryn Morris of SAWS and three meetings have been held thus far. The group has also managed to bring together deployment teams and networks from the DBCP and others to provide even more possibilities for instrumenting of the Indian Ocean. While the work has not yet successfully filled in the SW Indian Ocean gap in the Argo array, opportunities have allowed for resources to be sent on the RV Laura Bassi cruise transiting the Indian Ocean from the Red Sea to Australia to cover some key gaps in the array.

Pacific Ocean:

This group is chaired by Sarah Purkey and one meeting has been held in the last year. The Pacific Ocean array is currently healthy, despite regions requiring particular attention (pacific southeast, central north pacific) though ongoing efforts will be utilized to ensure it remains as such.

The efforts of the ocean basin coordination teams have been very well received, in particular in the Southern Ocean, which reached its deployment target in 2022, supported by the OceanOps Technical team who assist by determining available cruise opportunities, deployment plans loaded onto the OceanOps system and the age of the Argo floats and likelihood of failure in the short term.

In the following discussion, the option of float donation was suggested as a way to get more countries involved in Argo and to ease difficulties of deploying inside EEZs. These donations can be highlighted in newsletters and on the AST website to help raise recognition for the deploying country. However, it was noted that float donation is not always an option for countries. Finally, Susan thanked all the regional deployment planning teams for their efforts and the successes in more targeted deployments over the past year.

Core Argo Best Practices paper

The Core Argo Best Practices paper has been completed and was reviewed by 13 of the AST and ADMT members as part of the community review. Only a few outstanding issues still to be resolved. These include:

1. Should the paper include a standard sampling regime for setup of Core Argo floats (e.g. 2db from 1000db to the surface)?
2. A sampling frequency of 10.2 days (245 hours) was included to ensure profiles are not taken at the same time each day.
3. The following sentence was included to ensure all temperature / salinity / pressure profiles taken from Argo floats, including those from a shallower depth or on a higher frequency are included into the database: **"Argo floats should target the Core Argo profiling depth and cycle time, 2000 db and 10 days, respectively. However, data that contributes to the estimation of the state of the ocean on the scales of the Core Argo mission are also desirable"**

After discussions as part of this session at the AST, as well as from input over email, the Core Argo Best Practice paper will be finalized and sent to the co-chairs of the AST and ADMT for final input. Thereafter it will be loaded onto the Ocean Best Practice Repository and sent to the GOOS for endorsement. A summarized version will be prepared for the Frontiers Journal.

Finally, it is envisaged that a short training course based on this Core Argo Best Practice paper be held in Cape Town, South Africa, for young scientists and students to become more involved with the OneArgo Programme. These details will be communicated in due course.

In the discussion, Susan suggested that OneArgo should aim for a vertical resolution of 2db from **2000db** to as close to the surface as possible with the understanding that sometimes the resolution below 1000db is more coarse to save energy, but goal should be 2db. Emily asked if a float that contributes the classic Argo profile every 10 days, but also more frequently samples in between can be part of OneArgo. Susan said yes, but with the current budget, it should probably be discouraged unless there is a good connection with current National Programs.

Action 17: In the Core Argo Best Practices, adjust wording for statement to address request of fast profiling/shallow profiling floats and pass through the AST exec for feedback and approval. ***Who***: *Megan Scanderbeg, Tammy Morris, AST exec*

Core CTD vendors

SBE

Jochen Klinke presented on behalf of SeaBird Scientific (SBS) on their plan for Abrupt Salty Drift (ASD) CTD relief. He noted the serial number ranges for the SBE41 CP (S/N 10482 – 11252) and SBE 61 CTD (S/N 5669 – 5724). All undeployed CTDs in the recall range will get a no cost replacement CTD and he said that 95% of undeployed CTDs in the recall ranges have been serviced and returned. Warranty relief is being offered for already deployed CTDs in the recall range because of the clear link between a manufacturing issue and ASD. Relief will be in the form of a credit for a new, or partial, SBE41/61. Since ASD can occur in at any point in float lifetime, the warranty relief will be pro-rated based on number of cycles performed prior to failure. 169 CTDs with ASD from the recall range submitted to date. Most of the CTDs submitted already are SBe41CPs and Europe and Japan have made most of the requests. SBS is proposing a cycle cutoff of 220 cycles to take into account more rapidly profiling CTDs and the logistics still need to worked out for issuing credit. To submit a warranty request, email a list of CTDs with ASD to SBS (jklinke@seabird.com) with the subject line: ASD submission. The other information to include is: the CTD s/n and model, the WMO number, the last correctable cycle, the float age or total cycles to date, the an optional link to a DMQC plot demonstrating the CTD failure.

There was considerable discussion on how to issue credit and eventually it was decided to leave it up to National Programs. Some may want the credit to go back to the original purchaser which may be a float manufacturer while others may want it to go back to the National Program. Birgit asked which claims are missing and Jochen agreed to send information about which countries have submitted claims already with the understanding that more may be added over the next 18 months. It is important to keep the warranty open until the group of affected sensors have reached the end of their lifetime which is 220 cycles. A question was asked about how this will affect CTD prices and Jochen said there are no plans to immediate price increases due to this warranty issue.

Action 18: Ask National Programs to submit warranty requests for ASD SBE CTDs. See Jochen's presentation, meeting report, or ask Birgit for more details on the format submission. This will be revisited for up to 18 months. ***Who***: *National Programs with ASD CTDs*
https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing

RBR

The presentation included a review of the status of the RBR fleet, with active floats and failure rates. A review of the different identified, and non-identified, failure modes was provided with a clear explanation of the action taken to address the mode of failures, when possible.

A complete review of RBR commitments made to the Argo program was presented, with the status of each item. It included:

- The completion of the action items pertaining to RBR

- The distribution of DMQC tools to facilitate the DMQC of RBR floats
- The completion of the compressibility correction review for Pre-April 2021 floats
- The status of RBRargo-monitoring, the internal process to continuously monitor RBR floats.
- The implementation of onboard dynamic corrections

Finally, the introduction of the ongoing development of the 4th generation of RBRargo CTDs was presented, with a focus on the new pressure sensor to be rolled out.

In the discussion that followed, Brian King and Annie Wong thanked RBR for their work to get the RBRargo CTD up to standard, quantifying the compressibility coefficients, and for educating the Argo community on how to quality control the data.

Float performance and evaluation of the health of the array

A general comment about the Argo fleet is that the performances continue to grow. More floats last longer. Fruitful efforts have been made to correct early failures observed for floats deployed between 2018 and 2022.

This global statistic does not take into account the discrepancies between the different missions of each float. However, the current performance by mission highlights that to maintain each mission current array, it is needed to redeploy 35% of the BGC fleet, 28% of the deep fleet and 22% of the OneArgo fleet. This is, respectively, 340 BGC floats, 230 deep floats and 450 core floats. These numbers compared to the reality of annual deployment (155 BGC floats - T/S/O only excluded, 31 Deep float, 608 Core floats) show that there are still a little reservoir of Core float to be transferred to Deep and BGC but that would not be enough to reach the OneArgo objective, considering cost ratio between Core and BGC and Deep.

The improvement of the performance of the Argo fleet is absolutely essential to overcome the OneArgo implementation challenge, but Argo can not rely only on the improved performance and an optimized spatial distribution of the fleet to achieve the OneArgo design.

These analyzes also highlight some limitations of our monitoring capacity to better assess the performance of the OneArgo fleet.

- It has been identified that the BGC float should be monitored both in terms of cycles and longevity.

- Sensors performance should also be assessed in such a report.

- Depth dependance (i.e. float sampling down to 4000m, 5000m, 6000m) should be introduced to measure the performance of the deep float fleet.

Technician’s community of practice

Rick Rupin and Pat McMahon asked for the formalization of the Argo Technician's CoP to be endorsed by the Argo chairs. They have found their quarterly meetings valuable and have received positive feedback from other technicians. Having conversations has opened communication channels and highlighted different approaches groups use to solve similar problems. They are hoping that an official endorsement would help them to do activities like make recommendations on battery configurations, look for opportunities to share resources and, ultimately, provide more data at a reduced cost. The group would plan bi-annual meetings and could have open and closed sessions where the manufacturers could speak to the technicians. They would also like to plan and be involved in hosting another technical forum like the one in Seattle in 2017.

In the discussion, it was felt that the Technician's CoP has been very helpful and productive and the AST is happy to formally endorse the group's activity. The AST suggested a yearly report at the AST covering the activities for the year. The idea of a new technical workshop in Seattle in summer 2024 was endorsed and several AST members volunteered to help with the organization.

Action 19: AST formally recognizes the Technical Community of Practice as a key component of the program and will work with them to organize the next technical workshop (possibly summer 2024). ***Who***: *Pat McMahon, Rick Rupin, Steve Riser, Shigeki Hosoda, Brian King, Sarah Purkey, European person*

Float technical updates, including float production and supply chain issues

ALTO

Steve Jayne reported on updates with the ALTO float manufactured by MRV Systems. It has the same form factor as the S2A but with a higher efficiency hydraulic buoyancy system. It can carry the SBE or RBR CTD as well as other sensors such as oxygen, optics and surface waves. At the moment, WHOI has paused deploying ALTO floats while waiting for updates to the float's firmware. Testing has begun in WHOIs tall tank, but some issues still need to be worked out. When the firmware is updated, WHOI will deploy its 21 ALTOs (8 carry the RBR and 13 carry the SBE CTD).

MRV S2A

Pelle Robbins reported on the experience of operating MRV S2A in the WHOI Fleet. WHOI began deployment of the S2A platform in 2012 and has deployed 680+ platforms since then. S2A now composes 93% of the active WHOI fleet. The S2A is a capable float with good energy efficiency and a large degree of user control. Energy consumption is about 10 KJ per 2000-dbar cycle which suggests a potential float lifetime of up to 390 cycles (10.6 Years). WHOI recently switched to operational use of a smaller stability disk which reduces drag during profiling and is expected to yield an energy savings up about 6%. Additionally, WHOI continues to work to improve accuracy of the ballast trim procedure in order to maximize energy efficiency. Recorded float losses are not due to mechanical failure alone and we now have numerous documented instances of floats being captured by fishing activity, mostly along coastal shelves but also on high seas in regions near seamounts.

SOLO-II

Zilberman presented an update of the SOLO-II and S2A float performances. 1063 Core SOLO floats, including 663 SOLO-II floats and 400 S2As, are currently active. Core SOLO floats represent 25% of the Argo array. S2A and SOLO-II survival rate is 86% five years after deployment, and 80% after eight years. 18 cases of Scripps SOLO-II float failure were recorded due to faulty antenna and associated flooding (May 2021 batch of 32). The remaining active 14 SOLO-IIs with antennas from the same faulty batch are likely to fail in the future. A new antenna design from IDG and Maxtena is under development to mitigate antenna failure.

COPEX

Zenghong from CSIO introduced the COPEX float that NOTC (National Ocean Technology Center, MNR) developed. In early 2023, CSIO deployed 30 COPEX Iridium floats in Indian Ocean sponsored by a special program. The comparison between float observations and climatology have shown good temperature and salinity profiles reported from the floats. CSIO plans to include these floats into Argo which will increase the amount of active Chinese floats in the whole fleet.

Arvor

Noe Poffe updated the AST on the status of the Arvor float. In the past few years, Arvor floats are being deployed at a rate of 160 floats/year which is about the same as the SOLO-II/S2A and over 13 countries deployed Arvor floats in 2022. All Argo-France and half of the Euro-Argo Arvor floats are tested in Ifremer’s 20m tank. This resulted in 217 floats over three years and roughly 3 people working for 5 weeks each year. 4% of floats were rejected, but no systematic faults were found. The expected lifetime is 310 cycles with an SBE41 CTD. The Arvor can also carry the RBR CTD and 31 floats doing more than 1800 cycles with the RBR CTD have been deployed since 2020. There were a few early failures, but 27 floats are still active.

In the discussion that followed, Susan Wijffels congratulated NKE on improving the Arvor’s lifetime and reliability and hopes this will help with the implementation of OneArgo.

SeaTrec

Emily Smith presented on behalf of Yi Chao about the new SeaTrec float that integrates a thermal battery inside of the float body. They have been used in the Gulf of Mexico to run some acoustic work and fast cycling for hurricane initial conditions data. It can perform a standard Argo cycle and carries an RBRctd, a hydrophone and an echosounder. In the following discussion, it was thought that these floats will operate best between 40N and 40S. It is a larger size as well which could make it more difficult to deploy. Finally, it was noted that the hydrophone and echosounder are not Argo parameters and so it would be necessary to apply for permissions for deployments.

Under-ice floats

SOLO Arctic float

Craig Lee updated the AST on the progress of the SOLO-II Arctic float development which is delayed by a year. A few hardware changes are needed including the integration of a new modem to allow for more data to be telemetered back to accommodate the under-ice profile backlog, a hardened antenna, an ice avoidance mast and a hydrophone port needs to be added. New electronics are needed as well as software to accommodate the hardware changes. The plan is to fabricate 30 SOLO-IIs for the Arctic at a rate of 10/year starting in 2023. Local testing will take place the first year, followed by Arctic deployments in the autumn of 2024. All data will be distributed on the Argo GDAC.

UW under-ice floats

Steve Riser updated the AST on the status of under-ice floats in the Southern Ocean. For SOCCOM, 12.7% of its profiles are under ice and 25 floats have at least 50% of their profiles under ice. He showed a histogram of the minimum pressure under the ice for floats collecting under-ice profiles. There were 2338 profiles with two peaks: one centered around 10db and one centered around 26db. He then shared data from several floats operating in the Southern Ocean and how much can be learned from this unique dataset.

Deep floats

Zilberman presented on behalf of the Deep Argo Mission team the performances of the Deep Argo floats. There are four operational Deep Argo float models: the 4000-m Deep NINJA and Deep Arvor, and the 6000m Deep SOLO and Xuanwu. The 4000m Moby and 6000m IFREMER model are under development. The 4000m HM400 and 6000m Deep APEX are no longer available for purchase. Most active Deep Argo floats are Deep SOLOs (58%) and Deep Arvors (31%). There is a need to diversify the Deep Argo fleet to sustain the array. The survival rate of Deep Argo floats has increased by ~10% between floats deployed in 2016 and 2018. Differences of survival rates between Core and Deep floats are small: 6-8% 1-3 years after deployment, and 14-16% 4-5 years after deployment. Using DO sensors on Deep Arvor floats reduces the float lifetime by ~8 months (120 instead of 150 cycles) below the 4-year target. Technology improvement (e.g. battery increase, and improvement of software and antenna design) should continue to increase float longevity to the 4-year target across all Deep Argo float models.

There was lots of discussion after the presentation and it was agreed that Deep floats should be switched to drifting at 1000db when there are more floats in the water so they can contribute to the OneArgo mission. However, when that happens, more Deep floats may be needed since they will drift more at 1000db than they are currently when drifting at depth. With the development of more 6k capable floats, the AST hopes they will become more affordable and have long lifetimes so that they do not need to be replaced every few years. It was again noted that a mix of 4k and 6k floats may be needed to balance cost with ocean depth and technical capabilities. Finally, there were questions for SeaBird on the technical capabilities of the SBE41 and SBE61 which will be discussed again at ADMT-24.

Action 20: Ask SBS for clarification on spot sampling details and pumping rate for SBE41 and SBE61 and report back to ADMT-24. Concerned about need to clear sensor for first few measurements taken during drift and start of profile. ***Who**: Nathalie Zilberman, Greg Johnson*

Action 21: Ask all Deep SOLO floats to profile upon ascent to comply with operational centers. Ask John Gilson and SIO Argo for recommendations for how to adjust settings for current floats. *Who: Deep SOLO deployers*

Sensor progress

Monitoring and warranty progress in Abrupt Salty Drift in SBE41

The presentation gave an update on the monitoring of ASD and the status of the warranty talks with SBS. The joint spreadsheet on salty drifters is continuously updated by the DMQC-operators. It presently contains 829 floats and has only slowly been growing during the last year.https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit#gid=1096144849)

The appearance of the table has been simplified during the last year to gather only information essential for performing statistics. All other information is now taken from the GDAC files directly and repeated sanity checks are performed on the entries in the table.

Updated statistics were performed from the spreadsheet for the SBE41cp on those floats with unadjustable data. These show three peaks with faulty float data in the order of 30%, two of which appear prior to the recall range of 10482-11252. Failure modes in all three peaks show similar characteristics.

The progress of the warranty talk was presented and updated with information provided by SBS on the 22.03.2023. In 2021 Sea-Bird Scientific had issued an immediate “Do Not Deploy” directive for un-deployed SBE 41CP and SBE 61 CTDs built in 2018 with specific SN ranges. Floats not yet deployed could be returned to SBS for a warranty service. Customers with floats already deployed were advised to wait until SBS determined criteria for claiming warranty on those. A meeting with SBS to discuss terms of warranty proposal was scheduled for the European national programs on 18.01.2023. The meeting was also attended by other national programs (Australia, India, Japan and US). In preparation of the meeting it had been decided by the partners from the EuroArgo ERIC and Japan to create lists with floats from the recall range with the following specification:

List only floats from the recall range which have reached un-adjustable state within 180 cycles (corresponding to life time of 5 years based on 10-day cycles). To better represent floats on a fast cycling missing the criteria was changed to also consider the age at which un-adjustability was reached.

Based on the entries in the google spreadsheet, 164 out of 568 floats with CTDs in the recall range have listed ASD out of which 150 had reached already un-adjustability. 86 of these floats are associated with the US program, 29 to Japan and 3 to Australia. Within the EU fleet 32 floats are spread 6 national programs: France (16), Germany (6), Norway (4) and Ireland, Italy, UK (2 each).

SBS presented their selection of criteria for warranty at the meeting on the 18.01.2023. They propose a warranty in terms of a credit for a new CTD for floats with uncorrectable data. The credit would be rated based on profiles obtained until failure, with a cutoff at 160 cycles or 4.4 years. Programs were asked to email lists to jklinke@seabird.com with subject line: SBE41 ASD Warranty. Discussion during the meeting on 18.01.2023 asked for extending the cutoff cycle to a full float lifetime and how to include floats with faster than 10 day cycles. It was asked if their credit based on their age instead of a fixed cycle.

SBS provided feedback to these questions in their presentation at AST24 on 22.03.2023. They proposed to move the cut-off cycle to 220 and keep the rated credit based on cycles as proposed initially. National programs were asked to respond to this new proposal and report back to SBS. Checks of the lists submitted so far have not turned up non-eligible cases. SBS is planning to start the compensation soon. As discussed, compensation could be in the form of certificates issued to the float owners to be used with any of the available float manufacturers. Since some floats from the recall range are still young, another round of submissions (to be scheduled) is necessary to include them in the warranty lists if they turn unadjustable. Timeline for a next round of submission is proposed mid 2024.

Programs not yet concerned with unadjustable floats in recall range, but floats listed in the spreadsheet will be included in the process for future submissions. Australia offered help to d-mode floats from the

Indian fleet to determine the status. Please feel free to contact the EuroArgo Office for help or additional information (contact@euro-argo.eu).

RBRargo

Clark Richards presented work done in collaboration with RBR to understand and correct RBR 2k CTDs in real time and delayed mode. This work has resulted in a better understanding of how the sensor works and will facilitate on-board corrections in the future which will ease the work of DACs and DM operators. He noted that the dynamic corrections that need to be done are all flow speed dependent and so understanding this speed is important and reliant upon high resolution (1Hz) data. He suggested that floats should profile at a fast speed (e.g. 20cm/s) and the best corrections should be done on 1Hz or faster data. He urged DACs and DM operators to make the suggested corrections to the data and suggested that the RBR data task team evaluate the impact of the corrections on the dataset.

Action 22: Ask RBR data Task Team to evaluate the dynamic corrections both in real time and delayed mode. ***Who**: RBR data task team*

Data Management issues

Feedback from ADMT-23

Megan Scanderberg delivered feedback from the ADMT-23 meeting on behalf of the ADMT co-chairs. She stated that the data management system is evolving to manage all components of the OneArgo array in real time, near real time and delayed mode. Some of the parts of the system continue to need development to accommodate the newer BGC parameters and to improve on the current quality control done on the core parameters which was developed twenty years ago.

She noted that DACs are stressed and need more manpower and funding in order to perform the tasks of them each year at the ADMT meetings including implementing new real time tests, corrections and formats. The idea of code sharing between DACs needs to continue to be explored, especially with targeted blocks of code which can be shared via GitHub, ideally in a code-agnostic manner that could be maintained by a group of coders around the world. A working group has been formed to lead a series of virtual workshops targeting different topics to help DACs make advances on difficult tasks.

In terms of timely delivery on the GTS, 98% of the data is delivered within 12 hours and 89% of the data is being delivered within 6 hours. This is great news in terms of availability for operational users. She noted that the BGC Argo mission is working to get the BUFR format approved for more BGC parameters besides oxygen. The BGC Argo mission is also developing recommendations on what data should go on the GTS. The ADMT is working to implement BGC data on the GTS as requested by the AST.

In terms of the GDAC, services are functioning well and while the size continues to expand, it is less than 10% per year. Most of the users get data via FTP server rather than https or ERDAPP.

For delayed mode quality control of core parameters, the python library for OWC has been released via the EuroArgo GitHub: [GitHub - euroargodev/argodmqc_owc: Argo float salinity calibration software](). This package is comparable with the Matlab OWC version and performs about 25% faster and is a great step towards expanding the availability of codes to the DMQC community. Other groups are working to improve the DMQC process by more easily selecting the reference data using machine learning methods and by comparing anomalous profiles to eddy tracks. Given the interest in improving DMQC methods, the ADMT co-chairs are proposing a session at ADMT focusing on new methods or augmentations.

For pilot data, Megan reported that most DACs have changed the flagging of RBRctd data in real time to comply with the new recommendations of qc flags of '1' in certain circumstances. Most DACs are in the process of implementing the real time salinity adjustment described in the QC manual that will produce an adjusted salinity data stream in real time with a qc of '1'.

The ADMT has chosen to begin using the Argo Vocabulary Task Team GitHub dashboard to manage requests to changes to the Argo vocabularies and reference tables. https://github.com/orgs/nvs-vocabs/projects/2?fullscreen=true. The ADMT website contains instructions on how to request a change and then the ticket follows a process to gather feedback, approval and implementation.

The File Checker has been shared on GitHub and the updated version that accepts v3.2 trajectory files has been implemented. A new archival system at NCEI continues to be tested to allow for reproducibility for a specific date.

Finally, Megan ended by emphasizing the need to improve communications with our users. A few suggestions were made on how to do this and a small group was formed to make a regular update of the Argo data system each year.

Action 23: AST suggests the formation of a working group to find best way to communicate 'what's up with Argo data?' for the year. Could be a video describing amount of data added, data issues encountered, show percentage of data refreshed in the past calendar year. ***Who**: ADMT co-chairs, Susan Wijffels, Tanya Maurer, Fiona Carse, Deep Argo person, Fiona Carse*

Action 24: AST asks ADMT to begin looking forward to the next generation way of serving the data to users through an upgrade of GDAC web services (using cloud based solutions e.g.), and to facilitating DAC work through code sharing. ***Who**: ADMT co-chairs*

Action 25: AST recommends the ADMT investigate how to improve real time QC tests by more rapid implementation of the Min/Max tests by Christine, DACs implementing it themselves or another solution. ***Who**: Annie Wong, Christine, Breck Owens, and Virginie Thierry*

Interactions with the modeling community to improve communications

Recent real-time and climate change analyses have significant errors due to the use of data from Argo floats with Abrupt Salty Drifts. For real-time data, it is important that the quality control flags contained in the GTS BUFR messages are used to eliminate bad data. For climate analyses, the real-time data should be replaced with D-mode, quality-controlled data files from the Argo GDACs. Most climate analyses use either the Hadley Center EN4 or Coriolis Ocean database for ReAnalysis (CORA) databases which contain all types of ocean data which are updated on a long time interval. To improve coordination between the Argo Float Program and ocean analysis centers, a group including B. Owens, A. Wong, P. Oke and M. Scanderbeg was set up to develop materials to guide analysis centers on the best use of Argo data. A. Wong prepared a presentation detailing the best use of Argo data. This presentation can be found at: https://argo.ucsd.edu/wp-content/uploads/sites/361/2023/04/HowToUseArgoData_awong.pdf.

The first meeting, using Zoom, was held on 2 March, 2023. It included Hao Zuo of ECMWF and Fiona Carse and Mathew Martin of the UK Met Office. Wong, Oke and Owens represented Argo. Both analysis groups are using the GTS BUFR QC flags. The UK Met Office has a 7-hour cut off for the delay between the observation and receipt times. ECMWF requires receipt of the data within 7-12 days for their seasonal forecast. ECMWF will reach out to other analysis centers to make sure they are using Argo QC flags. The delay in updating the EN4 database is partially due to personnel issues and will be addressed shortly. Discussion on 2 March and at the AST meeting suggest that we work with the Hadley Center and Coriolis to decrease the time interval for updating the ocean databases. We will reach out to the curators of these databases in the near future.

A recommendation from the 2 March meeting is that Argo needs to shorten the delay time to identify floats with failing sensors. It was recommended that Argo provide results of automated procedures, such as the Coriolis Min/Max tests, as quickly as possible.

We will be scheduling meetings with other analysis centers in the near future. Additionally, we will work through OceanPredict and other meetings to advertise best practices for using Argo data. To that end, some communication attempts have already been made. These included presentations by Toshio Suga (in person) and A. Wong (remote) at the OceanPredict/SynObs Workshop in Tsukuba, Japan, in November 2022.

Several people contributed to a discussion afterwards and it was reiterated that, unfortunately, many centers do not go back and refresh their Argo dataset. Two providers in particular were discussed and a plan was made to reach out to them directly. It was also noted that Argo could improve their real time data tests which could help ease the problem of bad real time data not being replaced.

Action: AST recommends the ADMT investigate how to improve real time QC tests by more rapid implementation of the Min/Max tests by Christine, DACs implementing it themselves or another solution. ***Who****: Annie Wong, Christine Coatanoan, Breck Owens, and Virginie Thierry*

Metadata, tech data from manufacturers into the data system

Brian King updated the AST on his efforts with manufacturers to create machine readable pre-deployment metadata. The motivations behind this include the ability for DACs and PIs to quickly and accurately obtain the pre-deployment metadata by machine to machine transfer. This should ease the introduction of new float or sensor models, but also increase the speed and accuracy of current float and sensor metadata in the Argo data system.

At ADMT-23, both RBR and SBS shared examples of their APIs to serve metadata and this was used as a starting point for creating a JSON file to capture metadata for each sensor or platform. The field names will exactly match the variable names in the Argo netcdf files and the content of those fields will match the Argo controlled vocabularies. There will also be a field for extra information from the vendor which they find useful even if not currently stored in the Argo metadata. A float's JSON file will aggregate the JSON files for each sensor on the float. Several examples were shown along with a very short Matlab function to read in the JSON files.

Brian reported that a few things still need to be finalized with RBR and SBS and when that is done, the JSON format will be circulated widely to both vendors and users for further feedback. Once agreement is reached, Argo will request all vendors start implementing it as soon as possible. At that point, tools may need to be developed to combine platform and sensor JSON. In addition, code to access and read the JSON files, and possibly to turn the information into an Argo netCDF will be shared. During the process, some new metadata fields may be suggested and proposed to the ADMT.

Depending on the outcome, Argo may consider working with vendors on similar initiatives for the tech, trajectory and even profile data coming from the floats.

This work was warmly received and could be a way to help reduce the burden on DACs and PIs when new sensors become available which could enable further innovation and improvement in sensors and float technologies.

Action 26: Ask manufacturers to provide decoders that produce json files with data that matches the Argo variable names. Could also work to improve decoding of other information to make it make more closely match Argo data format. Ask that DACs agree to work with these data formats. ***Who**: Brian King, Claire Gourcuff, Megan Scanderbeg*

CTD ref data

CCHDO continued to provide Ifremer with reference ship-based data that is ingested into the Core and deep Argo reference databases and made available to Argo DMQC groups. CCHDO's holdings include over 64,000 high quality, ship based profiles. This year, 2250 stations were either updated or added to the public repository. In addition, CCHDO provides Ifremer with non-public CTD data from institutions who would like to make their data available for QC of Argo data, but not for public research yet. This year, this included 1377 profiles collected from South Africa, Poland, JAMSTEC, KMA, and the SO-CHIC program.

Demonstrating Argo's value

Argo bibliography

Megan Scanderbeg presented on the status of the Argo bibliography over the past year. 500+ papers have been found in the past three years and the total number of papers is remaining pretty steady. The number of BGC Argo papers is rising while the number of Deep Argo papers remains small. New countries continue to publish Argo papers including Barbados, Estonia and Morocco in the past year. When looking at the source of Argo data in the papers, there continues to be a large uptake of gridded fields, model outputs and curated databases. Megan noted that the number of authors that are Argo PIs is trending down, but this may also be due to the explosion of the number of Argo PIs which are not all be tracked. She suggested that we stop following this statistic as it has been clearly shown that people outside of the AST publish papers using Argo data. She noted that the webpage had to be adjusted because it was too much HTML on one page. Now the landing page for the bibliography contains the plots plus the current year. To access other years, users need to click on them.

AST website

Megan Scanderbeg reported on updates made to the AST website over the past year including updates to the available tools, the new Awards page and the new Adopt a float page. She presented drafts of the float deployment page and the email list serve page and asked for input prior to publication. She also proposed adding a short document that could be handed to manufacturers to help explain what is an Argo float and what isn't an Argo float.

Update on OneArgo as part of the UN Ocean Decade

Megan Scanderbeg updated the AST on OneArgo activities over the past year which included Breck attending several virtual meetings with our parent program, 'Ocean Observing Co-Design'. She also said that the OneArgo project has not been attached to a Decade Collaborative Office (DCO) or Decade Collaborative Centre (DCC) and suggested that we ask for the DCO for Ocean Observing hosted by IOC-GOOS. She also stated that we need to report on our activities for the period of 1 July 2022 to 30 June 2023 by 7 May 2023. The format is Survey Monkey and we need to report on our progress towards applicable challenges. The main form of the reporting involves identifying the number of knowledge documents produced during the year although the outreach efforts also ask about number of participants, country of origin, etc. After some discussion, it was suggested to create a form to make reporting on these outreach activities easier in the coming years. She asked for volunteers from the different missions to help her compile the necessary information for the report.

Action 27: Ask AST liasons for UN Ocean Decade actions to report back at AST-25 on activities done in the past year. *Who:* https://docs.google.com/document/d/1STWY2kqqphgv0dFYVg8fQGl7vEOxU88YmoeO6Bc3VQ8/edit?usp=sharing

Action 28: Ask for volunteers to work with Megan Scanderbeg to complete the UN Ocean Decade report. Due May 7, 2023. *Who: Breck Owens, Orens de Fommervault*

7th Argo Science Workshop report

The 7th Argo Science Workshop was organised as a hybrid event on 11-13 October 2022, in Brussels, Belgium. It was endorsed by the UN Decade of Ocean Science and Clivar and funded through the EA-RISE and EuroSea H2020 projects. The workshop was prepared by an international scientific committee who defined the workshop format, call for abstract and sessions, and reviewed the 112 abstracts received. The workshop was organised along three thematic sessions, each of them made of oral plenary presentations and 100% virtual poster sessions, some of the posters were highlighted through plenary flash-talks. In total, 45 talks, 23 flash-talks and 57 posters were presented. Two specific sessions were organised at the end of the first two days: a Q&A session with a panel of Argo experts, and a round table with EU delegates to discuss the sustainability of the OneArgo array. 305 persons registered for the workshop, with a large international representativity, and in the end, 99 people came to Brussels and more than 50 persons attended virtually. 40 responses to the short feedback survey were received and show a global satisfaction of the participants, in spite of an obvious failure of the poster session. Organising hybrid events is challenging, and we'll have to be innovative in the future to find new ways to exchange in such formats. The floor is now open for the planning of the next ASW, and Euro-Argo will be happy to provide more detailed feedback to the organiser of ASW8.

European Ocean Observing Awareness campaign

The « European Ocean Observing Capacity Awareness » campaign was launched by Mercator Ocean International and involved:

- Maria Hood and Audrey Hasson, who lead the European coordination for the G7 FSOI and GEO Blue Planet respectively and are part of the EU4OceanObs team.
- Lillian Diarra, Communication Officer of Mercator Ocean International.
- Marine Bollard, Communication Officer of Euro-Argo ERIC.
- Relying on EuroGOOS, EMODnet, EMB and Copernicus Marine to guide us in our work.

The campaign targets the public at large, the Argo community, stakeholders and decision makers and its mains objectives are:

- To raise public awareness of the European ocean observing capacity and the importance of in situ ocean observations for society.
- To present Argo and Euro-Argo scientific missions and challenges.
- To highlight a cross-generational component, showing the importance of collaboration between early career professionals and experts.

The three videos can be shared through those links:

- https://youtu.be/im4HVlK4hVU, to present Argo and OneArgo missions.
- https://youtu.be/cd-Z-uY-394, to learn more about Euro-Argo ERIC's contribution to the European Global Ocean Observing System
- https://youtu.be/NHFhMaHaUJQ, to get an overview of future needs and challenges faced by Euro-Argo ERIC and Europe's strong engagement for in situ global ocean observing

OneArgo brochure

Susan accepted the offer of OceanOPS to make a OneArgo brochure and to kick off a OneArgo communication campaign which may include a new animation, other videos/promotional materials and a brochure. A group was formed to work on the campaign.

Action 29: Make a OneArgo brochure with help from the community and OceanOPS. ***Who**: OceanOPS, Megan Scanderberg, Blair Greenan, Virginie Thierry, Orens de Fommervault, Marine Bollard, Jessica from NOAA*

Argo trajectory products, SIO

Megan Scanderberg presented the new Scripps Argo trajectory-based velocity products on behalf of her collaborators. She explained that there are two products: one in the 800-1200db range and one in the 100 – 6200db range. Both contain over one million velocities, some of which are based on transmitted positions and times like is done in ANDRO and YoMaHa and some that are based on extrapolated positions and times for Argos floats following on work done by Park et al 2005, ANDRO and the DAC

Trajectory Cookbook. The products are freely available both from the UCSD Digital libraries (https://doi.org/10.6075/J0KD1Z35) and Argovis (https://github.com/argovis/demo_notebooks).

A couple of potential uses of the product were presented which included a mapping done by Alison Gray and a comparison with the BRAN2020 model. A brief overview of the in-depth comparison between the Scripps product and both ANDRO and YoMaHa was shown. For more details, please see the paper:

Zilberman, N. V., M. Scanderbeg, A. R. Gray, and P. R. Oke, 2023: Scripps Argo Trajectory-Based Velocity Product: Global Estimates of Absolute Velocity Derived from Core, Biogeochemical, and Deep Argo Float Trajectories at Parking Depth. J. Atmos. Oceanic Technol., 40, 361–374, https://doi.org/10.1175/JTECH-D-22-0065.1.

Argo trajectory products, ANDRO

ANDRO : An Atlas of Argo Floats Trajectories in Delayed Mode

Since early 2000’s, thousands of Argo floats have been deployed over the World Ocean, gathering temperature and salinity data from the upper 2000 m with a 10-day or so sampling period. Between each profiles the Argo floats drift at a nominal parking depth around 1000 dbar. Meanwhile their deep displacements can be used to map the ocean circulation at their drifting depth.

ANDRO dataset is a comprehensive delayed mode processing procedure of the Argo trajectory data along with a freely distributed global atlas of deep displacements (Rannou and Ollitrault, 2013). The delayed mode check consist of visual control by a delayed mode operator of the float times and metadata; launch position and date ; floats positions. Also, the Representative Parking Pressure (RPP) is computed and controlled. Eventually, visual identification of the cycle which have non nominal behavior and/or have grounded is performed.

The processing of the whole Argo dataset collected prior to 1 January 2010 has been initially performed to produce a world-wide dataset of deep displacements. Since 2010, regular but incomplete updates are conducted. Up to now 1,360,753 trajectories have been processed in delayed mode and distributed.

To complete the dataset since 2010, Near Real Time automatic checks have been implemented following the data flow of ANDRO processing. These automatic checks provide deeper controls of the trajectory file than those existing at DAC level and help to improve the dataset quality. This automatic NRTQC procedure are currently being implemented at Coriolis data center. The NRT quality controlled data will be progressively replaced by the full delayed mode ANDRO data.

Ollitrault Michel, Rannou Philippe, Brion Emilie, Cabanes Cecile, Piron Anne, Reverdin Gilles, Kolodziejczyk Nicolas (2022). ANDRO: An Argo-based deep displacement dataset. SEANOE. https://doi.org/10.17882/47077

In the discussion after both trajectory talks, it was noted that the trajectory files are difficult to use and that these products go a long way towards making the data more accessible to the user community. It was also noted how important it is to keep the drift depth at 1000db to add to this dataset.

Argovis 2.0

Argovis is a web app and database (argovis.colorado.edu). Argovis allows, for the first time, easy access to user-selected regional and temporal subsets of Argo and GO-SHIP oceanic profiles, drifter observations, weather events, and gridded products relevant for the study of Earth's climate and ocean biogeochemistry, enhancing co-location capabilities across these data and accelerating climate science workflows, outreach, and education. More gridded datasets (e.g. surface winds, sea surface height) are in the process of being included in Argovis.

With its emphasis on facilitating data access and co-location capabilities across datasets, Argovis is well positioned to play a key role towards the realization of one of the desired outcomes of the 2021-2030 United Nations Decade of Ocean Science for Sustainable Development, i.e. to increase use of ocean knowledge and understanding by increasing ocean literacy across diverse stakeholders. Argovis accelerates new findings minimizing the time to science, as data subsets of interest are easily accessible even for large and complex data, and improves STEM teaching, as now students with different backgrounds can participate in activities that leverage these data (e.g. analysis of upper ocean changes during weather events and, in general, air-sea interactions). Providing targeted searches that allow access to large and complex dataset including from regions with low bandwidth internet connections, Argovis is committed to break barriers and increase diversity in geosciences.

Donata Giglio shared the updated version of web app and database Argovis with the AST. The ability to perform a targeted search allows users to download only the data needed which saves bandwidth and post-processing efforts. She then introduced the new front end and demonstrated how to query profiles in a region and time of interest. There is now a 'max day range' on the left which indicates the largest time window possible to search from the front end which is based on the dataset you are browsing. Another new feature is the custom 3-D plots to visualize profile data. Users can control the variables on the axes (including axis limits), the choice of the color of the dots, and the colorbar. One can even extend to a 4D plot, or choose to connect the dots with a line.

For the backend access via the API, she reminded the group of the numerous demo notebooks available on the Argovis GitHub repository (https://github.com/argovis/demo_notebooks). To launch the notebook, click on the 'launch binder' badge. There are demo notebooks on a variety of topics including: downloading and plotting Argo data by variable in a region and time of interest, downloading metadata and plotting numbers of Argo profiles by year, co-locating Argo profiles and ship-based profiles, exploring Argo profiles colocated with tropical cyclones, exploring drifter data or gridded Argo products.

Moving back to the front end, she introduced the new module to explore ship-based profiles where users can search by WOCE line or Cruise ID. She also showcased the gridded product front end capabilities to map variables at a time and pressure level of interest or to compare two different times of interest. She also pointed to links (in the explore menu) to pages for drifter data or colocation of different datasets.

She ended by noting that the Argovis documentation will be completed soon, more datasets will be added such as SSH, SST, etc and that more Argovis-based educational activities are planned (in addition to those already available on the Argovis GitHub repository). She welcomed collaborations and feedback.

Upcoming science conferences and technical workshops

Deep Ocean Collective Solution Accelerator" - 2-5 October 2023 at Scripps

This event is brought to you by the Deep Ocean Observing Strategy (DOOS) in partnership with COBRA and the Ocean Discovery League. Click here to learn more: https://docs.google.com/forms/d/e/1FAIpQLSfBCodPyhE4R7XQv5IUKlQvd2c7R83tVMtaJo6BS2vKQLpwuQ/viewform

CLICK HERE TO APPLY (applications are due by April 14th)

The event will be composed of five concurrently run mini-workshops each ranging from 12-18 people in size. The goal of the "Collective Solution Accelerator" is to make meaningful progress toward addressing large deep sea science challenges by strategically aligning the community, leveraging existing efforts and resources, and finding pathways forward of mutual community benefit to continue progress. While each attendee will only be able to attend one of these workshops, there will be opportunities to interact with and learn from the other groups during the event through plenaries, report outs, and personal exchanges.

Mini-workshops include:

1) Cheap and Deep Technology and a Means for Capacity Development (Led by the Ocean Discovery League)

2) Deepening the Decade: Better Together

3) Habitat Conservation and Marine Spatial Planning

4) Synergizing Models and Observations to Fill Key Climate Gaps

5) Seafloor Microbial Ecosystem Services (Led by COBRA)

Meeting AMOC Observing Needs in a Changing Climate in 18 - 20 July 2023

This is being organized by the CLIVAR AMOC Task Team and has been awarded funding by US CLIVAR. It will take place 18-20 July 2023 at Hamburg University, Germany. See here for more details: https://www.conferences.uni-hamburg.de/event/316/

The proposal suggested 70 in-person attendees and 40+ additional virtual participants.

The primary goal of the workshop is to inform the design of a future-focused AMOC observing system that can provide continuous measurements of key variables while also remaining sustainable over multiple decades. We hope to bring the community together to discuss the value of different existing AMOC observing methods/networks, define a collective set of observational priorities, and outline a roadmap for future AMOC observing. The latter includes identifying potentially beneficial observing system assessment and design experiments. Also relevant to our project: we want to ensure the traditional set of AMOC-related observational priorities (volume, heat and freshwater transports) is expanded to consider BGC variables required for understanding the role of the AMOC in oxygen, carbon and nutrient cycling.

Pathways Connecting Climate Changes to the Deep Ocean – Tracing physical, biogeochemical, and ecological signals from the surface to the deep sea

This has been proposed by DOOS and the CLIVAR POS Panel and has been awarded funding.

The workshop is anticipated to take place for 2.5 days in the Spring of 2024 with around 80 in-person attendees and 40+ additional virtual participants.

The primary goal of the workshop is to develop a collective set of requirements for improved characterization of variability and the detection and attribution of change in the deep ocean, with a focus on better serving and supporting deep ocean science across disciplines. We hope to bring together observational oceanographers and modelers across physical, BGC, and ecological research communities to assess our current understanding of deep ocean changes and processes propagating climate variability to depth, review the adequacy of existing observational and modeling tools, and develop a collective set of recommendations for improved detection and attribution of deep ocean change. The date has still not been fixed. Our aim is to postpone the whole way until spring 2024 so that we can have a long webinar series leading up to the event that will cover the broad scope proposed.

Virtual Deep DMQC workshop in June 2023

Cecile Cabanes, Annie Wong and Nathalie Zilberman are organizing a virtual workshop in June 2023 to demonstrate and discuss how to apply the Cpcor correction to Deep Argo floats in DMQC. There will also be discussion on best practices for DMQC of Deep Argo floats. All DMQC operators are encouraged to attend. Look for more information on email and the AST website.

Virtual trajectory DMQC workshop in November 2023 – February 2024

A virtual trajectory DMQC workshop is planned for later in this year or early next year after DACs have had time to produce the v3.2 trajectory files. This virtual workshop will focus on familiarizing DMQC operators with the tasks needed to complete DMQC on trajectory files. The Trajectory working group will help organize.

OSTST Workshop Nov 2023

Susan commented that her attendance, along with Emily Smith and Nathalie Zilberman, at the OSTST workshop last year was very valuable and encouraged others in Argo to participate as well. The workshop this year will likely take place the week of November 6th, 2023 and Josh Willis would like to include some Argo science talks. Anyone interested in attending was encouraged to contact Susan.

Action 30: Interact with OSTST for their next meeting in November 2023. ***Who****: Emily Smith, Susan Wijffels, Nathalie Zilberman, Greg Johnson*

Glider workshop in June 2024 in Sweden

Susan asked what the glider community would like to hear from Argo at the planned glider workshop in June 2024. Several in the AST also work with gliders, Tetjana Ross, Victor Turpin, Emily Smith, etc. and they suggested there is a lot of potential overlap between the sensor technology and the data format. Argo suggests two possible talks at the workshop: one on sensors to be given by a BGC Argo person and one on data to be given by an ADMT co-chair.

Action 31: Work with BGC Argo co-chairs, OceanOPS to identify speakers on sensor issues and data issues at the glider workshop in June 2024. ***Who***: *Victor Turpin, Yui Takahashi, Herve Claustre, ADMT person, ?*

Oxygen workshops

During the discussion about oxygen, it became clear that two oxygen task teams are needed. One will focus on array design and one on sensors. The one on array design will be lead by Peter and Nathalie and will involve both scientists and modelers. The one on sensors will focus on improving the sensor's accuracy, stability, drift, etc and would really benefit from other users of these sensors outside of Argo like the glider community, OceanSITES, moorings, etc.

Action 32: Form oxygen design array task team to study scientific array design. Modelers and scientists will be included and results could be presented at a workshop likely in 2025. ***Who***: *Peter Oke to lead, Nathalie Zilberman, Claire Gourcuff, others?*

Action 33: Form an oxygen sensor task team to study the accuracy and stability of the sensors, including for deep deployments. Suggest the involvement of other groups such as OceanSITES, moorings, gliders, etc. Results could be presented at a workshop or presented back to Argo. ***Who***: *Virginie Thierry, Jannes Koelling, Doug Wallace, Ken Johnson, Yui Takahashi, Roo Nicholson, Brian King, Seth Bushinsky, Nathalie Zilberman, JAMSTEC, Tetjana Ross*

G7 FSOI 2023

The G7 FSOI 2023 work plan has been set and OneArgo is one of the five priority topics. This year the meeting will be hosted by Japan in November 2023 and the AST encourages all Argo representatives for G7 countries to contact their government to identify their delegates. If possible, AST members could brief their delegates prior to the workshop with the clear message that we have a great plan for OneArgo that is ready to implement, but we need support. If possible, it would be beneficial to provide promotional materials such as a new OneArgo animation. .

COP 28

COP28 will take place in December in Dubai. Susan noted this is the main meeting where nations come together to negotiate carbon emissions, so it is very high profile. WHOI led the new Ocean Pavilion at COP 27 and Scripps and Ifremer both joined in, but without much lead time. This year, it would be beneficial to prepare in advance with a nice updated brochure and a great audio visual – possibly an updated OneArgo animation. One possible way to frame the presentation could be in terms of Carbon Dioxide Removal (CDR) which is popular right now.

Future Argo meetings

ADMT-24

CSIRO in Hobart, Tasmania has offered to host the ADMT-24 meeting which will take place the week of 23 – 27 October 2023. Stay tuned to learn more about registration and agendas.

AST-25

Brian King renewed his offer to host AST-25 at BODC in Southampton. The AST had been all set to go there in March 2020 when everything was cancelled due to Covid-19. The AST gladly accepts the renewed offer to go to BODC.

Scripps Institution of Oceanography offered to host AST-26. IFREMER in Brest also offered to host any future meetings.

AST Membership

Toshio Suga spoke to the AST and acknowledged that Argo is now at a critical juncture and that not a moment can be wasted as we move to implement the OneArgo array. This calls for AST co-chairs who have lots of energy and time to accomplish the plan with with his increased responsibility at Tohoku University, he has decided to step down as AST co-chair. He thanked the Argo community for their support over the past 5 years and reiterated that he will still be involved in the AST, but not as co-chair.

Susan went on to explain that the AST executive committee had a discussion about who the next co-chair should be and Brian King was suggested as a candidate. He would be the first European co-chair, has lots of experience with Argo and the expansion into the BGC and Deep Argo missions. Susan asked the AST for feedback. Everyone agreed Brian was a good choice, so he was selected as the next AST co-chair.

Susan then noted that the AST executive committee will continue to think about succession planning for co-chairs and how best to organize the AST meeting next year to make efficient use of time and to allow time for all missions.

Agenda

Action Items

National Reports

BGC Argo Mission SCHEDULE

March 20

Make a copy of this spreadsheet and then set your local start time in box B9 and all other times will automatically adjust

Link to google drive for AST-24 with presentations and reports

Link to google doc with AST-24 meeting doc

Start time	duration	Presentation	Speaker	Blue text means a virtual speaker
Time is UTC - 3		**Introductory session**		
9:00 AM	0:10	Welcome by Director, Ocean Science, DFO	Keith Lennon	
9:10 AM	0:10	Welcome by CEO & Scientific Director, Dalhousie University Associate Vice-President Research (Ocean), GOOS Steering Committee Co-chair)	Dr. Anya Waite	
9:20 AM	0:05	Introduction/general objectives of the meeting	Ken Johnson	
9:25 AM	0:05	BGC Argo Mission status	Orens de Fommervault	
		National reports		
9:30 AM	0:05	Australia	Peter Strutton	
9:35 AM	0:05	Canada	Katja Fennel	
9:40 AM	0:05	China	Fei Chai	
9:45 AM	0:05	UK	Nathan Briggs	
9:50 AM	0:05	EuroArgo	Claire Gourcuff	
9:55 AM	0:05	France	Herve Claustre	
10:00 AM	0:05	German	Arne Kortzinger	
10:05 AM	0:25	BREAK		
10:30 AM	0:05	India	Uday Bhaskar	
10:35 AM	0:05	Italy	Giorgio Dall'Olmo	
10:40 AM	0:05	Japan	Tetsuichi Fujiki	
10:45 AM	0:05	Norway	Kjell Arne Mork	
10:50 AM	0:05	US	Ken Johnson	
10:55 AM	0:05	Saudi Arabia	Malika Kheredine	
		Data Management		
11:00 AM	0:25	ADMT23 report	Catherine Schmectig, Tanya Maurer	
11:25 AM	0:25	BGC DMQC report	Catherine Schmectig, Tanya Maurer	
11:50 AM	0:20	DAC status and issues, consistency	Ken Johnson	
12:10 PM	0:20	Products	Herve Claustre	
12:30 PM	1:30	LUNCH BREAK		
		Implementation		
2:00 PM	0:10	Radiometry WB report	Emanuele Organelli	
2:10 PM	0:10	BGC Argo Float timing and scientific objectives	Steve Riser	
2:20 PM	0:15	Deployment planning: tools and communicaiton	Orens de Fommervault and Ken Johnson	
		Sensor and float updates		
2:35 PM	0:10	BGC-SOLO	Sarah Purkey	
2:45 PM	0:10	Jumbo CTS5 NKE	Herve Claustre	
2:55 PM	0:15	NAVIS/APEX floats	Steve Riser	
3:10 PM	0:10	pH sensor	Ken Johnson	
3:20 PM	0:10	mini-ISUS sensor	Ken Johnson	
3:30 PM	0:30	BREAK		
4:00 PM	0:10	Opus sensor	Herve Claustre	
4:10 PM	0:10	UVP sensor	Herve Claustre	
4:20 PM	0:10	Hyperspectral radiometry	Herve Claustre	
4:30 PM	0:10	New RBR BGC sensors	John Talor	
4:40 PM	0:10	New SBE BGC sensors	Eric Rehm	
4:50 PM	0:05	ARO-FT sensor	Kanako Sato	
4:55 PM		**END OF MEETING**		

BGC Argo Mission SCHEDULE

		March 21				
			Make a copy of this spreadsheet and then set your local start time in box B9 and all other times will automa			
		Link to google drive for AST-24 with presentations and reports				
		Link to google doc with AST-24 meeting doc			**Blue text means a virtual speak**	
	Start time	**duration**				
	Time is UTC - 3					
	9:00 AM	0:15	Diversification of sensors (for the same variable): impact on DAC dataset	Herve Claustre/Ken Johnson		
	9:15 AM	0:20	The need to set up a technological TT ?	Herve Claustre/Ken Johnson		
	9:35 AM	0:20	Long term sensor performance assessment	Ken Johnson		
	9:55 AM	0:10	How OceanOps can help in setting BGC-Argo monitoring tools	Orens de Fommervault		
	10:05 AM	0:25	BREAK			
	10:30 AM	0:05	BECI and BGC Argo	Tetjana Ross		
	10:35 AM	0:30	Revising the Implementation Plan	Ken Johnson/Herve Claustre		
	11:05 AM	0:30	Website / newsletters / outreach	Orens de Fommervault		
	11:35 AM		**END OF MEETING**			

Deep Argo Mission SCHEDULE

March 21

Make a copy of this spreadsheet and then set your local start time in box B9 and all other times will automa

Link to google drive for AST-24 with presentations and reports

Link to google doc with AST-24 meeting doc

Blue text mean

Start time	duration	Presentation
Time is UTC - 3		
1:00 PM	0:00	
		1. Deep Argo implementation
1:00 PM	0:15	*1.1 Status of the Deep Argo array, deployments/year, lifetime, aging of the fleet (Victor)*
		1.2 Reports from the Deep Argo national programs
1:15 PM	0:08	France (Virginie)
1:23 PM	0:08	U.S. (Nathalie)
1:31 PM	0:08	Japan (Hosoda)
1:39 PM	0:08	U.K. (Brian)
1:47 PM	0:08	Australia (Annie)
1:55 PM	0:08	Europe (Claire Gourcuff)
2:03 PM	0:08	Norway (Kjell Arne)
2:11 PM	0:08	Italy (Giulio)
2:19 PM	0:08	China (Zhaohui, Zenghong)
2:27 PM	0:08	Canada (Tetjana)
2:35 PM	0:10	Discussion: Planned extension of the Deep Argo array based on the reports of the National Program. Upda
		2. Data Management
2:45 PM	0:15	Recommendations from the ADMT regarding near-real time and delayed-mode adjustment of T & S, including CPcor (Virginie Thierry)
3:00 PM	0:10	Discussion: How is SeaBird planning to resolve the Cpcor issue?
		3. Technology
		3.1 Deep Argo floats
3:10 PM	0:08	Deep Arvor (Xavier Andre and Virginie Thierry)
3:18 PM	0:08	Deep SOLO (Nathalie)
3:26 PM	0:08	Mermaid (Hosoda)
3:34 PM	0:08	Deep XUANWU (Zhaohui, Zenghong)
3:42 PM	0:10	BREAK
		3.2 CTD Sensors
3:52 PM	0:08	Updates 2-head, 3-head & 6000-m RBR (Virginie, SeaBird & RBR)
4:00 PM	0:15	Updates on RBR6000 and other potential Deep Argo sensors (Mat Dever)
4:15 PM	0:15	Discussions on Deep Argo floats and CTDs
		3.3 Oxygen Sensors
4:30 PM	0:08	AROD-FT (Kanako Sato)
4:38 PM	0:08	Upcoming Tangaroa cruise on DO (Nathalie)
4:46 PM	0:20	Discussion: Deep Argo DO sensor improvement
		3.4 Emerging work on backscattering Sensors
5:06 PM	0:08	On-going study of the RBR BBP sensor performances to 6000 m (Giorgio)
5:14 PM		**END OF MEETING**
		needs to be 5pm

AST-24 DAY 1 SCHEDULE

March 22

Make a copy of this spreadsheet and then set your local start time in box B9 and all other

Link to google doc with AST-24 meeting doc | **blue text means**

Link to google drive for AST-24 with presentations and reports

Start time	duration	Presentation	Speaker
Time is UTC - 3		**Introductory session**	
9:00 AM	0:05	Welcome	AST co-chairs
9:05 AM	0:10	Objectives of the meeting	AST co-chairs
9:15 AM	0:15	Status of Action Items form AST-23	M. Scanderbeg
9:30 AM	0:15	Update commitments table	V. Turpin
9:45 AM	0:15	WMO, IOC, GOOS OCG update	M. Belbeoch
10:00 AM	0:30	BREAK	
		OneArgo Status Update	
10:30 AM	0:20	Argo's status report	V. Turpin
10:50 AM	0:20	BGC Argo Mission status and challenges	K. Johnson, H. Claustre
11:10 AM	0:20	Deep Argo Mission status and challenges	N. Zilberman, B. King
11:30 AM	0:20	Polar Argo Mission status and challenges	N. Kolodziejczyk
11:50 AM	0:30	One Argo Array Design status discussion	S. Wijffels to lead
12:20 PM	1:15	LUNCH BREAK	
		Implementation issues	
1:35 PM	0:15	OceanOPS update, including new BGC Argo coordinator	OceanOPS
1:50 PM	0:15	EEZ guidelines and strategies	M. Belbéoch
2:05 PM	0:10	AIC, OceanOPS funding	M. Belbéoch
2:15 PM	0:20	EuroArgo Status	Y-H DeRoeck
2:35 PM	0:10	Exploring the OMZ in the Atlantic	Xavier Capet
2:45 PM	0:20	Deployment coordination across missions	T. Morris
3:05 PM	0:10	Core Argo Best Practices paper	T. Morris
3:15 PM	0:30	BREAK	
		Core CTD vendors	
3:45 PM	0:40	SBE	
4:25 PM	0:40	RBR	
5:05 PM		**END OF MEETING**	
5:30:00 PM - 7:30PM		**Social event at OFI**	

AST24 DAY 2 SCHEDULE

CLOSED SESSION

March 23

Make a copy of this spreadsheet and then set your local start time in box B9 and all other times will automatically adjust

Link to google doc with AST-24 meeting doc

Link to google drive for AST-24 with presentations and reports

Start time	duration	Presentation	Speaker	Blue text means a virtual speaker		
						Monitor
Time is UTC - 3		**Float performance & evaluation of the health of the array**				Orens
9:00 AM	0:20	Report & discussion on current float lifetimes, including by core, Deep, BGC Mission	Led by V. Turpin, M. Belbeoch with input from community			
9:20 AM	0:10	**Technical Community of Practice group**				
		Float technical updates, including float production and supply chain issues				
		Core floats				
9:30 AM	0:10	APEX	Steve Riser			
9:40 AM	0:10	NAVIS	Steve Riser			
9:50 AM	0:10	ALTO	Steve Jayne			
10:00 AM	0:10	SOLO-II	N. Zilberman			
10:10 AM	0:10	MRV S2A	P. Robbins	we will share slides		
10:20 AM	0:30	BREAK				
10:50 AM	0:10	COPEX	Zenghong Liu			
11:00 AM	0:10	Arvor	Noe Poffa			
11:10 AM	0:10	SeaTrec	Emily Smith			
11:20 AM	0:15	**Deep floats**	N. Zilberman			
11:35 AM	0:15	**BGC floats**	H. Claustre			
		Sensor progress				
11:50 AM	0:10	Monitoring and warranty progress in Abrupt Salty Drift in SBE41	B. Klein			
12:00 PM	0:15	SBE61	N. Zilberman			
12:15 PM	1:15	LUNCH - working lunch OceanOPS tutorial/Q&A				
1:30 PM	0:15	RBRargo	C. Richards			Monitor:
1:45 PM	0:15	BGC Sensors	H. Claustre, K. Johnson			Victor
		Under-ice floats				
2:00 PM	0:10	Under-ice floats	Steve Riser			
2:10 PM	0:05	SOLO Arctic float	C. Lee, D. Rudnick			
		Data Management related issues				
2:15 PM	0:30	Feedback from ADMT-23	M. Scanderbeg, C. Gourcuff			
2:45 PM	0:15	Interactions with the modeling community to improve communications	B. Owens, A. Wong			
3:00 PM	0:15	Metadata, tech data from manufacturers into the data system	B. King		351pm	
3:15 PM	0:10	CTD reference data	S. Purkey			
3:25 PM	0:30	BREAK				
		Tour of labs				
3:55 PM	0:30	Aquatron: https://www.dal.ca/dept/aquatron.html				
4:25 PM	0:30	Doug Wallace's lab: https://www.dal.ca/diff/cerc.html				
4:55 PM		**END OF DAY**				

AST-24 DAY 3 SCHEDULE

CLOSED SESSION

March 24

Make a copy of this spreadsheet and then set your local start time in box B9 and all other times w

Link to google doc with AST-24 meeting doc

Link to google drive for AST-24 with presentations and reports

Start time	duration	Presentation	Speaker	Blue text mean:
Time is UTC - 3		**Demonstrating Argo's value**		
9:00 AM	0:15	Argo bibliography	M. Scanderbeg	
9:15 AM	0:10	Argo Steering Team Website Updates	M. Scanderbeg	
9:25 AM	0:15	Update on OneArgo as part of the UN Ocean Decade	M. Scanderbeg	
9:40 AM	0:10	7th Argo Science Workshop report	Claire Gourcuff	
9:50 AM	0:10	European Ocean Observing Awareness campaign	Marine Bollard	
10:00 AM	0:10	OneArgo brochure + promotion materials TT		
10:10 AM	0:30	BREAK		
10:40 AM	0:10	Argo Trajectory Products, SIO	M. Scanderberg, N. Zilberman	
10:50 AM	0:10	Argo Trajectory Products, ANDRO	Cecile Cabanes, Nicolas Kolodziej	
11:00 AM	0:20	Argovis 2.0	Donata Giglio	
		Upcoming science conferences and technical workshops		
11:20 AM	0:03	Pathways Connecting Climate Changes to the Deep Ocean – Tracing physical, biogeochemical, and ecological signals from the surface to the deep sea in spring 2024 (CLIVAR)	N. Zilberman	
11:23 AM	0:03	Meeting AMOC Observing Needs in a Changing Climate in 18 - 20 July 2023	N. Zilberman	
11:26 AM	0:03	Deep Ocean Collective Solution Accelerator: 2 -5 October 2023 at Scripps	N. Zilberman	
11:29 AM	0:05	ADMT workshops	M. Scanderbeg	
11:34 AM	0:10	OSTST Workshop November 2023	S. Wijffels	
11:44 AM	0:10	Glider community meeting in Europe June 2024	Victor Turpin	
11:54 AM	0:10	Oxygen TT workshop outcomes 2025 (possibly with SynObs, GSOP)	N. Zilberman	
12:04 PM	0:10	8th WMO workshop in May 2024	B. Owens	
12:14 PM	0:10	G7 in Tokyo, Nov 2023 - OneArgo is one of 5 chosen topics		
12:24 PM	0:10	COP28 Nov 30 - Dec 12, 2023, Dubai		
12:34 PM	1:30	LUNCH BREAK		
		Future meetings		
2:04 PM	0:05	ADMT-24: 23-27 October 2023 in Hobart, Tasmania, Australia		
2:09 PM	0:05	AST-25		
2:14 PM	0:20	**AST Membership & business**		
2:34 PM	0:30	**Review of action items**		
3:04 PM		**END OF MEETING**		

	Action	Responsible	Status	Notes
1	Write a letter of thanks to Blair Greenan and DFO for hosting AST-24	AST co-chairs		
2	Ask for a report at ADMT-24 & AST-25 on the time of day of profiles in the past year and if the extra noon profiles have been added.	Steve Riser, ?		
3	Ask ADMT to find a way to flag noon time profiles in the data system for those who want to remove them from their analyses.	John Gilson, Megan Scanderbeg, ?		
4	AST suggests the formation of a Technology Task Team for BGC Argo sensors	Edouard Leymarie, Orens de Fommervault, ?		
5	AST suggests the formation of a task team to work with manufacturers to find a way to well document big changes and track this through the appropriate metadata.	Brian King to lead		
6	Ask EA Rise to report back to AST on Boundary Current study	Guillaume Maze		
7	Form a task team to interact with the organizers of the 8th WMO Workshop on the Impact of Various Observing Systems on NWP and Earth System Prediction : Contribution from the designers of the Ocean observing networks in May 2024. Find people to attend. Contact Mary Laure Gregoire	Breck Owens, Mathieu, Susan, Peter, Ken/Herve/BGC, Molly, Annie Wong		
8	AST suggests that we write an opinion piece about the urgent need to measure the status of BGC parameters in the ocean now, specifically carbon and pH, at minimum. Target publications could include New York Times, Nature, etc.	Ken Johnson, Katia Fennel, Susan Wijffels, Tetjana Ross,		
9	AST asks ADMT to find the best way to indicate deep Argo profiles in the index lists.	Deep Argo co-chairs, ADMT co-chairs, GDACs, John Gilson		
10	AST strongly supports the acceleration of the formation of the Polar Argo Mission to consider tasks such as deployment coordination, improving ice avoidance and acquisition, and perhaps qc, of reference data. If interested, please contact Nicolas Kolodziejczyk or Esmee van Wijk	PIs who deploy in polar regions		
11	Ask ADMT to consider how to store information floats send back about ice avoidance	Esmee van Wijk, John Gilson, Annie Wong, Steve Riser, Matt Alkire, Robert Drucker, Megan Scanderbeg, Niolas Kolodziejczyk		
12	AST suggests the formation of a task team to develop and tune indicators on OceanOPS to better define targets, missions, float monitoring, coverage, density, etc.	Chris Gordon, Claire, Gourcuff, Catherine Schmechtig, Romain Cancouet, Ken Johnson, Hervé Claustre, Katja Kennel, OceanOPS, Susan Wijffels, ?		
13	Ask Matheiu Belbeoch to ask IOC to send a new circular letter asking for new national focal points	Mathieu Belbeoch		
14	Add EEZ deployment table to the new Float Deployment page on AST website. Also add it to the Argo one pager explaining what an Argo float is and is not.	Megan Scanderbeg		
15	Work to inform the research community of legal issues surrounding EEZs and that Argo floats have special permissions and obligations regarding EEZs. Consider adding information to websites as well as to manufacturers to clearly identify what an Argo float is. Ask Emily to raise with OCG	Megan, Victor, Nathalie, Emily		
16	AST asks National Programs to consider either making a new contribution to OceanOPS (a small one is welcome) or to increase their current contribution to account for inflation (perhaps 10% more).			
17	In the Core Argo Best Practices, adjust wording for statement to address request of fast profiling/shallow profiling floats and pass through the AST exec for feedback and approval.	Megan Scanderbeg, Tammy Morris, AST exec		
18	Ask National Programs to submit warranty requests for ASD SBE CTDs. See Jochen's presentation, meeting report, or ask Birgit for more details on the format submission. This will be revisited for up to 18 months. https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing	National Programs with ASD SBE CTDs		
19	AST formally recognizes the Technical Community of Practice as a key component of the program and will work with them to organize the next technical workshop (possibly summer 2024).	Pat McMahon, Rick Rupin, Steve Riser, Shigeki Hosoda, Brian King, Sarah Purkey, European person		
20	Ask SBS for clarification on spot sampling details and pumping rate for SBE41 and SBE61 and report back to ADMT-24. Concerned about need to clear sensor for first few measurements taken during drift and start of profile.	Nathalie Zilberman, Greg Johnson		
21	Ask all Deep SOLO floats to profile upon ascent to comply with operational centers. Ask John Gilson and SIO Argo for recommendations for how to adjust settings for current floats			
22	Ask RBR data Task Team to evaluate the dynamic corrections both in real time and delayed mode	RBR data task team		
23	AST suggests the formation of a working group to find best way to communicate 'what's up with Argo data?' for the year. Could be a video describing amount of data added, data issues encountered, show percentage of data refreshed in the past calendar year.	ADMT co-chairs, Susan Wijffels, Tanya Maurer, Fiona Carse, Deep Argo person, Fiona Carse		
24	AST asks ADMT to begin looking forward to the next generation way of serving the data to users through an upgrade of GDAC web services (using cloud based solutions e.g.), and to facilitating DAC work through code sharing.	ADMT co-chairs, ?		
25	AST recommends the ADMT investigate how to improve real time QC tests by more rapid implementation of the Min/Max tests by Christine, DACs implementing it themselves or another solution.	Annie Wong, Christine, Breck Owens, and Virginie to work on this prior to ADMT-24		
26	Ask manufacturers to provide decoders that produce json files with data that matches the Argo variable names. Could also work to improve decoding of other information to make it make more closely match Argo data format. Ask that DACs agree to work with these data formats.	Brian King, Claire Gourcuff, Megan Scanderbeg		
27	Ask AST liasons for UN Ocean Decade actions to report back at AST-25 on activities done in the past year	https://docs.google.com/document/d/1STWY2kqqphgv0dFYVg8fQGl7vEOxU88YmoeO6Bc3VQ8/edit?usp=sharing		
28	Ask for volunteers to work with Megan Scanderbeg to complete the UN Ocean Decade report. Due May 7, 2023	Orens, Breck, co-chairs		

29	Make a OneArgo brochure with help from OceanOPS and the community	OceanOPS, Megan Scanderbeg, Blair Greenan, Virginie Thierry, Orens de Fommervault, Marine Bollard, Jessica from NOAA		
30	Interact with OSTST for their next meeting in November 2023	Emily Smith, Susan Wijffels, Nathalie Zilberman, Greg Johnson		
31	Work with BGC Argo co-chairs, OceanOPS to identify speakers on sensor issues and data issues at the glider workshop in June 2024.	Victor Turpin, Yui Takahashi, Herve Claustre, ADMT person, ?		
32	Form oxygen design array task team to study scientific array design. Modelers and scientists will be included and results could be presented at a workshop likely in 2025	Peter Oke to lead, Nathalie Zilberman, Claire Gourcuff, Alison Gray, others?		
33	Form an oxygen sensor task team to study the accuracy and stability of the sensors, including for deep deployments. Suggest the involvement of other groups such as OceanSITES, moorings, gliders, etc. Results could be presented at a workshop or presented back to Argo.	Virginie Thierry, Jannes Koelling, Doug Wallace, Ken Johnson, Yui, Roo Nicholson, Brian King, Seth Bushinsky, Nathalie Zilberman, JAMSTEC, Tetjana Ross		
	Ask that float deployers please inform OceanOPS upon notification if ice-detection software is included in the float. Ask that OceanOPS makes it easy to indicate upon notification.			
	Ask Mathieu about article 247 for UNCLOS. waiting for feedback from GOOS. then set up working group to see how to proceed			
	Ask OceanOPS to identify a way to pilot a regional agreement for float notifications under UNCLOS.	OceanOPS		

Argo Australia National Report 2023 – AST-24

Peter Oke[1], Craig Hanstein[1], Lyudmila Koziy[1], Lisa Krummel[2], Jenny Lovell[1], Pat McMahon[1], Gabriela Pilo[1], Steve Rintoul[1], Tatiana Rykova[1], Christina Schallenberg[1], Roger Scott[1], Dirk Slawinski[1], Peter Strutton[3], Tom Trull[1], Esmee Van Wijk[1]

[1]CSIRO Oceans and Atmosphere; [2]Bureau of Meteorology; [3]University of Tasmania

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. Floats deployed and their performance

Between March 2022 and February 2023, Argo Australia deployed 62 floats, including 56 Core floats and 6 BGC floats. All 6 BGC floats include all six BGC sensors, and one also included a UVP. The locations of the floats deployed in 2022 are shown in in **Error! Reference source not found.**. We deployed floats from 8 different vessels[1]. Floats were funded from 6 different sources[2]. Our deployments included 17 floats south of 60°S; 35 floats in the Indian Ocean sector (west of 130°E) and 26 floats in the Pacific Ocean Sector (east of 130°E).

The fleet of core floats deployed in 2022 included 13 Altos, with RBR CTDs; 20 Arvors, 17 Navis, and 12 Apex floats.

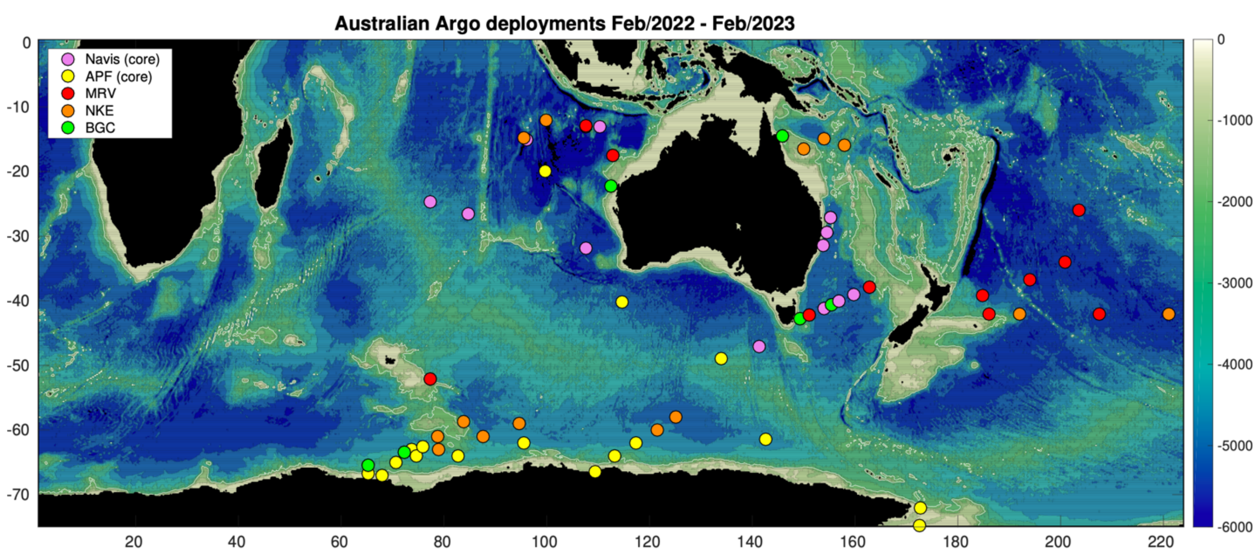

Figure 1: Map showing the deployment locations for floats deployed by Argo Australia in 2023. The colours of the dots denote the float types.

[1] RV Investigator, L'Astrolabe, Antarctic Aurora, RV Kaharoa, Aiviq, Swan River Bridge, Pangaea Ocean Explorer, PMG Pride.

[2] IMOS, CSIRO, AGO, BoM, AAPP, IMAS.

b. Technical problems encountered and solved

Argo Technical Community of Practice

Argo Technical Community of Practice (CoP) continued to meet in 2022. The Argo Technical CoP is a forum for collaboration, knowledge sharing and coordinated action between Argo Technicians to establish, review, and refine best practice procedures for pre-deployment testing of floats to eliminate premature deaths and performance-debilitating failures for core and BGC Argo. Recent meetings have included discussion of Argo deployment methods and MBARI coastal float development.

The group nominally meet each quarter. Founding members are Pat McMahon (CSIRO, Founding Chair), Deb West-Mack (WHOI), Ryan Anderson (WHOI), Rick Rupan (UW), Elizabeth Steffan (PMEL), and Chanelle Cadot (PMEL). A website containing more information is at:
http://www.cmar.csiro.au/argo/dmqc/html/ArgoCop.html

Recent Alto-RBR performance

CSIRO purchased 30 Alto floats with RBRL3 loggers over two financial years as a contribution to the RBR Pilot array. We have deployed 22 of these floats, with 14 early failures. Six floats had problems communicating with the CTD. These floats continued to operate but returned no CTD data. We regard these floats as dead. Of the 30 floats deployed, only four have had no known technical problems.

In FY2019-20 CSIRO purchased 18 Alto floats with RBR sensors. We deployed 16 of these floats and have returned 2 with a CTD fault. Of the 16 floats deployed, 12 are dead. All floats from this order were impacted by a hardware fault that mean the Bluetooth module was constantly powered, resulting in early battery depletion. Four floats died from early battery depletion between Profile 110 and Profile 123. We expect four more floats from this order to exhaust the battery packs by Profile 125. We have been unable to determine the failure mode of 4 floats from this order.

In FY2020-21 we purchased 12 Alto floats with RBR sensors. We have deployed six of these floats, and two are already dead. One float stopped communicating with the CTD at profile 6, and one developed a hydraulic valve fault shortly after deployment.

Despite the issues we've had with these floats, our communication with Manufacturers has always been productive and open. We hoped to demonstrate good performance of the RBR CTDs and extended floats life. But the problems we encountered hampered our efforts.

Processing data with unconventional sampling

Several BGC floats were programmed for continuous sampling above 1000m and sparser sampling below. The data were initially recorded with a short primary profile and a full-depth secondary profile. This caused problems in DMQC as PSAL drift analysis systems are built with the assumption that deep PSAL data will be available in the primary profile. This problem has been rectified by creating a merged profile, recording data to 2000m in the primary profile.

Deep float malfunction and recovery

We deployed an MRV Deep SOLO float (WMO# 7900923) in December of 2021 and it began to malfunction soon after. The CTD fouled when the float was stuck at the surface. Salinity readings went from ~34 to ~7 psu (cycle 10), before continuing to profile in subsequent cycles. Further, the humidity inside the float increased by ~8% and then ~25%, indicating a leak (cycles 32 and 40, respectively). The float then remained on the ocean surface sending "abort" messages. The float was recovered by a nearby ship (FNS L'Astrolabe) and returned to Hobart in February 2022. On closer inspection by MRV, it was revealed that the float could not be repaired. The top glass was cracked and water droplets were found on the inside of the glass; the antenna was broken; there appeared to be a leak path to the communications board; and the CTD suffered a leak. Although the root cause could not be confidently determined, all lines of evidence indicate some sort of impact that broke the CTD, glass, and antenna. We suspect impact with sea ice.

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

We are currently not able to issue v3.2 Traj files (including BGC variables) because it seems that the file checker isn't ready to accept them. This is a problem because the v3.2 Traj file is needed for the in-air oxygen calibration that is the recommended QC procedure for Aanderaa 4330 oxygen optodes. Without v3.2 Traj files (and their incorporation into the relevant QC programs such as SAGE), we can't do this recommended DOXY QC, and we are therefore stuck with using other DOXY adjustment methods that have a larger error bar. We are waiting for the file checker to accept the new v3.2 Traj files in order to start producing these, and in order to start in-air calibration of DOXY. To be clear, we are still processing DOXY data. But we wish to apply the in-air corrections to improve data quality – and this requires v3.2 Traj files.

d. Status of delayed mode quality control process

Our Matlab-based DMQC system is actively maintained to ensure that all of our data can be processed efficiently. Our system now uses OWC-v3. We currently have three DMQC Operators regularly performing DMQC on our data (Tatiana Rykova, Jenny Lovell, and Lyudmila Koziy), and one software engineer supporting the code (Dirk Slawinski). We lost a long-term DMQC Operator (to holier pastures – she became a church minister) in June 2023, and recruited a replacement (Lyudmila Koziy) in April 2023.

We have submitted Dfiles for the first of our RBR-sensor floats and are now ready to process several more. To do this we needed to implement code for QC of TEMP_CNDC (Matlab GUI), incorporate the compressibility coefficients and thermal lag (short and long timeframe) code provided by RBR into our workflow. In addition there were some modifications to the ingest and output stages.

We are waiting on updated compressibility coefficients for 5 RBR sensors and have provided RBR with the wmoid of buddy floats and reference CTDs.

We have some problems in handling core DMQC of BGC floats where there are more than 2 profiles of data per cycle. We have done extensive testing of our workflow to discover which stages need modification and expect this to be addressed in 3-4 months.

We have identified three ASD floats in the SBR recall and sent that information to SBR. Updates are made to the ASD google spreadsheet at least twice per year.

We are starting to see data in DM from floats that have known hardware issues (e.g. valve problem, stuck bladders) and have had modified missions in attempts to rectify the issues. To ensure these are correctly handled, we continue to improve communication between RT and DM systems e.g. floats that exhibit the stuck bladder problem tend to have intermittent communication and thus deliver partial log files. The RT updates the Rfiles as more data are received and maintains a record of the cycle number beyond which the Rfiles may not be complete so that DM does not ingest them.

As we have diversified our fleet (including floats with RBR sensors, Deep Argo floats, and BGC floats) we are finding more float-specific processing is required, some of which would ideally be done on-board the float. RBR are progressing in this direction with their new individually calibrated compressibility coefficients being handled on-board, but the user still needs to be able to accommodate older units. A more wide-spread example is surface pressure correction which may be done on-board or in post-processing and in the latter case the SP value may be delivered with the current profile or with the subsequent profile depending on the float controller.

We continue to support Argo-China with updates to DMQC software (Matlab system) and provide advice when requested.

We currently use the most up-to-date reference databases for OWC (ARGO_for_DMQC_2022V03, CTD_for_DMQC_2021V02) and are using the Matlab OWC V3.

Table 1: GDAC status as of 7 March 2023.

Number of R-files (NR)	15331
Number of R-files > 365 d (NN)	4845
Number of D-files (ND)	193960
Raw percent D 100*ND/(NR+ND)	92.7%
Percent of Elligible D-files (100-100*NN)/(NN+ND)	97.6%
Number of D-files submitted in previous 365 d	46888
Number of floats submitted in previous 365 d	342

The DMQC Discussion series that started in January 2022 has continued. Tatiana Rykova has organised these meetings, with virtual meetings every other month. Topics covered have included DMQC of Deep floats (Meeting 2), Southern Ocean floats (Meeting 3), DMQC of floats with RBR sensors (Meeting 4), Difficult floats (Meeting 5 and 6), and Demonstrations of DMQC systems (Meeting 7). Meetings are typically attended by 15-20 people from more than 10 different countries. There seems to be strong interest in maintaining this discussion series, with future meetings planned. This discussion series is intended to promote collaboration between Argo DMQC Operators and interested members of the Argo Community. This forum is an opportunity for newer Operators to learn from more experienced Operators, to ask questions, seek second opinions, to promote a sense of community, and to promote consistent DMQC practices. The meeting is open to anyone interested. A record of meetings and speakers is maintained at: http://www.marine.csiro.au/argo/dmqc/html/ArgoDM-Disc.html.

2. **Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)**

Contracts funding Argo Australia will end in June 2023. We have been assured by funders that funding will continue, but contracting has not started. We're also hopeful of expanding our program to include new funding for Deep Argo (hopefully 4 Deep floats per year, plus additional funding for salary).

Argo Australia has (some fraction of) two Technicians (1.1 FTE); two real-time Operators (0.5 FTE); seven delayed-mode Operators (2 FTE), and several people in leadership and science roles (0.9 FTE). Our technicians and real-time operators support activities of Core, BGC, and Deep Argo. Our delayed-mode team includes only one person working on BGC data.

Argo Australia intends to continue providing AUD$100K funding to support operations of the RV Kaharoa (and its successor), and AUD$30K funding to support OceanOps. We continue to receive scrutiny over these budget items, but we will work hard to maintain this level of support.

3. **Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**

We plan to deploy 47 floats in 2023-2024, including 4 BGC floats and 43 core floats.

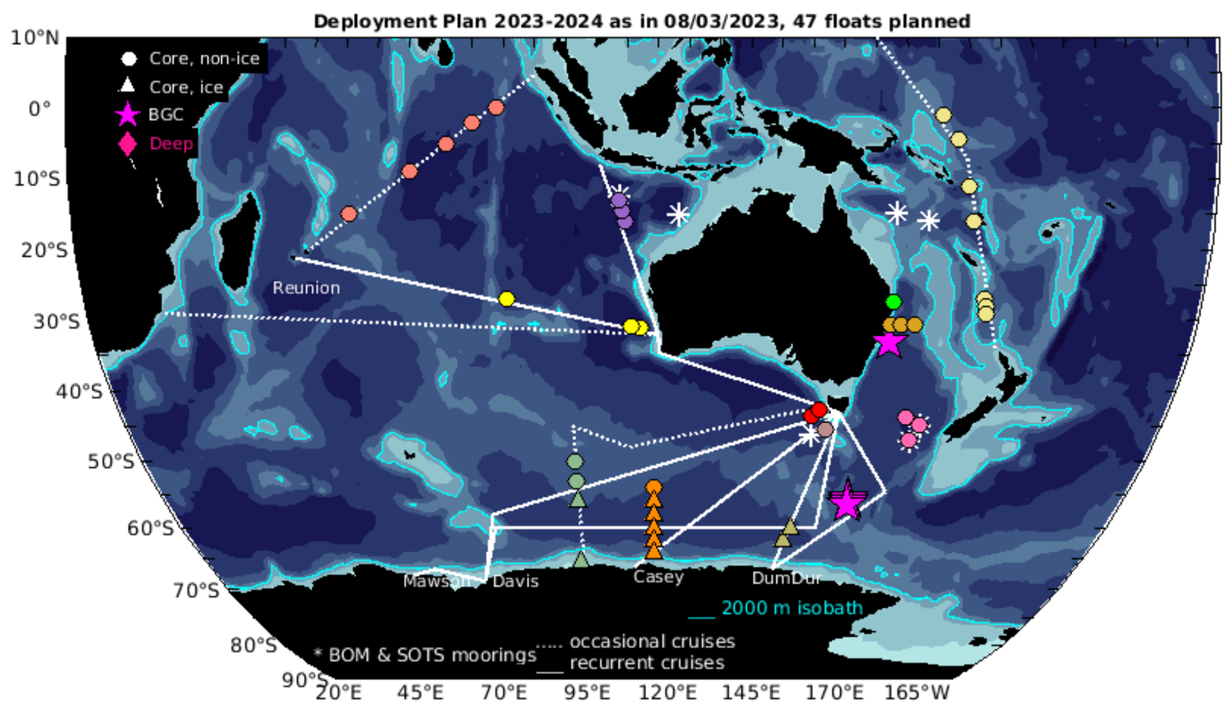

Figure 2: Approximate locations of planned deployments for 2023-2024.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Argo data are used operationally to underpin Australia's short-range ocean forecast system (OceanMAPS; www.bom.gov.au/oceanography/forecasts/), ocean, and seasonal prediction systems (POAMA; www.bom.gov.au/climate/ocean/outlooks/). Science applications include the investigation of decadal prediction, climate studies, biogeochemical response to dust and smoke, and some studies into mesoscale variability around Australia.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

We are seeking clarity on the status of the file checker. It seems that we are currently not able to issue v3.2 Traj files (including BGC variables) because it seems that the file checker isn't ready to accept them. This is stopping us from applying in-air corrections to DOXY data.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Details of the following CTD profiles have been included in the floats' meta files.

- CTD cast with BGC sampling at time of deployment of float 7900947: RV Investigator, voyage IN2023_V01, 03 CTD, Station 4; PI Alix Post (Geoscience Australia)
- CTD cast with BGC sampling at time of deployment of float 5905519: RV Investigator, voyage IN2022_T01, CTD cast #001
- CTD cast with BGC sampling at time of deployment of float 5905501: RV Investigator, voyage IN2022_V02, CTD cast #001; PI Martin Jutzeler (University of Tasmania)
- CTD cast with BGC sampling at time of deployment of float 5905505: RV Investigator, voyage IN2022_V02, CTD cast #002; PI Martin Jutzeler (University of Tasmania)

7. **Bibliography**

We use the Argo Bibliography, maintained by UCSD, as the definitive source of papers that use Argo data. We know of no additional publications that should be included.

We understand that this isn't the place to report interesting science results, but we can't resist sharing some results that we hope might provide relief from the dryness of National reports. Last year we published a "fun" paper on the merging of two eddies in the Tasman Sea (Rykova and Oke 2022, JGR-Oceans). The analysis used Argo data to show that when these two eddies merged (Figure 3a), the smaller, deeper eddy (that we called Tom, after the authors' littlest boy) wrapped around and subducted beneath the bigger, lighter eddy (that we named Bob, after the authors' second littlest boy) and spiralled in towards the eddy centre. The result of the merging was Bob stacked on top of Tom, with multiple layers that penetrated to about 800-m depth (Figure 3b,c). The eddies were sampled by two Argo floats. As the eddies were merging, the floats were 11 km apart (Figure 3d), and the sub-ducted water is seen on the outer-most profile, but not on the inner-most (compare the pink and green profiles in Figure 3e, when only the green has multiple layers that is clearest in salinity). About twenty days later, the sub-ducted water is seen on the inner-most profile, but not the outer-most (compare the green and cyan profiles in Figure 3g, when only the cyan has multiple layers). The dynamics of a smaller eddy "spirally" around a larger eddy when they merge is well-documented in theory – but not previously observed in the field. Who said that Argo doesn't resolve eddies?!? The authors of this paper found it fitting that after an energetic interaction, Bob ended up on top of Tom … just like their boys.

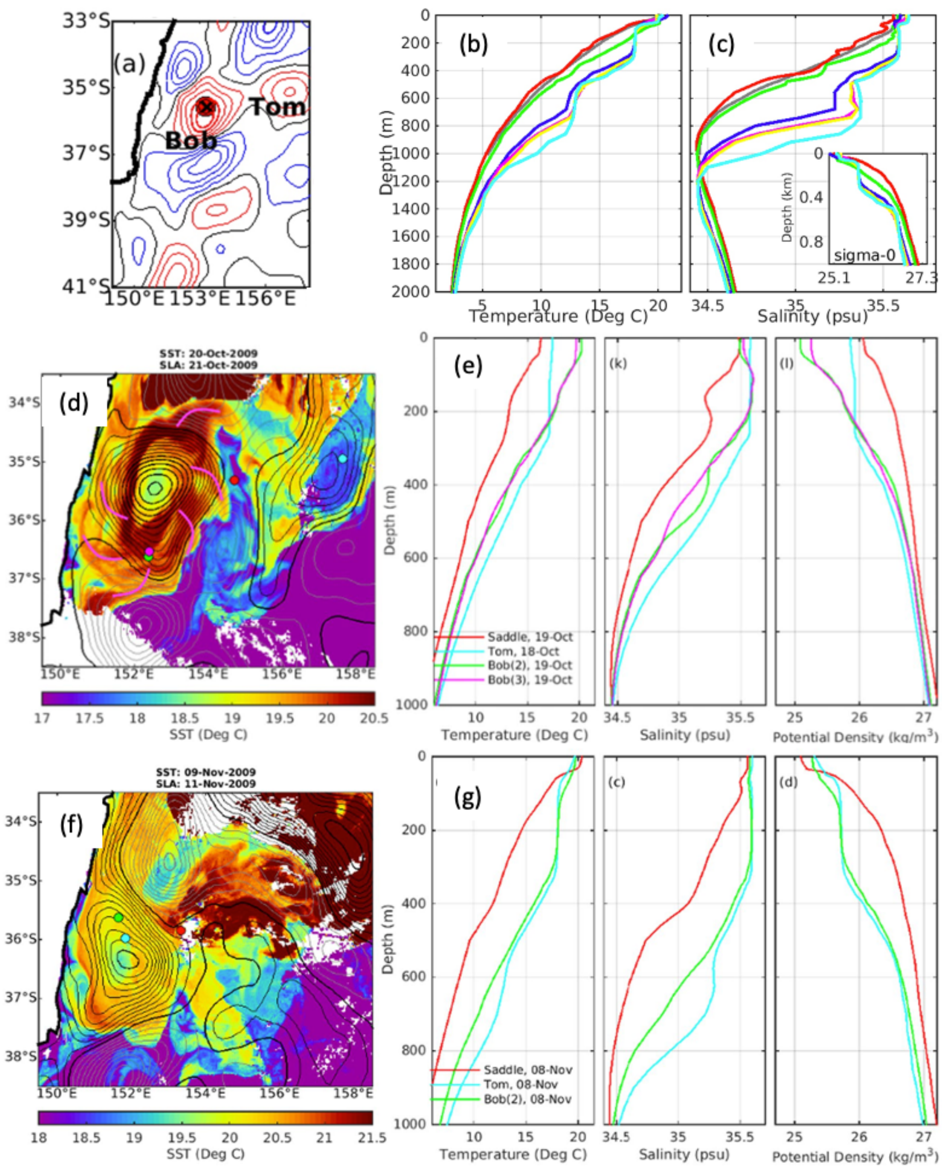

Figure 3: Figures adapted from Rykova and Oke (2022; JGR-Oceans), showing (a) a map of sea-level anomaly where two eddies (Bob and Tom) are evident in close proximity; (b,c) profiles from within eddy Bob, before and after the merging event; (d,f) SST images as the eddies merge, showing the location of Argo floats (coloured dots), and (e,g) profiles from within the merged eddy.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

Nothing to report.

9. Argo is still interested in piloting the RBR CTD. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2021 and 2022 (if known) and where they might be deployed.

We report on the performance of floats with RBR sensors in section 1b, above.

ARGO National Report 2022: Bulgaria

1. Status of implementation

BulArgo programme is a component of the project MASRI – Infrastructure for Sustainable Development of Marine Research and Participation in European Infrastructure (Euro-Argo). (http://masri.io-bas.bg/), a part of the National roadmap for scientific Infrastructure (2020-2027) of the Republic of Bulgaria. The BulArgo programme comprises a consortium of three scientific organizations: Institute of Oceanology (IO-BAS) in Varna, Sofia University "St. Kliment Ohridski" and National Institute of Meteorology and Hydrology in Sofia.

Since 2011 IO-BAS has deployed altogether 12 floats under the BulArgo programme, which is the Bulgarian contribution to the Euro-Argo ERIC infrastructure. The floats have provided more than 2200 T/S profiles (Fig.1). Currently the number of active floats in the Black Sea is 11 out of which 8 are operated by Bulgaria.

Figure 1. Profiles of the BulArgo floats

a) Floats deployment and their performance

During 2022, two Argo floats were deployed in the Black Sea under the framework of the MASRI project. Both floats were ARVOR - DO - I manufactured by NKE (France). The floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The BulArgo floats (WMO 5906866 and 3902006) were deployed on 3rd of November 2022 in Bulgarian Black Sea waters at depths 1400 m and 1500m, respectively. Both floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 750 dbar. Currently, the floats still operate. The status information for the Bulgarian floats deployed in the Black Sea during 2022 is presented on Table 1.

Table 1. Status information for the Bulgarian floats deployed in the Black Sea during 2022

Model	WMO	Deployment date	Deployment time	Latitude	Longitude	№ of Cycles	Status
Arvor-I-DO	5906866	3/11/2022	04:54	42.9337	28.859	8	Active
Arvor-I-DO	3902006	3/11/2022	08:00	43.1216	29.1122	8	Active

b) Technical problems encountered and solved

Both floats were deployed by the Institute of oceanology, Bulgarian Academy of Sciences from board of the fishing vessel. No technical issues have been found regarding the floats deployments and monitoring.

c) Status of contributions to Argo data management (including status of conversion to V3 file, formats, pressure corrections, etc.)

After float deployments, detailed technical information was provided to the Euro-Argo ERIC Office and the OceanOps. The BulArgo program is aware of the changes in the technical and metadata data formats and is providing the necessary information.

d) Status of delayed mode quality control process

The delayed mode quality control of the data delivered from the BulArgo floats are processed by the MedArgo data center (OGS, Italy).

2. Present level and future prospects for; national funding for Argo including a summary of the level of human resources devoted to Argo.

In 2023, Bulgaria continues to be a committed member of the Euro-Argo ERIC. The national funding for 2023 covers float procurements, deployment and communication costs. BulArgo programme has not yet received a decision on funding in the following years. Two persons from IO-BAS are working on the Euro- Argo and BulArgo activities. They do so besides their other duties.

a) Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management)for the upcoming year and beyond where possible).

In 2023, Bulgaria plans to deploy:

- two ARVOR -I floats in the Bulgarian Black Sea waters;
- two PROVOR CT4 floats (provided by Euro- Argo ERIC and IO-BAS) equipped with suites of 5 biogeochemical sensors allowing measuring Dissolved Oxygen, Nitrate, CHL-a/CDOM/Backscattering and Radiometry variables in addition to temperature, conductivity and pressure (provided by H2020 project, Developing Optimal and Open Research Support

for the Black Sea - DOORS). The floats will be deployed in Romanian and Bulgarian waters during the 1st DOORS cruise (1-20, May 2023).

The deployment plan of these floats could be affected if the conflict between Russia and Ukraine is deepened.

3. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centres. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

BulArgo focuses on both research topics and marine climate monitoring of the Black Sea.

Argo data are routinely assimilated into the BS-MFC operational Black Sea forecasting system of the Copernicus Marine Environment Monitoring Service (CMEMS).

Argo data are being used by the researchers from the Black Sea countries to improve the understanding of Black Sea physical and biogeochemical properties.

IO-BAS developed and maintains the BulArgo website https://bulargo.io-bas.bg/ (Fig. 2). It provides information about ARGO international, Euro-Argo and BulArgo programmes, BulArgo fleet status, data access, etc.

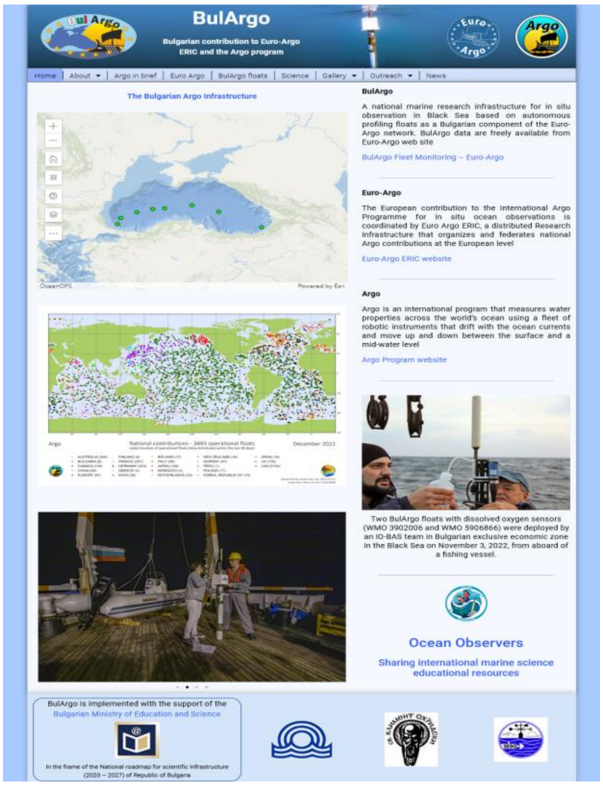

Figure 2. Screenshot of the BulArgo webpage

4. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.**

Nothing.

5. CTD data uploaded to CCHDO

No data uploaded to the Argo reference database.

6. Does your National Program have any deployment plans for RBR floats in the next couple years?

Planned in 2023.

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Argo Canada – Report of Activities for 2022

Submitted by: Blair Greenan (DFO), Katja Fennel (Dal) and Tetjana Ross (DFO)

24th meeting of the Argo Steering Team (AST-24)

Location: Hybrid (Halifax & Virtual)

20-24 March 2023

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)
    a. floats deployed and their performance

       As of 14 February 2023, Canada has 149 operational floats in the Argo Canada program.

       From January to December 2022, Argo Canada deployed at total of 44 floats in the following Basins, managed by the MEDS DAC:

       - Pacific Ocean (13 floats):
         - 3 NKE Arvor floats (CTD)
         - 10 NKE Arvor floats (CTD + O2)
       - Atlantic Ocean (27 floats):
         - 18 NKE Arvor floats (CTD)
         - 7 NKE Arvor floats (CTD + O2)
         - 2 NKE Provor floats (CTD, O2, Chla, backscatter)
       - Indian Ocean (4 floats):
         - 2 NKE Provor floats (CTD, DO, Chla, backscatter)
         - 2 NKE Provor floats (CTD, DO, Chla, backscatter, pH)

       In the fall 2022, the Takuvik lab (Université Laval) deployed the following floats in Baffin Bay (CCGS Amundsen), managed by the Coriolis DAC:

       - 2 BGC floats (model CTS5-Usea by NKE)
       - Both floats have SBE CTD, Anderaa optode, SBE SUNA, SBE ECO-puck, SBE OCR 504, Biospherical MPE-PAR (new design)
       - One float is equipped with Hydroptics UVP6
       - Two BGC floats have were recovered (Aug. 2022), in the central Baffin Bay as well. These floats were deployed in 2021 in the same area and have been recovered for refit.

b. technical problems encountered and solved

One NKE Arvor (CTD + O2) failed after one cycle. We have not been able to get an explanation from NKE regarding the possible cause of the failure.

One PROVOR float deployed in the North Atlantic reported grounding, despite being in water depths much greater than 2000m. There was no change in data quality, the only notable change is the cycle number jumped from 4 to 7. Again we have enquired with NKE as to why this happened but have not received a response.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

The MEDS DAC continues to acquire data from 149 Argo floats of which 3 floats have had trouble reporting in the last 4 months. Data are issued to the GTS and GDACs hourly in BUFR TM315003 and NetCDF formats. Data are available for delayed mode QC as soon as they are sent to the GDACs. The data of all Canadian floats together with some graphics are posted on a website and updated daily: http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html

From January 2022 to January 2023, on average, 413 messages per month were issued to the GTS in BUFR format, of which 72% of the data were available within 12 hours of the float reporting.

Since AST-23, the following tasks have been completed:

- Implementing of the modules to process and quality control data collected from BGC floats (PROVORBio-II) and publishing BUFR data to the GTS , and meta, profile, technical NetCDF files GDACs.
- Develop the quality control tests and adjustment procedure recommending by ADMT for RBR Argo float and Deep Argo float.
- Develop the decoders for NOVA and DOVA float because MetOcean Telematics is no longer providing this service.
- Continue processing of core Argo variables and DOXY data after they have been delayed mode QC to GDAC and updating the internal database.
- Provide ADMT reports on the performance of Argo data on the GTS in BUFR formats to assist DACs in monitoring the BUFR timeliness transmission.
- Yearly update of the monthly maps and anomaly maps of temperature and salinity along line P in the Gulf of Alaska. For more information on the Line-P products and other uses of Argo to monitor the N.E. Pacific go to: https://www.isdm.gc.ca/isdm-gdsi/argo/canadian-products/Argo-LineP-eng.html

d. status of delayed mode quality control process

In 2022, the regular core DMQC process was interrupted because of short staffing. The shortage was recently filled with two core DMQC operators and the DMQC work was back to normal starting February 2023. The in-house Matlab package for Argo DMQC has been updated to a more accessible and user-friendly version with the following changes:

- Streamlined configuration files and modules
- Maintained version control through Github repository

This year, the thermal mass correction will be integrated to the Matlab package. With a minimum maintenance planned for the Matlab version, a new python version for Argo DMQC will be actively developed utilizing modules from EuroArgo as well as other international partners.

Statistics have been calculated to summarize the DMQC work during the last year. As of February 21, 2023, there is a total of 651 Argo floats from the Canadian DAC. Of these 651 floats, 17 (i.e., 2.6%) have no profile files reported to the GDAC due to the failure of floats back to surface. 73% of all active floats, had their profiles DMQCed following the latest delayed-mode procedures at least once. About 2559 profiles from 16 active core Argo floats have been DMQCed within the last year. All these profiles have been fully QCed.

The backlog of core DMQC is persistent and will still be the priority this year. To clear the backlog for core DMQC, efforts will be made to collect floats information from monthly anomaly reports and OCEANOPS altimetric checks. Floats will be geographically assigned to the two DMQC operators for QC.

Of all BGC floats, 824 of 5974 profiles (13%) have been DMQC'ed. 2581 (43%) profiles have oxygen in 'A' mode. It should be noted that DMQC only applies to DOXY for Argo B-profiles. Clearing the backlog of now inactive floats requiring DMQC and fixing historical DOXY_QC flags that are '1' when they should now be '3' remains the main priority. Implementing real-time adjustment of DOXY following sufficient profiles to calculate a gain is also a priority.

Development of a BGC-Argo DMQC tool written in python (https://github.com/ArgoCanada/bgcArgoDMQC) has continued and is now the primary method for visualizing, calculating gain, and exporting D-mode files for the MEDS DAC. The software was presented at the BGC-Argo DMQC workshop and the results are in good agreement with existing tools such as SAGE-O2.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

   Financial resources

   Argo Canada has ongoing funding for the O&M expenditures related to the International Argo program. The majority of these expenditures are related to Iridium telecommunications costs which are managed by Shared Services Canada (SSC) and paid for by DFO.

   Ongoing capital for float purchases has not been identified and, therefore, it remains necessary to request capital resources on an annual basis to obtain the funding required to purchase new floats. The Government of Canada (DFO and Department of National Defence – DND) committed $1.2M CAD for purchases of core NKE Arvor-I, NKE Arvor-RBR, and Provor CTS4 floats in the Fiscal Year 1 April 2022 to 31 March 2023. The funding will result in acquisition of 17 core Argo floats, 4 CTD+O2 floats, 10 BGC-Argo floats (3 BGC sensors) and 4 NKE Arvor floats with RBR CTDs for a total of 35 floats.

   At the G7 meeting in Halifax in October 2018, the Government of Canada announced new funding for the International Argo Program (up to $5.6M over 4 years ending in March 2023). The primary intention of this investment is to support the implementation of the BGC-Argo array with a strong emphasis on having ocean observations benefit Small Island Developing States. This initiative also links to Canada's leadership on the Ocean Observations Action Group under the Commonwealth Blue Charter.

   In addition, the project "A BGC Argo Program for the NW North Atlantic Ocean" led by Dalhousie University and the Memorial University of Newfoundland, has been funded by the Canadian Foundation for Innovation (CFI), Research Nova Scotia (RNS), and the province of Newfoundland for a total cost of $8.8M. The current plan is to acquire 33 BGC-Argo floats for deployment in the NW North Atlantic. 5 NKE CTS5 floats with oxygen, backscatter, chlorophyll, and irradiance sensors have been ordered to date.

   CFI funding held jointly by the Universities of Victoria and British Columbia (C-PROOF, see details in Section 4) that has been providing additionally oxygen sensors for floats deployed in the Northeast Pacific. In the Fiscal Year 1 April 2022 to 31 March 2023, UVic has purchased four O2 sensors to be added to DFO Arvor floats and five SUNA (nitrate) sensors plus the jumbo option for DFO Provor floats being delivered to the Institute of Ocean Sciences in Sidney, BC in March 2023.

   In 2022, Ocean Networks Canada (ONC) was successful in obtaining funding for the procurement of 18 Deep Arvor floats equipped with CTD + O2. Two of these floats were delivered to ONC in Victoria, BC in December 2022, and the remaining floats will be delivered in the first half of 2023.

   Since 2016, Takuvik has deployed 22 BGC Argo floats (funding being provided by French and Canadian projects, each up to 50 %), which have acquired more than 2,500 profiles (temperature, salinity, backscattering coefficient at 700 nm, radiometric data along 4 channels, as well as concentrations of a) dissolved oxygen, b) chlorophyll-a, c) colored dissolved organic matter, d) nitrate.

The development of close links between the Argo Canada program and both the operational meteorology and operational oceanography R&D activities at the Canadian Meteorological Centre (Dorval, Québec) has been beneficial. An inter-departmental (Environment and Climate Change Canada, Department of National Defence, Fisheries and Oceans) Memorandum of Understanding entitled CONCEPTS (Canadian Operation Network of Coupled Environmental PredicTion Systems) has provided strong advocacy for the Argo program.

Human resources

The following people contribute to the logistics and data management for Argo Canada:

- Anh Tran (DFO, MEDS, Ottawa) – DAC lead, RTQC Operator
- Zhimin Ma (DFO, MEDS, Ottawa) – DMQC Operator (core Argo)
- Trajce Alcinov (DFO, MEDS, Ottawa) – DMQC Operator (core Argo)
- Jenny Chiu (DFO, MEDS, Ottawa) – RTQC support
- Andrew Stewart (DFO, OSB, Ottawa) – National Manager, Ocean Monitoring and Observing
- Tyler Emmott (DFO, OSB, Ottawa) – Float procurement, contracting
- Blair Greenan (DFO, BIO, Halifax) – AST member, Argo Canada lead
- Chris Gordon (DFO, BIO, Halifax) – DMQC Operator (BGC), deployment planning, logistics, performance monitoring
- Clark Richards (DFO, BIO, Halifax) – Research scientist, RBRArgo data task team member, ArgoFloats R package development
- Jaimie Harbin (DFO, BIO, Halifax) – ArgoFloats R package developer and Commonwealth Blue Charter training coordinator
- Igor Yashayaev (DFO, BIO, Halifax) – Research Scientist
- Adam Hartling (DFO, BIO, Halifax) – Field support
- Tetjana Ross (DFO, IOS, Sidney) – Pacific deployment planning, Canadian member of the International Deep Argo Mission Team
- Lindsay Mazzei (DFO, IOS, Sidney) – Field support
- Katja Fennel (Dalhousie University, Halifax) – Canadian member of the International BGC-Argo Steering Committee
- Dan Kelley (Dalhousie University, Halifax) – ArgoFloats R package developer
- Kohen Bauer (Ocean Networks Canada) – Principal Investigator, Deep Argo
- Richard Dewey (Ocean Networks Canada) – Principal Investigator, Deep Argo
- Herminio Folio Neto, Jeannette Bedard, and Kohen Bauer (Ocean Networks Canada) – DMQC Operators, Deep Argo

In addition to the above persons, we benefit from the technical support of many sea-going staff that follow pre-deployment protocols and perform the float deployments.

National Coordination

With increasing participation in the Argo program within Canada, both in core Argo, BGC-Argo and Deep Argo, it was decided to establish a new governance structure in 2018. The Canadian Argo Steering Team (CAST) provides scientific leadership and oversees the development and implementation of the Canadian contribution to the International Argo Program. The CAST is chaired by Blair Greenan and meeting annually prior to the Argo Steering Team meeting.

The Canadian Biogeochemical-Argo Committee facilitates the implementation of the Canadian contribution to the Biogeochemical-Argo program by coordinating and advising national efforts, and acting as liaison to the International Biogeochemical-Argo Steering Committee. The Committee is chaired by Katja Fennel.

Float Testing Facility

In partnership with Defence Research and Development Canada (DRDC), DFO has established a testing facility on the DRDC Barge in Bedford Basin. This facility will enable us to do short-term testing of floats and sensors to evaluate performance. This is a low-current environment that facilitates tethered profiling to a water depth of 35 m.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Here is a link to the commitments table at OceanOPS (if the link isn't working, visit OceanOPS and choose 'commitments' from the farthest right icon at the top of the page). If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

In 2023, Argo Canada plans to deploy approximately 28 floats in the Northeast Pacific and North/South Atlantic:

- 14 Core Argo (9 SBE CTD, 5 RBR CTD)
- 8 BGC-Argo (2 O2 only, 4 O2 + bio-optical triplet, 2 O2 + bio-optics + pH)
- 2 Dalhousie BGC -Argo (O2 + bio-optics + radiometry)
- 4 ONC Deep Argo (Arvor with CTD + O2)

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

The Government of Canada CONCEPTS initiative (Canadian Operational Network for Coupled Environmental Prediction Systems; http://science.gc.ca/eic/site/063.nsf/eng/h_97620.html) uses observations from the Argo array for a variety of operational and research applications.

These include direct assimilation into operational weather and environmental prediction systems, monitoring of forecast quality (verification), and well as detailed research to improve model physics (e.g. further development and optimization of model parameterizations) and data assimilation (e.g. Observing System Experiments). The CONCEPTS Global and Regional Ice Ocean Prediction Systems (GIOPS and RIOPS) provide daily estimates (analyses) of ocean and sea ice properties using a multi-variate data assimilation system assimilating Argo observations together with other sources of in situ temperature and salinity, satellite altimetry, and sea surface temperature data. GIOPS analyses are used to initialize the ice-ocean components of the coupled Global Deterministic Prediction System (GDPS), responsible for providing operational medium-range weather forecasts for Canadians. GIOPS analyses are also used to initialize the operational forecasts from the Canadian Seasonal-Interannual Prediction System (CanSIPS). Temperature and salinity from GIOPS analyses are also used to represent the baroclinic effects in the Global Deterministic storm Surge Prediction System (GDSPS). RIOPS analyses are produced in a model that includes tides and provides daily three-dimensional state of the ocean estimates for Canada's three coastlines on a domain covering the North Pacific, Arctic, and North Atlantic Oceans. An observing system experiment is underway to assess the impact and potential benefits of assimilating seasonal Argo floats from the Arctic Ocean into RIOPS. Coastal forecasts are produced for the east and west coast of Canada at 2km resolution using a spectrally nudging to RIOPS analyses.

DFO also extensively used the GLORYS global ocean reanalysis product from Mercator-Ocean International, produced with assimilating Argo data. The applications of this include providing lateral open boundary condition for regional models, and analyses for interpreting observations and understanding ocean variability.

Argo data is used in the verification of Canadian and international prediction systems to enable predicted and observed profile comparison. Part of OceanPredict Inter-comparison and Validation Task Team. Comparisons of Argo based class 4 is visible on https://navigator.oceansdata.ca under the class 4 tab.

The Department of National Defence (DND) scientists, operational oceanographers and sonar operators routinely use real time Argo vertical profiles to assess model performance and in some instances use as data to compute acoustic range predictions (both at sea and in the Meteorology and Oceanography Centres (Esquimalt and Halifax)). DND uses the web-based Ocean Navigator tool to assist with these activities.

The Argo Canada web site is maintained by Fisheries and Oceans Canada at http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html. A repository of Argo-related code under development through DFO has been made available on Github at https://github.com/argoCanada. Repositories include the under-development python BGC DMQC tools, the argoFloats and argodata R packages, a new python package for finding and working with Argo data (argopandas), and an informal blog used to highlight interesting floats and issues encountered when working on Argo DMQC.

Argo data are used in the preparation of Fisheries and Oceans Canada's State of the Ocean reporting (https://www.dfo-mpo.gc.ca/oceans/publications/index-eng.html).

The Canadian-Pacific Robotic Ocean Observing Facility (C-PROOF, http://cproof.uvic.ca/) is funded by the Canadian Foundation for Innovation (CFI) and B.C. Knowledge Development Fund (BCKDF) to build ocean observing capacity off the British Columbia coast. C-PROOF is based at the University of Victoria. A fleet of autonomous gliders, Argo floats, and moorings will provide ocean scientists with long-term monitoring of the ocean at the small scales important to resolve upper ocean physical and biological properties.

Dalhousie University and the University of Newfoundland are leading an infrastructure project for implementation of a regional BGC Argo array in the northwest North Atlantic with funding from the Canada Foundation for Innovation, Research Nova Scotia, and the province of Newfoundland. Research questions to be addressed include the sensitivity of carbon sequestration and ocean ventilation in the Labrador Sea to changing atmospheric and oceanic conditions, new approaches to biological rate measurements using Argo measurements (e.g., NCP, vertical carbon flux), assessment of the skill of climate models in the region, and implementation of a data-assimilative physical-biogeochemical ocean model for the region. As part of the project, a Canadian adopt-a-float program was launched (https://adopt-a-float.ocean.dal.ca/). The Canadian BGC Argo website is maintained by Katja Fennel's research group at http://bgc-argo.ocean.dal.ca/

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

   Argo Canada would like to thank the leads for the Basin Planning Working Groups. This has improved information-sharing among the groups deploying floats and is helping to identify deployment opportunities.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

   CCHDO currently acquires Line-P data up directly from the https://waterproperties.ca/linep website. MEDS will send CTD data collected by other DFO institutions to NOAA NCEI and then the data will be available to CCHDO.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

Journal Publications

Chomiak, L. N., Yashayaev, I., Volkov, D. L., Schmid, C., & Hooper, J. A. (2022). Inferring Advective Timescales and Overturning Pathways of the Deep Western Boundary Current in the North Atlantic through Labrador Sea Water Advection. Journal of Geophysical Research: Oceans, 127(12), e2022JC018892.

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Gillard, Laura C., Clark Pennelly , Helen L. Johnson c, Paul G. Myers. The Effects of Atmospheric and Lateral Buoyancy Fluxes on Labrador Sea Mixed Layer Depth. Ocean Modelling 171 (2022) 101974 https://doi.org/10.1016/j.ocemod.2022.101974

Izett, R. W., Castro de la Guardia, L., Chanona, M., Myers, P. G., Waterman, S., & Tortell, P. D. (2022). Impact of vertical mixing on summertime net community production in Canadian Arctic and Subarctic waters: Insights from in situ measurements and numerical simulations. Journal of Geophysical Research: Oceans, 127, e2021JC018215. https://doi.org/10.1029/2021JC018215

LaBrie, R., Péquin, B., Fortin St-Gelais, N., Yashayaev, I., Cherrier, J., Gélinas, Y., ... & Maranger, R. (2022). Deep ocean microbial communities produce more stable dissolved organic matter through the succession of rare prokaryotes. Science Advances, 8(27), eabn0035.

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Tesdal, J. E., Ducklow, H. W., Goes, J. I., & Yashayaev, I. (2022). Recent nutrient enrichment and

high biological productivity in the Labrador Sea is tied to enhanced winter convection. Progress in Oceanography, 206, 102848.

Wang, B., Fennel, K., Biogeochemical Argo data suggest only a minor contribution of small particles to long-term carbon sequestration in the subpolar North Atlantic, Limnology and Oceanography, , https://doi.org/10.1002/lno.12209, 2022

Wang, Z., Yang, J., Johnson, C., & DeTracey, B. (2022). Changes in deep ocean contribute to a "see-sawing" Gulf Stream path. Geophysical Research Letters, 49, e2022GL100937. https://doi.org/10.1029/2022GL100937

Ph.D./M.Sc. Thesis

Bin Wang, BIOGEOCHEMICAL (BGC) ARGO IMPROVES UNDERSTANDING AND QUANTIFICATION OF THE OCEAN'S BIOLOGICAL CARBON PUMP, Dalhousie PhD thesis, 2022

Books

Nothing to report

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

   Deployments for 2022 were impacted by a combination of COVID-19 and vessel availability issues. The primary platform for oceanographic research on the east coast of Canada has been the CCGS Hudson. In January 2022, DFO announced that the 59 year-old Hudson would be decommissioned after it had deemed the ship "beyond economical repair" following a catastrophic mechanical failure. This resulted in a loss of opportunity to deploy Argo floats. A replacement vessel is under construction with delivery expected in 2025 (https://www.seaspan.com/press-release/canadian-coast-guard-offshore-oceanographic-science-vessel-achieves-important-construction-milestone/) . DFO has committed to find solutions for the gap before the replacement vessel arrives, but at this time the future remains uncertain and presents challenges for Argo float deployment planning.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

   Argo Canada is committed to deploying additional floats equipped with RBR CTDs. The procurement plan for 2023 is not known at this time, but we expect to procure about 50% of our core Argo floats with RBR CTDs. We had encouraged NKE to consider upgrading the Arvor float firmware to enable sampling and transmitting RBR CTD data at ~1 Hz to allow for further research on the CTD response characteristics in a range of oceanographic conditions. In late 2022, NKE confirmed that this capability would be available in future Arvor float shipments.

Dalhousie University and the Memorial University of Newfoundland are interested in procuring BGC Argo floats with the RBR CTD and possibly other RBR sensors.

The 24th Argo Steering Team Meeting, Halifax, March 20-24, 2023

Argo Chinese National Report 2022

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1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. floats deployed and their performance

In 2022, China deployed 5 floats in the western Pacific and Bay of Bengal, which includes 2 PROVOR (one float with FLBBCD sensor and the other with six parameters), 2 HM2000 (one float with DO sensor) and 1 deep XUANWU. These floats were contributed by CSIO, Ocean University of China (OUC) and Laoshan Laboratory (formerly Qingdao Pilot National Laboratory for Marine Science and Technology), respectively.

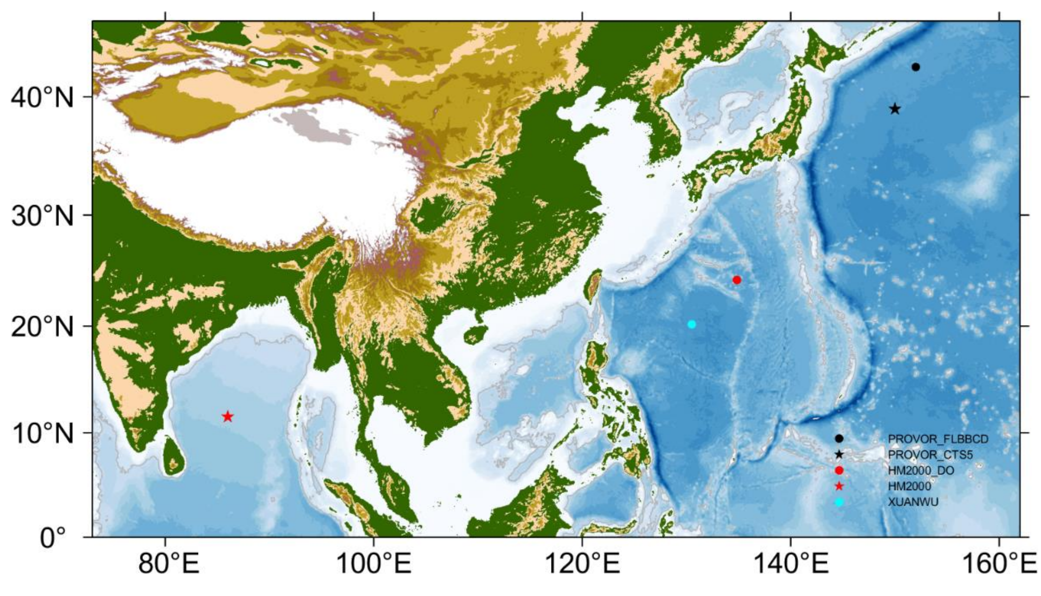

Fig.1 Launch positions of the Chinese floats in 2022

In July 2022, the first deep XUANWU float (6000-m) manufactured by Laoshan Laboratory was deployed in the northwestern Pacific, which was sponsored by the project “The construction of China deep Argo regional array”. Additionally, the first PROVOR_CTS5 float with six parameters was deployed by OUC in July. The PI agreed to share the observations within Argo 6 months after the deployment.

In a special program about the construction of the observing network in Indian Ocean, 30 COPEX floats (manufactured by NOTC) had been deployed by CSIO in the northern Indian Ocean. These floats are all equipped with SBE41 CTD and transmit data by Iridium satellite. In order to add these floats into Argo, CSIO is validating their observations and float performance.

b. technical problems encountered and solved

One deep XUANWU float didn’t transmit data after its deployment in July. The failure may be caused by the communication failure between the float and its SBE61 CTD sensor. Unfortunately, the trial for recovering was unsuccessful.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

During 2022 CSIO received 5,834 core profiles plus 904 DOXY, 607 CHLA, 668 BBP, 546 CDOM, 849 IRRADIANCE, 322 NITRATE and 61 pH profiles from 81 active floats (Fig.2). All the profiles were submitted into GDACs and core & DOXY profiles have been inserted into GTS via CMA after being converted into BUFR bulletin.

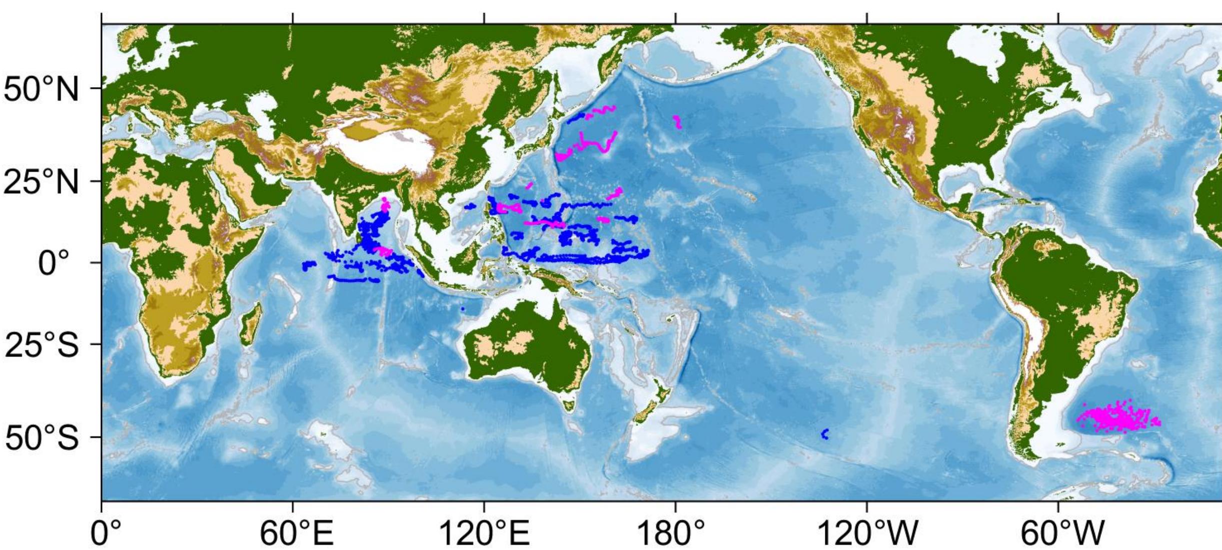

Fig.2 Positions of core (blue) and BGC (red) profiles.

d. status of delayed mode quality control process

Last year of 2022, with the help of Jenny Lovell (CSIRO), Dirk Slawinski (CSIRO), Annie Wong (UW), Cecile Cabanes (Ifremer) etc., CSIO had sent about 12, 045 D-files of Core Argo to GDACs. In total above 77% R-files has been DMQC'd. Here we express to them our sincere gratitude. Next, with the help of CSIRO, we are planning to update the DMQC system in order to process the data that collected by RBR CTD.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

The national funding for China Argo has not been secured. The deployment of float relies on various research and special programs from institutions and universities. A project that implements the development and pilot deployment of deep XUANWU float had been granted by Laoshan Laboratory (PI: Dr. Zhaohui Chen from OUC), from which about 60 XUANWU floats are going to be deployed in the northwestern Pacific by the end of 2025.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Another 30 COPEX floats in the special program of the construction of the observing system in Indian Ocean will be deployed in 2023, the data will be delivered to GDACs when COPEX float gets qualification. About 10 BGC-Argo floats will be deployed in the northwest Pacific this year, including 5 from CSIO (4 Navis-BGC floats with SeaTrec rechargeable batteries will be delivered to CSIO soon), 2 PROVOR_CTS5 floats with six parameters from OUC, 2 from Hainan Tropical Ocean University (HTOU), and one from South China Sea Institute of Oceanology (SCSIO). Laoshan Laboratory plans to deploy 4 XUANWU floats through a survey cruise in the northwestern Pacific (2 in the Kuroshio Extension region and 2 in the Philippine basin) during this May. Another 4 XUANWU floats will be deployed by Institute of Oceanology, Chinese Academy of Sciences (IOCAS) via a joint cruise in the western Pacific (all floats will be deployed in the Philippine basin) in November.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

The value of Argo data has been fully recognized, and Argo dataset and data products have been widely used in scientific research and operational forecasts. For instance, Argo T/S profiles have become the most important data in the global data assimilation system in NMEFC (National Marine Environmental Forecasting Center); the post-QC'd Argo T/S profiles have been applied in the IAP (Institute of Atmospheric Physics, Chinese Academy of Sciences) reanalysis (http://www.ocean.iap.ac.cn/?navAnchor=home).

CSIO maintains the website of the China Argo Real-time Data Center (https://www.argo.org.cn) where the implementation status of China Argo, real-time data display including observed profiles, float trajectory, profile data, the derived products and status of global Argo are accessible.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-23 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

None.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Two full-depth CTD casts obtained from the deployments of deep XUANWU float were submitted to Coriolis data center.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)**) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**

There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)**). If you know of any doctorate theses published in your country that are missing from the list, please let me know.**

Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

The list of publications not listed in the Argo bibliography

Gao, Z.K., Y.T. Jiang, J.Y. He, J.P WU and G. Christakos (2021), Bayesian maximum entropy interpolation of sea surface temperature data: A comparative assessment. Internation Journal of Remote Sensing, 43, https://doi.org/10.1080/01431161.2021.2003905

ARGO Denmark National Report

Colin A. Stedmon

1. **Status**

- Candidate membership of EuroArgo initiated in 2022.
- Initial purchasing of first floats initiated in 2022 and completed early 2023.
- Sea trials and learning about float operations (Spring 2023).

2. **Level of support**

Currently funded by a national infrastructure investment. Once deployments and data flow are initiated, plans are to push for a sustained national program. Likely to mainly have focus in Baltic, North Atlantic and Arctic region.

3. **Deployment and purchase plans**

We have purchased two NKE PROVOR floats (Jumbo with CTD+Oxygen+Chl-Bscat-CDOM) to be deployed at 78N in the Fram Strait in September this year. We are experimenting with grounding on purpose between profiles (spikes mounted), for “stationary” shelf sea deployment, and also aiming for experience with under ice operations.

For 2023 we currently plan to purchase four floats. Two with CTD sensors only for potential deployment in East Greenland this year (potentially with RBR sensors to contribute to trials). Two similar to the PROVOR for deployment on the East Greenland shelf next year.

4. **Summary of national research and operational uses of Argo data**

At the Technical University of Denmark (DTU) global ARGO program data is currently used in teaching and research. ARGO data is also used for operational modelling activities by Danish institutions.

ARGO National Report 2023 – The Netherlands

1) **Status of implementation**
The Dutch Argo program started in 2004 and is run by the Royal Netherlands Meteorological Institute (KNMI).
The Netherlands are a founding member of the Euro Argo ERIC.
Contribution to the Argo array:
    - 112 floats have been purchased since 2004
    - 35 are working
    - 7 are ordered for 2023 and will be deployed later this year

2) **Present level of (and future prospects for) national funding for Argo including summary of human resources devoted to Argo**.
In their observation strategy adopted in 2006 KNMI has expressed the intention to deploy about 7 floats per year. However, the actual number of floats purchased varied a lot during the past years.
Presently, the Netherlands only contributes to the core mission.
One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.

3) **Summary of deployment plans.**
Eight floats will be deployed in the southern Atlantic Ocean later this year.

4) **Summary of national research and operational uses of Argo data**
Argo data and/or products derived from Argo data are used to initialize climate models by groups at KNMI and Utrecht University.
Process studies using Argo data are performed at the Netherlands Institute for Sea Research (NIOZ).

5) **Issues that your country wishes to be considered (and resolved) by AST regarding the international operation of Argo**
Nothing.

6) **CTD data uploaded to CCHDO**
No.

7) **Bibliography**
-

8) **COVID-19 impact**
Backlog cleared.

9) **RBR sensors**
Four floats with RBR CTDs have been deployed in the Caribbean Sea in 2022 alongside four French floats equipped with a SBE sensor. Results are positive. Floats ordered for 2023 will have RBR sensors, too.

Euro-Argo Report – AST24

The Euro-Argo Research Infrastructure organises and federates European contributions to Argo (www.euro-argo.eu). The Euro-Argo ERIC (European Research Infrastructure Consortium) and its governance structure (Council, Management Board and Science and Technological Advisory Group) was set up by the European Commission in May 2014, with 9 funding countries. Currently the Euro-Argo ERIC has 11 members, one observer and one candidate. The Euro-Argo ERIC is made up of a central office based in France (Ifremer, Brest) and distributed national facilities (Figure 1). The distributed national facilities operate with direct national resources. As part of the Euro-Argo Research Infrastructure, they agree to a multi-annual commitment of resources (in particular in terms of floats to be deployed and for the data system), and to coordinate their activities through the Euro-Argo ERIC. The Euro-Argo ERIC delegates some of its activities to the national facilities who have the relevant expertise (e.g. data management and quality control, float deployment), and according to their areas of responsibility.

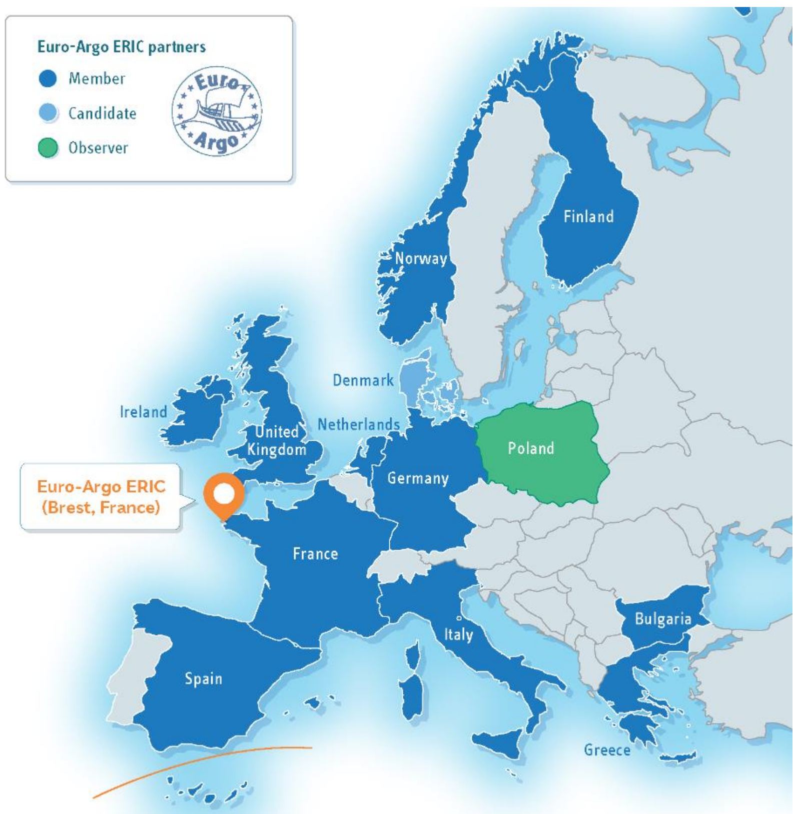

Figure 1. Euro-Argo ERIC membership in 2022

In December 2022, the Euro-Argo ERIC involved 13 countries: **11 Members, 1 Observer** and 1 Candidate.

This report presents the contribution of EU funded Argo activities as well as the integrated view of EU plus national European contributions.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. floats deployed and their performance

In 2022, 8 EU-funded floats were deployed, including 3 core floats (funded by Orange Group) and 5 T/S/O2 floats (funded under Euro-Argo ERIC own budget) deployed during Endurance22 and Resilience cruises - deployments coordinated by Tammy Morris. These 8 floats come in addition to the 223 floats deployed by the National members. The table below shows the floats deployed, both as number of floats measuring a specific variable and per type of float.

Table 1. European floats deployed in 2022, per parameter measured (blue, 7 first columns) and per type of float (green, 5 last columns). "BGC" stands for floats measuring the 6 BGC variables and "Bio" stands for other floats equipped with 1 to 5 BGC sensors, except the Deep-O2 floats only counted in the "DEEP" column.

	Variables							**Float types**				
	T&S	O2	Chla	BBP	NO3	Irradiance	pH	core	BGC	Bio	Deep	**Total (floats)**
EU funded	8	5	0	0	0	0	0	3	0	5	0	**8**
Member states	223	61	35	35	20	30	21	160	20	28	15	**223**
total	**231**	**66**	**35**	**35**	**20**	**30**	**21**	**163**	**20**	**33**	**15**	**231**

A total of 231 floats have been deployed in 2022, with 75% of them being NKE floats. In March 2023, only 216 out of the 231 floats were still active, most of them being lost at deployment, a larger amount than usual. In next year's report, we envisage to provide a complete list of ending causes of Euro-Argo floats dead in 2022.

About 10 European floats have been recovered in 2022, mainly in marginal Seas, but also 2 in the Southern Ocean.

The launch locations of all Argo floats deployed in 2022 are shown in Figure 2.

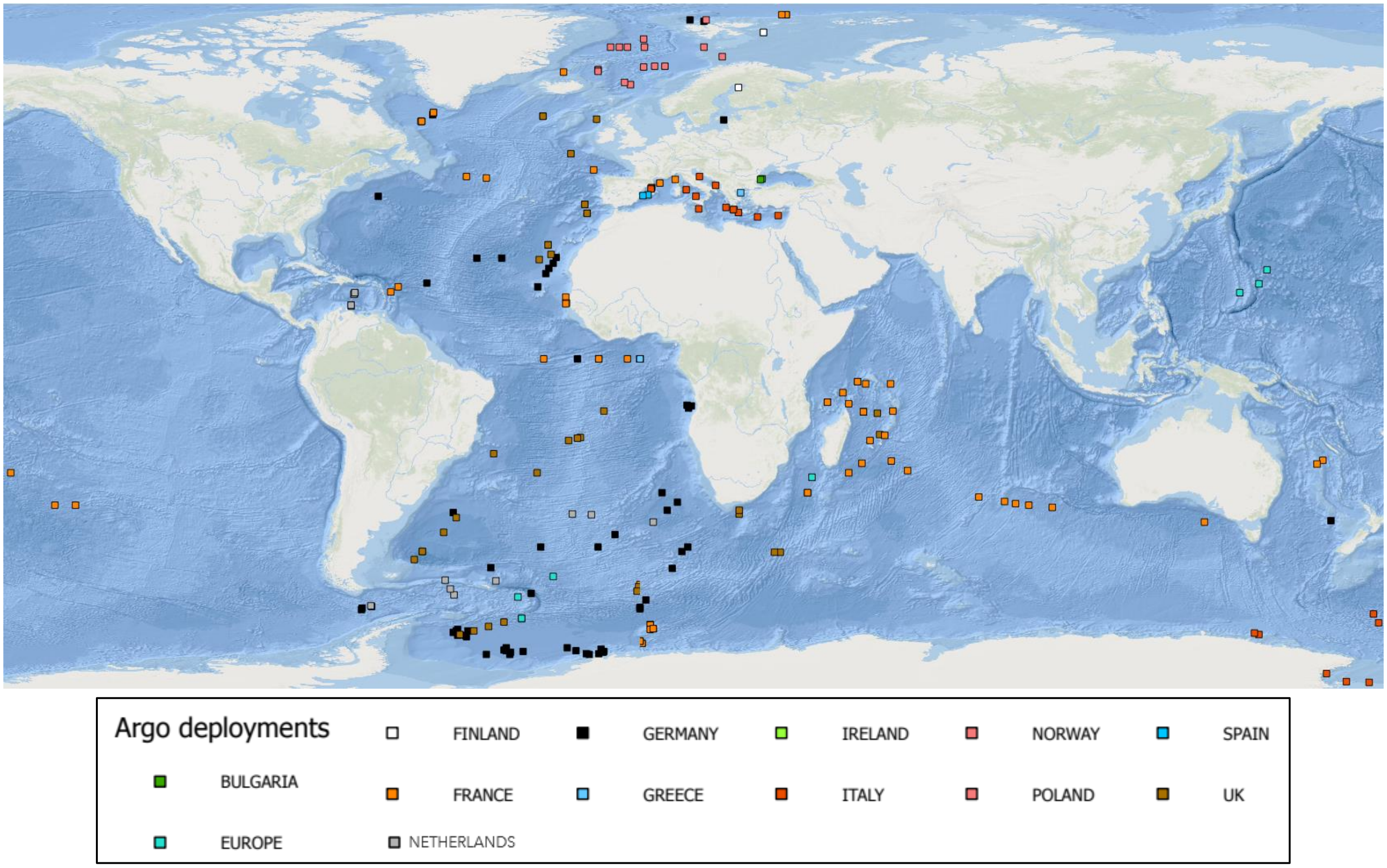

Figure 2. Deployment positions of the European floats deployed in 2022 (Credit OceanOPS)

In 2022, Euro-Argo took part in "Deployment Planning meetings" organised internationally and across ocean observing networks, resulting in coordinated launches of Argo floats in Atlantic and Indian Oceans. Euro-Argo also continued the implementation in the Nordic Seas and, on a lower level, in European Marginal Seas, for the benefit of more deployments in the Southern Oceans and Arctic Oceans, where the global Argo network coverage was on stress.

The European contribution is progressing towards the implementation of the Deep (15 floats deployed) and BGC missions (53 floats carrying at least one BGC sensor deployed) (see Table 1). A major outcome is the significant number of 20 "full BGC floats" deployed – measuring the six variables, and sometimes experimenting new observation systems, such as UVP, hyperspectral radiometry, etc. The oxygen network is again progressing with about 30% of Euro-Argo floats deployed in 2022 carrying an oxygen sensor. 15% of the deployed floats are equipped with a chlorophyll and suspended particles sensor, 13% with irradiance and 9% with pH and nitrate.

Figure 3 presents the evolution of Euro-Argo deployments since 2008. In 2022 Euro-Argo deployed 231 floats, representing 31% of the global effort, comparable to last year.

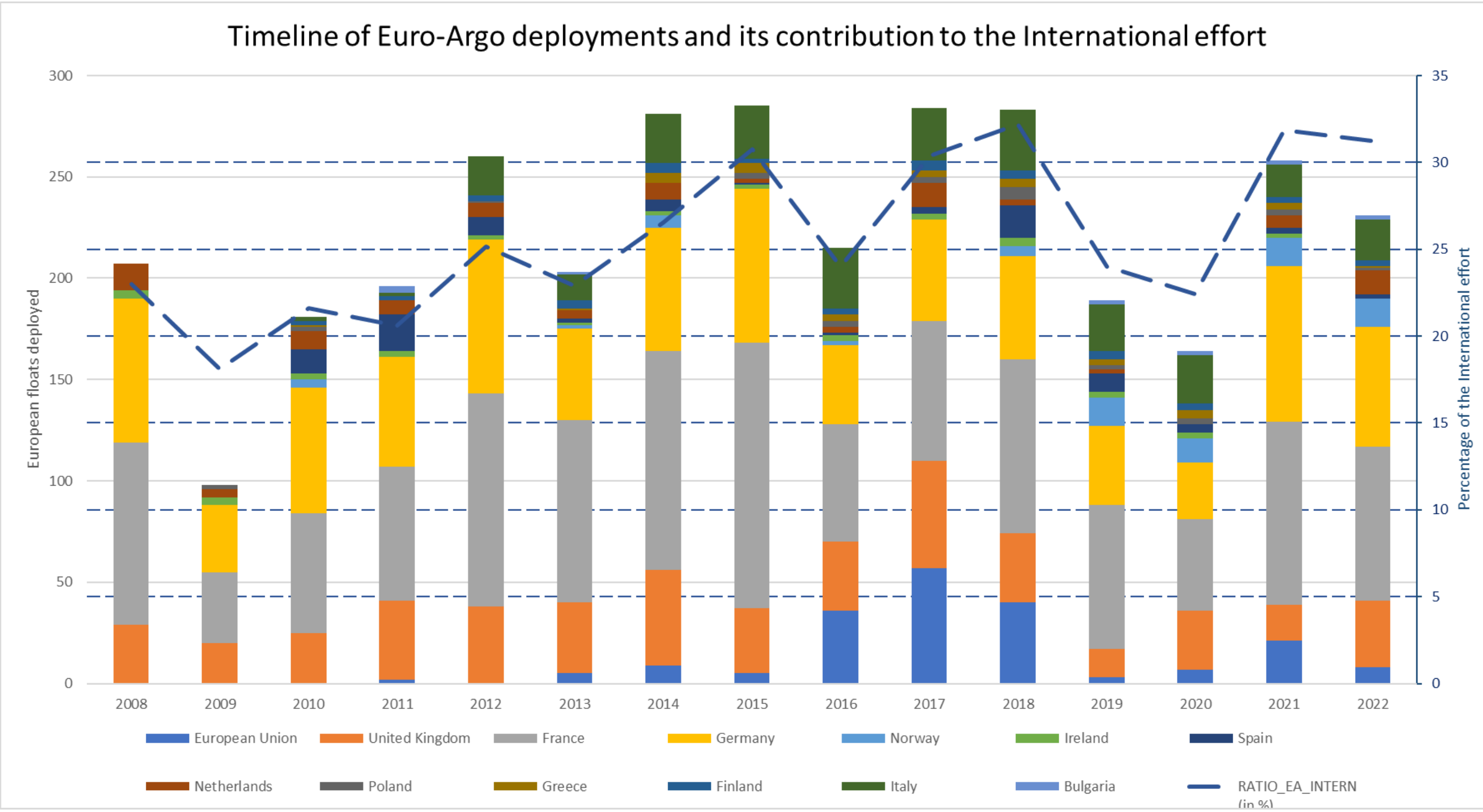

Figure 3. Timeline of Euro-Argo deployments (in number of floats, colored bars, left axis) and its contribution to the international effort (in %, blue dashed line, right axis).

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

It should be observed that while the Euro-Argo number of BGC floats deployed persists or slightly increases, our relative contribution to the BGC international array is decreasing. This translates also in terms of operational floats, as shown in Figure 4.

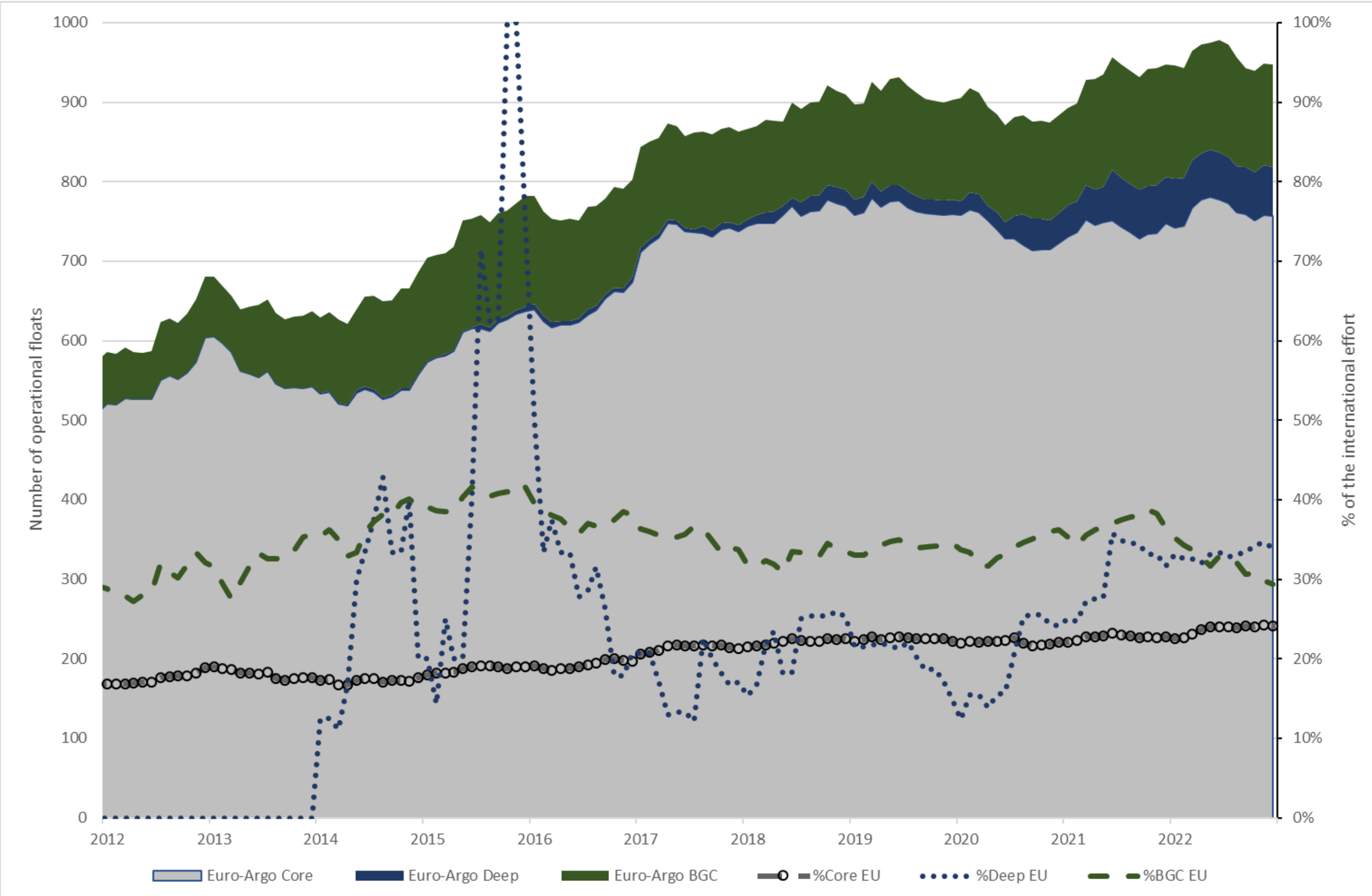

Figure 4. Evolution of the Core (T&S), BGC and Deep missions, in number of operational floats (colour, left axis) and in percentage of the international effort (blue, grey and green lines, right axis). © OceanOPS

b. technical problems encountered and solved

European partners have been affected by the pH sensor failure for sensor in the SN range [10000-11117]. This issue is supplemented by the current difficulties in pH sensor procurement. This issue has severely compromised both the quality and the amount of pH data of European floats.

As noted earlier, a larger amount of European floats were lost at deployment compared to previous years (Deep and core floats), with no clear explanation.

c. **status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)**

- **European data processing & DMQC**

All European floats are processed by Coriolis and BODC DACs (respectively 83% and 17% of European profiles in 2022), and DMQC of T and S parameters is currently shared between 7 institutes (BSH, OGS, Ifremer, BODC, IMR, IOPAN and IEO), plus a small Euro-Argo ERIC contribution for some of the EU-funded floats, through subcontracting. European partners are also strongly involved in the development of DMQC procedures for Deep Argo and BGC Argo (especially for BBP, Chl-A and Irradiance) or for Argo operating in specific areas (e.g. Baltic Sea), and in the monitoring of high salinity drifting floats. Partners deploying Argo floats in the Baltic Sea are organising an Argo-Baltic DMQC workshop in April 2023 to train newcomers.

- **Abrupt Salinity Drift**

The European fleet is impacted by the abrupt salinity drift on SBS sensors. Euro-Argo maintains the international Google spreadsheet to monitor the issue. In 2022, the spreadsheet has been simplified and statistics are now computed from data taken directly from the GDAC. An important work to clean the dataset, including identification and correction of metadata, was performed in 2022. This work allowed to provide more robust statistics and to progress in the negotiation with SBS regarding warranty of data loss for CDT SN in the recall range (see below).

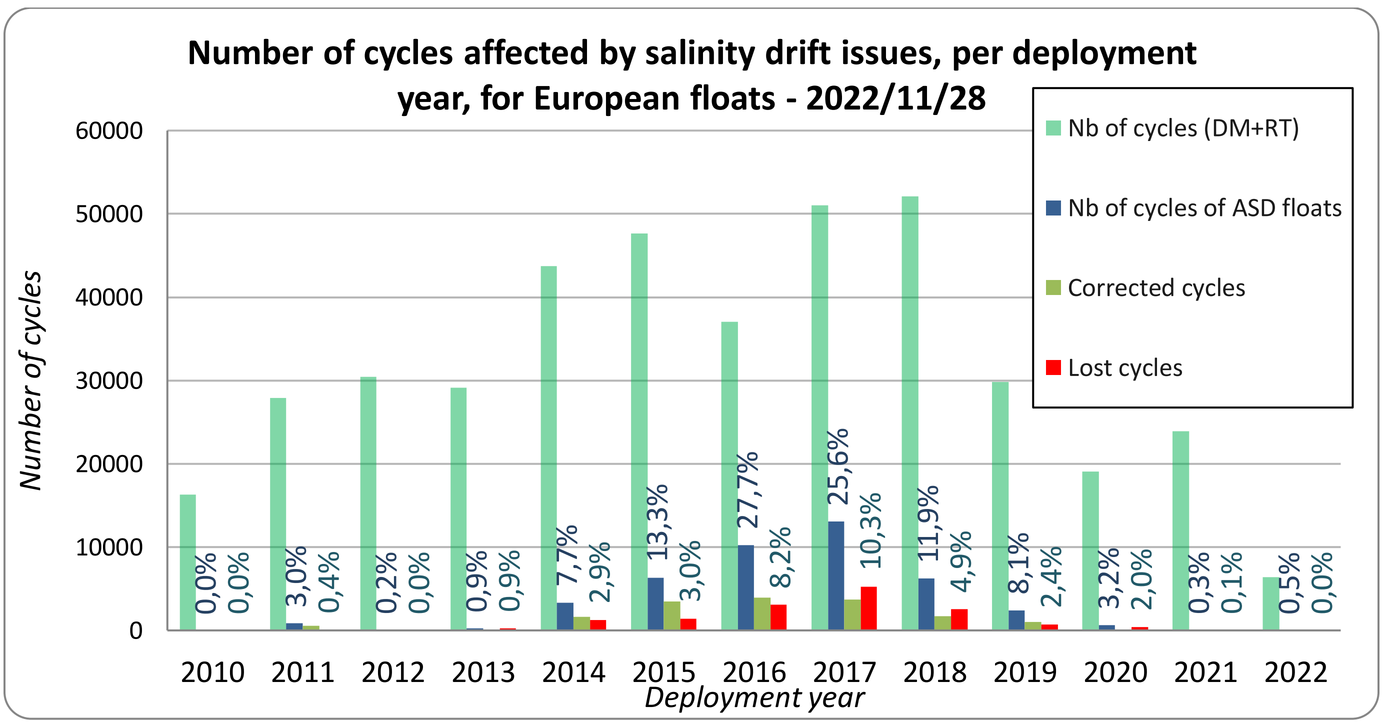

Figure 5. Percentage of cycles affected by abrupt salinity drift problem in the European fleet – as of Nov. 2022.

Figure 5 shows that (as of November 2022) the issue was most significantly present in profiles made by floats deployed in 2015-2018 (up to 10% of data lost), but is still affecting data made by floats deployed in the more recent years: 3.2% of data made by floats deployed in 2020 are impacted by a drift, with 2% of the data being lost (uncorrectable drift).

A meeting was organised late 2022 between all European partners to prepare a negotiation with SBS for the loss of data due to faulty CTD sensors in the SBS recall range (10482-11252). If focussing on this range, along the 568 floats deployed at international level, 150 floats have reached unadjustability (international fleet) and among them 32 are European floats, spread across 6 national programs: France (16), Germany (6), Norway (4) and Ireland, Italy, UK (2 each). A meeting was held (on line) with SBS in January 2023, and Europe is now waiting for feedback from SBS to agree on a final list of floats for which the warranty process that was agreed in January will be put in place (see Birgit Klein's presentation).

- **BGC data management**

Athough BGC DMQC of European floats has started thanks to local initiatives, it is still disorganised and not fully funded. The organisation of BGC DMQC is presently in discussion at Euro-Argo level, with various scenarios investigated, and a consolidated proposition of organisation between various institutes involved should be set up during the course of 2023.

d. status of delayed mode quality control process

At the end of 2022, the percentage of the whole European fleet (EU-funded + National) processed in Delayed Mode amongst eligible floats (more than 1 year old) was almost 98%.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

In 2022, the Euro-Argo ERIC coordination office was a team of ~5.3 FTE (4.3 permanent, 0.5 project-funded and 0.5 consultant). This team supports European countries to sustain and optimise the European contribution to the Argo International programme, and comes in addition to the national members' personnel.

The European contribution to Argo has still benefited from the Euro-Argo RISE EU project (Euro-Argo Research Infrastructure Sustainability and Enhancement), that has involved all the Euro-Argo ERIC members except Netherlands for a 4 year duration (until December 2022). Euro-Argo RISE was coordinated by the Euro-Argo ERIC. The project was granted 4M€, including funds for float purchase (**12 floats in total including Deep and BGC floats, all deployed prior to 2022**) and a total of more than **100**

person months per year dedicated to Argo activities in all aspects (technological development, science, data management, outreach, legislation, etc.). In 2022, Euro-Argo RISE issued recommendations for deploying Argo floats in the Arctic Ocean and in shallower areas of the European Marginal Seas. For boundary current applications, the Virtual Fleet software was created to compute and analyse simulations of virtual Argo float trajectories and had a new release early 2023.

Euro-Argo is also involved in the **EuroSea EU project** that funded **5 Deep floats and 5 BGC floats** deployed in 2021 and allows collaborations with other ocean observing networks, and in the **ENVRI-FAIR EU project** in which Euro-Argo is funded to work on improving **FAIRness** (FAIR: Findable, Accessible, Interoperable, Reusable) of **Argo data**, through the involvement of the two European Argo DACs (BODC & Coriolis).

The EU project DOORS (Developing Optimal and Open Research Support for the Black Sea), started in 2021, will also allow Europe to further develop Argo in the Black Sea and demonstrate the importance of BGC-Argo for Blue Growth development in the Black Sea as part of a multiplatform integrated observing system. The project includes the funding of sensors for 2 BGC floats that were planned to be deployed in 2022 (by Bulgaria) but postponed to 2023 due to the political situation in the countries surrounding the Black Sea.

The EU Project GEORGE, for next GEneration multiplatform Ocean obseRvinG tEchnologies for research infrastructures, started in January 2023. The overall objective of GEORGE is to advance the global technological competitiveness of European ocean observing research infrastructures (EMSO, ICOS, Euro-Argo) through the development and demonstration of a state-of-the-art biogeochemical, multi-platform observing system from sensor to data repositories, for characterisation of the ocean carbon system.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

Float deployments planned for 2023 are presented in Table 2 per region and type of float. In total, Europe plans to deploy 301 floats, significantly more than the number of floats effectively deployed in 2022, but these numbers are to be taken with care because of uncertainties in funding availability for several partners, as well as unforeseen inflation in float prices. Only 4 of these floats will be funded by the Euro-Argo ERIC.

Table 2. European deployment plans for 2023: total [national + EU-funded] & (EU-funded in brackets). "T/S/O2" stands for core floats equipped with an additional oxygen sensor (DEEP floats equipped with an oxygen sensors are counted in the DEEP column), and "BGC" stands for floats with 6 BGC parameters, and "Bio" for all other floats able to measure some other BGC variables.

	Core	T/S/O2	BGC	**Bio**	**DEEP**	**total**
Nordic	7	4	5	4	0	20
Med Sea	15	7	3	2	2	29
Black Sea	1	1	0	2 (1)	0	4 (1)
Baltic	1 (1)	3	4	2	0	10 (1)
Southern	39	0	4	0	4	47
Arctic	8	0	3	0	0	11
Global	127	10	21	15	7 (2)	180 (2)
Total	**198 (1)**	**25**	**40**	**25 (1)**	**13 (2)**	**301 (4)**

In addition to data processing, European institutes are continuing **their R&D work for improving data quality**, through the development of new DMQC methods, both for T/S and for BGC parameters. Collaboration at European level is being enhanced and this will continue in the coming years, thanks to work carried out in **ENVRI-FAIR**. The work done to handle Argo vocabularies via the Nerc Vocabulary Server (NVS) was pursued in 2022, and Argo Reference tables are now almost all converted, which will allow to start relying on the NVS for all Argo vocabulary issues and thus increase the GDAC reliability.

BGC data management is also being organised at European level and this work will continue in 2023. A new 3-year EU project has started in September 2022 (**FAIR-EASE**) in which Euro-Argo is funded (150 k€) to develop a BGC data QC workbench that should ease the use of QC tools and methods, in particular for Oxygen, by a wide community.

European Research teams are also involved in **technological activities**, e.g. ice avoidance systems and tests of alternative sensors (RBR, TRIOS, etc.), and work carried out in current EU projects also includes **outreach and training activities**, as well as **community strengthening**. In particular, the **7th Argo Science Workshop** was hosted by Euro-Argo in Brussels on 11-13 October 2022.

Euro-Argo is concerned by the lack of resources available to fully implement OneArgo and has started to think of ways to approach key stakeholders to solve this issue. One first example of this kind of **advocacy activities** is the production of a series of general videos on Argo / Euro-Argo, as well as 10 thematic plain language articles **showing the importance of Argo**. This work has been done in collaboration with Mercator Ocean in the framework of the EU4OceanObs initiative.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Argo data and/or products derived from Argo data are used by European operational services such as Copernicus Services and ECMWF, for satellite calibration and validation and for research carried on by the Euro-Argo ERIC partners in various domains, including Deep and BGC (see national reports for details). Regarding operational services, following the **MoU** signed in 2021 between **Euro-Argo ERIC and** Mercator Ocean international / Copernicus Marine Service to better define areas of collaboration between the two entities, another **MoU** was also signed in 2022 between **Euro-Argo ERIC and ECMWF,** one key user of Argo data in Europe, and in charge of the implementation of **the Copernicus Climate Change Service.**

Within the Euro-Argo RISE EU project, European contribution to Argo ARCs was temporarily reinforced, in particular in the Southern Ocean ARC.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

Here is a list of several issues that Euro-Argo would like to mention:

- Large costs increase on sensors and other float components, combined with high exchange rate variation will have a significant impact on network implementation, for 2023 and the years to come.
- Recent European floats are impacted by salty drifts. It is essential to continue to evaluate and monitor the impact in terms of data loss.
- Some European partners are currently facing difficulties in the procurement of pH sensors / floats with pH sensors.
- Funding for the NVS work will stop mid-2023 and no further development will be possible without additional resources (although efforts are ongoing to find new opportunities, in particular through EU projects). The BODC Vocabulary Management Group is responsible for supporting NVS activities, and will continue to do so, but the maintenance of the Argo metadata lists and mappings on the NVS will rely on the Argo vocabulary “editors” who are currently acting on their own funds, and this could be seen as a potential issue for the future.

- The current political situation is impacting the development of Argo in several regions of European interest: Arctic Ocean, Black Sea and Baltic Sea, including delays or cancellation of cruises for deployments.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

See national reports.

7. Keeping the Argo bibliography ([Bibliography | Argo (ucsd.edu)]) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
There is also the thesis citation list ([Thesis Citations | Argo (ucsd.edu)]). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

The Euro-Argo ERIC maintains a summary of the European bibliography at https://www.euro-argo.eu/Outreach/Bibliography. It includes a subsection “Read of the Month” that proposes plain language summaries of scientific publications, one each month, advertised through Twitter. In 2021, the Bibliography section of the website was enhanced with a new presentation of the full Euro-Argo bibliography in a “sortable” table (similar to BGC-Argo bibliography). This bibliography is updated once a year in collaboration with Argo international, after the AST annual meeting.

8. How has COVID-19 impacted your National Program’s ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

There is a global lengthening of the delays due to tensions at the international level and Euro-Argo is facing difficulties in terms of float and sensor procurement. However, Euro-Argo caught-up its back log of 2020-2021 in 2022 and is no longer impacted for now in terms of number of floats deployed.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2022 and 2023 (if known) and where they might be deployed.

Europe has been involved in RBR CTD pilot studies, with a 3 head deep float prototype (for intercomparison with SBE CTDs) and an Arvor-I RBR developed within the Euro-Argo RISE project and successfully deployed in 2020, and 2 more floats equipped with RBR CTDs deployed in 2021. Two ‘2–Headed’ and one ‘3-Headed’ Deep Argo floats (range 4000 m depth) have also been deployed in March 2022 in the Canary basin under the framework of the EA-RISE project, through collaborative work between Ifremer & IEO. The data obtained thanks to these experiences have been useful in first assessments of the RBR CTDs potential, and Europe will continue to investigate the potential of these new CTD in the coming years, with most of the European partners planning to have part of their fleet (about 10% of the core fleet at least) equipped with RBR sensors (e.g. UK, Germany, France), following the AST recommendations (about 10% of the core fleet at least).

Argo National Report 2022 – Finland

1. Status of implementation

The Finnish Argo program is run by the Finnish Meteorological Institute (FMI). Since 2010 FMI has deployed altogether 14 floats in the Nordic Seas, including four on Barents sea 2018, 2020 and two in 2022. In addition of oceanic operations, 32 floats (starting 2012) have also been deployed into the shallow and low salinity Baltic Sea. Six of the Baltic float deployments have bio-optical sensor suite.

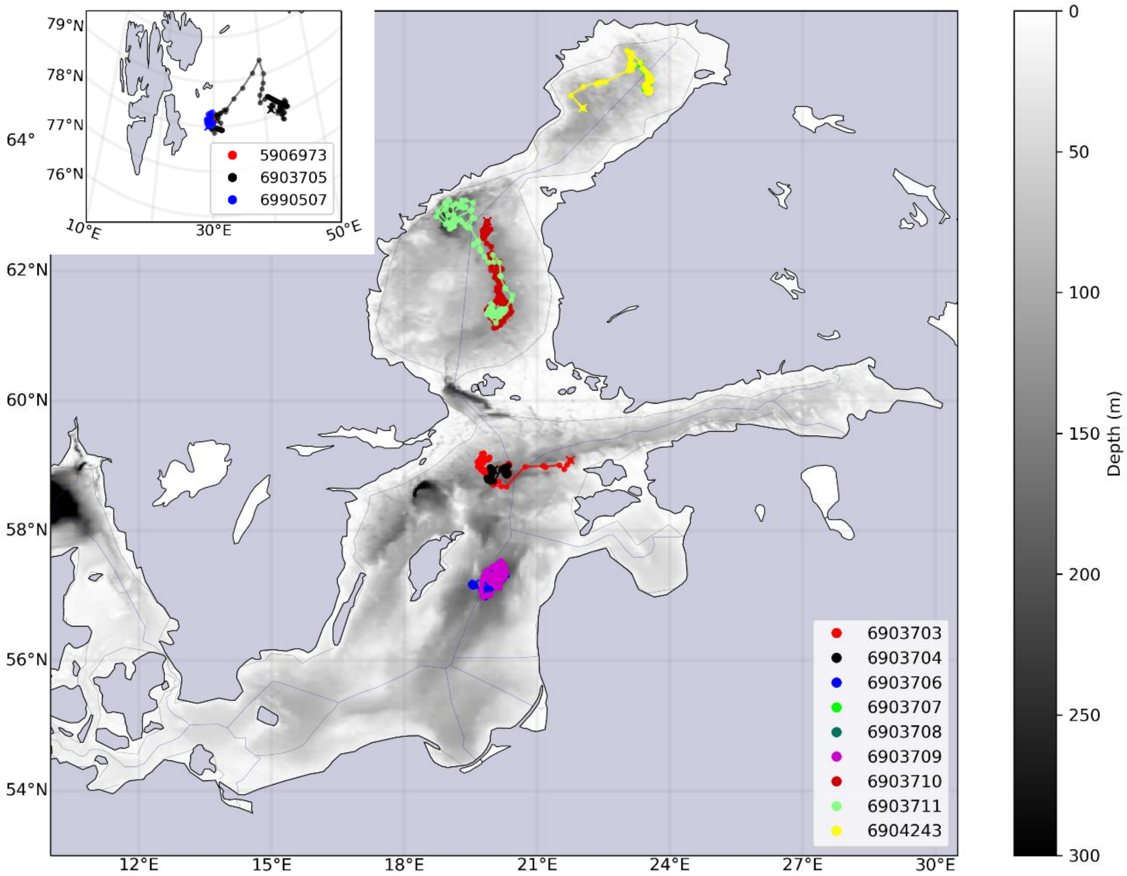

Figure 1, Routes of FMI Argo floats which operated in the Baltic Sea in 2022. Upper left inset shows the trajections of the Barents Sea floats. The dot indicates the deployment location. Cross indicates the recovery point or latest measurement for each Argo float. Light blue lines indicate the borders of national EEZ.

In 2022 FMI deployed total of 3 floats. One Apex float was deployed on Bothnian Bay (WMO 6904243) and two in Barents Sea (WMO's 5906973 and 6990507)

2. Present level and future prospects for national funding for Argo including summary of human resources devoted to Argo

FMI has committed to deploy three floats in a year, at minimum, and spends roughly 3 person months in Argo operations each year. Euro-Argo RISE project has made it possible to increase the total person months used in Argo activities closer to 12. Our main geographical operation area is the Baltic Sea. Currently we are further developing the operation of Argo floats in shallow, and ice-covered seas. First experiments with ice-avoidance on the Baltic Sea has been performed during winter 2015-1016. 2018 one float (6802026) has been successfully under ice on Bay of Bothnia. In summer 2019 another float (6903700) was deployed in same area. A float deployed on Barents Sea in autumn 2018 (6903695) spent successfully two winters under ice, and another (6903705) was deployed on Barents Sea autumn 2020, which succesfully measured for two winters and is currently under ice. The two Barent's Sea flaots deployed in 2022 are currently under ice.

3. Summary of deployment plans

FMI plans to deploy at least 3 floats in 2023. One float will be deployed on Northern Baltic Proper, one or two in Bothnian Sea and one in Bothnian Bay.

4. Summary of national research and operational uses of Argo data

Argo data sets gathered from Baltic Sea are used for validating the operational and research circulation models, studies in hydrography and currents. Operating Argo floats in the Baltic Sea has been a research on the limits of usability of Argos in shallow seas. On this work three papers and one doctoral thesis were published on 2018-2019. (Haavisto et al. 2018, Roiha et al. 2018 and Siiriä et al. 2018, Roiha 2019) Ongoing research is done on assimilating Argo data in the operational Baltic Sea circulation models for enhancing their forecasting skills, further developing the operations in both shallow, and icy conditions, as well as quality control of the Baltic Sea Argo data.

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo

Finland considers that more resources should be allocated for the environmental monitoring of the Arctic Ocean. Also, extension of the Argo program to the marginal seas, where Argo floats are an improtant addition in monitoring of these areas should be continued.

6. CTD data uploaded to CCHDO

No data uploaded.

7. Bibliography

Haavisto N, Tuomi L, Roiha P, Siiria SM, Alenius P, Purokoski T. 2018. Argo floats as a novel part of the monitoring the hydrography of the Bothnian Sea. Frontiers in Marine Science. 5:324. https://www.frontiersin.org/article/10.3389/fmars.2018.00324.

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Siiria S, Roiha P, Tuomi L, Purokoski T, Haavisto N, Alenius P. 2018. Applying area-locked, shallow water argo floats in baltic sea monitoring. Journal of Operational Oceanography. 0(0):1–15. Available from: https://doi.org/10.1080/1755876X.2018.1544783.

8. RBR CTD piloting and deployment plans

Two deployments of Argo floats with RBR sensors were done within the EuroArgo RISE project in 2021. The results of these floats were promising, and FMI is considering to aquire more floats with RBR sensors to further continue operations with RBR sensors in addition to the SeaBird models.

French National Report on Argo - 2022

AST 24

By the Argo-France Management Board :
X.André, C. Cabanes, T. Carval, H. Claustre, C. Coatanoan, F. D'Ortenzio, N. Kolodziejczyk, N. Lebreton, E. Leymarie, A. Poteau, R. Sauzède, C. Schmechtig, P.Y. Le Traon, N. Poffa, V. Thierry and J. Uitz

Background, organization and funding of the French Argo activities

Organization

Argo-France (https://www.argo-france.fr) gathers all the French activities related to Argo and its extension toward deep and biogeochemical measurements. Argo-France is the French contribution to the Euro-Argo European research infrastructure (ERIC) that organizes and federates European contributions to Argo.

All Argo-France activities are led and coordinated by:

- a scientific committee shared with the CNRS/LEFE Group Mission Mercator Coriolis (GMMC),
- a steering team has slightly evolved in 2022 with: a national coordinator (V. Thierry), scientific coordinators for the physical and biogeochemical missions (N. Kolodziejczyk, F. D'Ortenzio, H. Claustre, J. Uitz), technical coordinators for the physical and biogeochemical missions (V. Thierry, E. Leymarie), head of the data center (T. Carval), data center officer for BGC (C. Schmechtig) and heads of operational and infrastructure activities (N. Lebreton, N. Poffa, A. Poteau) and heads of quality control activities (C. Cabanes and R. Sauzède).

Argo-France is part of the Ministry of Research national roadmap on large research infrastructure (IR*). Argo-France operational activities are organized through the Coriolis partnership (IFREMER, SHOM, INSU, IRD, Météo France, CEREMA, CNES and IPEV). Two research laboratories are leading the Argo-France scientific activities: the "Laboratory for Ocean Physics and Satellite remote sensing" (LOPS, Brest, France) and the "Laboratoire d'Océanographie de Villefranche"/"Institut de la Mer de Villefranche" (IMEV/LOV, Villefranche-sur-Mer, France). Coriolis and Argo-France have strong links with Mercator Ocean International (the French operational ocean forecasting center).

Funding

Argo-France is mainly funded by the ministry of Research through Ifremer as part of the national roadmap on large scale infrastructures and contribution to Euro-Argo (IR*). This is a long term commitment. Argo-France is also funded through Ifremer, SHOM (Ministry of Defense), CNRS/INSU and other French institutes involved in oceanography (CNES, IRD, Météo-France), and by the Brittany and Provence Alpes-Côte d'Azur régions (CPER projects). The National Observation Services (SNO) Argo-France is supported by CNRS/INSU and the IUEM institute at University of Brest OSU (Observatory). The French contribution to the Argo global array is at the level of 60 to 65 floats per year with funding from Ifremer (50 to 55 floats/year) and SHOM (about 10 floats/year).

Since 2000, around 1467 French floats have been deployed in different geographic areas. Deployments focused on meeting specific French requirements while also contributing to the global array.

To complement Argo-France, the NAOS project (Novel Argo Ocean observing System, 2011-2019) was funded by the Ministry of Research to consolidate and improve the French contribution to Argo and to prepare the next scientific challenges for Argo**.** The project provided an additional funding of 15 to 20 floats per year from 2012 to 2019, which allowed Ifremer to increase its long-term contribution to Argo from 50 to 65-70 floats/year. NAOS also developed the new generation of French Argo floats and set up pilot experiments for biogeochemical floats (Mediterranean Sea, Arctic), Under Ice BGC floats (baffin bay) and deep floats (North Atlantic).

As follow up of this project:

-the Ifremer PIANO project (2021-2025) will consolidate and improve the French contribution to BGC-Argo (funding of 15 BGC floats) and develop the next generation french of deep-Argo floats (6000m), and BGC-ECO floats (BGC float with ecological sensors).

-the ANR EQUIPEX+ Argo2030 project (2021-2028) has been recently launch (kick off meeting January 2022) and funded by the Ministry of research to consolidate and improve the French contribution to BGC-Argo (funding of 15 BGC floats), and to test the next generation of french deep-Argo-6000 floats (funding of 22 floats), and of BGC-ECO floats (funding of 14 BGC-ECO float).

The level of support, additional to float purchase, is as indicated in Tableau 1 (manpower for coordination activities, float preparation, deployment and data management activities).

Year	Funding	**Man/Year**	***French floats***	***Co-funded EU floats***	***Total***
2000	300k€		*11*		*11*
2001	633k€	3	*12*		*12*
2002	980k€	6	*7*	*4*	*11*
2003	900k€	9	*34*	*20*	*54*
2004	1400k€	15	*85*	*18*	*103*
2005	450k€	15	*89*	*11*	*100*
2006	900k€	12	*51*	*14*	*65*
2007	900k€	12	*36*		*36*
2008	1200k€	12	*90*		*90*
2009	1200k€	12	*35*	*8*	*43*
2010	1400k€	12	*59*		*59*
2011	1400k€	12	*64*		*64*
2012	1400k€	12	*105*		*105*
2013	1400k€	12	*89*		*89*
2014	1400k€	12	*108*		*108*
2015	1400k€	14	*131*		*131*
2016	1400k€	14	*57*		*57*
2017	1400k€	14	69		69
2018	1400k€	14	86		86
2019	1400k€	14	71		71
2020	1400k€	15	45		45
2021	1400k€	15	90		90
2022	1400k€	15	43		43

Total (2000-2020)			*1467*	*75*	*1542*
2023	**1400k€**	**15**	**55**		

Tableau 1: (*Man/year* column) Manpower dedicated to Argo for coordination activities, float preparation, deployment and data management activities (GDAC, DAC, NAARC, DMQC) within Argo-France. (*French floats* column) French floats contributing to Argo deployed by year. (*Co-funded EU floats* column) EU floats are the additional floats co-funded by the European Union within the Gyroscope, Mersea and MFSTEP projects. Estimated value is given for 2022.

Long term evolution of Argo

At the national level, Argo-France will contribute to the new phase of Argo with about 55 floats/year with the following repartition:

- 27 core Argo floats /year
- 7 core Argo floats with O2 sensor /year
- 10 Deep-Argo-4000 floats /year (+ 22 Deep-Argo-6000 floats)
- 9 BGC-Argo floats /year (+ 14 BGC-ECO floats)

Core T/S, deep floats and oxygen sensors will be funded until 2027 (National Research Infrastructure IR* Euro-Argo France and CPER Brittany region), the biogeochemical mission is funded through different projects (CPER PACA and Brittany regions, ERC Refine, Argo-2030 and PIANO projects).

Argo-France strategy will be adjusted according to international recommendations with regard to the deep and BGC extensions. Euro-Argo has published a long term roadmap for the next phase of Argo and as part of the ERIC Euro-Argo countries will work on the implementation of a new sustained phase for Argo in Europe.

Float development

As part of the EA-RISE 2019-2022 H2020 project (final meeting 29 november 2022):

- An Arvor model equipped with the RBR CTD has been developed and deployed in December 2020.
- Two Deep-Arvor equipped with 2-CTDs (the RBRargoDeep|OEM and the SBE61) and two Deep-Arvor equipped with 3-CTDs (the RBRargoDeep|OEM, the SBE41 and the SBE61) were developed. Due to delay in sensor provisioning, the two 2-head floats will be deployed in 2022. After first deployments in 2020, a 3-head float will with the new design of the RBRargoDeep|OEM sensor will be deployed in 2022.
- Two Provor floats with SUNA + OPUS + O2 + EcoTriplet and with OC4 + RAMSES + O2 + EcoTriplet are developed, tested in the Mediterranean Sea and will be deployed in the Baltic.

As part of the new ERC REFINE project (see details in the National research section) technological developments are expected to provide:

- Extended battery packs for longer mission
- New electronic for targeted exploration and adaptative sampling
- New sensors for particles and zooplankton characterization

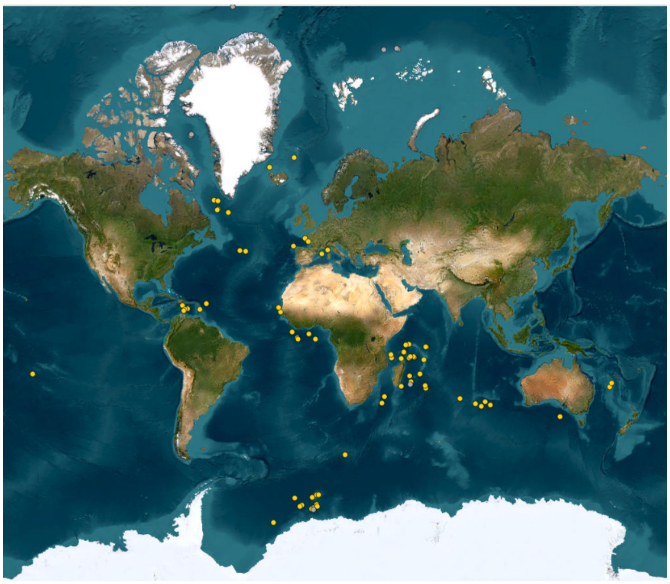
As part of the new Ifremer PIANO project the expected technological developments are :

- New T/S and BGC sensors (optical sensors, sonar, chemical sensor)
- improvement of Deep-Argo 4000 and development of new Deep-Argo 6000 m
- Improve float technology (communications and electronics)
- Test of a Deep-Arvor float with two oxygen sensors: Aanderaa optode and RINKO sensor.

The status of implementation

Floats deployed and their performance

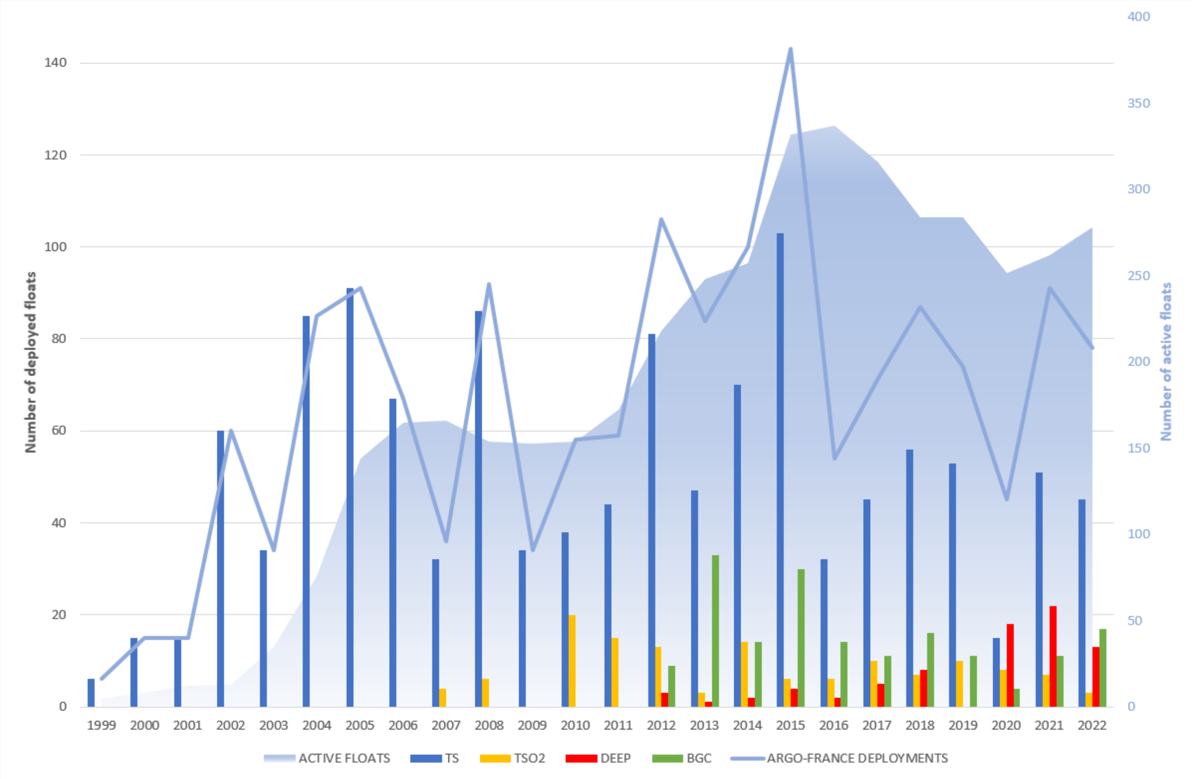
78 floats have been deployed by France in 2022 (45 T/S Core, 3 T/S/O2, 17 BGC, 13 DEEP). We deployed those floats from French RVs Atalante, Thalassa, Marion Dufresne and Beautemps Beaupre, international RVs Sonne, Amundsen and Sarmiento de Gamboa but also from ships of opportunity (commercial ship, fishing vessels and sailing yachts Tara and Iris). The deployment areas are chosen to meet French requirements in terms of research and operational activities and also to contribute in establishing the global array (especially in the Southern Ocean) using OceanOPS tools.



Deployment locations of Argo-France floats in 2022 by float types.
In January 2023, among 78 floats deployed in 2022 :

- 70 are still active
- 6 are under ice
- 2 Deep Arvor have disappeared after 1 single cycle and no identified reason.

The French Argo fleet operated in 2022 includes 69% of core, 14% of deep, 7% of T/S/O2 et 10% of BGC. 53 french floats died in 2022, mainly due to end of battery.Dead floats shows a average of 206 cycles and 3.7 years at sea.



Argo France fleet deployment since 1999.

In 2022, Argo France have updated and published the National Strategy for Argo Global Network Profiling floats deployments. This is a document of recommendation, including the most recent recommendations from AST, for GMMC scientific board and Argo France community : https://doi.org/10.13155/59297.

Technical problems encountered and solved

Technical problems.

2 DEEP disappeared prematurely after one cycle : Unidentified problems

Seabird batch of drifting CTDs is being assessed and monitored.

Since 2014, a larger than expected percentage of SBE conductivity sensors have drifted prematurely, eventually to an uncorrectable state (Abrupt Salty Drift - ASD). Changes at the manufacturing level were introduced in 2018 to reduce such occurrences. To monitor this issue, floats affected are listed in a spreadsheet that is concatenated at the international level and updated regularly: https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit#gid=0

So far, 55 French Floats are listed as having a moderate or severe drift, this represents about 7% of the french float affected by this failure.

Status of contributions to Argo data management

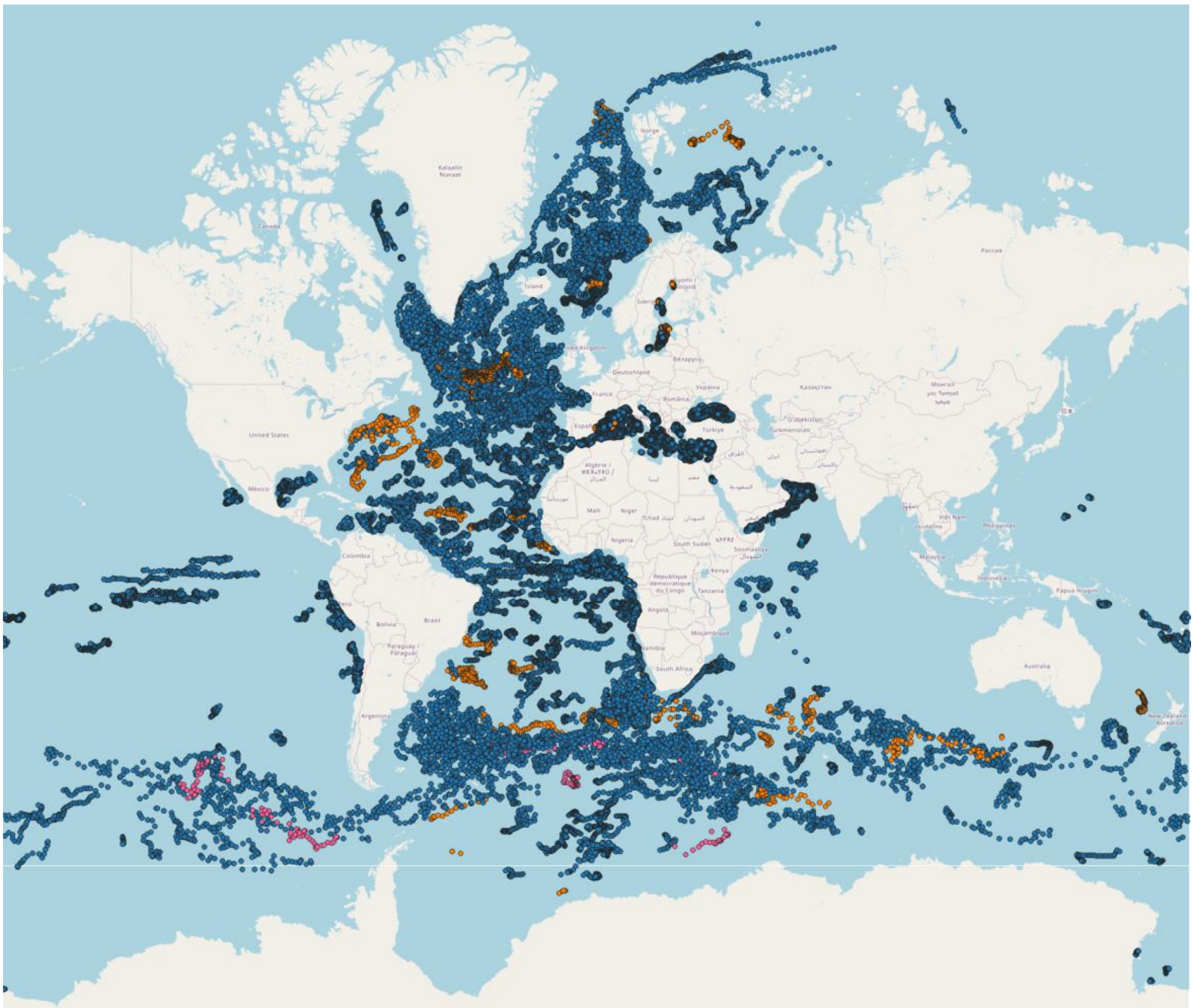
Within Argo-France, data management is undertaken by Coriolis, which plays three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM. Since 2016, the BGC floats processing chain has been fully operational and integrated within the Coriolis data management stream.

All Argo data management details are in the Coriolis DAC and GDAC 2022 annual report (english) : https://archimer.ifremer.fr/doc/00808/92009/

Data Assembly Center

Coriolis processes in Real Time and Delayed Mode float data deployed by France and 7 European countries (Germany, Spain, Netherlands, Norway, Italy, Greece, Bulgaria).

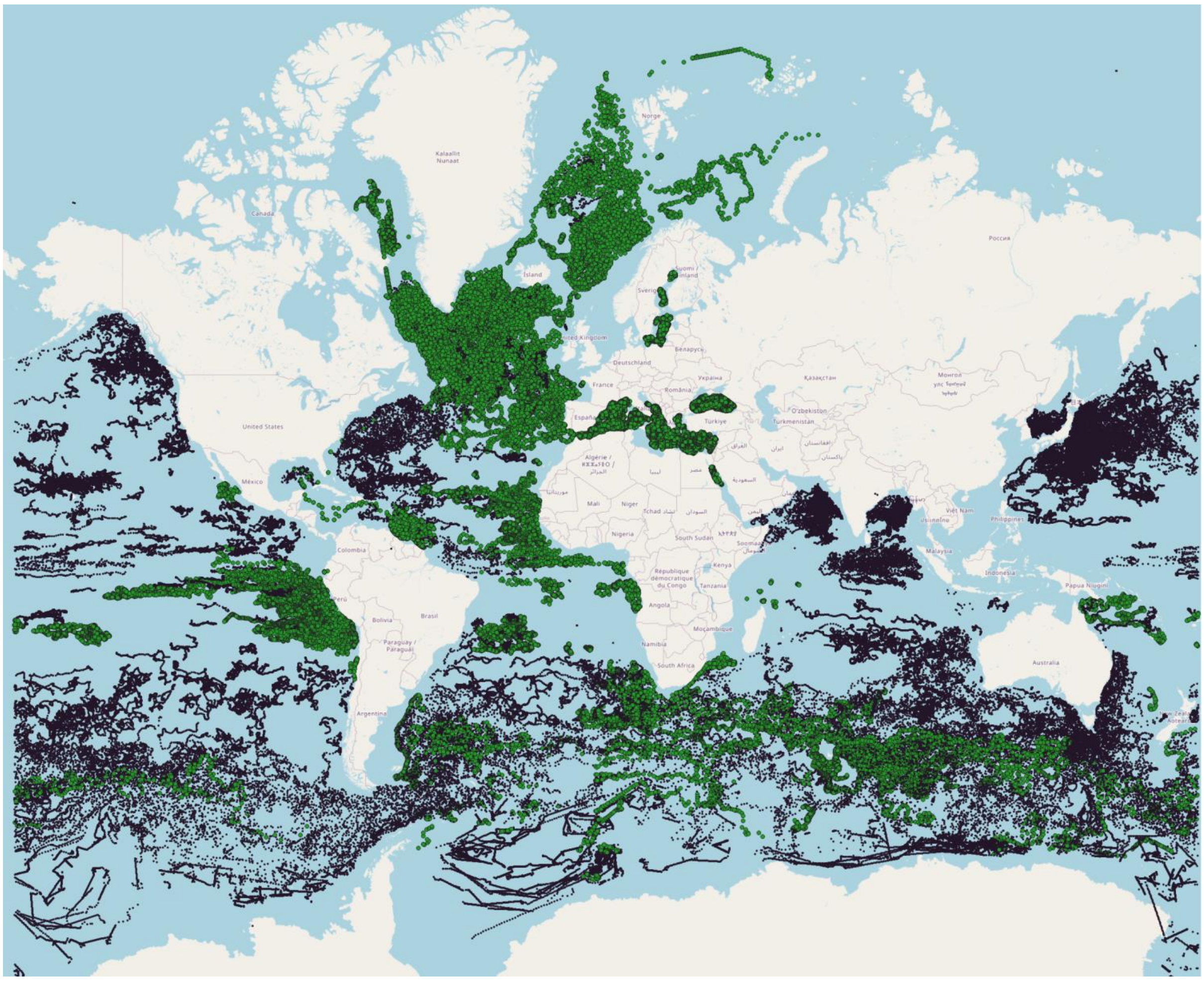
In the last 12 months, 64 452 profiles from 888 active floats were collected, controlled and distributed. Compared to 2021, the number of profiles keeps increasing (+10%), the number of floats increased by 7%. These figures show a fair stability in Coriolis DAC activity. The 888 floats managed during that period had 51 versions of data formats.



Map showing the 64 452 profiles from 888 active float décoded by Coriolis DAC in 2022
Apex Nova Provor

The data processing chain based on Matlab to manage data and metadata from Coriolis BGC-floats is continuously improved. These are advanced types of floats performing bio-geo-chemical (BGC) measurements.

- Coriolis DAC manages 677 BGC-Argo floats from 5 families. They performed 90 115 cycles.
- The data processing chain is freely available: Coriolis Argo floats data processing chain, http://doi.org/10.17882/45589



Map of the 677 BGC-Argo floats managed by Coriolis DAC (grey dots: the others DACs BGC floats). They measure parameters such as oxygen, chlorophyll, turbidity, CDOM, back-scattering, UV, nitrate, bisulfide, pH, radiance, irradiance, PAR.

Global Argo Data Centre

Coriolis hosts one of the two global data assembly centres (GDAC) for Argo that contains the whole official Argo dataset. Ifremer manage a dashboard (Semaphore) to monitor data distribution and give credit to data providers such as Argo floats: https://audience-argo.ifremer.fr

FTP, HTTPS and ERDDAP downloads log files are ingested in an Elasticsearch index. A link between downloaded files, download originators, floats included in the downloaded files and institution owners of the floats is performed. These links are displayed in a [Kibana dashboard](). This dashboard offers the possibility to give credit to Floats owner institutions such as how many data from one particular institution was downloaded, by whose data users. Semaphore key figures for 2022:

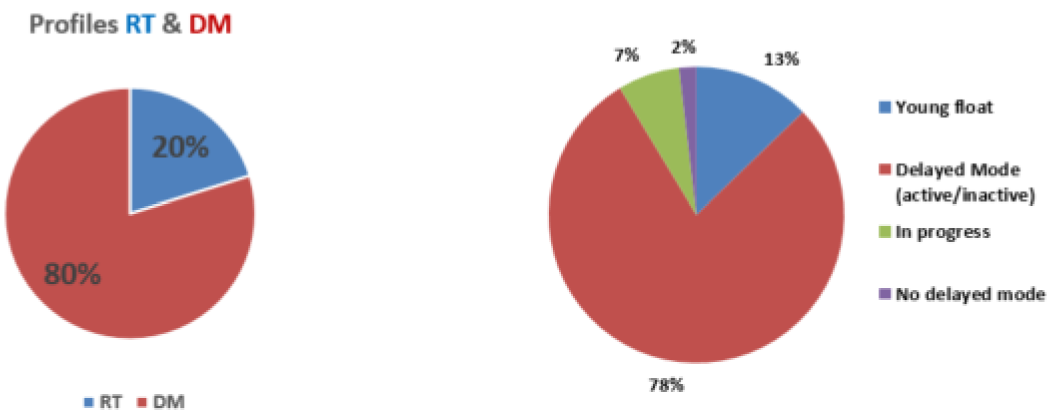
- 2 million sessions for Argo data downloads
- 655 million of files downloaded
- 80% of ftp downloads, 20% of https downloads
- 20 petabytes daily downloads

Atlantic Argo Regional Centre

See section 5.4

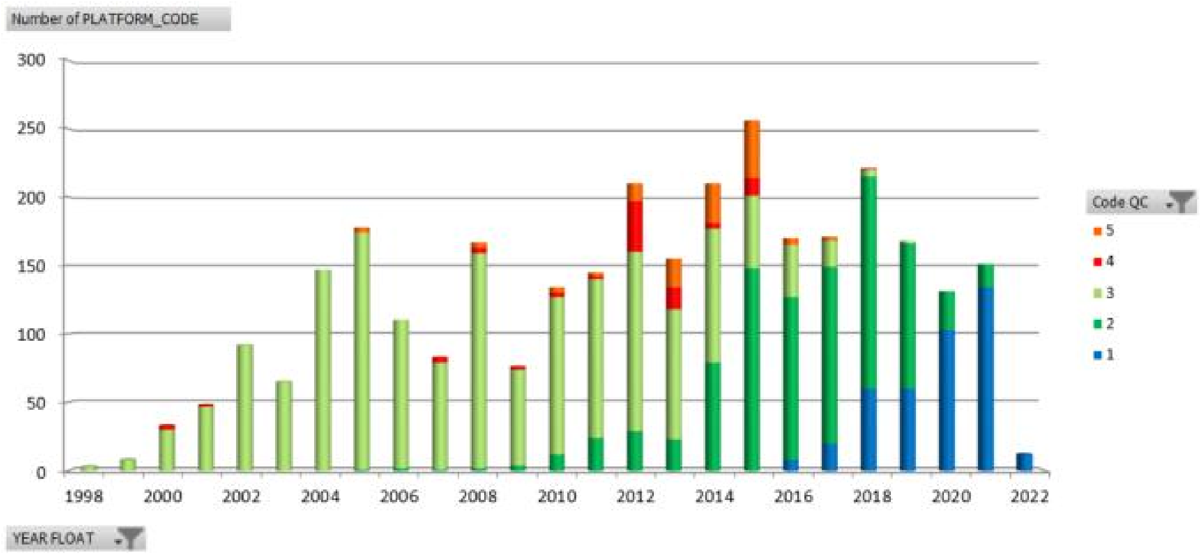
Status of delayed mode quality control process

During the last year (from November 2021 to November 2022), 27386 new delayed mode profiles were produced and validated by PIs. A total of 350836 delayed mode profiles were produced and validated since 2005. In November 2021, 83.05% (75%) of the profiles (floats) processed by the Coriolis DAC were in delayed mode (see Figure below).



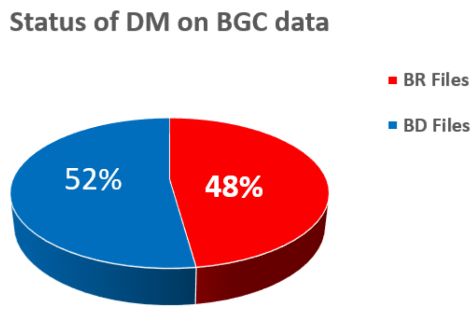
Status of the floats processed by Coriolis DAC. Left: in terms of profile percent (DM available) and right: in terms of float percent (DM : delayed mode – RT : real time).

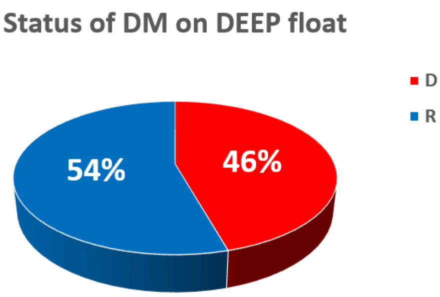
The status of the quality control done on the Coriolis floats is presented in the following plot. For the three last years (2020-2022), most of the floats are still too young (code 1) to be performed in delayed mode. For the years 2012 to 2016, we are still working on the DMQC of some floats. The codes 2 and 3 show the delayed mode profiles for respectively active and dead floats.



Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM, code 6 : problems with float.

Looking in more detail to focus on BGC or Deep Argo data, a great effort has also been made to increase the count of mode profiles: at least 52% of floats have one parameter in D mode for BGC profiles when 46% of Deep Argo floats have been processed in delayed mode.



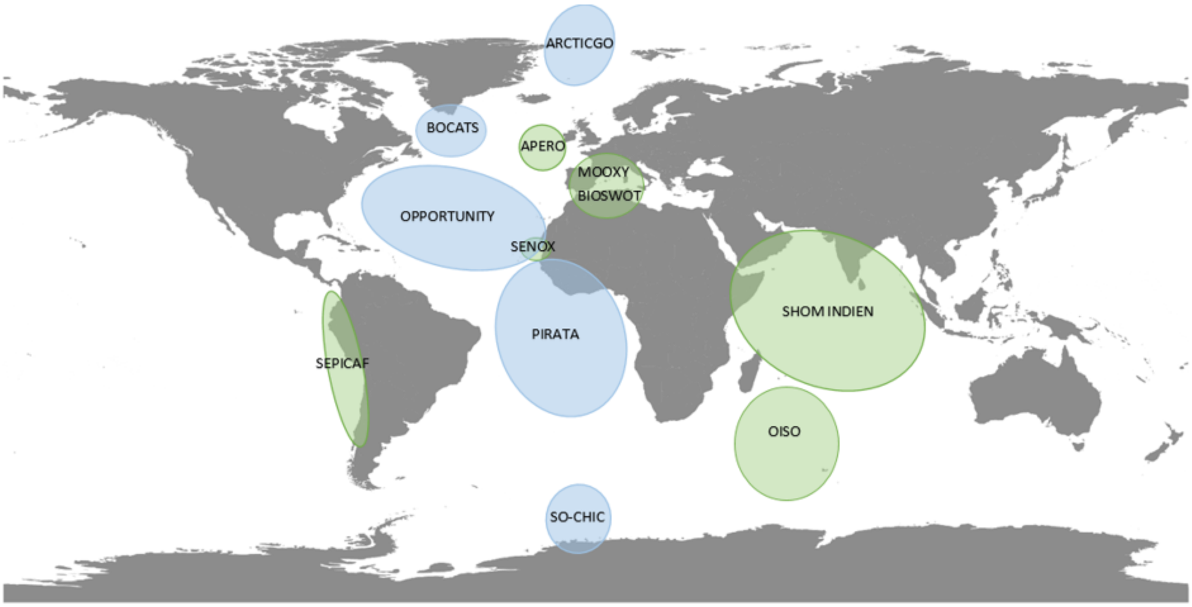


Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible

According to the current deployment plan, around 94 floats are scheduled to be deployed in 2023 (51 T/S, 11 T/S/O2, 23 BGC, 9 DEEP), see map below.

Coriolis will continue to run the Coriolis DAC and the European GDAC as well as coordinating the Atlantic ARC (A-ARC) activities. Within Euro-Argo, development will be carried out to improve anomalies detection at GDAC both in RT and DM, to monitor in real time the behaviour of the European fleet and to improve data consistency check within A-ARC.

France also will continue to contribute to the funding of the AIC.



Deployment locations of Argo-France floats planned in 2023 by ship cruises : blue are core Argo deployments and greens will include BGC floats.

COVID19: In 2022, Argo-France has managed all deployment postponed from 2020. The COVID19 impact has been reported at the OceanOPS and Euro-Argo level for possible coordinations to sustain the array (https://docs.google.com/spreadsheets/d/1ofo5ipeBLFRpNVKpcbTZuiKjpCmWwVU2TPI3-bBO0BM/edit#gid=0).

Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers

Operational ocean forecasting

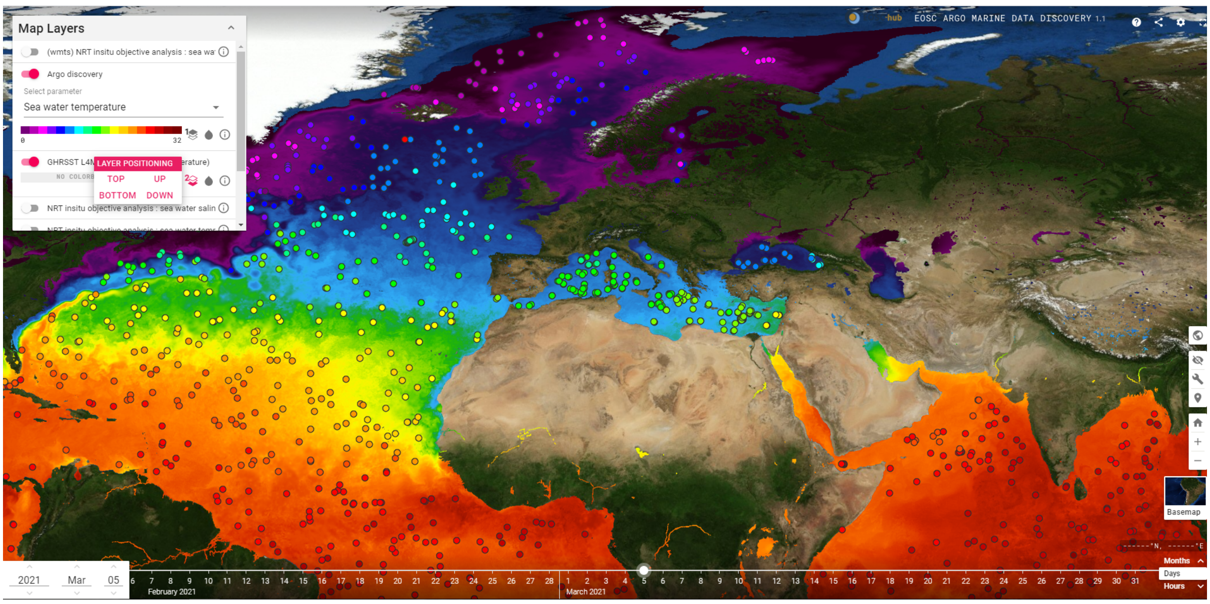
All Argo data (alongside with other in-situ and remotely sensed ocean data) are routinely assimilated into the MERCATOR operational ocean forecasting system run by the MERCATOR-Ocean structure. MERCATOR also operates the Global component of the European Copernicus Marine Environment Monitoring Service (CMEMS).

Support to the Mercator and Coriolis scientific activities

Coriolis has developed together with MERCATOR (The French operational oceanography forecast center) a strong connection with the French research community via the Mercator-Coriolis Mission Group (GMMC). It consists of about one hundred researchers (with some turnover each year) following a scientific announcement of opportunities and a call for scientific proposals. Its task is to support the Mercator and Coriolis scientific activities and to participate in product validation. The call for scientific proposals proposes to the community Core, BGC and Deep Argo floats. These new opportunities strengthen the link between the French scientific community and Coriolis with regard to the development of qualification procedures for "Argo extensions" floats.

European Argo-data project involving French Argo community

- Euro-Argo RISE (2019-2022): https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022/News/Euro-Argo-RISE-progress-already-halfway-there
    - Development & Implementation of DMQC machine learning methods
    - Improvement of data access
    - Sensors: addressing SBE61 accuracy and stability & testing RBR on core and deep floats
    - DMQC method for Argo extended missions (Deep, BGC)
    - Viewing service : https://dataselection.euro-argo.eu/
    - Outreach
- ENVRI-FAIR: connecting ERICs (Euro-Argo) to EOSC Blue Cloud:
    - Improving data access to European data base including Argo dataset through new API on Coriolis GDAC
- EOSC-Blue cloud
    - Improving visualization tools for Argo data combined with satellite information (http://bluecloud.odatis-ocean.fr/)



Map of Argo-Float surface temperature overloaded with satellite SST

National Research

Argo data are being used by many researchers in France to improve the understanding of ocean properties (e.g. circulation, heat and freshwater storage and budget, and mixing), climate monitoring and on how they are applied in ocean models (e.g. improved salinity assimilation, …).

A list of France bibliography is available at the end of this report.

Key project activities

ISAS T/S gridded fields

Argo France provide updated T/S gridded monthly fields from Argo profiles and some other CTDs (CCHDO,ICES, PIRATA-TAO-RAMA, MEOP, ITP, …), all the ISAS releases have been now accessible from an unique DOI:

Kolodziejczyk Nicolas, Prigent-Mazella Annaig, Gaillard Fabienne (2021). ISAS temperature and salinity gridded fields. SEANOE. https://doi.org/10.17882/52367

ANDRO Trajectory dataset

Argo-France contributes to the DMQC on Argo float trajectories and provides updates to the ANDRO product (Atlas of Argo trajectories). An update for the period 2010-2022 including the floats of the AOML and Coriolis DACs was published in 2022. The delayed-time QCs of the Argo float trajectory data have been updated, as well as the Andro Atlas of float travel velocities at DOI:

Ollitrault Michel, Rannou Philippe, Brion Emilie, Cabanes Cecile, Reverdin Gilles, Kolodziejczyk Nicolas (2022). ANDRO: An Argo-based deep displacement dataset. SEANOE. doi:https://doi.org/10.17882/47077

ICES North Atlantic OCean State Report (IROC)

As every year, in 2022, Argo-France contributed and assembled the French contribution to the ICES report on the state of the North Atlantic Ocean in 2020 (and 2021 not yet published). The ISAS temperature and salinity fields are used in its "Ocean State Report" : www.ices.dk. González-Pola, C., Larsen, K. M. H., Fratantoni, P., and Beszczynska-Möller, A. (Eds.). 2022. ICES Report on ocean climate 2020. ICES Cooperative Research Reports Vol. 356. 121 pp. https://doi.org/10.17895/ices.pub.19248602

H2020 EARISE (Euro-Argo Research Infrastructure Sustainability and Enhancement, 2019-2022)

The H2020 EARISE project has seen its third year of activities (see above):

- design of the integration of the new RBR probes on the Arvor and Arvor-Deep
- start of the implementation of a DAC for the BGC extension (Coriolis)
- integration design of new bio-optical sensors on PROVOR
- Implementation of a collaborative framework for the Argo community. Collaborative tools are available on github.com/euroargodev. All these tools are free and available for the global Argo community, among others:
    - A public forum on Argo QC to be used by the Argo-France community: github.com/euroargodev/publicQCforum
    - Hosting of digital codes for distribution and development (repositories),
    - Tools for team organization and discussion

○ Project management tools.

ERC REFINE (Robots Explore plankton-driven Fluxes in the marine twIlight zoNE, 2019-2022)

After obtaining a first ERC in 2011 (remOcean), Hervé Claustre obtained in 2019 a second ERC (Advanced Grant) for the REFINE project . The scientific objective of REFINE is to understand and quantify the physical, biological and biogeochemical processes that control the biological carbon pump, a key element in CO_2 sequestration. It is in the mesopelagic zone (or twilight zone), between 200 m and 1000 m, that most of the key processes occur. Yet this zone represents one of the least well known ecosystems on our planet. The REFINE project will therefore focus on exploring the meso-pelagic zone and will be implemented through four major coordinated actions:

1. Development of a new generation of multidisciplinary profiling floats, focusing in particular on the composition of phyto- and zooplankton communities.
2. Realization of ~4 years of robotic studies in five ocean areas, representative of the diversity of biogeochemical conditions and responses to climate change in the world ocean, on a continuum of time scales from diurnal to interannual.
3. In-depth analysis of the REFINE dataset, enabling carbon flux budgets to be established for each of the five areas, and understanding the physical and biogeochemical mechanisms involved in the transfer of organic carbon to the deep ocean.
4. "Upscaling" regional processes to the global ocean, notably through the use of artificial intelligence that takes advantage of multi-source observations from REFINE robots and Earth observation satellites.

PIE Ifremer PIANO (Argo Novel Observations Investment Plan ; 2021-2025)

The objective of the PIE PIANO project (Argo New Observations Investment Plan) is to carry out innovative technological developments on Argo floats, on sensors (for T/S and BGC-Argo) and to implement the French contribution to the new Argo phase over 2021-2027. This will involve:

- procurement of BGC-Argo floats (12 floats over 5 years)
- to develop a French offer of BGC sensors (active optics, passive optics, micro sonar and pH chemini)
- to develop a Deep-Argo 6000 m float
- to improve float technology (electronics, communication)
- finally to ensure the processing of project data including the development of innovative methods

Equipex+ Argo-2030 (3^{td} Investment Plan of French Research Ministry; 2021-2028)

The objective of the Equipex PIA3 Argo-2030 project is to acquire BGC floats to consolidate the French contribution to the BGC component of the Argo network (15 floats, i.e. 2-3 floats/year over 8 years). Argo-2030 also plans scientific experiments to test and validate the new generations of BGC and Deep floats developed in complementary projects (ERC Refine for the platform, PIE Ifremer PIANO for “Made in France” sensors) :

- The new generation of French BGC-Argo floats (referred to as "BGC-ECO" Argo) will add unique imagery and active acoustics capabilities. These floats will allow the exploration of the mesopelagic zone (100-1000 m)including its biological/fishering dimension (it is believed that the protein resources of this zone are underestimated by at least an order of magnitude) assuming the it is the main site of the remineralization of CO_2, and therefore it is decisive for CO_2 sequestration.
- The new generation of French Deep-Argo floats (the Deep-Arvor “6000”) will target 6000 m depth (the floats developed and successfully tested in the NAOS Equipex are designed to

target 4000 m depth). It will offer a high capacity for carrying additional sensors (oxygen in particular), allowing the Deep-Arvor "6000" to be positioned as the first Deep + BGC mixed float. These floats will help estimate the role of the deep ocean on the planet's energy balance, sea level rise, deoxygenation, and acidification in key regions (Atlantic, Southern Ocean). Their deployment will be combined with Deep-Argo 4000 floats to best resolve geographic structures and seasonal to interannual variations in heat and freshwater content, steric height and circulation at the basin scale within deep (> 2000 dbar) and abyssal (> 4000 dbar) oceanic layers.

Argo-Regional Center: Atlantic

France leads the A-ARC, which is a collaborative effort between Germany (IFM-HH, BSH), Spain (IEO), Italy (OGS), Netherlands (KNMI), UK (NOCS, UKHO), Ireland (IMR), Norway (IMR), Canada (DFO), and USA (AOML), Greece (HCMR) and Bulgaria (IOBAS). Coriolis coordinates the Atlantic ARC activities and in particular the float deployment in Atlantic.

1903 floats that have been processed in delayed time in the Atlantic ARC, north of 35°S, with a check made using a modified OW method that has been published by Cabanes et al (http://dx.doi.org/10.1016/j.dsr.2016.05.007). Floats for which it may be necessary to revise the original DM correction are reported to PIs. The list is available online at:

http://www.umr-lops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-corrections

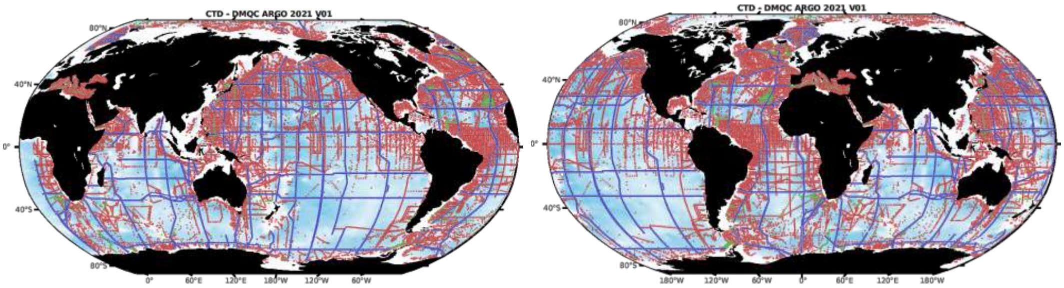
Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. *These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.*

- Increase of the float's prices under flat funding from project and IR* Argo France may reduce the number of purchased float in the next years

CTD cruise data in the reference database

To continue improving the number of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include the number and location of CTD cruise data uploaded by PIs within your country to the CCHDO website in the past year. These cruises could be used for Argo calibration purposes only or could be cruises that are open to the public as well.

In March 2021, an updated version 2021V01 was provided including the GO-SHIP EASY ocean data product (16231 stations) for the DEEP baseline. Where the GO-SHIP profile from the CCHDO existed in the previous version, it has been replaced by the easy product version (higher QC version). In the reference database, this data can be identified with the GSD QCLevel (for GO-SHIP Deep Argo).



Version 2021V01: GSD Easy-Ocean, GSH GO-SHIP and Others

In mid-December 2021, a new version 2021V02 has been provided with minor corrections, following the feedback received by the users. Some CTDs have also been added: CTDs provided by scientists, CTDs made during float deployments and some GO-SHIP CTDs retrieved from the CCHDO website.

No update in 2022, but a new version is in preparation and will include updates from ocean climate library, CTD from CCHDO (confidential and GO-SHIP data), CTD from deployment, data from PANGEA and CTD provided by scientist (Arctic area).

Coriolis manages the Argo reference databases for the DMQC (CTD boat casts and Argo floats). In order to facilitate access by QC software, Ifremer undertakes to serve these databases via the ERDDAP API: https://www.ifremer.fr/erddap/info/ArgoFloats-ref/index.html. For the moment, only Argo reference data is available (because it is freely accessible). Ship data will also be provided via a simple authentication system. The new Argo simplified data access library (such as Argopy library) also provides access to reference data.

Bibliography

List of publications in which a scientist from a french laboratory is involved

In 2022, at least 43 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website and on the Argo Bibliography web page. To date, more than 400 articles have been listed: https://www.argo-france.fr/en/Bibliography/Publications

How has COVID-19 impacted your National Program's ability to implement Argo in the past year?

Argo France program

The Argo France program has not been impacted by the Covid-19 pandemic. The steering meetings were carried out remotely.

Purchases and tests

The activity was nominal, with no postponed deliveries, the usual tests (pressure tests, basin tests) were not impacted. The teams remained mobilized and Ifremer's test resources adapted with great responsiveness. The slots were shared with the Euro-Argo ERIC team, with an optimization of the weeks in terms of the quantity of instruments tested.

Deployments at sea

Due to COVID19 pandemic ship opportunities from the French Scientific fleet previously scheduled in 2020 have been deployed in 2022.

DAC/GDAC and data management

Data management activities (DAC, GDAC, DMQC, A-ARC)) have been carried on as planned despite the fact that most people were working from home thanks to the services set up by the IT departments of Ifremer and CNRS.).

Meeting/outreach

Most of meeting and outreach events have taken place in mixed presential/remote in 2022

Does your National Program have any deployment plans for RBR floats in the next couple years?

In the framework of the H2020 Euro-Argo-RISE project, Ifremer has developed the Arvor-I/RBR, which is a standard Arvor-I float equipped with the RBR CTD. 2 floats of this type were deployed during the Spanish RAPROCAN2020 campaign off the Canary Islands in December 2020. 2 other Arvor RBRs purchased by Argo-France (Ifremer budget) were also deployed in the North Atlantic in 2021. The data will be analyzed by LOPS in the framework of Euro-Argo RISE. 6 Arvor

RBRs were purchased by Argo-France in 2021 and deployed in 2022 (Atlantic, Indian Ocean and Mediterranean region). Argo-France also provided 4 Arvor with SBE41CP that were deployed by Argo Netherlands in the Caribbean in April 2022 with simultaneous deployments of 4 Arvor RBR owned by KNMI.

In 2022, 15 Arvor RBR were purchased for deployment in 2023. All were upgraded with a new software allowing transmission of 1hz data sampling in order to test the thermal inertia correction and to provide more robust bin-averaged data as more data points will be included in typical 2-dbar bin compared to the current sampling rate (0,1 Hz). Some Arvor-RBR should be purchased in 2023 (the exact number still needs to be defined). In addition, NKE is working on updated software allowing corrected/uncorrected 1Hz salinity transmission to better understand the sensor response at sea in the Argo context. This updated software will be available in 2023.

New RBR CTD mounted on the head of the Arvor float (left) and deep-Arvor prototype equipped with 3 CTDS: RBR, SBE41 and SBE61 (right).

Argo-France:https://www.argo-france.fr/
French bibliography:https://www.argo-france.fr/en/Bibliography/Publications
Argo PhD list:https://www.argo-france.fr/Bibliographie/Theses
A-ARC data mining website:https://www.umr-lops.fr/SNO-Argo/Activities/A-ARC
Coriolis Argo Download (doi):
https://www.coriolis.eu.org/Data-Products/Catalogue#/metadata/3df904de-e47d-4bf9-85a0-7c0942aff8b6
Coriolis DAC/GDAC: https://www.coriolis.eu.org/Observing-the-Ocean/ARGO
IUEM OSU: https://www-iuem.univ-brest.fr/observation/Argo2030
project : https://www.argo-france.fr/en/Projects/Argo-2030
PIANO project : https://www.argo-france.fr/en/Projects/PIE-PIANO
NAOS project: http://www.naos-equipex.fr
Euro-Argo: http://www.euro-argo.eu
Coriolis: http://www.coriolis.eu.org
Laboratoire d'Océanographie Physique et Spatiale: http://www.umr-lops.fr/
Laboratoire d’Océanographie de Villefranche: http://www.obs-vlfr.fr/LOV
Mercator: http://www.mercator-ocean.fr

German National Report 2022 for the Argo Steering Team Meeting AST24

Submitted by Birgit Klein on behalf of Argo Germany

1. **The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)**
   a. **floats deployed and their performance**

Floats deployed by Germany in 2022 were operated by BSH and AWI. 59 floats were deployed in 2022 with a focus on the Atlantic. 37 of the floats deployed in 2022 were funded from the operational budget provided by the BMDV and 22 were funded from institutional funds at AWI. 8 more have been put on RV Meteor on transit to Namibia and have now been deployed in early 2023. Most deployments were carried out on research vessels, which comprised German and South African ships. The South African Weather Service (thanks to Tamaryn Morris) had kindly accepted to store 5 German floats delivered in late 2022 on their premises to be picked up by research ships calling into Cape Town and also to be deployed on the regular South African cruises (SANAE, SAMBA, Good Hope). These 5 floats all carry RBR CTDs. Another four floats were delivered to the Bark Europa, a sail-ship operating tourist cruises around Antarctica and the Southern Ocean. The deployment locations for 2022 are shown in Fig. 1.

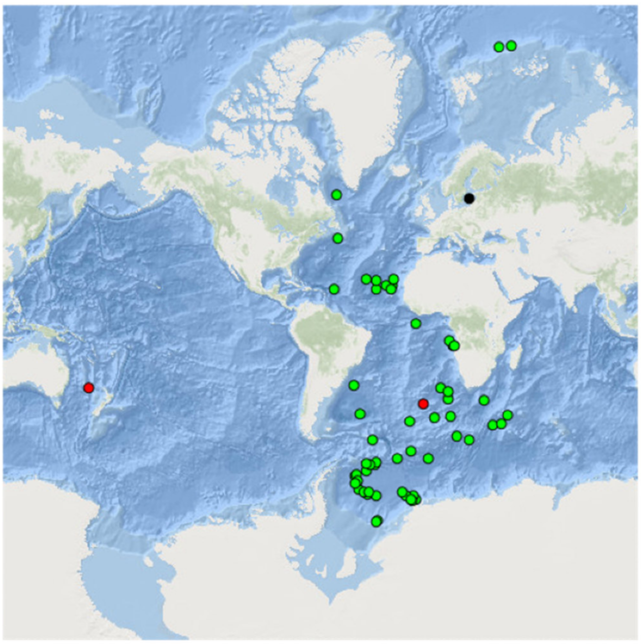


Fig. 1: Deployment positions for floats operated nationally in 2022 in the Atlantic Ocean (green: operational, red: inactive, black: closed).

Most of the floats deployed in 2022 were TS floats only, with the exception of three floats carrying BGC sensors in the Baltic, Coral Sea and Labrador Sea. The performance of the floats in general was fine, the float in the Baltic (co-operated with IOW) has intentionally been recovered and has been redeployed in 2023. The float in the Coral Sea (cooperated with ICBM) has performed 39 cycles before communication ceased. The Apex float seemed to have problems with its buoyancy and had difficulties to ascend to the surface. Maybe it will surface again after seasonal stratification has changed. One float in the South Atlantic failed after deployment. It delivered only one shallow profile and remained then in an emergency mode at surface. It has been added to the recovery list operated by the EuroArgo ERIC.

b. technical problems encountered and solved

5 floats with pH sensors bought in the beginning of 2020 and deployed in 2021 had all been showing either low quality pH data or complete failure of the sensors shortly into their life (after ~40 cycles). We have recovered one of these floats (6904115) during 2022 and shipped it back to SBS via the manufacturer.

WMO	SBE41 Sn	pH Sensor SN	Data quality
6904114	41-12948	720-10617	drift
6904115	41-12951	720-10707	uncorrectable, recovered
6904110	41-12945	720-10722	uncorrectable
6904111	41-12949	720-10727	uncorrectable
6904112	41-13304	720-10730	drift

The pH sensor performance is still a concern since SBS warned about the reference electrode failure mode evident in floats deployed with pH serial number 10000 to 11000. Two floats bought in 2021 with pH/O2 sensor had pH sensor SN within or close to the range and were therefore shipped back to SBS via the manufacturer for warranty replacement of the sensors to minimize the remaining risks (6904232 with pH SN 11199, and 6904233 with pH SN 10764). A third float bought in 2021 (6904321) has been deployed in the Labrador Sea and has up to now performed 39 cycles without signs of pH sensor failure.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc.)

Germany has been engaged in the monitoring of high salinity drift and has continued to update the joint spreadsheet of floats affected by abrupt salinity drift shared at international level:

https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit?usp=sharing

This spreadsheet contains entries from all DMQC operators with information on floats showing ASD symptoms.

SBS had announced a manufacturing problem in the SN range 10482 – 11252 relating this to the high occurrence of abrupt salty drift behavior. In order to prepare the warranty talks a meeting was held on 15.12.2022 to define criteria for constructing lists of eligible floats in the SN range 10482 – 11252 gathering the view of Europe and Japan. The decision made during the meeting was to include all floats in the proposed serial number range, which had reached an uncorrectable state of drift within 180 cycles (equivalent to a nominal lifetime of 5 years at a 10 day cycle). Lists for Europe and Japan were prepared and presented at a later meeting with SBS on 18.01.2023. The link to the meeting was shared with the other concerned national programs (Australia and US). SBS proposed during the meeting a rated credit for failed CTDs with a cutoff at 160 cycles or 4.4 years. How to best consider high frequency sampling in some of the floats in the cutoff-criteria still needs to be worked out. The list of European floats prepared after the meeting on 18.01.2023 contains up to six Germany floats. The lists are now under review at SBS. Updates to the list will be performed at regular intervals since some of the deployed floats in the range are still alive.

Several of the German institutes have engaged at European level to define quality control procedures for BGC variables. The knowledge gained will be transferred during 2023 to the newly filled full time-position of a DMQC operator for BGC variables at BSH. No deep floats have yet been deployed by Germany and will build into the DMQC capabilities at BSH.

d. status of delayed mode quality control process

BSH had adopted floats from all German universities and agreed to perform similar services for the AWI floats. The status of delayed mode quality process for German floats is good, but decreased a bit compared to previous years. The overall percentage of D-files from all German programs is remaining at a high level (>90%). DMQC has now also been performed for all re-processed AWI floats (now in V3.1) and after discussion with the AWI PIs in January 2023 files are ready for submission to the GDACs. The remaining issue is the correction of the 'TBTO' signal in the first cycles, which will be discussed during the upcoming group meeting of the argo dm-operators. Now only 69% of the AWI files are available as D-files. The census of the delayed mode quality control was given in detail in the data management report from November 2022.

BSH has also adopted a subset of floats from Finland (10 floats), the Netherlands (121 floats), Norway (30 floats) and Poland (15 floats) for DMQC and is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of 54 MOCCA floats in the Nordic Seas, the subpolar gyre and the Southern Ocean. The progress in these programs providing D-files is generally good. Since Argo-Norway has received funding from the national research council to increase the number of Norwegian floats deployed per year, the program has got more involved in the DMQC activities since 2020 and floats deployed after 2020 have been covered by Norwegian and Polish DMQC operators.

Delayed mode quality control of floats in the Baltic will be discussed during a workshop in Sopot (18.04-19.04.2023).

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

Up until last year all operational funding from the BMDV (Federal Ministry for Digital and Transport) has been for core Argo only. The ministry had been asked to support the implementation of One Argo and to switch the national contribution to a mix of 36 core floats, 14 deep floats and 12 BGC floats annually and supply more funding. The budget increase was principally approved by the BMDV and increased funds were included in the national budget negotiations in 2022. The budget is increased by 350.000 € in 2023 and will ramp up to an increase of 1.1 Mio. € in 2026 which amounts to a total budget of 1.9 Mio € in 2026 (excluding costs for personal). Due to the strong price increase and insufficient funds to cover the full implementation, it is expected to open negotiations with the BMDV again in 2025.

The Federal Ministry of Science (BMBF) had provided considerable funding in 2020 to start the transition into the new multidisciplinary strategy. The project DArgo2025 (08/2020-12/2021) had received funding in 2020 for 20 floats, 15 of which are BGC floats and 5 core floats, but equipped with RBR CTDs. Some of the BGC floats carried novel sensors such as nitrate sensors and hyperspectral sensors from the German TRIOS company and have been evaluated successfully. In the project C-Scope (01/2021-12/2023) additional funding has been received to promote pH measurements on floats, these experiments are delayed because of the quality issues with the pH sensors . In the project C-Scope a new sensor of pCO_2 has been deployed in the Baltic and analysis of the data is continuing.

In the context of the European Project EuroArgo-Rise (finished end of 2022) the BSH has worked on a contribution for the Arctic and has developed a decision tool for selecting parameters for Ice Avoidance algorithms (ISA). A cooperation has been established with the AWI and its Arctic working group to participate in upcoming Polarstern expeditions to the High Arctic with two floats per year.

For the Southern Ocean AWI has restarted its activities in float deployments including RAFOS technology. AWI has deployed 22 floats in the southern Weddell Gyre in 2022, but no long-term funding scheme is available. 3 Floats from a research project (Ocean:Ice) will be deployed on PS140 together with 4 floats from BSH in the Pacific sector. More activities are planned for the following years in support of the AWI project VERTEXO (VERTical EXchange in the Southern Ocean).

GEOMAR is continuing its analysis of the pH data set in the Labrador Sea and direct comparisons to surface measurements on the SOOP line Atlantic Sail in the North Atlantic. It is also planned to participate in experiments with new pH sensors from Pyronics. ICBM is continuing to redeploy its floats with hyperspectral radiometers, while IOW is experimenting with the pCO2 sensor.

Birgit Klein of the Federal Maritime and Hydrographic Agency (BSH) has continued to coordinate the national Argo Germany program and is also responsible for data management of the core floats. Meike Martins has just joined the BSH Argo team and will be responsible to establish the BGC DMQC. BSH logistics related to technical aspects, float deployments and satellite data transmission are handled by Anja Schneehorst and Simon Tewes. Ingrid Angel Benavides was involved in Argo project related matters. The national BGC group established in 2020 involves four research institutes: AWI, GEOMAR, ICBM and IOW. A complete list of people involved is given below.

Name and institution	Area of expertise
Birgit Klein (BSH)	National program lead, research scientist (DArgo2025, C-Scope, EuroArgo Rise), DMQC operator (core Argo)
Meike Martins (BSH)	Research scientist, DMQC operator (BGC Argo)

Ingrid Angel-Benavides (BSH)	Research scientist (EuroArgo Rise) and related DMQC obligations
Simon Tewes (BSH)	Technician, technical support, and performance monitoring
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring
Arne Körtzinger (GEOMAR)	Research scientist, BGC Argo, DMQC expert pH-sensor (BGC sensors)
Tobias Steinhoff (GEOMAR)	Research scientist, BGC group, DMQC expert pH-sensor (BGC sensors)
Cathy Wimart-Rousseau (GEOMAR)	Research scientist, BGC group, DMQC expert pH-sensor (BGC sensors)
Rainer Kiko (GEOMAR)	Research scientist, expert UVP sensor
Henry Bittig (IOW)	Research scientist (DArgo2025, C-Scope), BGC group, DMQC expert (BGC sensors)
Malin Waern (IOW)	Research scientist, BGC group
Oliver Zielinski (ICBM)	Research scientist, BGC group
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC expert radiometry (BGC sensors)
Ahlem Jemai (ICBM(	Research scientist, BGC group, DMQC radiometry expert
Olaf Boebel (AWI)	Research scientist, RAFOS technology
Marcus Janout (AWI)	Research scientist, project Ocean:Ice
Alexander Haumann (AWI)	Research scientist, project VERTEXO
Benjamin Rabe (AWI)	Research scientist, project ArcWatch
Krissy Reeve (AWI)	Research scientist, Weddell Gyre

Table 1: People involved in Argo in Germany and their associated institutes.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

GER	2023					
	Total	T/S Core	T/S/O2	BGC	Bio	Deep
Nordic Seas	0					
Mediterranean Sea	0					
Black Sea	0					
Baltic Sea	4			4		
Southern Ocean	3	3				
Arctic Ocean	2	2				
Global Ocean	57	46	4	4	3	
Total	66	51	4	8	3	0

Table 2: Planned deployments for 2023 gathering deployments from all German partners. Not all deployments have already been registered at OceanOps. BSH expects to order about 11 additional floats (depending on remaining funds) for the global ocean and will add them as soon as possible.

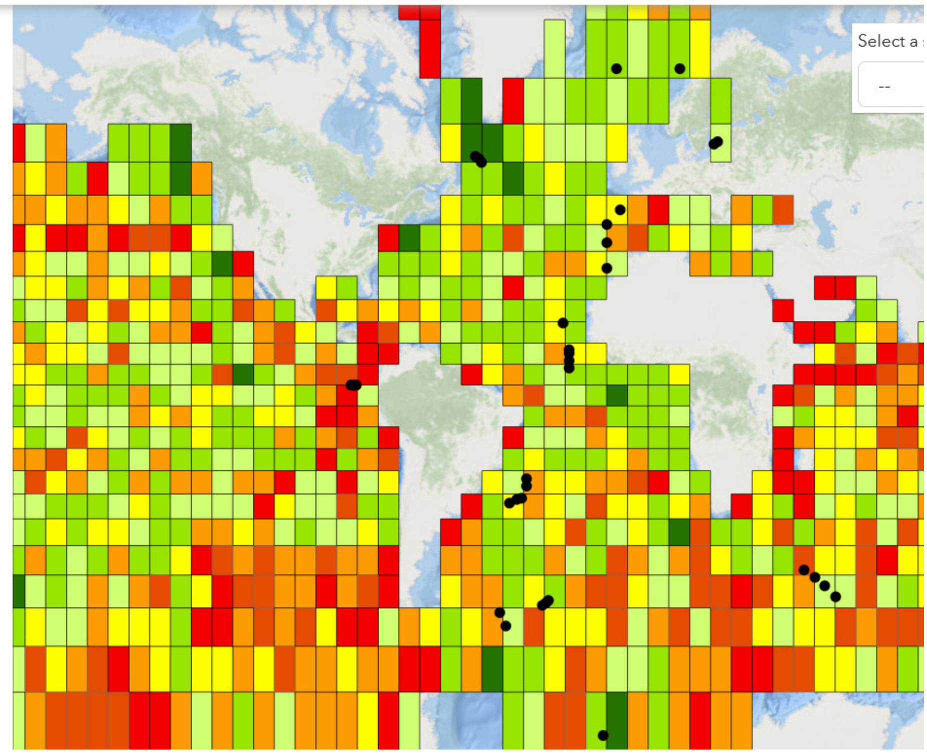


Fig.2: Planned positions of the BSH deployments confirmed so far (28.02.2023).

Focus of the deployments of the operational floats has been gap filling. Mostly areas have been targeted which lack floats including the tropical Pacific.

GER	2024					
	Total	T/S Core	T/S/O2	BGC	Bio	Deep
Nordic Seas	2			2		
Mediterranean Sea	2			2		
Black Sea	0					
Baltic Sea	2			2		
Southern Ocean	7	7				
Arctic Ocean	2	2				
Global Ocean	50	43		7		
Total	65	52	0	13	0	0

Table 3: Planned deployments for 2024 gathering deployments from all German partners

4. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites**.

BSH is maintaining the Argo Germany web site. We have recently updated our webpage and have added content. It provides information about the international Argo Program, German contribution to Argo, Argo array status, data access and deployment plans.

https://www.bsh.de/DE/THEMEN/Beobachtungssysteme/ARGO/argo_node.html

Currently no statistics of Argo data usage are available. The German Navy uses Argo data on a regular basis for the operational support of the fleet. Their needs are communicated through a liaison officer stationed at BSH. The SeaDataNet portal uses German Argo data operationally for the Northwest European Shelf. Argo data are routinely assimilated into the GECCO reanalysis, which is used for the initialisation the decadal prediction system MiKlip. At BSH, the data are used within several projects for data interpretation in the eastern North Atlantic and the Expert Network on climate change of the BMDV.

Several Phd-thesis using Argo data are conducted at the research institutes.

The annual user workshop for 2022 was held as a hybrid event on 21.06.2022. The meeting was well attended and provided a good forum for users to share their scientific work and methods.

Germany contributes to the NAARC and joined recently the SOARC. Researchers from German institutions have continued to contribute recent CTD data to the Argo climatology.

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.**

The strong increase in expenses in the order of 20% is cutting into the budget and will have a negative impact on the number of floats deployed. It is unreasonable to expect increase in funding from the ministry in the order of 20%. An additional concern is the increasing lead time between orders and delivery. This is complicating the logistics and is challenging in terms of meeting budgets in FY.

6. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

   Not followed up during 2022 due to shortage of staff.

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**
   There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

   Organelli, E., E. Leymarie, O. Zielinski, J. Uitz, F. D'Ortenzio, and H. Claustre, 2021. Hyperspectral radiometry on Biogeochemical-Argo floats: A bright perspective for phytoplankton diversity. Pp. 90–91 in *Frontiers in Ocean Observing: Documenting Ecosystems, Understanding Environmental Changes, Forecasting Hazards.* E.S. Kappel, S.K. Juniper, S. Seeyave, E. Smith, and M. Visbeck, eds, A Supplement to *Oceanography* 34(4), https://doi.org/10.5670/oceanog.2021.supplement.02-33. Published online on 07.01.2022.

   Jemai Ahlem, Wollschläger Jochen, Voß Daniela, Zielinski Oliver, Radiometry on Argo floats: From the multispectral state-of-the-art on the step to hyperspectral technology, Frontiers in Marine Science, Volume 8 - 2021 | https://doi.org/10.3389/fmars.2021.676537.

   Henri Renzelmann (2022), B.Sc. Physik, Uni Bremen
   Räumliche Variabilität von Frequenzspektren interner Wellen anhand von Argo-Parkphasendaten

   Daniel, Molkenthin (2022), B.Sc. Physik Lehramt, Uni Bremen
   Stärke der Umwälzzirkulation im subpolaren Nordatlantik bei 47°N

Bastin, S., M. Claus, P. Brandt, and R. J. Greatbatch, 2022: Atlantic Equatorial Deep Jets in Argo Float Data. *J. Phys. Oceanogr.*, **52**, 1315–1332, https://doi.org/10.1175/JPO-D-21-0140.1.

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Pohlmann, H., Brune, S., Fröhlich, K. *et al.* Impact of ocean data assimilation on climate predictions with ICON-ESM. *Clim Dyn* (2022). https://doi.org/10.1007/s00382-022-06558-w

Kiko, R., Picheral, M., Antoine, D., Babin, M., Berline, L., Biard, T., Boss, E., Brandt, P., Carlotti, F., Christiansen, S., Coppola, L., de la Cruz, L., Diamond-Riquier, E., Durrieu de Madron, X., Elineau, A., Gorsky, G., Guidi, L., Hauss, H., Irisson, J.-O., Karp-Boss, L., Karstensen, J., Kim, D., Lekanoff, R. M., Lombard, F., Lopes, R. M., Marec, C., McDonnell, A. M. P., Niemeyer, D., Noyon, M., O'Daly, S. H., Ohman, M. D., Pretty, J. L., Rogge, A., Searson, S., Shibata, M., Tanaka, Y., Tanhua, T., Taucher, J., Trudnowska, E., Turner, J. S., Waite, A., and Stemmann, L.: A global marine particle size distribution dataset obtained with the Underwater Vision Profiler 5, Earth Syst. Sci. Data, 14, 4315–4337, https://doi.org/10.5194/essd-14-4315-2022, 2022.

Drago, L., Panaïotis, T., Irisson, J.-O., Babin, M., Biard, T., Carlotti, F., Coppola, L., Guidi, L., Hauss, H., Karp-Boss, L., Lombard, F., McDonnell, A.M.P., Picheral, M., Rogge, A., Waite, A.M., Stemmann, L., Kiko, R. Global Distribution of Zooplankton Biomass Estimated by In Situ Imaging and Machine Learning, Frontiers in Marine Science, Volume 99, August 2022, Article number 894372, DOI: 10.3389/fmars.2022.89437

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

Impact of COVID has faded away.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

Germany will order >10% floats with CTDs from RBR, preferentially after the software issues of handling high frequency data on the NKE floats are finished.

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

D. Kassis and G. Korres
HCMR
April 2023

1. Background and organization of GREEK ARGO activities and implementation status

Greece established national contribution to the ARGO project through national funding to the Greek Argo programme (2012-2015). The programme was co-financed by Greece and the European Union. Through the national programme Hellenic Integrated Marine Inland water Observing Forecasting and offshore Technology System (HIMIOFoTS) www.himiofots.gr (2018-2021), HCMR has established further contribution to the ARGO project. Since November 2021, when HIMIOFoTS finished, there is not any existing national funding for Greek Argo.

1.1 Floats deployed and their performance

During 2022, four (4) Argo floats were deployed in the Greek Seas under the framework of the Greek-Argo RI activities, and the Euro-Argo ERIC cooperation activities. One (1) float was Arvor-I type purchased by the Greek Argo RI whilst, three Italian floats, one (1) Arvor-DO, one (1) Provor CTS4, and one (1) Arvor – Deep, were deployed by Greek Argo team on behalf of the Argo-Italy. The floats were deployed in the Aegean and Ionian basins. All floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability allowing modification of the configuration in real-time. The performance of the floats has been satisfactory until now with the exception of the Deep-Arvor which presented a failure during the first profile (see Table 1). Regarding the Greek float, it was deployed in the north Aegean during POSEIDON network maintenance. The three deployments related to Italian floats were undertaken by the Greek MSFD winter cruise. Further information on these missions are available in the Euro-Argo fleet monitoring tool (https://fleetmonitoring.euro-argo.eu/dashboard?Status=Active).

Table 1. Active floats and new deployments performed from Greek Argo team during 2022

A/A	Float type	WMO	SERIAL NUMBER	Deployment Date	Deployment time	Deployment Latitude	Deployment Longitude	Available profiles	Status
1	PROVOR CTS4	6903828	P41306-22EU002	18/12/2022	05:18	35.77	22.30	23	Active
2	ARVOR DO	6903826	AI2632-20EU009	15/12/2022	13:20	34.9	23.5	23	Active
3	ARVOR Deep	N/A	AD2700-20EU001	16/12/2022	21:11	35.6	22.47	0	Inactive
4	ARVOR I	7901017	AI2600-21GR002	26/11/2022	15:30	39.73	24.15	26	Active

All floats have been integrated in the MedArgo project. The 7901017 float was configured to cycle every 119 hours, drift at 650 m and acquire profiles from 900 m under its special test mission for coastal monitoring in targeted areas. The raw data of the Greek float are delivered at the Coriolis data Centre where the real time quality control takes place while the delayed mode quality control of the data will be processed by the MedArgo Centre at OGS.

1.2 Floats recovered

No float recoveries were performed within 2022.

1.3 Technical problems encountered and solved

Based on previous experience on platform monitoring systems, HCMR has been utilizing an automatic alerting system (http://poseidonsystem.gr/alerts/?m=2) for the monitor of basic parameters of the floats' location and data transmission. This system has been partially updated to enhance the operational monitoring needs of the Euro-Argo RISE coastal deployment needs for the 6903288 float deployed in 2020. The automatic alerting system incorporated additional features for the real-time monitoring of crucial parameters that described the float's operation. Such are the bathymetry and the maximal depth reached by the float in order to keep track of grounding events. The alerting system is based in pre-defined thresholds and an alert message is transmitted in cases the monitored parameters overcome these thresholds. Thus, similar to the alerting messages whether there are delays or major differences in the transmission time, alert messages were sent to the PI when profiling or parking pressure was recorded to be less than 155.0 dbar or in cases the float is approaching towards the shore.

1.3 Status of contribution to Argo infrastructure, data management and delayed mode quality control process

HCMR has run an extended network of buoys within the Aegean and Ionian Seas including the multi-parametric M3A observatory of the Cretan Sea and a deep sea (2000 m) bottom platform which is part of the EMSO network and has been deployed in the Ionian Sea (POSEIDON & POSEIDON-II monitoring, forecasting and information systems). HCMR also operates the Hellenic National Oceanographic Data Centre (HNODC) established in 1986, as part of the National Centre for Marine Research (NCMR). HNODC operates as a National Agency and is responsible for processing, archiving and distributing marine data. HNODC is also developing techniques for oceanographic data processing and data base maintenance. Furthermore it promotes the International Exchange of Data in the frame of its cooperation with the "Intergovernmental Oceanographic Commission IOC) of UNESCO as it is responsible for the coordination of International Data Exchange (IODE) in Greece.
HCMR operates a large-scale integrated infrastructure that includes all marine observational systems together with ocean engineering infrastructures. Regarding the delayed mode data processing HCMR has a capability of a delayed-mode quality control for the Greek Argo data. The delayed mode quality control of the data delivered from the Greek Argo float are currently processed by the MedArgo data centre. HCMR considers the possibility of further developing a delayed-mode data processing for ARGO profiles collected within the Eastern Mediterranean region. HCMR may also contribute to the improvement of the delayed mode quality control processing conceding CTD data collected through several HCMR research cruises. HCMR operates the Med Sea data portal that was set up for the needs of Copernicus CMEMS services. Within this framework HCMR is in charge of validating biochemical data from Argo floats that are operating in the Mediterranean.

2. Present level and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo

2.1 Existing funding for Greek Argo

The procurement, deployment and operation costs of the first Greek float launched in 2010/2011 were covered by HCMR internal funds. During 2012, Greece established national funding to the Greek Argo programme through the General Secretariat of Research and Technology (GSRT), Ministry of Education, Lifelong Learning and Religious Affairs (funding agency). A major achievement is that Greece participates to the European infrastructure E-A ERIC as a full member. Until recently, the only existing national funding for the Greek Argo was through HIMIOFoTS national RI through which the purchase of 6 floats is finalized and covered the deployment needs for 2021 and 2022.

2.2 On the future funding, organization and planning for Greek Argo

Efforts from the Institute of Oceanography of HCMR for further national funding for the long-term sustainability of Greek Argo are ongoing. Since HIMIOFoTS RI has ended in 2021, several actions have been undertaken by the Greek Argo team towards the General Secretariat of Research and Innovation (GSRI) in order the latter to contribute for the Greek Argo programme continuation and sustainability. Within 2023, a small national funding to cover the basic needs of operational oceanographic activities is expected. Under this, we envisage the purchase of 3 additional floats.
As part of the Euro-Argo, HCMR has undertaken all necessary efforts and managed to establish long term national funding for the E-A ERIC infrastructure and to meet the standards of a full member. Regarding the Greek Argo RI annual contribution to Euro-Argo RI an indicative estimation is the following:

Personnel committed/dedicated to Euro-Argo activities (person months/year):

- National representation, member commitments: 2.5
- Float preparation, deployments, procurements: 1

Personnel committed/dedicated to Greek-Argo activities (person months/year):

- Greek Argo coordination and management: 2
- Float preparation, deployments, procurements: 2
- Monitoring of the fleet performance: 2
- Data management and analysis: 3

3. Summary of deployment plans

Greece has deployment capabilities for the Aegean, the Ionian Sea and the central Levantine basin. Float deployments in 2023 will be performed according to the 2022 plans of the Greek-Argo research infrastructure. The main goal within 2023 is to continue the efforts for a sustainable funding scheme for the Greek-Argo infrastructure in accordance with the Euro-Argo infrastructure. In 2023, a new tender is envisaged for the purchase of 3 floats. Future deployments are a function of the operational needs of the Greek Argo network and the current coverage of areas of interest. Although the final decisions for the areas that floats will be deployed may change, the plan for 2023 includes:

- 1 float deployment in the South Aegean
- 1 float deployments in the North Aegean

4. Summary of national research and use of Argo data

4.1. Operational and scientific use of Argo data

An important part of the Greek-Argo activities is the exploitation of Argo data for operational forecasting as well as for research applications. Along this direction, HCMR established a network of relevant Greek scientific groups mainly from Universities and Research Institutes which constitute the Greek Argo Users group/network. These different groups are already using or will be using ARGO data in ocean/atmospheric forecasting, climate studies and for educational purposes. It is expected that the Greek Argo Users Group will further grow and expand its activities concerning the scientific exploitation of Argo data and the cooperation among Greek scientists. The next step will be the expansion of the Greek Argo network in more members. The network is already in contact with many organizations / agencies / institutions and it is foreseen that the establishment of the Euro-Argo ERIC will increase the interaction of the Greek Argo Users Group with the European and international ARGO scientific community in the near future.
Additionally, Argo data are used for educational purposes in some Greek University Departments. Due to HCMR initiatives within Euro-Argo, Greek Argo, Euro-Argo RISE, and SIDERI programmes to contact potentially interested Greek and other scientists from the eastern Mediterranean region and inform them about the benefits of Argo programme. An increasing demand for Argo data along the Aegean and Ionian Sea for both scientific and educational purposes has been registered.

4.2. Dissemination activities of the Greek Argo– links with Euro-Argo infrastructure

During 2019 the Greek Argo RI hosted the 7th Euro-Argo Science Meeting that took place in Athens on 22-23 October. The meeting has been successful and managed to bring together users of Argo data providing an opportunity for high-level science interactions. Similarly, HCMR Argo team organized the 1st Mediterranean and Black Seas Argo workshop (https://www.euro-argo.eu/News-Meetings/Meetings/Others/Mediterranean-and-Black-Seas-workshop), under Euro-Argo RISE activities, in April 2021, and is further preparing a follow-up to the workshop special session in the upcoming HCMR's Marine and Inlands Waters Symposium in September 2022 (https://symposia.gr/special-sessions/). Within 2019 several dissemination activities were carried out by the Greek Argo RI such as the participation of Greek Argo in the 2019 Researchers Night and the educational activities for high school students throughout the year. However, during 2020, similar activities were cancelled due to the Covid-19 situation. In 2021, presentations of the Greek Argo and the Euro-Argo activities have been made at high schools of Athens during 2021, and at the University of Aegean (Marine Sciences department) in November 2022 following the previous in November of 2016. Within 2022, several activities were performed mainly under the Euro-RISE H2020 project that ended in December 2022. More specifically, in January 2022, a report was published from the meeting organized by HCMR in collaboration with the Euro-Argo Office within the framework of the 9th EuroGOOS International Conference 2021 Marine Research Infrastructures Side Event 5th May 2021 "Cooperation Framework between Marine RIs".
In September 2022, the Greek infrastructure organized a special session entitled "Argo floats contribution to the marine research and operational monitoring of the Mediterranean Sea – Evolution, Achievements, and Future Needs" within the framework of the Marine and Inland

Waters Research Symposium, Argolida, Greece. In the session, scientists specializing in Argo activities in the Mediterranean were invited and hosted, while the several papers were also presented.
In October 2022, the Greek Infrastructure participated in the 7th Argo Science Workshop, Brussels, Belgium, October 2022 where the work "An update of North Aegean hydrography derived from autonomous profiling floats" was presented.
Several educational and outreach activities were also performed targeting high school teachers and students. In February 2022 a presentation of Greek Argo activities was given to students and teachers of the 6th General Lyceum of Egaleo. In May 2022 a presentation of Greek Argo activities was given to students and teachers of the 7th High school of Nikaia. In July 2022 a presentation of Greek Argo was given in an educational activity that took place by the municipality of Derveni, Corinthia. During November-December 2022, two more presentations and dissemination of material took place in high schools of Attica.

By the end of 2013 Greek Argo has launched its web page: www.greekargo.gr that demonstrates and promotes Greek-Argo and Euro-Argo activities. At the end of 2014 Greek-Argo web portal was upgraded providing information and data access from all floats operating in the Mediterranean and presenting all Greek Argo activities, news and data from Greek Argo floats. A continuous upgrade is ongoing integrating more images and videos from Greek Argo deployment activities. Furthermore, new education material has been released and a school visit programme has been established since 2015.
The Greek Argo and Euro-Argo Research Infrastructures, along with the Euro-Argo RISE project, are demonstrated on the POSEIDON updated web page, https://poseidon.hcmr.gr/components/observing-components/argo-floats. The POSEIDON system is the operational monitoring and forecasting system for the Greek Seas and many of its forecasting components use T/S Argo profiles for data assimilation purposes. The POSEIDON web page is also hosting the links to the Euro-Argo educational web site as well as to the floats from each European country. The above links along with other informative material (Euro Argo leaflet, focused questionnaire) were forwarded directly to all active and potential users of Argo data in Greece. Many research groups filled and sent back the questionnaire providing valuable feedback to HCMR team. Furthermore, the Euro-Argo poster and leaflet translated in Greek and they are hosted in the POSEIDON website.

5. Greek Argo contribution to Argo bibliography

5.1 Operational oceanography and ocean forecasting

Med-Argo data have been already used as independent data in order to assess the impact of remote sensed and Ferry-box SSS data assimilation into the Aegean Sea hydrodynamic model component of the POSEIDON system running operationally at HCMR within the framework of POSEIDON system.

Med-Argo data are routinely assimilated (using localized Singular Evolutive Extended Kalman filtering techniques) on a weekly basis in three different modelling forecasting components (Mediterranean 1/10^o resolution, Aegean Sea 1/130^o resolution and Ionian – Adriatic Sea at 1/50^o resolution) of the POSEIDON operational system.

Some of the results of the works described above are included in the following scientific publications:

Ntoumas, M.; Perivoliotis, L.; Petihakis, G.; Korres, G.; Frangoulis, C.; Ballas, D.; Pagonis, P.; Sotiropoulou, M.; Pettas, M.; Bourma, E.; Christodoulaki, S.; Kassis, D.; Zisis, N.; Michelinakis, S.; Denaxa, D.; Moira, A.; Mavroudi, A.; Anastasopoulou, G.; Papapostolou, A.; Oikonomou, C.; Stamataki, N. The POSEIDON Ocean Observing System: Technological Development and Challenges. *Journal of Marine Science and Engineering. 2022*, *10*, 1932. https://doi.org/10.3390/jmse10121932

Bourma E, Perivoliotis L, Petihakis G, Korres G, Frangoulis C, Ballas D, Zervakis V, Tragou E, Katsafados P, Spyrou C, Dassenakis M, Poulos S, Megalofonou P, Sofianos S, Paramana T, Katsaounis G, Karditsa A, Petrakis S, Mavropoulou A-M, Paraskevopoulou V, Milatou N, Pagonis P, Velanas S, Ntoumas M, Mamoutos I, Pettas M, Christodoulaki S, Kassis D, Sotiropoulou M, Mavroudi A, Moira A, Denaxa D, Anastasopoulou G, Potiris E, Kolovogiannis V, Dimitrakopoulos A-A, Petalas S, Zissis N. The Hellenic Marine Observing, Forecasting and Technology System—An Integrated Infrastructure for Marine Research. *Journal of Marine Science and Engineering*. 2022; 10(3):329. https://doi.org/10.3390/jmse10030329

Petihakis, G., Perivoliotis, L., Korres, G., Ballas, D., Frangoulis, C., Pagonis, P., Ntoumas, M., Pettas, M., Chalkiopoulos, A., Sotiropoulou, M., Bekiari, M., Kalampokis, A., Ravdas, M., Bourma, E., Christodoulaki, S., Zacharioudaki, A., Kassis, D., Potiris, E., Triantafyllou, G., Tsiaras, K., 2018: An integrated open-coastal biogeochemistry, ecosystem and biodiversity observatory of the eastern Mediterranean-the Cretan Sea component of the POSEIDON system. *Ocean Science*, *14*(5), 1223-1223.

L. Perivoliotis , G. Petihakis , M. Korres , D. Ballas , C. Frangoulis , P. Pagonis , M. Ntoumas , M. Pettas , A. Chalkiopoulos , M. Sotiropoulou , M. Bekiari , A. Kalampokis , M. Ravdas , E. Bourma , S. Christodoulaki , A. Zacharioudaki , D. Kassis , M. Potiris , G. Triantafyllou , A. Papadopoulos , K. Tsiaras and S. Velanas, 2017. The POSEIDON system, an integrated observing infrastructure at the Eastern Mediterranean as a contribution to the European Ocean Observing System. Proceedings of the 8th EuroGOOS International Conference, 03-05 October 2017, Bergen, Norway

Kassis, D., Korres, G., Konstantinidou, A., Perivoliotis, L., 2017. Comparison of high-resolution hydrodynamic model outputs with in situ Argo profiles in the Ionian Sea. Mediterranean Marine Science, 0, 22-37. doi:10.12681/mms.1753

Kassis, D., Konstantinidou, A., Perivoliotis, L., Korres, G., 2015. Inter-comparing numerical model simulations in the Ionian Sea with Argo T/S profiles for the period 2008-2012. In proceedings of the 11th Panhellenic Symposium on Oceanography and Fisheries, p.945-948, ISBN 978-960-9798-08-2

Kassis D., Perivoliotis L. & G. Korres, 2014. Greek Argo: Towards monitoring the Eastern Mediterranean - First deployments preliminary results and future planning. In proceedings of the 7th International Conference on EuroGOOS, Lisbon – Portugal, 28-30 October 2014

Korres, G., M. Ntoumas, M. Potiris and G. Petihakis, 2014. Assimilating Ferry Box data into the Aegean Sea model. Journal of Marine Systems, 140 (2014) 59–72

Korres, G., K. Nittis, L. Perivoliotis, K. Tsiaras, A. Papadopoulos, I. Hoteit and G. Triantafyllou, 2010. Forecasting the Aegean Sea hydrodynamics within the POSEIDON-II operational system. *Journal of Operational Oceanography*, Vol. 3, nu. 1, 37-49.

Korres, G., K. Nittis, I. Hoteit, and G. Triantafyllou, 2009: A high resolution data assimilation system for the Aegean Sea hydrodynamics. *Journal of Marine Systems*, 77, 325-340.

Korres, G., K. Nittis, L. Perivoliotis, G. Triantafyllou and M. Chatzinaki, 2009. The Aegean Sea –Poseidon model. Hellenic Centre For Marine Research, Greece.

5.2 Ocean science and environmental studies

Med-Argo data are currently used by a small group of researchers in Greece for studies of water mass characteristics and climatic signals of the different deep basins of the Mediterranean Sea. The continuous record of T/S characteristics provides insight in the seasonal and inter-annual variability of the Mediterranean Sea and its sub-basins. A number of publications and scientific results have been released regarding the Greek Argo acquired data during the last 4 years.

Publications in scientific journals and conferences proceedings:

Kassis, D., and G. Korres, 2021. Recent hydrological status of the Aegean Sea derived from free drifting profilers. *Mediterranean Marine Science, 22*(2), 347-361. https://doi.org/10.12681/mms.24833

Kassis, D., and G. Varlas, 2020: Hydrographic effects of an intense “medicane” over the central-eastern Mediterranean Sea in 2018. Dynamics of Atmospheres and Oceans, 2020, 101185, ISSN 0377-0265, https://doi.org/10.1016/j.dynatmoce.2020.101185

Kassis, D., and G. Korres, 2020: Hydrography of the Eastern Mediterranean basin derived from argo floats profile data. *Deep Sea Research Part II: Topical Studies in Oceanography*, *171*, 104712, https://doi.org/10.1016/j.dsr2.2019.104712

Zervakis, V., Krauzig, N., Tragou, E., Kunze, E., 2019: Estimating vertical mixing in the deep North Aegean Sea using Argo data corrected for conductivity sensor drift. Deep Sea Res Part I Oceanogr Res Papers 154. https://doi.org/10.1016/j.dsr.2019.103144

Kassis D., Korres G., 2018: Recent hydrological status of the Aegean Sea derived from free drifting profilers. In proceedings of the 12th Panhellenic Symposium on Oceanography and Fisheries, «Blue Growth for the Adriatic-Ionian Macroregion and the Eastern Mediterranean», Ionian University, Corfu, 30 May – 3 June 2018

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Kassis, D., Krasakopoulou, E., Korres, G., Petihakis, G., Triantafyllou, G.S., 2016. Hydrodynamic features of the South Aegean Sea as derived from Argo T/S and dissolved oxygen profiles in the area. Ocean Dyn. 1–18. doi:10.1007/s10236-016-0987-2

Kassis, D., Korres, G., Petihakis, G., Perivoliotis, L., 2015. : Hydrodynamic variability of the Cretan Sea derived from Argo float profiles and multi-parametric buoy measurements during 2010–2012. Ocean Dynamics, 15-00058. doi: 10.1007/s10236-015-0892-0

Doctorate theses:

Kassis, D., 2017: Operational in - situ monitoring of the Greek seas as a tool to describe hydrodynamic variability and its effect on the biochemical distribution, National Technical University of Athens (NTUA),
https://www.didaktorika.gr/eadd/handle/10442/40700?locale=en

Scientific Sheets in Greek Argo web page:

"Use of Lagrangian methods in optimizing Argo float deployment locations in the Mediterranean Sea" Summary of the scientific report of the University of Aegean in the framework of the Greek Argo Project.

"The integration of Argo floats in numerical weather prediction" Summary of the scientific report of the Harokopio University in the framework of the Greek Argo Project.

"Use of Argo data in ocean numerical simulations" Summary of the scientific report of the Aristotle University of Thessaloniki in the framework of the Greek Argo Project.

"Evaluation of climate and biochemical models using Argo data" Summary of the scientific report of the University of Crete in the framework of the Greek Argo Project.

Scientific Sheets in Euro-Argo web page:

Kassis D., Konstantinidou A., Perivoliotis L. and Korres G., 2014: Comparison of Argo profiles observations against numerical model simulations in Ionian Sea. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Kassis D. and Korres G., 2014: Hydrological variability derived from the first Argo mission in the Cretan Sea basin. Euro Argo RI web page http://www.euro-argo.eu/Main-Achievements/European-Contributions/Science/Regional-Seas/Med-Black-Seas/

Presentations in conferences, science meetings, and scientific workshops:

Berry, A., Kassis, D., Gourcuff, C., Pouliquen, S., 2022."Cooperation Framework between Marine RIs" Cooperation Framework between Marine RI - Meeting Report. Zenodo. https://doi.org/10.5281/zenodo.6810214

Notarstefano G., Kassis D., Díaz-Barroso L., Allen J., Tintoré J., Taillandier V., Gallo A., Pacciaroni M., Mauri E., Evrard E., Cancouët R., and Plaisant L. A. “MONITORING TARGETED SHALLOW/COASTAL WATERS OF THE MEDITERRANEAN SEA WITH ARGO FLOATS” Proc. Mar. & Inl. Wat.Res.Symp. 2022 ISBN: 978-960-9798-31-0 ISSN: 2944-9723

Kassis D. “ARGO FLOAT MISSIONS IN TARGETED COASTAL AREAS OF THE AEGEAN SEA” Proc. Mar. & Inl. Wat.Res.Symp. 2022 ISBN: 978-960-9798-31-0 ISSN: 2944-9723

Kassis D. “An update of North Aegean hydrography derived from autonomous profiling floats” in proceedings of the 7th Argo Science Workshop, 11-13 October 2022, Brussels, Belgium

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Kassis D., Korres G., 2019: Argo missions and synergies with other platforms in marginal seas: The north Aegean and south Ionian test cases. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019
Kassis D., Varlas G., 2019: Investigating the impacts of a strong Medicane on the upper layers of the Eastern Mediterranean Sea. In proceedings of the 7th Euro-Argo Science Meeting Workshop - Athens, October 22-23 2019

Kassis, D., Perivoliotis, L., Korres, G., 2015: Hydrological variability of the Eastern Ionian and Adriatic Seas derived from two new Argo missions in 2014. In proceedings of the 5th Euro-Argo User Workshop - Brest, March 16-17 2015 http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/5th-User-Workshop-March-2015/Workshop-Programme

Kassis D., Von Schuckmann K., Korres G., 2013: Hydrographic properties of Cretan Sea derived from Argo float’s profiles and buoy data measurements during 2010-2012. In proceedings of the 4th Euro-Argo Science Meeting and Workshop, June 2013, Southampton, UK http://www.euro-argo.eu/News-Meetings/Meetings/Users-Meetings/4th-Users-meeting-June-2013

National report of India (2023)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

INCOIS has made a total contribution of 494 floats to the Argo programme so far. Though no floats were deployed during 2022-23 period, 52 floats previously deployed are still active and transmitting data. All the active floats data are processed and sent to GDAC.

1.1b Performance Analysis of Floats deployed

Of the 494 floats deployed so far, 52 are presently active and transmitting data

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

  India had deployed 494 floats so far (till Jan 31, 2023). Out of these 52 floats are active. All the active floats data are processed and sent to GDAC.

- **Data issued to GTS**

  BUFR format messages from these floats are being sent to GTS via RTH New Delhi.

- **Data issued to GDACs after real-time QC**

  All the active floats (52) data are subject to real time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS maintains a comprehensive Web-GIS based site for the Indian Argo Program. This site contains all of the data on Indian Ocean floats, including their trajectories, providing a valuable resource for researchers and anyone interested in the program. For those who want to learn more, please follow the link to access additional details: https://incois.gov.in/argo/argo.jsp

- **Statistics of Argo data usage**

  In India, the Argo data is widely used by a diverse range of users, including students and researchers from academia, research centers, and operational centers. The Indian Meteorological Department (IMD), which serves as the nodal agency for monsoon forecasting in India, relies on Argo data for its operational purposes. Meanwhile, scientists, students, and researchers from organizations such as INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, and IISc have incorporated Argo data into various analyses and published numerous peer-reviewed scientific papers utilizing this data. Additionally, the increasing availability of biogeochemical variables from Argo floats is being used to validate biogeochemical model outputs like ROMS with Fennel module, and for basic research on biogeochemical aspects.

  INCOIS Argo web page statistics during the year 2022-23 are as shown below:

Page	Number
Argo Web Page Views	19219
Argo Data Download	1821
Argo Products	1547

Products generated from Argo data

- During the reporting period, the generation of value-added products from the Argo profile data was continued. The Argo T/S data was first objectively analyzed, and the resulting gridded output was used to derive a variety of value-added products for scientific use. These products include Depth of 20º isotherm, depth of 25º isotherm, dynamic height, geostrophic currents, heat content, isothermal layer depth, mixed layer depth, and geostrophic currents. All of these valuable data are readily available for free download via INCOIS LAS, and those seeking further details can visit the link: http://las.incois.gov.in.

1.4 Status of Delayed Mode Quality Control process

Since July 2006, INCOIS has been generating and uploading D files to GDAC, and all eligible floats' profiles have now undergone DMQC. To achieve this, the Enhanced Delayed Mode Quality Control software OWC has been used, enabling the addressing of various issues such as pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts, and more. As a result, approximately 55% of eligible profiles have undergone DMQC and the delayed mode profiles have been successfully uploaded to GDAC. Furthermore, a majority of old dead float profiles that have passed DMQC have been converted to Ver 3.1 and are now also available on GDAC.

1.5 Trajectory files status:

Ver 3.1 trajectory files for all Indian floats are generated and uploaded to GDAC. Few files rejected owing to format issues are attended to and uploaded back to the GDAC.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

The Indian Argo Project is fully funded by the Ministry of Earth Sciences (MoES), Government of India. Currently, INCOIS is in the process of procuring 50 Argo floats (40 core floats and 10 BGC floats) through a global tender to be deployed in various sectors of the Indian Ocean, including the Bay of Bengal, Arabian Sea, Equatorial Indian Ocean, and Southern Ocean. The final number of floats procured/deployed will be determined by the ship-time availability and approved funding.

The Indian Argo project is supported by a dedicated team of four scientific and technical personnel, including individuals responsible for the deployment of Argo floats, data management, and data analysis.

3. Summary of deployment plans (level of commitment, areas of float deployment) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

INCOIS intends to address the significant data gaps in various sectors of the Indian Ocean by deploying more number of Argo floats. However, the final decision on the deployment location will depend on obtaining cruise approvals or collaborating with other research institutions that have research cruises planned in those data gap areas. Additionally, the availability of funds will also be a significant determinant in the final deployment status. Currently, INCOIS is moving forward with the procurement of 50 Argo floats, including 40 core floats and 10 BGC floats, to support the project.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers.

Operational: All Argo data is routinely assimilated into the Ocean Model to provide a global ocean analysis. This analysis is utilized by the Indian MET department for initializing the coupled ocean-atmosphere forecast of the Monsoon. Since 2011, India has been providing seasonal forecasts of the Monsoon using a dynamical model, in which Ocean analysis (with assimilation of Argo) plays a crucial role. The analysis products are accessible through the INCOIS live access server (las.incois.gov.in).

Research: Argo data is extensively used for various applications to understand the dynamics of the Indian Ocean, cyclone and monsoon system in relation to heat content, thermosteric component of sea level, and validation of OGCM by several Indian institutions and university students.

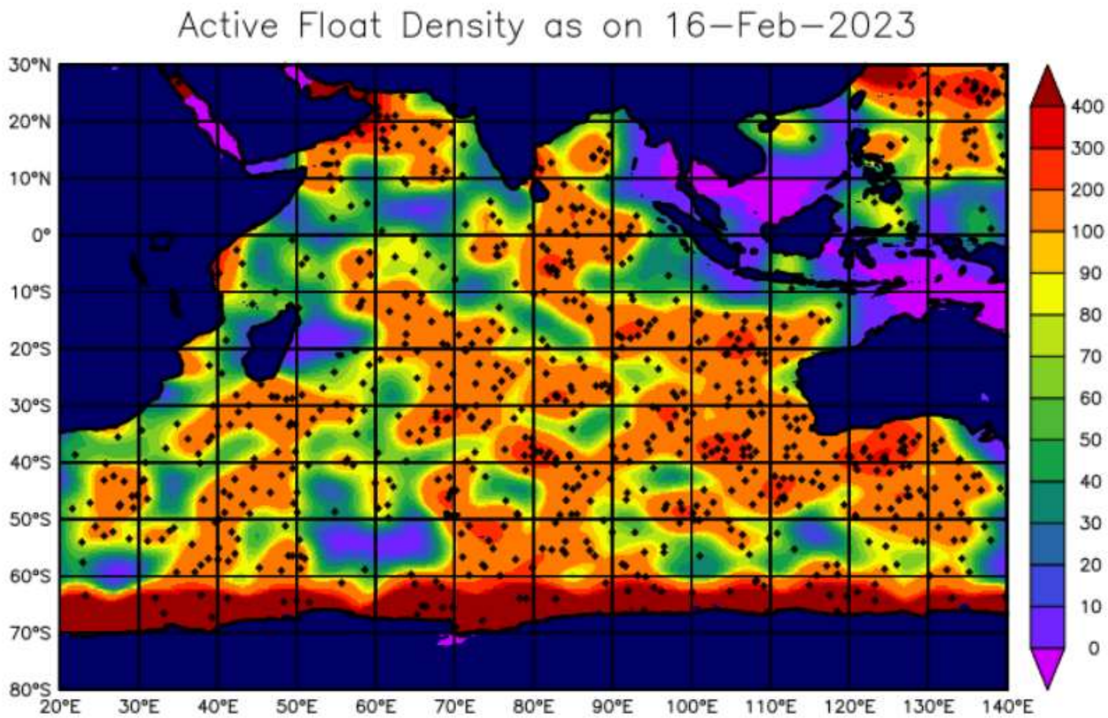
Argo Regional Centre (ARC) - Indian Ocean

(http://www.incois.gov.in/argo/ARDCenter.jsp)

- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- All these data sets are made available to the user through a s/w developed with all GUI facilities. This s/w is made available through FTP at INCOIS and UCSC web sites.
- Delayed Mode Quality Control (Refer 2.0 above)
- Data from the Indian Ocean regions are gridded into 1x1 box for monthly and 10 days and monthly intervals. These gridded data sets are made available through INCOIS Live Access Server (ILAS). Users can view and download data/images in their desired format.
- ERDDAP site was set up for the data and data products derived from Argo floats (http://erddap.incois.gov.in/erddap/index.html)
- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Value added products: Two types of products are currently being made available to various user from INCOIS web site. They are:
  (i) Time series plots corresponding to each float (only for Indian floats).
  (ii) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.

  These valued added products can be obtained from the following link https://incois.gov.in/argo/ANDCProducts.jsp

  float density in Indian Ocean as of February, 2023 is shown below.



5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.

None.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.

7. Argo bibliography

INCOIS is actively involved in utilization of Argo data in various studies pertaining to Indian Ocean. Also INCOIS is encouraging utilization of Argo data by various universities by funding them. Some of the publications resulted from Argo data which includes scientists from INDIA are given below:

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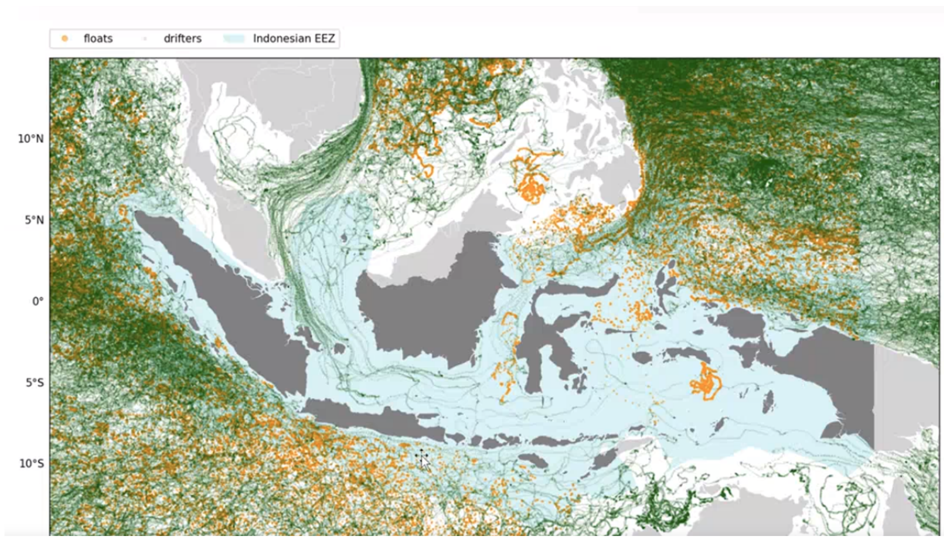
8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

Due to Covid19 pandemic-related constraints, INCOIS was not able to procure or deploy any floats in the reporting year. However, INCOIS continued to receive and process data from active floats deployed previously.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

Not decided.

Indonesia National Reports of Floats Mission by BMKG



"The Ocean Data Unavailability around Indonesian seas motivates us to initiated the floats mission"

During the 2022 period, Indonesia deployed around 26 floats around Indonesia's seas through the BMKG (the national meteorological services bureau) by the MMS-I (Maritime Meteorological Strengthening) Project. All of the floats distributed from the west part to the east part of Indonesia's seas. Some vital part of Indonesia's seas are also covered by the float measurement i.e. Natuna Sea, Karimata Strait, Makassar Strait, and the Banda Sea. The deployment intends to improve the meteorological services of BMKG, further in marine meteorological services.

Recently, Indonesia's floats initiated by BMKG have not integrated into the ARGO global system and OceanOPS, yet. Considering several matters related to national security, BMKG has established communication with parties related to national security . Indonesia put the effort to connect our floats data to the data ARGO global system by dealing with the national security permit, administration permit, and also the executive decision levels. In the next time, Indonesia hopes to realize data sharing and participate in the floats profile data shared to the global community through the Argo global and OceanOPS soon.

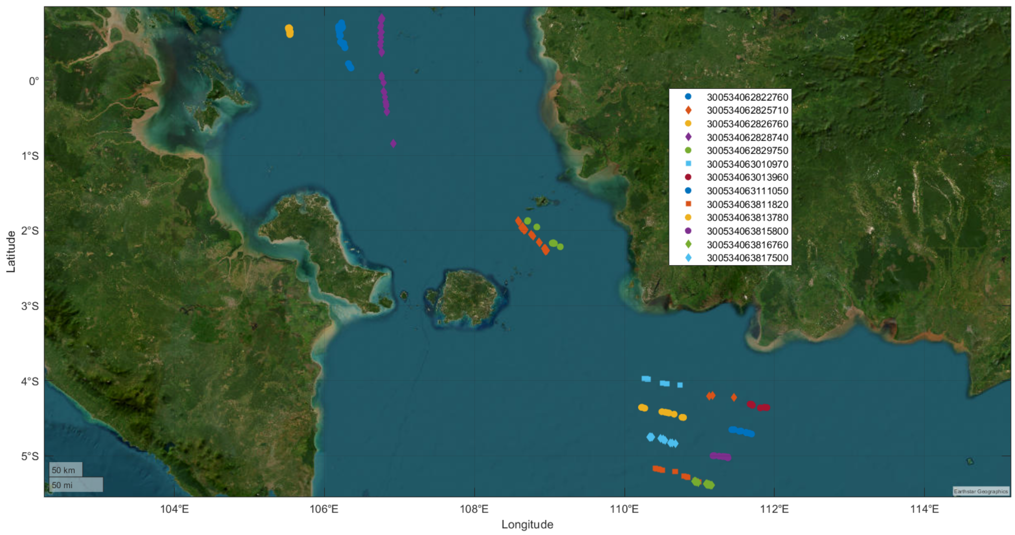


Figure 1. ARVOR-C tracks and distributions around Natuna Sea, Karimata Strait, and Java Sea. Every colored symbol represents one ARVOR-C device based on the legend description above.

The ARVOR-C floats are distributed around the shallow water seas around the western part of Indonesia. Then, the ARVOR-I floats are spreaded out around the eastern part of Indonesia's seas. The ARVOR-C floats are specified to study the ocean dynamics around North Natuna Sea, Natuna Sea, Karimata Strait, and the Java Sea which consist of shallow depth levels. On the other hand, ARVOR-I floats are deployed around the Makassar Strait and Banda Sea to investigate the complexity of ocean dynamics in the eastern seas which are dominated by the Pacific Ocean and also the Indonesian Throughflow. Figure 1 expresses the distribution and the movement of ARVOR-C floats and Figure 2 represents the ARVOR-I's in eastern seas.

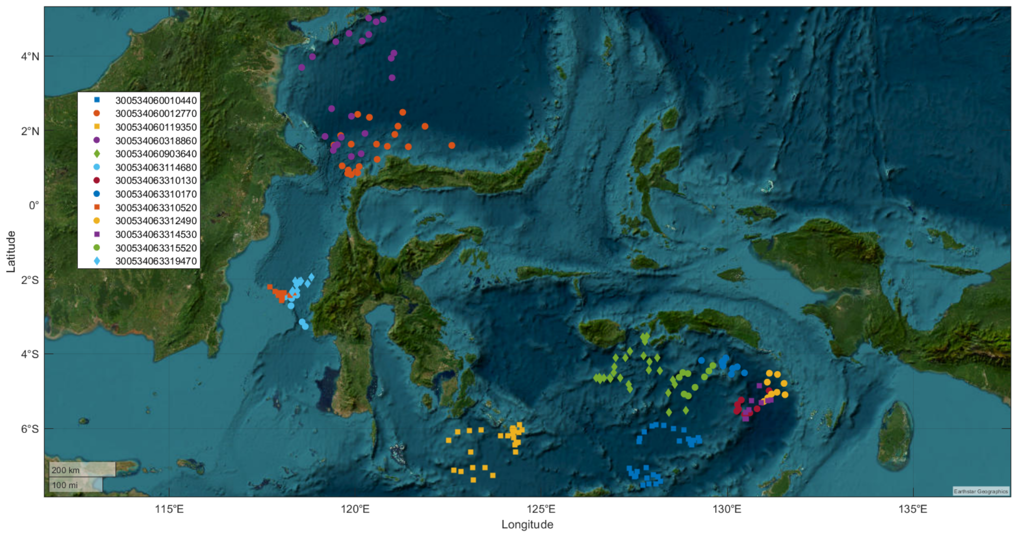


Figure 2. ARVOR-I positions tracks and distributions around Flores Sea, Banda Sea, and Makassar Strait. Every colored symbol represents one ARVOR-I device based on the legend description above.

Our floats mission brings successful data transmission without experiencing any harmful sabotage or vandalism which become our past impressions and concerns back in the day. Temporarily, we assume the satisfying performance of float devices safety is due to the float mechanism which describes how it works to profile the ocean. It prevents any person with bad intentions to harm and destroy the devices by appearing on the surface just to transmit the data and prepare to dive again.

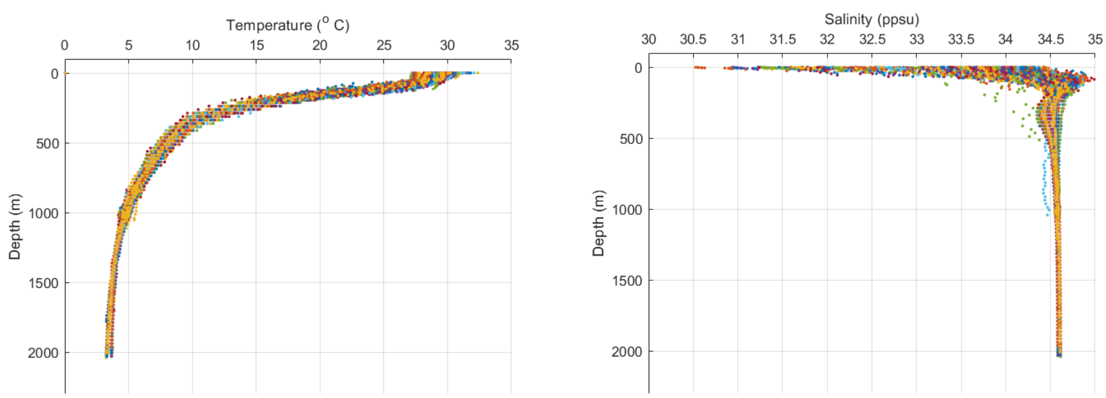


Figure 3. Temperature (left) and Salinity (right) profile from all of the deployed flotas since 2022.

Figure 3 shows all of the data transmitted from the devices through the IRIDIUM satellite. It represents the shallow water and deep water profile from Indonesia's seas. In general, it acquires three (3) datasets of profile each month by doing 10 days profiling for each cycle. Up to now for almost one year, we haven't experienced any technical issues with the profiling missions. We also want to notify that Indonesia initiated the SVP Drifter missions alongside the profiling floats missions. The SVP Drifter which afloat and appears on the surface experienced misunderstood rescue sabotage by fishermen or persons on boat.

BMKG managed to monitor and maintain the quality control of the profiling floats data through a specific web portal. For now, the public web portal of the BMKG floats profile is not available. The effort of integrating the data to the global system and making the data publicly available is going side by side.

As a float initiator and party in charge of the floats mission, there are personnels involved and dedicated to being responsible for the status and sustainability of float deployments in the Indonesian seas in BMKG. The funding to begin the floats initiation, delivered to BMKG from AFD in the MMS-I project with the aim of increasing maritime meteorology capacity.

In the future, the float's initiation will increase and be funded by the independent national fund involving related institutions and further researchers, which consider the principles of national security. Furthermore, BMKG is on the track to advance our human resources personnel capacity by holding a further education overseas funding program. It is a great opportunity for BMKG to increase personeel capacity as the party in charge of the Argo floats in local communities.

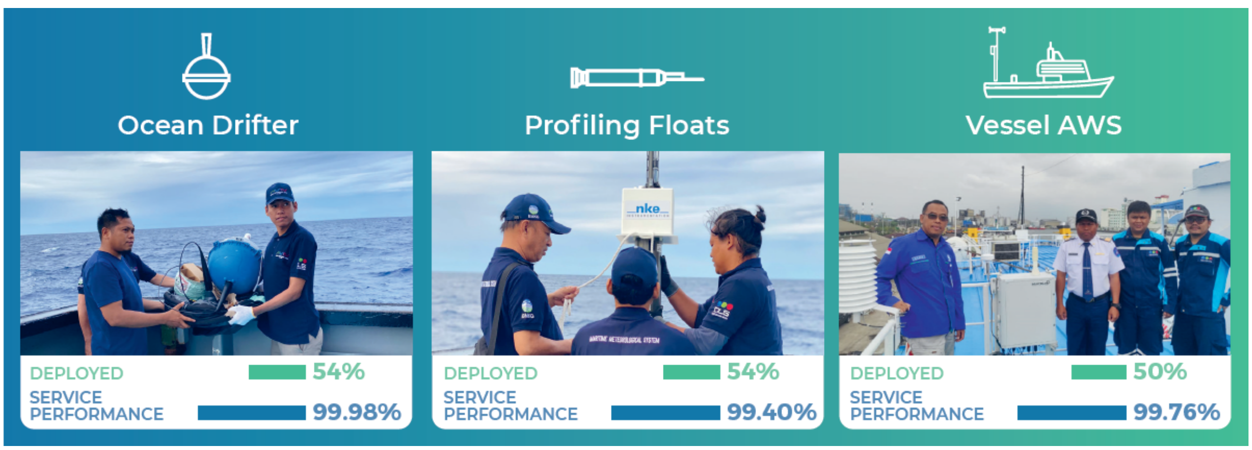


Figure 4. The deployment of ARVOR floats by BMKG personnels.

Through the MMS-I Project of BMKG, Indonesia, which was funded by AFD (Agence Française de Développement), Indonesia began the project in 2019. It projected the five-years term of work on several parts including the floats missions. The term was crossed with the COVID-19 event. The deployment should be launched around 2020 - 2021, but COVID-19 impacted its schedules and procurement process. The deployment of our floats started during the 2022 period.

This year, Indonesia plans to deploy more floats into the eastern Indonesia's seas.

Argo National Report 2022: Ireland

1) The status of implementation (major achievements and any issues in 2022):

a) Irish Argo float Overview

In 2022, Ireland did not deploy any Argo floats.

The Marine Institute had intended to deploy a TWR/APEX BGC float, WMO:6901936 in December of 2022. The float was sent to TWR in early 2022 for overhaul and re-calibration of its sensors. Once the float was received after this overhaul in November 2022 it failed its pre-deployment tests. On further investigation it was discovered that there was likely a hardware issue with the floats CTD sensor. This issue was not present prior to the float being shipped from TWR after the maintenance and calibration work carried out. The float was shipped back to TWR for repair in February 2023 and it is hoped this float will be deployed in Q.4 of 2023.

Marine Institute Argo Float Overview (2022)					
Operational Floats (2022)					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901919	7244	TWR/APEX	22/04/2015	OPERATIONAL
2	6901921	7243	TWR/APEX	23/03/2016	OPERATIONAL
3	6901922	7242	TWR/APEX	14/04/2016	OPERATIONAL
4	6901924	7240	TWR/APEX	10/02/2017	OPERATIONAL
5	6901925	7841	TWR/APEX	11/02/2017	OPERATIONAL
6	6901926	7842	TWR/APEX	20/05/2017	OPERATIONAL
7	6901928	7844	TWR/APEX	12/02/2018	OPERATIONAL
8	6901929	AI2600-17EU001	NKE/ARVOR	12/02/2018	OPERATIONAL
9	6901930	AI2600-17EU002	NKE/ARVOR	27/03/2018	OPERATIONAL
10	6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
11	6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
12	6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL
13	6901934	AI2600-18EU030	NKE/ARVOR	31/08/2020	OPERATIONAL
14	6901935	AI2600-18EU032	NKE/ARVOR	10/09/2020	OPERATIONAL
15	6901937	AI2600-18EU031	NKE/ARVOR	05/09/2020	OPERATIONAL
16	6901938	AI2600-18EU029	NKE/ARVOR	07/03/2021	OPERATIONAL
17	6901939	AI2632-18EU039	NKE/ARVOR	08/03/2021	OPERATIONAL

Floats to be deployed in 2023					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901936	8350	TWR/APEX BGC	TBC	REGISTERED

b) Technical problems encountered and solved

An issue with a TWR APEX BGC float earmarked for deployment precluded it from being deployed in

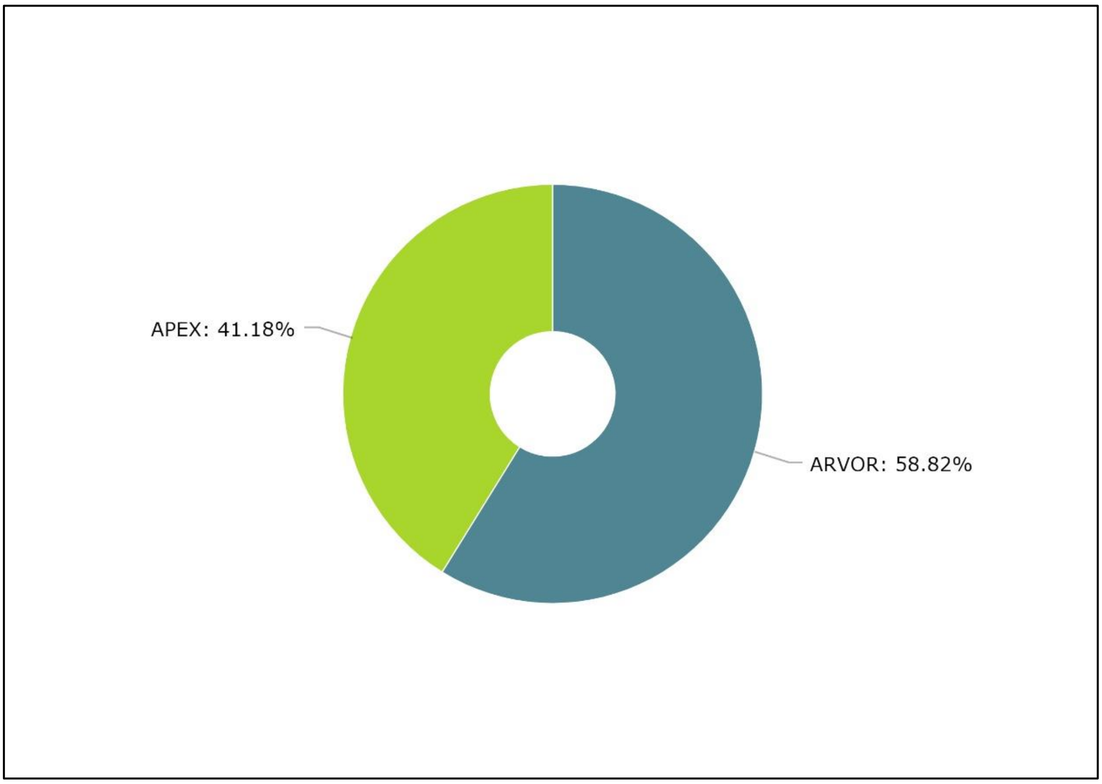
2022. The float issue is currently being investigated by TWR.

c) Status of contributions to Argo data management
Carried out by BODC for the Marine Institute (Ireland).

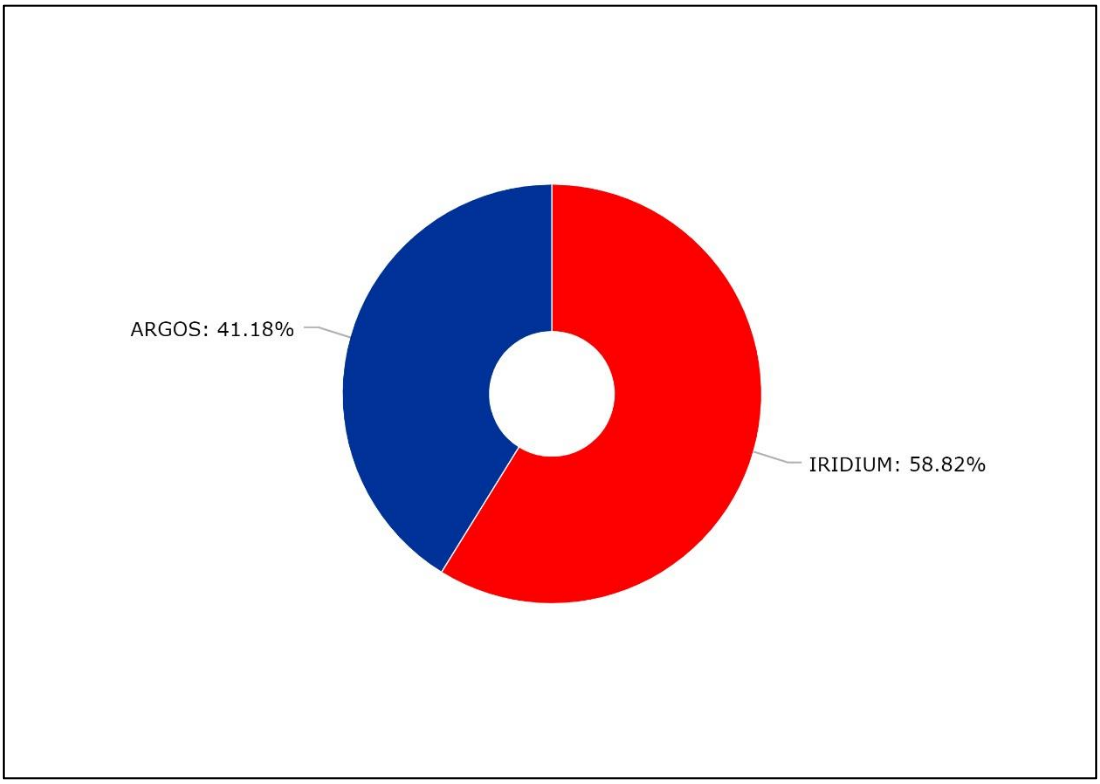
d) Status of delayed mode quality control process
Carried out by BODC for the Marine Institute (Ireland).

2) Present level of, and future prospects for; national funding for Argo including a summary of the level of human resources devoted to Argo.
Ireland continues to be a committed member of the Euro-Argo ERIC. Ireland, via the Marine Institute will deploy additional floats where funding allows and will also assist the ERIC in deploying project specific floats where appropriate. Efforts continue towards securing multi-annual funding for Ireland's Argo programme on the national level.

3) Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible.
The Marine Institute deployment plans for 2023 consist of the deployment of a Teledyne APEX BGC float in the North East Atlantic. Efforts continue towards securing multi-annual funding for Ireland's Argo programme on the national level.



Above: *Illustrating the breakdown of Irish floats (NKE (ARVOR) and Teledyne Webb (APEX).*



Above: *Graph showing the number of Irish floats using ARGOS or Iridium communications.*

4) **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centres. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**
Argo data is primarily used to validate ROMS models in the Oceanographic Services section of the Marine Institute. Argo data will also be utilised by a number of PhD students within the Marine Institute and 3rd level institutes across Ireland. Irish deployed Argo float data may also be used by researchers on an international level as all data is open and freely available.

Irish Argo National Webpage (hosted by the Marine Institute):
https://www.marine.ie/Home/site-area/infrastructure-facilities/marine-research-infrastructures/argo-network
Irish Argo Float Data*:
https://www.digitalocean.ie/
*May not visualise correctly via Internet Explorer web browser

5) **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.**
N/A. Any issues are dealt with via the Euro-Argo ERIC office.

6) **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data)**

taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.
No CTD data are uploaded to the CCHDO website.

However, all CTD data are emailed to Else Juul Green (else@ices.dk) who checks the data before it is uploaded to the ICES Oceanographic data portal annually:
http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes

7) **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**
There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.
N/A.

8) **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**
N/A

9) **Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.**
N/A

Submitted by: G. Notarstefano (OGS), E. Mauri (OGS), Giorgio Dall'Olmo (OGS), Massimo Pacciaroni (OGS), Antonella Gallo (OGS) and Emanuele Organelli (CNR-ISMAR)

Report on the Italian Argo Program for 2022

Note that in this report we use the AST terminology as reported in the table hereafter. BGC is also used, in a general manner, to indicate the Argo extension towards the biogeochemistry

T/S Core	Temperature and Salinity sensors
T/S/O2	Temperature, Salinity and Dissolved Oxygen sensors
BGC	Full Biogeochemical sensors suite (AST definition: oxygen, pH, nitrate, chlorophyll fluorescence, suspended particles, downwelling irradiance)
Bio	Other Bio like floats (carrying some of the BGC sensors)
Deep	Deep float
Southern Ocean	Below 60°S (AST definition)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. Floats deployed and their performance

A total of 21 Italian floats were deployed in 2022 (see Tables 1 and 2 for details). These floats were Apex, Arvor-I, Arvor-Ice, Provor CTS4 and Deep-Arvor designs manufactured by Teledyne Marine (USA) and NKE (France). All floats transmit data via Iridium telemetry.

Mediterranean and Black Sea deployments

Fourteen units were released in the Mediterranean (Table 1). The Core-Argo floats have a park pressure at 350 dbar and maximal profiling depths alternating between 700 and 2000 dbar. Bio-Argo floats have a park pressure at 1000 dbar and the maximal profiling pressure was set to 1000 dbar for one platform and to 2000 dbar for two platforms. To measure high-frequency processes in the Sicily Channel, all of these floats have cycles of 5 days during most of their initial operating life, except for one Arvor-I float (WMO 6903821) which had short cycles of 3 hours. One Italian float was deployed in the shallow northern Adriatic (WMO 6903815) to complement the Euro-Argo RISE (EU H2020 project) fleet. The platform was used in a targeted shallow mission close to the coast. The cycle time was set to 5 days and the parking depth equal to the maximum bathymetry (less than 80 m).

Most floats were deployed from research vessels of opportunity (i.e., R/V Dallaporta, R/V Pourquoi Pas?, R/V Belgica II, R/V Aegaeo, R/V Ammochostos, M/Y ROE, Malta Guard Coast for the Mediterranean and R/V Agulhas II and Laura Bassi for South Atlantic, South Pacific and Southern Ocean) with the help of colleagues from Greece, Malta, Italy and Cyprus.

South Pacific and Southern Ocean

With the help of Italian colleagues onboard the R/V Laura Bassi: a total of 7 Arvor-I equipped with ice-detection software were deployed: two of them, while crossing the circumpolar current (6903808, 6903809), two along the Ross Ice Shelf polynya (6903810, 6903811), one at Terra Nova Bay (6903812, as recovered and re-deployed float) and two (6903813, 6903814) in the Somov sea. The adopted configuration in the Ross Ice Shelf Polynya consisted of a cycle time of 7 days and a park and maximum profile pressure of 1000 dbar (i.e. a park pressure at the seafloor).

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Apex APF9	6903816	23-Feb-2022 16:20	40.56	2.62	107	26-Mar-2022 23:17	38.92	-0.05	D	-
Arvor - T/S Diss. Oxy	6903818	03-Mar-2022 13:53	40.73	2.67	220	21-Feb-2023 16:52	38.81	3.78	A	5
Arvor - T/S Core	6903817	04-Mar-2022 09:33	40.89	2.78	214	21-Feb-2023 09:58	40.61	2.63	A	5
Arvor - T/S Core	6903815	17-Mar-2022 10:17	43.68	14.27	69	22-Feb-2023 04:29	43.89	14.07	A	5
Arvor - T/S Core	6903819	19-May-2022 21:02	40.51	11.00	56	20-Feb-2023 07:54	41.09	11.33	A	5
Arvor - T/S Core	6903820	21-May-2022 18:49	38.89	13.29	56	22-Feb-2023 05:51	40.52	12.68	A	5
Arvor- T/S Core	6903821	25-May-2022 07:57	35.90	14.10	388	18-Feb-2023 12:58	36.13	15.63	A	5
Arvor - T/S Diss. Oxy	6903822	01-Jun-2022 11:41	36.26	20.52	53	17-Feb-2023 03:54	35.33	21.34	A	5
PROVOR CTS4	6903823	21-Nov-2022 08:42	34.31	33.08	25	18-Feb-2023 11:23	33.43	33.59	A	5
Arvor - T/S Diss. Oxy	6903824	25-Nov-2022 17:18	33.94	28.11	18	20-Feb-2023 14:22	33.26	28.56	A	5
PROVOR CTS4	6903825	14-Dec-2022 08:13	41.50	18.12	18	22-Feb-2023 11:46	42.02	18.08	A	5
Arvor - T/S Diss. Oxy	6903826	15-Dec-2022 13:20	34.90	23.50	15	19-Feb-2023 05:44	35.50	20.80	A	5
Arvor – I DEEP	6903827	16-Dec-2022 21:10	35.60	22.47	-	-	-	-	D	-
PROVOR CTS4	6903828	18-Dec-2022 05:18	35.77	22.30	15	19-Feb-2023 11:28	35.43	21.35	A	5

**Status in early February 2023: A = active, D = dead; **Cycle: Length of cycle in days*

Table 1. Status information for the 14 Italian floats deployed in the Mediterranean Sea during 2022.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-T/S ICE	6903808	11-Jan-2022 16:42	-61.01	175.36	41	16-Feb-2023 15:12	-59.85	-162.59	A	10
Arvor-T/S ICE	6903809	12-Jan-2022 06:47	-63.03	176.69	41	17-Feb-2023 05:33	-59.12	-163.93	A	10
Arvor-T/S ICE	**6903810**	**27-Jan-2022 11:53**	**-77.16**	**168.93**	**66**	**26-Jan-2023 08:51**	**-77.31**	**168.42**	**recovered**	**7**
Arvor-T/S ICE	**6903811**	**27-Jan-2022 21:41**	**-77.42**	**174.34**	**71**	**18-Feb-2023 05:37**	**-76.74**	**173.26**	**A**	**7**
Arvor-T/S ICE	**6903812**	**01-Feb-2022 08:56**	**-75.28**	**164.12**	**52**	**25-Jan-2023 06:45**	**-75.18**	**164.05**	**A**	**7**
Arvor-T/S ICE	6903813	08-Mar-2022 12:28	-66.00	148.05	67	18-Feb-2023 01:29	-64.52	130.64	A	10
Arvor-T/S ICE	6903814	11-Mar-2022 08:46	-65.53	146.90	67	23-Feb-2023 01:25	-64.68	160.37	A	10

**Status in early February 2023: A = active, D = dead; **Cycle: Length of cycle in days*

Table 2. Status information for the 7 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2022.

Overall status at the end of 2022

In summary, at the end of 2022, the Argo-Italy program had a total of 85 active floats, including 35 in the Mediterranean Sea, 1 in the Atlantic Ocean (it left the Mediterranean Sea through the Strait of Gibraltar), 2 in the Black Sea (Figure 1), and 47 in the South Pacific, South Atlantic, and Southern Oceans (south of 60°S, see Figure 2).

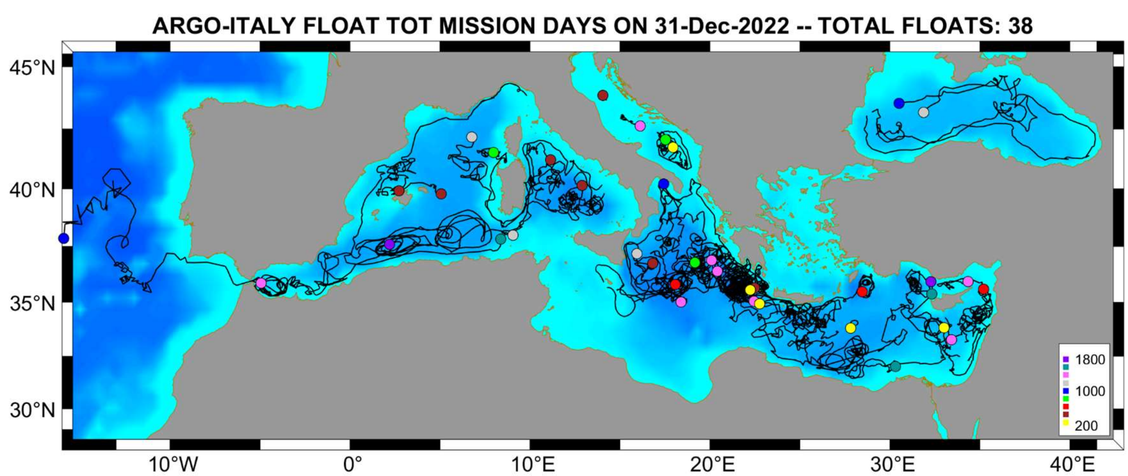


Figure 1. Trajectories and positions (circle symbols) on 31 December 2022 of the 38 Argo-Italy floats active in the Mediterranean and Black Sea. Circles are color coded as a function of float age in days.

ARGO-ITALY FLOAT TOT MISSION DAYS ON 31-Dec-2022 -- TOTAL FLOATS: 47

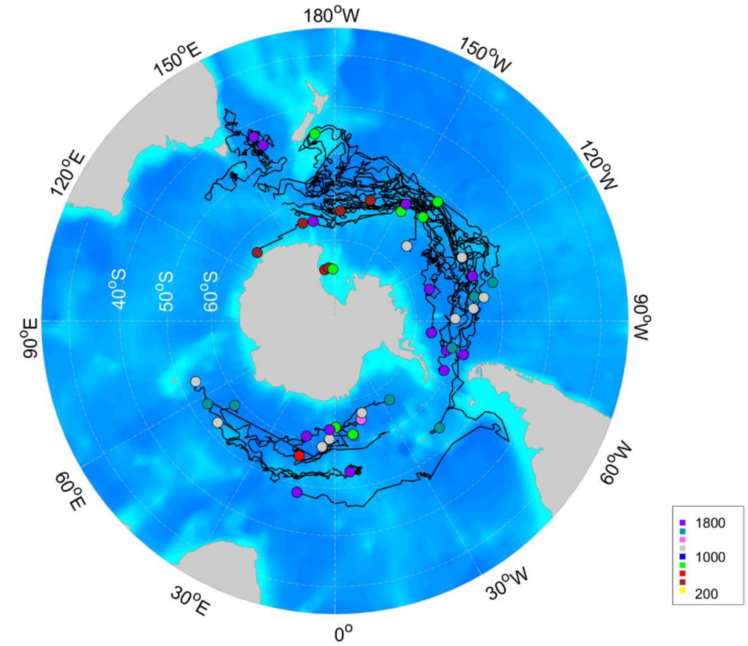


Figure 2. Trajectories and positions (circle symbols) on 31 December 2022 of the 47 Argo-Italy floats in the South Pacific, South Atlantic and Southern Oceans. Circles are color coded as a function of float age in days.

The temporal evolution of the number of active floats is shown in Figure 3 with weekly resolution, along with the annual numbers of float deployments and float deaths for the period 2012-2022. The float population in 2022 is quite stable at about 85 active instruments. In 2022, the number of deployments exceeded the number of dead floats.

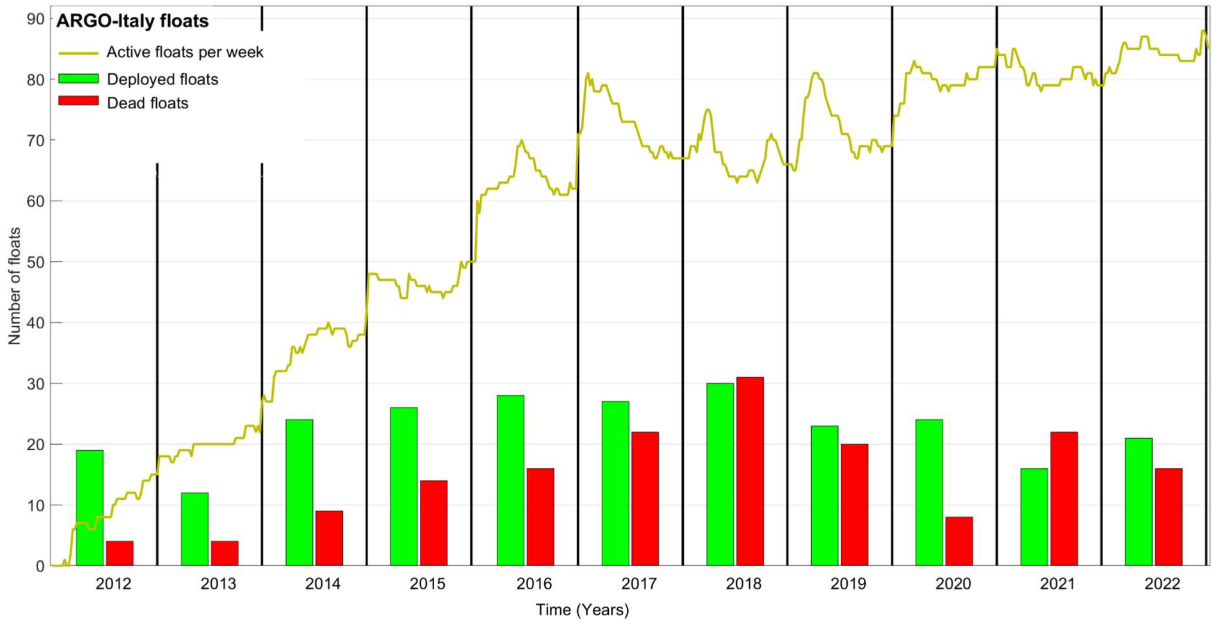


Figure 3. Temporal evolution of the number of Argo-Italy active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of 250 Argo-Italy floats have been deployed, 147 in the Mediterranean and Black Seas and 103 in the Southern Hemisphere oceans. Over a 10 year period, they have provided about 38000 CTD profiles. The histogram of the number of CTD profiles per float is shown in Figures 4a and 4b. One hundred and seven floats, about 43% of the total deployments, have collected more than 180 profiles. Overall (during 2012-2022), ~6% of floats failed shortly after deployment.

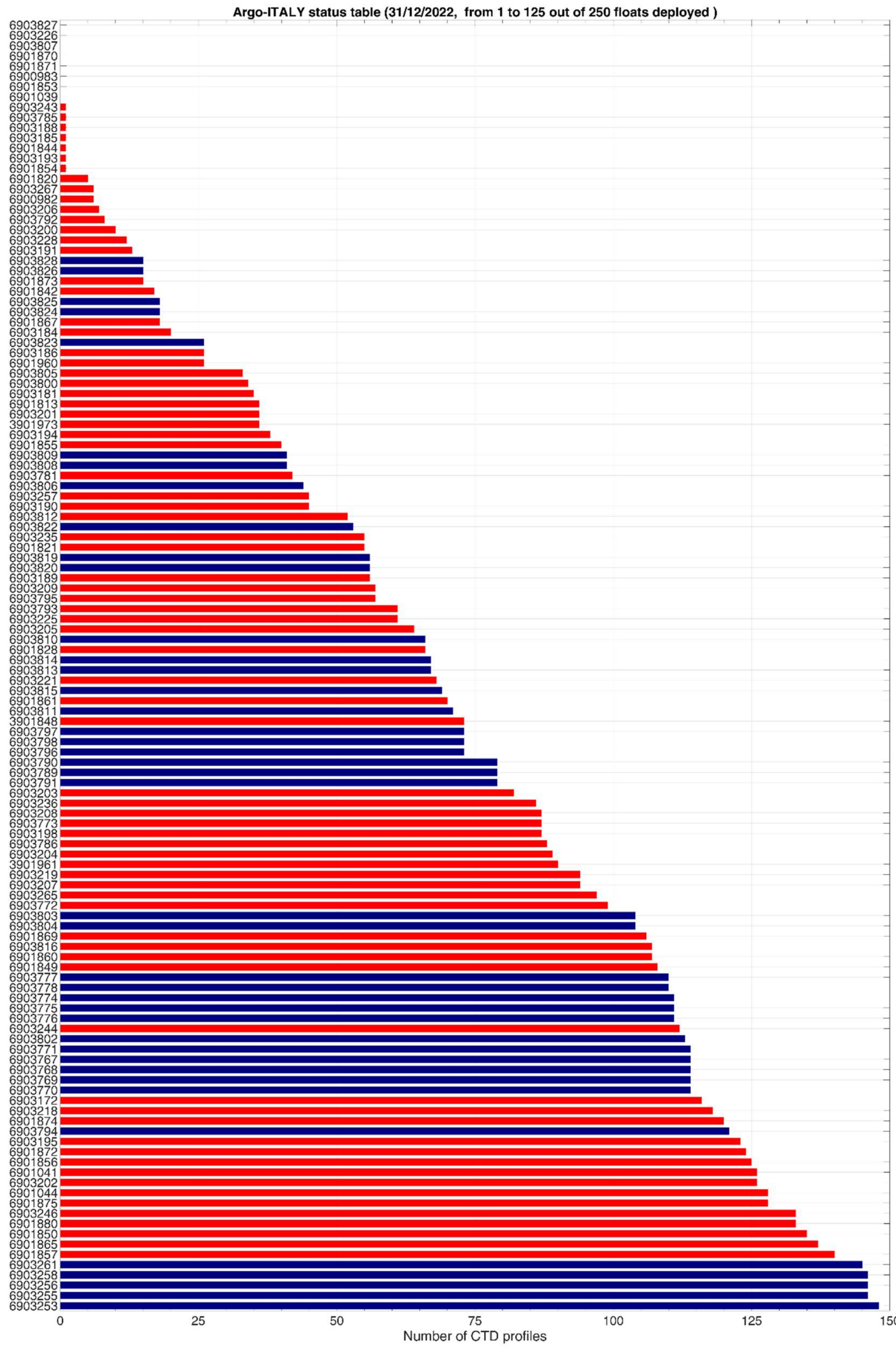


Figure 4a. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2022). Panel A from 1 to 125 floats.

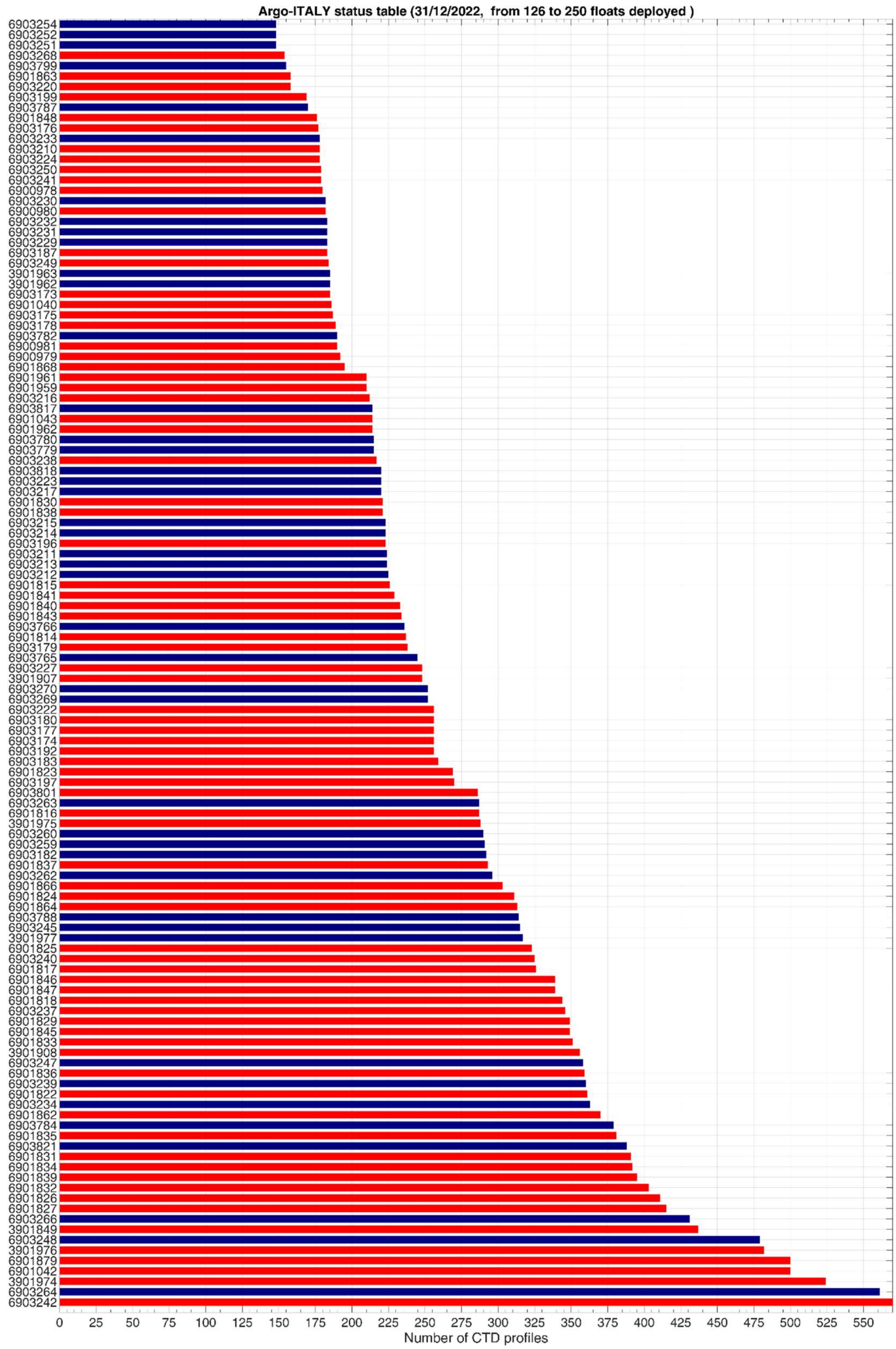


Figure 4b. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2022). Panel B from 126 to 250 floats.

b. Technical problems encountered and solved

Mediterranean Sea

The BGC-Argo 6903805 equipped with sensors to measure the 6 EOVs was deployed in the Southern Adriatic Pit in November 2021. The float stopped transmitting data after 33 cycles (end of January 2022) and the cause is unknown.

The Deep-Argo 6903827 was deployed in the eastern Ionian Sea in mid December 2022 and it failed at launch (it did not surface after the deployment). According to NKE a possible cause of failure could be the fact that the float stayed in the crate too long before the deployment. In such a case, a battery failure can happen and they suggested running an autotest next time to check the float. Unfortunately, due to logistical problems with the ship's time and plans, this float was not deployed soon (within a few months after its manufacture).

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

The data management for the Italian float is mostly done by the Coriolis GDAC. Metadata and data are available through the Coriolis web site in near real-time. The status of high salinity drift is regularly updated on the dedicated share file available at https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit#gid=1096144849

d. Status of delayed mode quality control process

The delayed mode quality control (DMQC) of the physical data (pressure, temperature and salinity) provided by the Italian floats in the Mediterranean and Black seas was done for approximately 70% of eligible floats (161 out of 229 eligible floats) deployed between 2010 and 2021 in the Mediterranean and Black Seas, and Southern Ocean (all information and statistics to create the D-files have been sent to Coriolis). Physical data were quality controlled in delayed-mode following the standard Argo procedure. In particular, the OWC method in conjunction with other procedures is adopted to check and adjust the salinity data. The OWC is a statistical method based on the comparison between float salinity profiles and an accurate historical reference dataset. The high-quality ship-based CTD reference data from the near-surface to depths more than 2000 m, for QC purposes of Core and Deep-Argo float data in the Mediterranean and Black seas, was reviewed and improved. OGS collected CTD data from several research institutes at regional level and from the main European Marine Services in order to complement the official reference dataset. The reference dataset was quality controlled to obtain a good spatial distribution with more recent/contemporaneous data to reduce the effects of both the inter-annual and the seasonal variability of the Mediterranean Sea, mostly in the upper and intermediate layers of the water column. In order to obtain an even more accurate reference dataset, the procedure developed at BSH is being adapted to marginal seas to find errors, suspicious data, large time gaps, etc. Due to the high natural variability in the water column of the Mediterranean Sea, additional qualitative checks (i.e., a comparison between nearby floats and analysis of the deepest portion of the temperature-salinity diagram) are used in conjunction with the OWC method to better interpret results and hence provide an improved quality control analysis. OGS continuously implements these procedures to solve some problems (i.e. when different vertical sampling is used) and to better adapt them to marginal seas in order to obtain data of increasingly high quality . The DMQC analysis has been conducted also on the deep floats deployed in the Mediterranean Sea. This analysis requires a different approach with respect to Core-Argo floats, due to the pressure-dependent salinity bias. Hence, the correction for pressure effects on conductivity, called CPcor correction, is necessary before applying the OWC procedure for checking any sensor drift and offset in salinity. The DMQC was applied to 5 out of 7 eligible floats. Of these, only two D-files were sent to Coriolis because the floats only have between 1 and 10 cycles and need no correction. For the other three that show potential drift and need correction, the procedure is under development.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

The Italian Ministry of Research has provided funding to buy 16 floats in 2022, including 2 with dissolved oxygen sensors, 4 standard T/S floats, 7 standard T/S floats with Ice Detection Algorithm implemented, 2 Deep floats and 1 Bio float. In addition, the Italian human resources per year devoted to Argo-Italy was about 50 man-months for technical, administrative and scientific personnel involved in the project in 2022. It is expected that the same level will be maintained in 2023, including the procurement of about 25 additional standard floats all equipped also with dissolved oxygen sensors, and 4 Deep floats. The Italian Ministry of Research has committed to provide funds in order to sustain the Italian contribution to Argo beyond 2023 as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to Italian national funding, in 2022 OGS received funding from EC projects (e.g. Euro-Argo RISE) for several activities related to Argo. CNR has purchased one Bio-Argo float that will be deployed in the Mediterranean Sea in late 2023.

In 2022, the Italian Ministry of Research has funded a 2.5-year grant (ITINERIS project) to purchase Bio/BGC floats (16 units by OGS and 9 units by CNR) to be deployed mainly in the Mediterranean but not only. The scientific aims span from bio-optical to biogeochemical issues related to climate change as well as a modelling component. The project involves both OGS and CNR. Our overall strategy will be to exploit the data from these new floats, together with those from previous floats, to further demonstrate to funders the value of BGC Argo in the Mediterranean Sea (but not only). In doing so, we aspire to secure sustained, long-term funding for the BGC extension of the Argo array. To realise this strategy, we are strengthening the interactions between the Italian observational BGC-Argo teams (OGS and CNR), the national and the European satellite community, and the biogeochemical modelling group at OGS.

3. **Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**
Here is a link to the commitments table at OceanOPS (if the link isn't working, visit OceanOPS and choose 'commitments' from the farthest right icon at the top of the page). If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

The Italian deployment plans for 2023 and 2024 are detailed in Table 3 (note that 2024 plans are only an estimate). The main areas of interest are the Mediterranean and the oceans of the South Hemisphere. Since 2023 it's been decided to equip the entire Core-Argo fleet with the dissolved oxygen sensor given the importance of this variable in water mass characterization.

Year	T/S floats (some of them with DO)		BGC/BIO floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2023	6-7 0 3 5	Mediterranean Black Sea South. Ocean Global	2 0	Mediterranean Black Sea	1-2	Mediterranean	**18-19**
2024	6 0 2 4	Mediterranean Black Sea South. Ocean Global	6-8 0	Mediterranean Black Sea	2	Mediterranean	**20-22**

Table 3. Italian float deployment plans for 2023 and an estimate for 2024.

Over a longer time frame, Italy is primarily interested in maintaining its contributions to the Core mission and supporting the BGC and Deep Argo missions as long as funds are available for these extensions. Float deployments in the next few years will be similar to those listed in Table 3.

OGS is committed to carrying out DMQC on all the Core-Argo floats of the Mediterranean and Black seas, and on some core floats in the World Ocean, as part of the Euro-Argo RISE, MOCCA project and other European projects over the coming years.

4. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

Operational ocean forecasting

Data from core- and Bio/BGC-Argo floats in the Mediterranean Sea are routinely assimilated into the Mediterranean Forecasting System (MFS) operational forecasting system run by the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) and OGS, respectively. 3D daily maps of Mediterranean ocean forecasting systems are produced and available on the Copernicus Marine Environment Monitoring Service (CMEMS) at https://data.marine.copernicus.eu/products?facets=areas%7EMediterranean+Sea. Assessments have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions. In particular, studies on the optimization of float sampling and cycling characteristics for the Mediterranean have been performed, and a methodology has been developed to assimilate Argo sub-surface velocities into numerical models.

Within the Marine Copernicus Service, BGC-Argo is an important asset (complementary to ocean colour) of the biogeochemical-model component of the Mediterranean Sea managed by OGS. BGC-Argo data are used for model development (Terzic et al.,2019), data assimilation (Cossarini et al., 2019, Teruzzi et al., 2021) and validation of operational and reanalysis Copernicus products (Salon et al., 2019; Cossarini et al., 2021). Novel artificial intelligence (Pietropolli et al., 2022) and ensemble data assimilation (SEAMLESS H2020 project) methods are ongoing activities to foster the exploitation of BGC-Argo information with a focus on carbon sequestration, oxygen dynamics, eutrophication and plankton dynamics.

Ocean science

Argo data are being used by several researchers in Italy to improve the understanding of marine properties (e.g. circulation, heat storage and budget, and mixing) in both the Mediterranean Sea and the Southern Ocean. Biogeochemical-Argo data are being used to explore carbon fluxes and analyse the impact of extreme events on marine ecosystem structure and functioning (Organelli et al., 2022), as well as to develop and validate new satellite products (Dionisi et al., 2022).

Web pages

The websites for the Italian contribution to Argo (Argo-Italy) are http://argo.ogs.it/#/. The link to the Mediterranean & Black Sea Argo Centre (MedArgo) is http://argo.ogs.it/medargo/.

Contribution at regional and international level

CNR organized and contributed to the joint floating school between EURO-Argo and EUROFLEETS+ carried out in September 2022 in Italy on board of the CNR's R/V Dallaporta.

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.**

   N/A

6. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

   OGS is committed to keeping the Mediterranean and Black Sea reference dataset up-to-date. For this purpose, OGS collects CTD data from different sources (Mediterranean and Black Sea riparian countries, national and European repositories) on a yearly basis. All non-restricted data are sent to the Coriolis GDAC for quality control, as some data policies do not allow the use of those data for scientific purpose and publication.

7. **Keeping the Argo bibliography ([Bibliography | Argo (ucsd.edu)]) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications. There is also the thesis citation list ([Thesis Citations | Argo (ucsd.edu)]). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.**

   Argo PIs: Elena Mauri and Giorgio Dall'Olmo (OGS), Emanuele Organelli (CNR)

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8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

We experienced some delays related to float procurements and deployments but the impact was not too strong. The situation has now returned back to normal.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

OGS will buy one Arvor I equipped with the RBR sensor in April 2023. The float will be deployed at the end of 2023 or in 2024.

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Japan National Report

(Submitted by Toshio Suga and Shigeki Hosoda)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 12 Core Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2022: 10 floats for Core Argo (APEX), 2 floats for BGC Argo (BGC-NAVIS and BGC-APEX). Since 1999, JAMSTEC had deployed 1433 Core Argo, Deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific and Southern Oceans. Because COVID-19 influenced cruse plans and the price of floats was higher, the number of float deployment was decreased. The current positions of all the active Japanese Argo floats are shown in Fig.1. The float deployments were conducted through collaboration with Japanese voluntary agencies, institutes, universities, and high schools. One float was deployed in the central part of North Pacific subarctic gyre by a voluntary cargo ship owned by a Japanese merchant ship company, NYK. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK. Three core floats equipped with RBRargo3 were deployed on an educational cruise of the Norwegian sailing vessel. One BGC APEX floats with RINKO ARO-FT oxygen sensor was deployed in the northwestern Pacific subtropical gyre, which is supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, Grant-in-Aid for Scientific Research on Innovative Areas (19H05700). One Deep NINJA float is planned to be deployed in the Southern Ocean in 2022/23 summer in corporation with CSIRO, Australia.

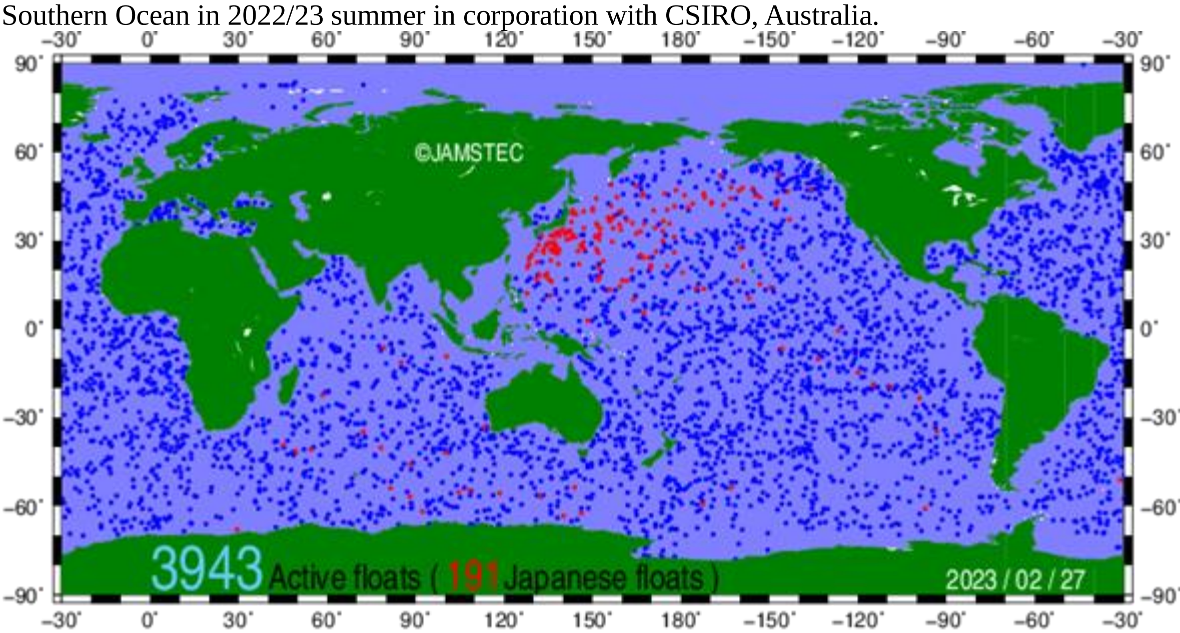

Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 22 Argo equivalent floats (22 ARVOR floats) in the seas around Japan from January to December 2022. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 387 floats (14 PROVOR, 194 APEX and 179 ARVOR floats) which JMA has deployed from 2005 to 2022, 53 floats (53 ARVOR floats) are active as of the end of December 2022, while 16 floats (16 ARVOR floats) terminated the transmission in 2022. JMA deployed 4 ARVOR floats from January to February 2023.

b. Technical problems encountered and solved

1) Sensor screening for SBE41 conductivity and pressure sensors

JAMSTEC developed a new CT sensor screening system, J-Calibration, for use with the SBE41 on the Argo float and is now in operation (Hosoda et al., 2018). Although the J-Calibration system requires careful temperature control of the artificial seawater as it is critical to maintaining a uniform water temperature, it is suitable for use in laboratory screening prior to deployment. In 2022, the J-Calibration has been conducted for 8 C sensors. Based on the screening, we did not find any doubt about C sensors. We also conduct P sensor screening using DWT. In 2022, 6 pressure sensors were checked. Two of the screened CT sensors were insufficient for the Argo criteria and were sent to SBE to conduct maintenance. In 2023, the screening performance will be investigated through a comparison using natural seawater or artificial seawater to find the appropriate solution in the J-Calibration.

2) Influence of suffering network security incident in JAMSTEC

In March 2021, JAMSTEC suffered unauthorized access to its core network system and leakage of personal information and had completely shut down the network (https://www.jamstec.go.jp/j/about/press_release/20210318_2/). Accordingly, the Argo JAMSTEC data management system and related websites were also shut down, and data submission to GDAC was suspended. The internet connection of JAMSTEC has been completely restored, so that JAMSTEC has restarted sending the raw data files of our active floats to JMA in real time since August 2022, and now back to normal. The websites of our product datasets have also been restarted at the same time. Note that their URLs have been changed from the ones before our security incident. And, JAMSTEC released the new version of PARC website in November 2022 (https://www.jamstec.go.jp/PARC/). The new URLs of products and PARC are listed on the Argo Project Office website.

c. Status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc.)

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 194 active floats as of February 28, 2023. 11 Japanese PIs agree to provide data for the international Argo. All the profiles from those floats are transmitted to GDACs in the netCDF format and are also issued to GTS using the BUFR codes after real-time QC on an operational basis. Argo BUFR messages have been put on GTS since May 2007. JMA has been developing real-time QC for each BGC parameter and implemented real-time QC for DOXY with adjustments based on WOA in August 2022.

JMA has made meta-, tech-, traj-, and Rprof-files v3.1 of the floats newly deployed since March 2016 and JAMSTEC has made meta-files in v3.1 of JAMSTEC’s floats newly deployed since October 2015. JAMSTEC has made meta- and Dprof-files in v3.1 since January 2016.

Abrupt salty drift floats

Japan has 85 floats, including Core, BGC, and Deep floats, suffering from Abrupt Salty Drift (ASD). 67 SBE41/41CPs have serious ASD which is unable to be adjusted. About 40% of them are equipped with SBE41/41CPs whose SNs are from 10482 to 11252. We lost about 4,500 salinity profiles because of ASD since 2015, and they are mainly in the northwestern Pacific at a rate of about 800~900 profiles every year. This is equivalent to 5~10% of the number of profiles measured by Japanese floats. Because most Japanese Core floats with serious ASD are still active, it is expected that salinity profile loss in the northwestern Pacific continues. We also have 5 Deep APEX floats with SBE61 suffering from serious ASD. We continue to monitor the salinity data of Japanese floats for detecting floats with high salinity drift and understanding features of high salinity drift found in floats. We have shared this information and joined the discussion about this issue through ADMT and the working group of this issue so that we contribute to improving salinity data quality.

As reported last year and two years ago in our national report, most of the salinity profiles in the global ocean flagged as probably bad or bad in all layers have been "Abrupt Salty Drift" in the past few years, and the number of salinity profiles flagged as probably bad or bad in all layers has been increasing every year. The percentage of global salinity profiles with all layers flagged as probably bad or bad in 2022 was about 17%, higher than that in 2020 and 2021. This is consistent with the results predicted years ago. JAMSTEC will continue to monitor the results.

New challenge to quality control for Core Argo profiles

JAMSTEC is now challenging to implement quality control methods using machine learning, developed by Sugiura and Hosoda (2020), for Core-Argo profiles. We performed supervised learning for existing Argo data with quality control flags by using the signature method, We aim to achieve efficient quality control by introducing this.

d. Status of delayed mode quality control process

JAMSTEC submitted the delayed-mode QCed Core files of 17,670 profiles in 2022, and the total number of submitted delayed-mode QCed Core data (P, T, and S) to GDACs is 188,714 profiles as of December 2022. About 77% of Japanese Core-profiles are published in GDAC as delayed-mode QCed profiles. Due to the restoration of the internet connection from a network security incident that occurred at JAMSTEC in March 2021, JAMSTEC was able to submit D files of about 18,000 profiles last year.

JAMSTEC has adjusted the salinity data of Deep floats by using optimal CPcor for each Deep float. When our Deep float is launched, shipboard-CTD observation is often performed. Therefore, the optimal CPcor for each Deep float is estimated by comparing its first profile with shipboard-CTD data at its deployment.

JAMSTEC has started performing delayed mode QC for our BGC floats. We are now preparing to process programs for DOXY-DMQC. We are also testing whether Nitrate and pH observed by our BGC floats in the North Pacific are corrected well by SAGE. We aim to start submitting D-mode DOXY_Adjusted of our BGC floats to GDAC this year.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of the

Millennium Project implemented under cooperation among the Ministry of Education, Culture, Sports, Science and Technology (operation: by JAMSTEC), the Ministry of Land, Infrastructure and Transport, JMA and Japan Coast Guard. After the Millennium Project terminated in March 2005, JAMSTEC continued the operation until FY2013 nearly on the same scale (about 80 floats to be deployed every year and associated delayed-mode data management) under its two consecutive mid-term programs for FY2004-2008 and FY2009-2013. JAMSTEC continues the float deployment and delayed mode data management but on a scale somewhat lower than before under its recent mid-term program FY2014-2018. Because of budget cuts in FY2014-2015, the number of technical staff devoted to delayed mode QC and PARC activities has decreased from 5 to 4 since FY 2015 and the number of purchased floats had been reduced to about 12-15. In FY2016, owing to ocean monitoring enhancement recommended by G7 Ise-Shima Summit, especially its Science and Technology Ministers' Meeting in Tsukuba, the additional fund for Core Argo and Argo extensions (Deep and BGC Argo) was allocated for aiming to sustain Core Argo array and to enhance Deep and BGC Argo. Furthermore, following its communique and our original research plans, JAMSTEC had got extra research funds to purchase 50 Core, 25 Deep, and 10 BGC Argo floats in FY2017, and are being deployed in the Pacific, Indian, and Southern Ocean in FY2018-19.

From FY2019, JAMSTEC has started new mid-term programs for 7 years. In FY2022, 13 Argo floats were deployed, including 10 Core, 1 Deep, and 2 BGC floats, following JAMSTEC's research purposes. In FY2022, the level of human resources for Argo deployment and QC is the same as in FY2021 (3 persons) including temporal staff. However, because of dmQC complexity, especially for BGC Argo, the number of technicians is insufficient. The deployment plan for Core, Deep, and BGC Argo floats in FY2023 is not yet fixed but will be maintained mostly at the same level as in this FY.

JAMSTEC is examining toward achievement of "next generation Argo" including ArgoMIX. The construction of the observing system is already addressed a load map of ocean science in Japan as "Global deployment of deep-sea Argo floats for more accurate prediction of climate and ecosystem change" and consensus among the Japanese ocean science community. The funding is not yet assigned. To support achieving ArgoMIX, JAMSTEC examines validations of Argo float equipped with turbulence sensor (RBR fast-response CTD and shear sensors) through the field test, in collaboration with Rockland and MRV. In 2022, we tested in situ ocean two times, and succeeded to get detailed turbulence data and to recover the two floats. In 2023, we plan to test deployment the two microALTO with ship turbulence measurements (VMP-X and L-ADCP) around the Izu-Ridge where turbulent mixing is enhanced due to rough topography. In addition, JAMSTEC purchased two Mermaid-Argo floats, called "MOBY", from OSEAN in France in 2023. One float equips with SBE61 and hydrophone sensors, and the other mounts SBE61 only. The two MOBY floats will be deployed in mid-2023 and examined to apply Argo data flow and to perform multiple observation networks.

JMA allocates operational budget to purchase 14 Core floats with Iridium communication in FY2023.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible

JAMSTEC will deploy 17 floats mainly in the North Pacific for 13 Core, 1 Deep, 3 BGC, and 2 Argo equivalent floats. The 13 Core Argo includes 3 RBR Argo floats. For the Argo equivalent floats, 2 RBR CTD Argo floats will be deployed in the western equatorial Pacific for the purpose of the air-sea interaction study. The one Deep Argo float is Deep NINJA with RINKO ARO-FT oxygen optode sensor. The 3 BGC Argo floats measure 4 parameters with a nutrient sensor (deep

SUNA) for 2, pH sensor (SeaFET) for one, oxygen sensor (SBE63) for all, and Chla and backscatter sensors (ECO-triplet) for all.

JMA plans to deploy 24 Argo equivalent floats (11 floats will be deployed in the western boundary region) around Japan in FY2023. All the JMA floats are identical with the Core Argo floats except that they are operated in a 5-day cycle, synchronized with JMA's real-time ocean data assimilation and forecast system.

JMA continues serving as the Japan DAC. JAMSTEC continues running the Pacific Argo Regional Center for the upcoming year.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers

Many groups in JAMSTEC, JMA, FRA, and Japanese universities use Argo data for climate, oceanographic and environmental research. Japanese fisheries research community is conducting their biogeochemical studies using Argo floats equipped with chlorophyll and/or oxygen sensors. Other institutes, agencies, and universities use Argo data through datasets of grided profile data or assimilation model data, although not all the activities are identified. Japan Argo supports the activities of the above institutions/agencies and promotes their further use. A national program Argo webpage works for them and has recently been updated as a site to exchange information between domestic and international programs (https://www.jamstec.go.jp/J-ARGO/?lang=en).

JMA issues operationally ocean analysis and forecast by using satellite data and in-situ data including the global Argo BUFR messages. Daily, 10 day mean and monthly products of subsurface temperatures and currents for the seas around Japan and North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-JPN), are distributed through the JMA web site (in Japanese). Numerical outputs of the system are available from the NEAR-GOOS Regional Real Time Data Base (https://www.data.jma.go.jp/goos/data/database.html) operated by JMA. Monthly diagnosis and outlook of El Niño-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the Seasonal Ensemble Prediction System (an ocean-atmosphere coupled model) are also operationally distributed through the JMA web site (in Japanese) and the Tokyo Climate Center (TCC) web site (https://ds.data.jma.go.jp/tcc/tcc/products/elnino/). These systems were upgraded in Feb. 2022 (for descriptions of the new systems, please refer tohttps://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g3_doc.html, andhttps://ds.data.jma.go.jp/tcc/tcc/products/model/outline/cps3_description.html). The ocean-atmosphere coupled model is also used for seasonal forecast of climate in Japan. The model products for seasonal forecast are available from the TCC web site (https://ds.data.jma.go.jp/tcc/tcc/products/model/).

JAMSTEC is providing gridded products of objectively mapped temperature and salinity field data (Grid Point Value of the Monthly Objective Analysis using Argo float data: MOAA-GPV), and gridded mixed layer depth with its related parameters (Mixed Layer data set of Argo, Grid Point Value: MILA-GPV). These products have two versions for each dataset, one is estimated by using mainly real-time QC Argo profiles and another is by using mainly delayed mode QC Argo profiles.

JAMSTEC has been providing objectively mapped velocity field data based on YoMaHa'07 (version September 2010), and Argo temperature and salinity profile data put through more advanced automatic checks than real-time quality controls (Advanced automatic QC Argo Data version 1.2a) since October 2014. JAMSTEC has also provided scientifically quality controlled data of Deep NINJA floats for convenient use on scientific or educational purposes. The QC is based on comparisons with highly accurate shipboard CTD observations conducted nearby float observations.

The Pacific Argo Regional Center (PARC) is operated by JAMSTEC, providing information about consistency check of float data related to delayed-mode QC through the website. Since 2006, PARC and its website had been operated by JAMSTEC and IPRC in collaboration with several coastal states of the Pacific region. JAMSTEC mainly operates PARC and had resumed to inform from the website as the mentor of the Pacific Ocean. Because the network incident occurred in early 2021, the plan for the new PARC website must have been modified to be more secure form. The new PARC website has been released in August 2022. It has the same functions as them before JAMSTEC's network incident. We have a plan to add functions of providing information about BGC and Deep floats as well as Core floats in the Pacific, sharing information about the deployment and technical issues, etc., in order to improve the status of the Pacific Argo array.

ESTOC (Estimated state of ocean for climate research) is a JAMSTEC product; an integrated dataset of ocean observations including Argo data by using a four-dimensional variational (4D - VAR) data assimilation approach. ESTOC is the open data that consists of not only physical but also biogeochemical parameters (See the website in JAMSTEC, http://www.godac.jamstec.go.jp/estoc/e/top/). We have been developing the system incorporating new subgrid-scale mixing schemes and it will be upgraded to reproduce more realistic ocean states in the upper layers, where Core Argos are exploring, as well as deep oceans to synthesize full-depth ocean states by 2024. In addition, we now start experiments for the evaluation of the impacts of dissolved oxygen measurements by BGC Argo for our system, which was reported in workshops (ex. SynObs). We plan to report these activities in scientific papers.

JCOPE2M (Japan Coastal Ocean Predictability Experiment 2 Modified) is the model for the prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2M is the updated version of JCOPE2, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSPP. The reanalysis data 29 years back (from 1993 to the present) and the forecast data 2 months ahead are disclosed on the following website: http://www.jamstec.go.jp/frcgc/jcope/. More information is shown at http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

JCOPE-T DA, a downscaled version of JCOPE2M, has been developed by the collaboration of JAMSTEC and JAXA. It is designed for real-time (daily-basis) assimilation of satellite and in-situ data including the Argo data and 10-day lead forecast updated every day. The latest available forecast information is available from: https://www.eorc.jaxa.jp/ptree/ocean_model/index.html.

FRA-ROMS is the nowcast and forecast system for the Western North Pacific Ocean developed by Japan Fisheries Research and Education Agency (FRA) based on the Regional Ocean Modeling System (ROMS). FRA-ROMS was operated from May 2012 to March 2022. Since March 2022, FRA began operating FRA-ROMSII, a new system based on FRA-ROMS with improved model performance in the Japan Sea. The outputs of FRA-ROMS/FRA-ROMSII are used primarily for fisheries resource surveys and are provided every week through the website: https://fra-roms.fra.go.jp/fra-roms/index.html/.

Tohoku University has released a gridded dataset of subsurface chlorophyll maximum depth, using Chl-a measurement data in the World Ocean Database 2018 (Boyer et al. 2018) and the Global Ocean Data Analysis Project version 2.2019 Release (Olsen et al., 2019). The Chl-a measurement data includes Argo profile data as well as bottle samples, CTD fluorescence, gliders, and so on. This gridded dataset can be downloaded on the websites (http://caos.sakura.ne.jp/sao/scm/).

5. Issues that our country wishes to be considered and resolved by the Argo Steering Team

regarding the international operation of Argo

As reported in 2011, the EEZ clearance procedure for Argo float deployed had been simplified following IOC Resolution XLI-4, which is performed by OceanOPS, the coordination of activities at an international level, and the performance of the Argo data system. This change reduced our time and effort for the process of EEZ clearance, while the traditional EEZ clearance is still needed for some key countries because Argo national focal points (NFPs) of those countries are not registered on the list at OceanOPS. Japan Argo hopes for more NFPs, especially of nations in and around the Pacific Ocean to provide more data measured in any EEZ and to optimize the deployment of Argo floats. This could be also helpful for the smooth implementation of any future extension of Argo and less trouble with the countries.

6. CTD cruise data being added to the reference database

After the last upload of CTD data to the CCHDO website in February 2022, which was included in the national report the year before last, we have uploaded 334 CTD cast data as "Private for Argo" in the western North Pacific.

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2022

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-

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2022

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Kawakami, Y. (2022). *Upper Ocean Variability in the North Pacific Subtropical Gyre: Viewpoint of Kuroshio and Water Masses*. Tohoku University.

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Iskandar, M.R. (2021). *Pathways, timescales and transpot of the Indonesian Throughflow, and*

water mass transformation in the Indonesian Seas. Tohoku University.

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Sakamoto. T. (2019). Studies on sardine (Sardinops spp.) stocks using oxygen stable isotope ratios in otoliths, the University of Tokyo.

Yamaguchi, R. (2019). *Formation of seasonal upper-ocean stratification and its variability.* Tohoku University.

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Oishi, S. (2017). *Frontogenesis and frontolysis in the Agulhas Return Current region.* The University of Tokyo.

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Kimiduka, M. (2015). *Mean structures and temporal variations of the North Pacific subtropical gyre as revealed from an analysis of observational data.* Tokyo University of Marin Science and Technology.

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Shimada, K. (2008). *The Mixing Efficiency Due To The Double Diffusive Convection In The World Ocean*. Tokyo University of Marin Science and Technology.

8. How has COVID-19 impacted our National Program's ability to implement Argo in the past year?

Due to COVID-19, some of the cruise plans were canceled or modified, mainly going to the far area from Japan. That must modify JAMSTEC's deployment plan, and we suffer difficulty to fill in the gap of the global Argo array. Recent impacts on Japanese Argo regarding COVID-19 becomes gradually smaller, however, ship cruise plan and track for deployment opportunities are still affected.

9. Deployment plans for RBR floats in the next couple years

In 2023, JAMSTEC will deploy 4 RBR APEX floats, 2 for Core Argo and 2 for Argo equivalent. The 2 RBR Core Argo floats will be deployed in the western North Pacific, at which shipboard CTD cast will be carried out. The 2 RBR Argo equivalent floats will be deployed in the western equatorial Pacific region, observing the air-sea interaction regarding MJO and ENSO. In 2024 and after, we do not have any plan yet.

Argo-KOREA Annual Report 2022

by National Inst. of Meteorological Sciences/KMA

24th Argo Steering Team Meeting (AST-24)
Halifax, Canada, 20-24 March 2023

1. Status of Implementation

The National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA) has contributed the Argo float deployment process around Korea and Northwestern Pacific area, however Argo float deployment was not carried out in 2022 due to the delayed purchasing process by COVID-19 and the rapid exchange rate between US dollar and Korean won. The purchasing process for 2022 budget was done March 2, 2023 and deployment will be carried out on July, 2023. And the Korea Institute of Ocean Science and Technology (KIOST) deployed 5 Argo floats: two floats were in the East Sea (ID 4903636, 4903637) on July 6, 2022 and three floats in the Northwestern Pacific (ID 3902470, 5906968, 7901012) on October 12 ~ 16, 2022. The East Sea float has 800 m parking depth and ten-day profiling cycle and the Northwestern pacific floats had 2000 m parking depth with same profile cycle.

a. Status of contributions to Argo data management

- To setup the regional range check procedure in the Yellow Sea data.
  - Temperature: -2.5 ~ 35 ℃; Salinity: 15 ~ 36 psu
- To evaluate the MEDD test for the Northwestern Pacific data
  - decreased bad data detection, still needed a spike-test for high quality
- To compare the upward casting and drift data set in the parking depth
  - confirmed that the quality control of drift data was done properly

b. Delayed Mode QC

- Total 3,492 profiles (1,905 from the East Sea, 1,587 from the Yellow Sea) were processed by the DMQC operation process, which had been observed from early September 2021 to early September 2022. The QCed profiles had been sent to the Ifremer GDAC on June 29 & October 21, 2022 with NetCDF format. The profiles will be DMQCed based on KMA DMQC process and OWC 3.0.0. The D-files will be sent to the Ifremer GDAC in the late June & October 2023 by NetCDF format.
- Constant salinity offsets were identified in the several shallow ARGO

floats right after deployments in the Yellow Sea by using shipboard CTD data. Since the floats in the Yellow Sea observed for relatively short period of time (due to shallow parking depths of less than 100m and short cycle times for about a day), they usually have initial salinity offsets rather than salinity drift.

- Additionally, Temporal and spatial scale of salinity variability were much smaller than those of the open ocean since the Yellow Sea is a wide continental shelf area. This indicates that the only shipboard CTD data collected at the similar time and location of deployment are needed as a reference. The identified offset for PSAL based on the shipboard CTD is adjusted by using LAUNCH_OFFSET in "MAIN_write_dmqc_files" (matlab code). We will be able to improve current DMQC prototype for the shallow Argo floats with collecting more accurate CTD data.

2. Present level of (and future prospects for) national funding for Argo including summary of human resources devoted to Argo.

In 2022, NIMS/KMA received the funding for 7 Argo floats (about USD 150,000,000) and KIOST was also done the procurement process of 5 floats for 2023 deployment. NIM/KMA will procure 7 floats by October 2023, and deploy them around Korea. Following persons contribute to the Argo-Korea program.

- KiRyong KANG, Hyeong-Jun JO (KMA)
- Sung-Dae KIM, Hyuk-Min PARK (KIOST)
- Jong-Jin PARK, Yumi SONG (Kyungpook National University)

3. Summary of deployment plans

NIMS/KMA plans to launch 14 floats in 2023 around Korean Peninsula: four floats will be deployed on July and November at the Yellow Sea to keep the shallow sea observation network, 7 floats deployed on July and November at southwest area of Jeju Island to monitor the summer low salinity and typhoon-ocean interaction, and finally 3 floats deployed on November at the East Sea to keep current observation network (Figure 1). According to KIOST's contact point, they also try to deploy 5 floats in October, 2023: two floats at the same location in the East Sea (129.92°E, 37.01°N), three at the Northwestern Pacific area (133.63°E, 14.99°N; 132.0°E, 15.0°N; 132.0°E, 17.0°N).

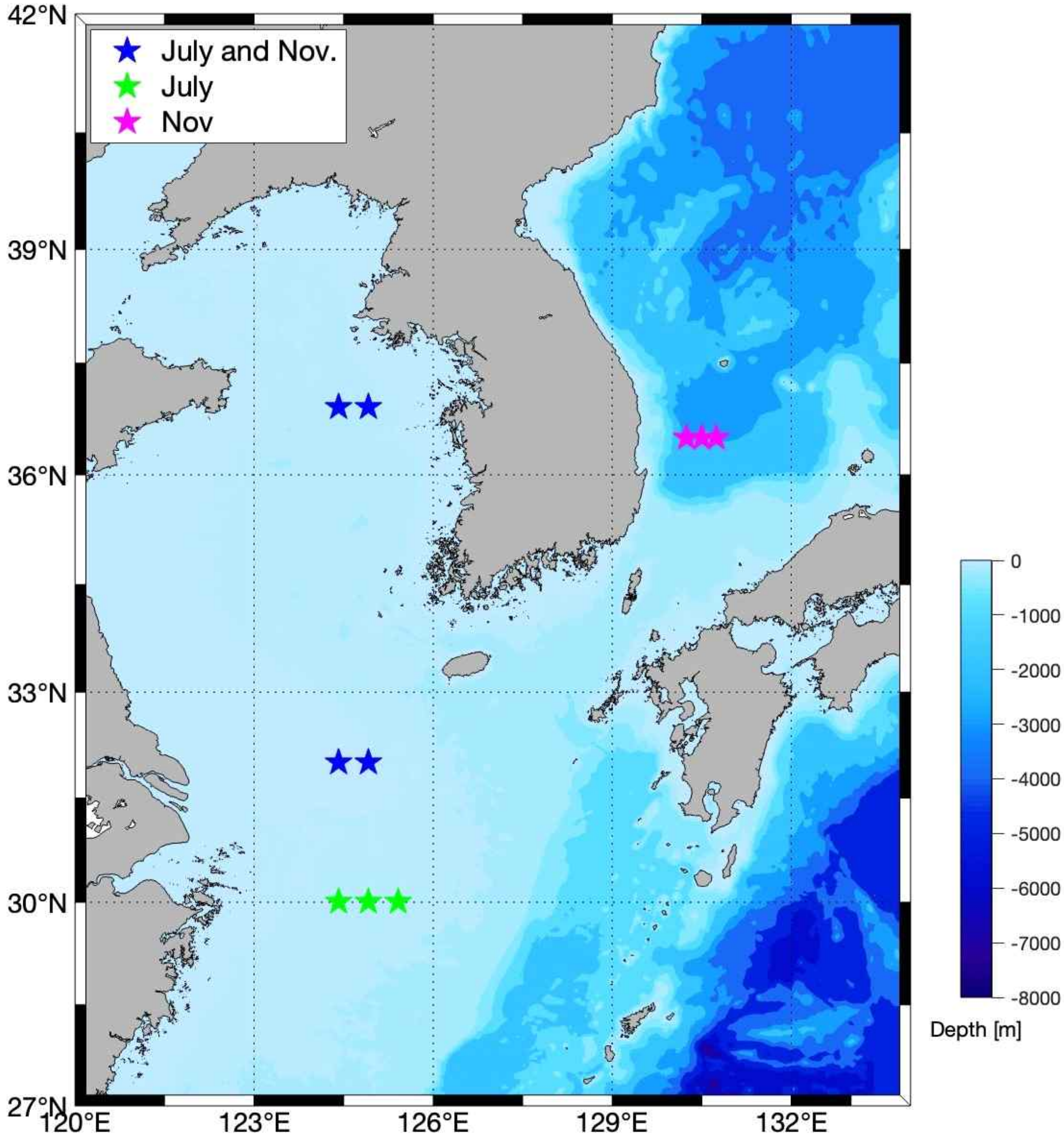


Fig.1 Position map of Argo float deployment in 2023 by NIMS/KMA

4. Summary of National Research and Operational Uses of Argo data as well as contributions to Argo Regional Centers.

In 2022, even thought there was no new float deployment, all Argo float-based temperature and salinity profile data have been used to the KMA's global ocean data assimilation and prediction system by near-real time mode. It was helpful to make more accurate initial field for the numerical ocean model and to increase the predictability.

At the East Sea Argo float data are used to monitor the long-term change of ocean condition around Ulleng-do and Dok-do such as water temperature and ocean heat content. And the Yellow Sea Argo data were also used to verify the ocean model and research about annual variation of temperature structure. Below shows the visitor number of the NIMS/KMA's Argo homepage for 5 years.

Table 1. Annual number of the NIMS/KMA Argo homepage visitor

	2018	2019	2020	2021	2022
argo.nims.go.kr	336,851	471,062	323,455	909,058	1,980,305

5. Issues that your country wishes to be considered (and resolved) by AST regarding the international operation of Argo.

- None.

6. CTD data uploaded to CCHDO

- None

7. Bibliography

- None

8. Effects of COVID-19

Deployment was impacted by a combination of COVID-19 and rapid exchange rate between US dollar and Korean won. Because of high exchange rate, we performed the procurement process two times, which made it delay at least three months. And total period from contract to arrival at our institute took about 5 months, which was 2-month longer than normal state. Due to these impacts we made delay the float deployment from November 2022 to July 2023.

9. RBR CTD piloting and deployment plans

- N/A

<The End>

Argo New Zealand National Report, March 2023.

Phil Sutton. National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. floats deployed and their performance:

2 Solo2 floats were purchased and deployed (WMO #s 5906770 and 5906892).

New Zealand also deployed floats for other organisations on two voyages:

i) R/V Kaharoa Voyage (Western Pacific):

R/V Kaharoa deployments November 2022-January 2023.

- 8 Scripps Institution of Oceanography Deep Solo
- 35 University of Washington Apex
- 14 University of Washington Apex BGC
- 8 CSIRO
- 52 Scripps Institution of Oceanography Solo2

ii) R/V Tangaroa Voyage (Southern Ocean):

R/V Tangaroa deployments January-February 2023

- 12 Scripps Institution of Oceanography Solo2
- 4 Scripps Institution of Oceanography Deep Solo

b. technical problems encountered and solved:

The NZ floats are functioning well. Other partners will report on their floats.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc):

none

d. status of delayed mode quality control process:

DMQC on NZ floats is performed by Scripps Institution of Oceanography (John Gilson).

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the core mission and the enhancements: BGC, Deep, Spatial (Polar, equator, WBCs)

New Zealand Argo float funding continues on a year-to-year basis at the level of two floats per year. Funding for personnel is via a research programme, also funded year-to-year and a contract with Scripps Institution of Oceanography associated with the R/V Kaharoa charter. This supports of the order of 2 months of personnel time.

A voyage undertaking Deep Argo Development is planned for May 2023.

3. **Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**

New Zealand floats: planned purchase and deployment of 2 Solo2 floats in the South Pacific

Deployments for other countries:

a) Planned 2024 Kaharoa Voyage (~ January 2024)
   This is being designed around the delivery voyage of the replacement 'Kaharoa' from Spain to New Zealand.

   153 deployments are planned:

   50 UW APEX (some BGC) from UW,
   50 SIO SOLOIIs
   5 SIO Deep SOLOs
   15 WHOI Core (perhaps including BGC) and
   1 WHOI Deep SOLO (to be confirmed),
   12 CSIRO Core (perhaps including BGC) to be confirmed.
   20 extra to be confirmed.

b) R/V Tangaroa Tsunami servicing voyages (southwest Pacific): May 2023.

12 SIO floats.

c) R/V Tangaroa DWBC and Deep Argo Development Voyage: May 2023.

4 SIO Deep SOLO.

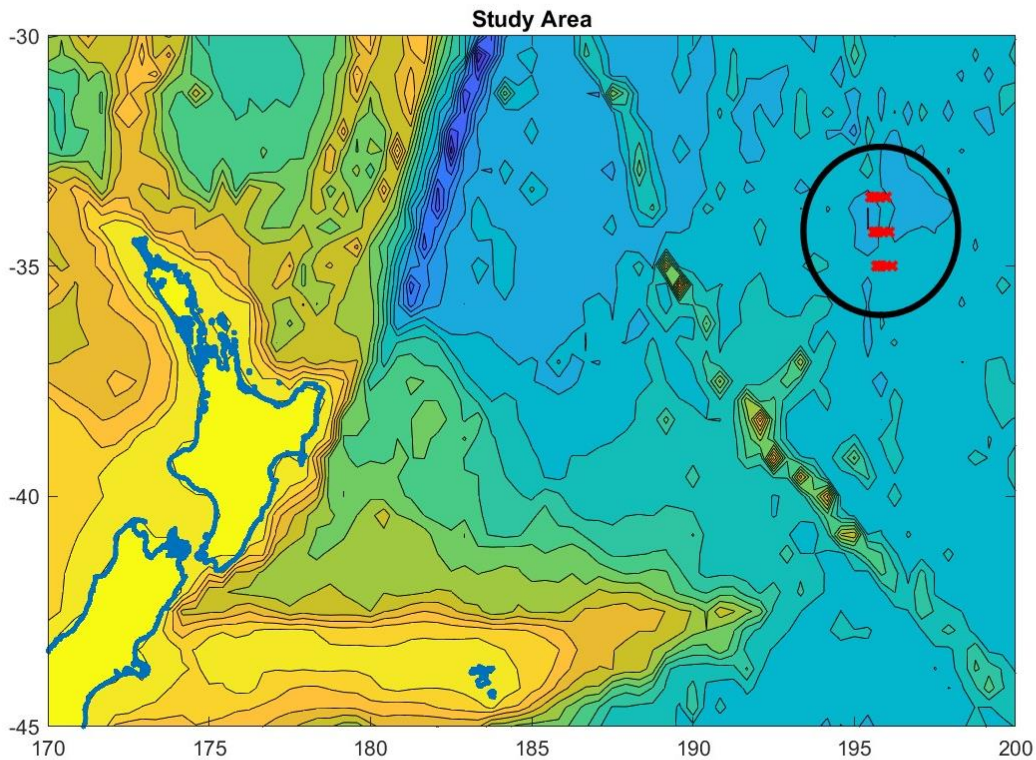
4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

Argo data and products are routinely used in research, including physical oceanography, marine ecosystems, climate and fisheries.

Deep Argo Development Voyage 3

A third R/V Tangaroa Deep Argo Development Voyage in collaboration with Scripps Institution of Oceanography (Nathalie Zilberman), Sea Bird Scientific and NOAA is planned for May 2023. The study area is east of New Zealand, targeting the eastern side of a deep ridge to combine a scientific study with the sensor development work.

A key aim of the voyage is to perform 6000m CTD casts with a number of experimental SBE sensors mounted on the CTD rosette to collect intercomparison data. Earlier work focused on pressure and conductivity sensors; this voyage will continue that work and will also focus on dissolved oxygen.



Study site bathymetry and station locations.

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOps, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.**

No issues beyond those faced universally, i.e., funding, EEZ permissions and Covid-19 disruptions.

6. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

CTD data from the Deep Argo Development Voyage will be provided for the reference database.

7. Argo bibliography (Bibliography | Argo (ucsd.edu))

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8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

- There are some restrictions on vessel access to minimise the risks of any crew or science party getting infected and sailing, in particular during mobilization. These are not too restrictive and can be managed.
- International shipping still isn't back to pre-covid levels of service- in particular with respect to cost and timeliness.

9. Does your National Program have any deployment plans for RBR floats in the next couple of years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

New Zealand currently has no intention to purchase RBR CTD floats. We will deploy other nations' RBR-equipped floats (e.g. SIO, CSIRO).

10. Other/Outreach

A decorating party for BGC Argo floats

Written by NIWA Communications Team

A class from Silverstream Primary School in Upper Hutt visited NIWA Wellington last week with a very important job to do: decorate the Argo floats on behalf of the schools overseas who named them. Lucky for these kids, one student has a NIWA physical oceanographer for a mum, Denise Fernandez.

Denise approached Silverstream School with this exciting opportunity as part of the GO-BGC Adopt-a-Float program. In this programme schools overseas 'adopted' and named Argo floats with the aim to inspire and educate students about global ocean biogeochemistry and climate change.

"Since my son is in his final year at primary school, I thought it would be great for him as his class to actually see what I talk about at home all the time," says Denise. "I went to the school and gave a talk about the floats and the teachers also played a few videos showing how the floats work and where are they going in the ocean and what they measure."

Then, with colourful sharpies in hand, it was over to the students to get creative.

"They googled where the schools were located and their school emblems and were so creative with the float drawings," says Denise.

"The school decided to call this float 'Thunder Float' because it is going into the stormy Southern Ocean," said one student.

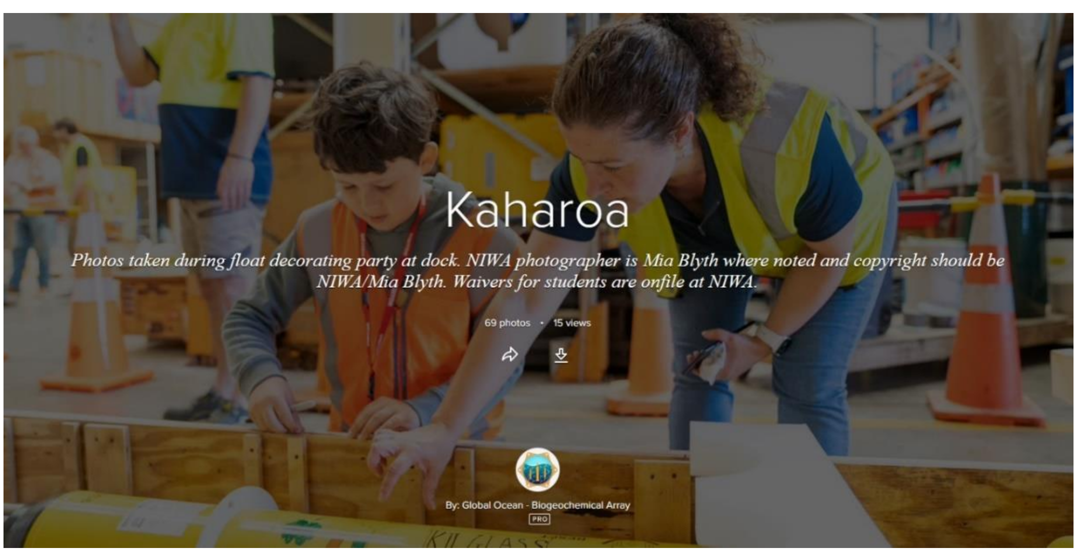
Rebecca Routhan, a teacher at Silverstream school was ecstatic that the children had this opportunity.

NIWA has been part of the international Argo programme for nearly two decades and this year *RV Kaharoa* deployed its 2000th float. RV Tangaroa has deployed around 300 and together NIWA has deployed the most of any single organisation.

"The Kaharoa's gone to Chile, Hawaii, Tahiti, Durban, Mauritius ...," says Physical Oceanographer Phil Sutton. The floats last typically four to six years. "One of the floats purchased by NIWA and deployed from Kaharoa in August 2013 looks to have just 'died' having not surfaced since 14 April. This means the float did 364 profiles over nearly ten years," says Phil.

More photos and story here:

https://www.flickr.com/photos/go-bgc/albums/72177720303802908



Argo National Report 2023 – Norway

Submitted by Kjell Arne Mork (IMR) on behalf of NorArgo

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

Argo Norway (NorArgo, https://norargo.hi.no) is the Norwegian contribution to the Euro-Argo European research infrastructure (ERIC), and some points in this report are therefore (also/instead) included in the report from Euro-Argo. Focus area for Argo Norway is the Nordic Seas (Greenland, Iceland and Norwegian Sea) and Arctic.

a. floats deployed and their performance

In 2022, Norway deployed **14 Argo floats**:

- 3 Deep+DO floats
- 4 BGC-floats (6 bgc-variables)
- 2 BGC-floats (4 bgc-variables)
- 2 core+DO floats
- 3 core floats

Since 2018, Norway has in total deployed 56 floats and at present has 47 operative floats that include Deep, BGC, and core (Figs. 1, 2).

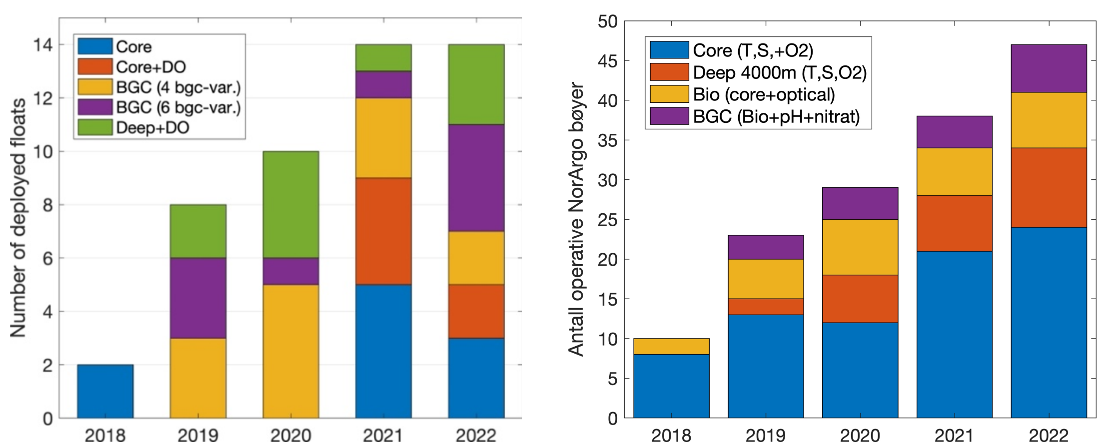


Figure 1. Number of deployed (left figure) and operative (right figure) floats.

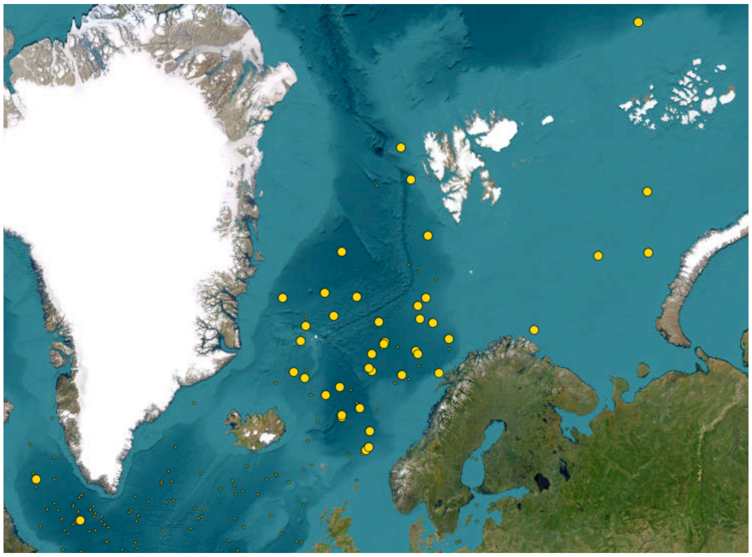


Figure 2. Last location of operative Norwegian floats.

b. <u>technical problems encountered and solved</u>

Some APEX floats (BGC floats) deployed in 2019 and 2020 had some issues with the buoyancy due to air loss of the floats.

Some BGC floats (PROVOR floats) had some issues with pH sensors, producing bad data.

c. <u>status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)</u>

We have defined 4 floats with abrupt salinity drift (ASD).

d. <u>status of delayed mode quality control process</u>

We do DMQC of our floats that were deployed in 2019 and later while Argo Germany did DMQC for our “older” floats. We do DMQC of core, bgc and deep floats.

We have done <u>DMQC of temperature/salinity</u> for 47 floats (16 core, 22 BGC and 9 deep floats) of total 53 floats deployed in 2019 and later. 6 floats that are not QC were deployed in the shallow Barents Sea where reference data are missing. However, work is ongoing to collect reference data also for the Barents Sea.

For the BGC-floats we have done DMQC for oxygen (18 of 33 floats), nitrate (4 of 9 floats) and pH (1 of 9 floats). DMQC-work of the other variables is ongoing and will be done within 2023. There have been issues with several pH-sensors that are uncorrectable.

NORCE is responsible for the DMQC of oxygen and pH, while IMR is responsible for the DMQC of T/S, nitrate, chlorophyll, backscatter and irradiance.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

Financial resources

The funding has been a combination of self-financed (i.e., funded by Institute of Marine Research) and funding from the Norwegian Research Council (NRC, Ministry of Education and Research) during 2012-2015.

For 2018-2023 we receive funding from the NRC for the extension of the national Argo infrastructure project (NorArgo2), approximately 600 k€ per year. Within this project we purchase and deploy approximately 13 floats per year in the Nordic Seas and the Arctic that include core, BGC and deep floats. To keep the target of having minimum 30 operative Argo floats beyond 2023, submission of a new project proposal to the NRC is planned.

Human resources

NorArgo2 has approximately 30 person months per year and more than 10 people contribute from six Norwegian institutes (IMR, Norce, NERSC, MET.no, Akvplan-niva, UoB). This includes Argo monitoring, logistic, deployment, quality control, and data management.

National coordination

The Norwegian Argo Infrastructure (NorArgo, https://norargo.hi.no) is coordinated by Kjell Arne Mork, Institute of Marine Research, who also is the leader of the NorArgo2 project.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

In 2023, we will deploy 12 Argo floats in the Nordic Seas/Arctic (2 BGC+UVP+CROVER, 2 BGC, 4 BIO, 2 core+DO, 2 core). Our financial support from the Norwegian Research Council ends in 2023 which means that it is very uncertain how (or if) many floats we will deploy the next years.

In 2023, we do DMQC of core, deep and BGC floats.

4. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

   Argo Norway focuses on both research topics and marine climate monitoring of the Nordic Seas. There is an increasing interest in using Argo data in Norway, and two climate centres are now using the data operationally in climate models (NERSC and MET.no). For instance, the operational TOPAZ4 modeling system assimilates Argo data into the ocean model to provide forecast product for the Nordic Seas and Arctic Ocean under the EUs Copernicus Marine Environment Monitoring Services (CMEMS, http://marine.copernicus.eu/).

   The present scientific topics are mainly within the Nordic Seas (Norwegian, Iceland and Greenland Seas) and Arctic, including:

   - Heat and fresh water contents in the Nordic Seas are regular updated
   - Water mass changes in relation with biological activities. This topic is also one of the reasons that we have included bgc sensors on the Argo floats.
   - Studies that involve the mixed layer, primary production and carbon cycle.

   Link to Argo Norway (NorArgo): https://norargo.hi.no

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.**

6. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

   At all deployment locations a CTD station with water samples are taken. All ship CTD-data are sent regular to the ICES, EUs CMEMS, and World Ocean Database. The ship-data will also be sent to Argo (Reference Database).

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**
   There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

   No new articles to add that are not included in the Argo bibliography.

8. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

   Two BGC-floats and one deep float were delivered too late for the cruise with Argo deployments in 2021. Instead, these floats were deployed one year later, in 2022. In addition, a cruise in 2021 was shortened due to COVID-issues, and as a result some planned Argo deployments needed to be modified.

9. **Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.**

   No RBR-floats will be deployed this year, but next time we will order floats we also plan to purchase some floats with RBR-sensors (~5 floats with RBR in 2023).

Argo-Poland National Report 2022

Waldemar Walczowski, Małgorzata Merchel

IO PAN, Sopot, Poland, 31.01.2023 r.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array

a. floats deployed and their performance

At the end of July 2022, during the AREX 2022 summer cruise, Poland launched one float from the board of the Institute of Oceanology Polish Academy of Sciences (IO PAN) vessel *r/v Oceania.* The float (WMO 3902116) was deployed in the Greenland Sea (76.51 °N, 00.92 °E) (Figure 1).

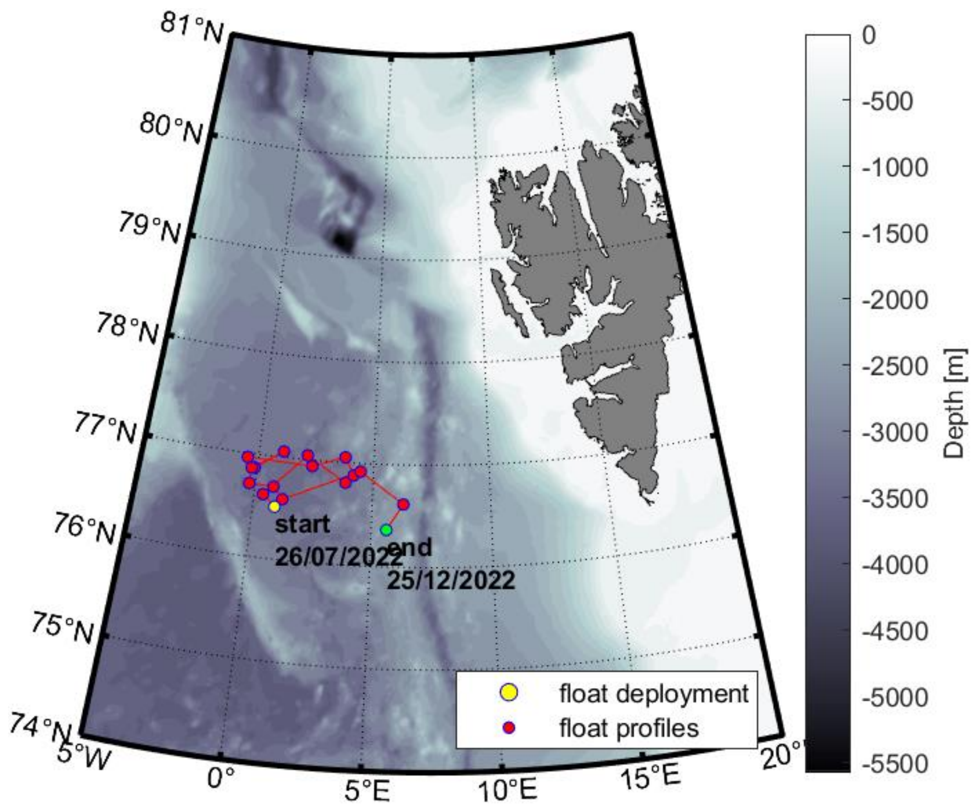


Figure 1. Position of deployment and trajectory of the Argo float (WMO 3902116) deployed in the Greenland Sea by the Argo Poland program in July 2022.

The parking depth was set at 1000 dbars and the profiling depth at 2000 dbars. The float has cycles of 10 days. The float was operated for the whole of 2022 and sent 16 complete sets of hydrographic data by the end of the year. The instrument is the ARVOR-I float with the Iridium transmission system. In addition to standard CTD measurements, the float also takes measurements of dissolved oxygen.

In 2022, IOPAN conducted two experiments using the Argo float in the very shallow water of the southern Baltic Sea. In both cases, we chose the Bay of Puck as the place to deploy the float (Figure 2). The first experiment consisted in anchoring the float at a depth of 15 m. An acoustic release, a buoyancy buoy and a 25 m long line were attached to the 25 kg ballast. The float was attached to the end of the line. The length of the line (about 1.7 times the depth of the water body) allows for free emergence, and the line (with a slightly positive buoyancy) does not reach the surface when the float stays at the bottom. The float was launched on May 26 at 1 p.m. in the sheltered waters of the Bay of Puck. The float was initially configured with a cycle time of 2 hours and a park pressure of 100 dbar. After 4 days the frequency of profiling was changed to 7 hours. The first test lasted until June 18, 2022. An acoustic release was used to disconnect the float from the dead anchor. The whole set - acoustic release, float and buoyancy buoy were recovered. The experiment was carried out with the wind up to 6 B, with a wave height of up to 1 m.

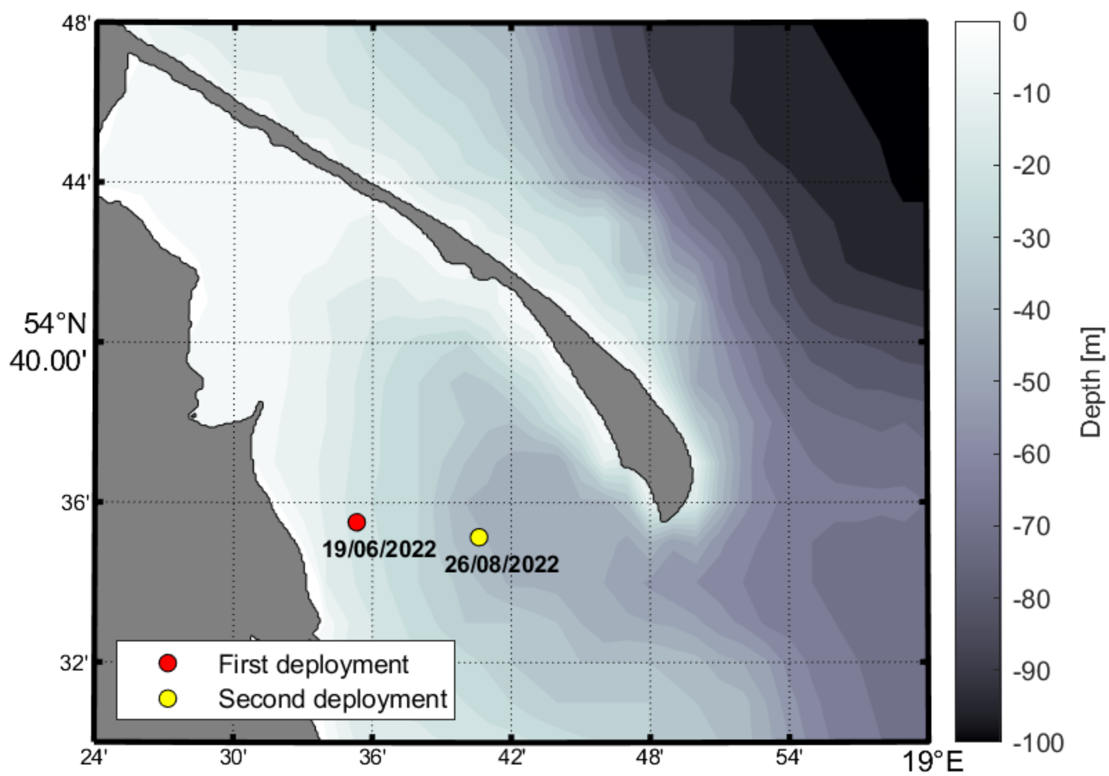


Figure 2. Deployment positions of the test Argo float launched in the southern Baltic Sea.

In August 2022 the experiment was repeated. The float was anchored at a depth of 40 m in a sheltered area of the Bay of Puck. A 60 m long line, an acoustic release and a dead anchor were used. The float was configured for sampling at a frequency of 7 hours. The second test lasted until December 5, 2022.

b. technical problems encountered and solved

The Arctic float was deployed by the Institute of Oceanology Polish Academy of Sciences (IO PAN) from the board of the Institute research vessel 'Oceania'. There were no technical problems with the float.

c. status of contributions to Argo data management.

Data from the Arctic float were provided to the Ifremer Argo Center and processed in the Center. All data are available online. IO PAN provided CTD data collected by *r/v Oceania* during AREX cruises in the Nordic Seas (2000-2018) and the Baltic Sea (2016-2021) to the Argo references database.

d. status of delayed mode quality control process

Standard DMQC procedures have been used by DMQC operator from IOPAN for the following Arctic floats:

3902102 – Salinity correction was needed.
3902103 – Salinity correction was needed.
3902105 - It is fine and needs no correction.
3902107 – It is fine and needs no correction.
3902108 – It is fine and needs no correction.
3902111 – It is fine and needs no correction.
3902112 – Salinity correction was needed.

D-files were submitted on GDAC.

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

In 2021, the Institute of Oceanology of the Polish Academy of Sciences applied to the Ministry of Science and Education for funding the Argo-Poland consortium. The members of the consortium are the Institute of Oceanology PAN, the Institute of Geophysics PAN and the Polish Naval Academy. In 2022, we received funding from the Polish Ministry for the next five years.

3. **Summary of deployment plans.**

Argo-Poland plans to launch one float a year in the Baltic Sea and at least two in the European Arctic.

4. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers.**

IO PAN runs the long-term Nordic Seas observation program AREX. Argo floats are a valuable source of data complementing the measurement data obtained by *r/v Oceania*. This applies in particular to the variability of the seasonal properties of water masses (cruises are conducted only in summer) and sea currents pathways in the Svalbard region.
https://old.iopan.pl/hydrodynamics/po/Argo/argo.html

At the Baltic Sea Argo floats data are used to monitor the inflow of salty waters from the North Sea. Also, data on the oxygen content in the depths of the Baltic Sea and current pathways are especially valuable. Argo data are also used for the modelling in the SatBaltyk project.
http://www.satbaltyk.pl/en/

Also, project SufMix (Turbulent Mixing in the Slupsk Furrow) uses Argo data.

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo.**

   No issues.

6. **CTD stations**

   In 2022 one Polish float was deployed during IOPAN Arctic cruise AREX, when 249 CTD profiles have been done. The CTD station was also performed just before the float deployment. IOPAN can provide the data from this station to compare it with the Argo float.

   The rest of the data from the Nordic Seas are available via IOPAN database. Contact point: Waldemar Walczowski, walczows@iopan.pl.

7. **Argo blibliography**

   There are two research articles using the Argo data in progress.

8. **How has COVID-19 impacted your National Program's**

   No problems with floats deployment and recovery.

Portuguese Argo Activities

Report 2022 for the 24th Argo Steering Team Meeting (AST24)

Submitted by A. Miguel Piecho-Santos

IPMA-Portuguese Institute for the Sea and the Atmosphere
and CCMAR-Centre of Marine Sciences Univ. Algarve

March 2023

Activities

1. Participation in the European project "Euro-Argo Research Infrastructure Sustainability and Enhancement (Euro-Argo RISE)", namely in the WP2-Evolution of the core Argo mission / Task 2.3-Improve Argo observation of boundary regions. In this context, an article is in preparation about the simulations of the best Argo floats configurations to maximise their retention in the Gulf of Cadiz, NE Atlantic, using the VirtualFleet software and a "genetic" algorithm;

2. IPMA acquired, at the end of 2022, four core Argo floats, one full biogeochemical (BGC) Argo float and one BGC Argo float with dissolved oxygen sensor only. These floats are foreseen to be deployed during the first semester of 2023, namely the four core Argo floats in the Gulf of Cadiz (Fig. 1 and Table 1) and the BGC in route from Mainland Portugal to the Azores Islands, in the frame of the "Atlantic Observatory- Data and Monitoring Infrastructure" project[1] summer school on "Ocean Observing Systems and the Mediterranean Water Outflow";

3. The EuroGOOS Argo Task Team has been renewed during 2022 with the kick off meeting to be held on February 7th, 2023. The Task Team is Co-Chaired by A. Miguel Santos (IPMA, Portugal) and Griet Neukermans (University of Ghent, Belgium) and integrates the Euro-Argo ERIC into the EuroGOOS framework to mutually

[1] https://www.ipma.pt/en/investigacao/eeagrants/detail.jsp?f=/en/investigacao/eeagrants/atlanticobservatory.xml and https://www.eeagrants.gov.pt/en/programmes/blue-growth/projects/pre-definided-projects/data-and-monitoring-infrastructure/

coordinate actions related to operational oceanography. The main objective of the Task Team is to facilitate interactions between non-Euro-Argo ERIC institutes/countries and the Euro-Argo ERIC governance structure, especially the Management Board. For more information, please visit https://eurogoos.eu/eurogoos-argo-task-team/.

4. Contacts have been started with the Portuguese Ministry of Economy and the Sea to begin the process of Portugal Euro-Argo ERIC membership.

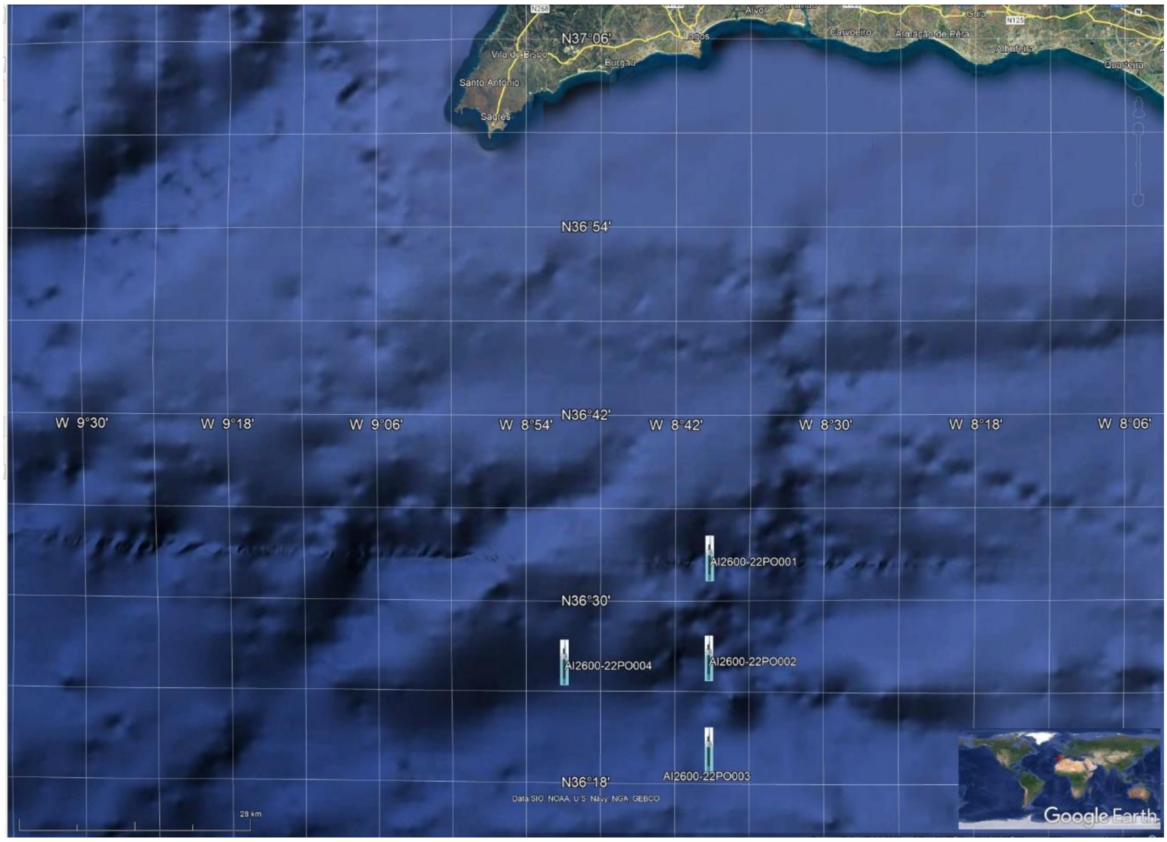


Figure 1. Foreseen deployments of the four core Argo floats in the Gulf of Cadiz during the first semester of 2023 (see Table 1 for actual locations).

Table 1 – Locations for the deployment of the four core Argo floats in the Gulf of Cadiz, during the first semester of 2023

Cruise: **ARGO.PT**	1-3 March 2023				
Float serial number	**lat**	**long**	**lat**	**long**	**depth (m)**
AI2600-22PO001	36°32'51.54"N	8°39'21.70"W	36.54765	-8.65603	2110
AI2600-22PO002	36°26'29.75"N	8°39'26.01"W	36.44160	-8.65723	2076
AI2600-22PO003	36°20'37.47"N	8°39'26.45"W	36.34374	-8.65735	2770
AI2600-22PO004	36°26'13.77"N	8°50'52.88"W	36.43716	-8.84802	2500

Plans for 2023

1. Deployment of the four core Argo floats in the Gulf of Cadiz;
2. Deployment of two BGC Argo floats between Portugal Mainland and the Azores Islands;
3. Publish Le Jeune et al.(in preparation) paper to be submitted to *Oceans*, during the first semester of 2023;
4. Preparation of proposals to fund the consolidation and the continuation of ARGO.PT, the Portuguese contribution to the Argo Program;
5. Continuation of the process of Portugal Euro-Argo ERIC membership;
6. Under EuroGOOS Argo Task Team it is foreseen the following activities for 2023:
    - ACTION 1: Liaise with Euro-Argo ERIC to arrange joint TT-MB meeting online in June or September 2023 (Co-Chairs, 28th February 2023);
    - ACTION 2: Liaise with Euro-Argo ERIC to initiate planning for a DMQC training course or workshop for TT and ERIC members (M Santos, summer 2023);

- ACTION 3: Prepare short news item announcing kick off of renewed TT (Co-Chairs and J Nolan, February 2023);

- ACTION 4: Develop a procedure for TT members to efficiently share plans for Argo float deployments with each other (Co-Chairs, summer 2023);

- ACTION 5: Present Argo float information from TT members (extracted from OceanOPS) on the Argo TT webpage (Co-Chairs and J Nolan, 2023);

- ACTION 6: Prepare report on TT activities for the EuroGOOS General Assembly (Co-Chairs, May 2023).

References

Le Jeune, M., Piecho-Santos, A.M., Balem, K., Maze, G. (in preparation). Monitoring the Gulf of Cadiz, NE Atlantic, with Argo floats. To be submitted to *Oceans*.

National Reports for Argo Steering Team Meetings

South Africa

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)
    a. floats deployed and their performance

    Argo floats deployed on behalf of other countries which will be reported in those country reports.

    b. technical problems encountered and solved

    Not applicable

    c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

    Not applicable

    d. status of delayed mode quality control process

    Not applicable

2. Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)

    Present level – no funding

    Future prospects – through the South African National Polar Infrastructure (SAPRI) and initiatives to increase observations within the Agulhas Current (WBC), we are looking to procure and deploy Argo floats. Likely Core Argo floats only.

3. Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

    Argo floats deployed on behalf of other countries which will be reported in those country reports.

    Here is a link to the commitments table at OceanOPS (if the link isn't working, visit OceanOPS and choose 'commitments' from the farthest right icon at the top of the page). If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

4. Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.

    - **Finalizing Core Argo Best Practice Document**
    - **Organizing a national (regional) Argo training course for June 2023**
    - **Argo data being used for student projects.**

5. Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

    None currently.

6. To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.

    Data from the SEAmester training cruise (July 2022) was loaded onto the CCHDO. This included nine CTD stations – two of which were collocated with UK MetOffice Argo float deployments (WMO#1901940 and WMO#1901941). Stations are not however very deep.

    Data from the Marion Island (Indian Ocean sector of the Southern Ocean) and potentially the SAMBA cruise (South Atlantic) will be loaded in due course.

7. Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.
    There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

    None currently.

8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

   No impacts – we continued to deploy where and when we could on take-over voyages to Gough and Marion Islands and Antarctica.

9. Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats will you be buying in 2023 and 2024 (if known) and where they might be deployed.

   Not at this stage.

Argo-Spain National Report 2022

Alberto González (IEO-CSIC), Lara Díaz-Barroso (SOCIB), Irene Lizarán (SOCIB), Pedro Vélez-Belchí (IEO-CSIC), Joaquín Tintoré (SOCIB)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2022)

a. floats deployed and their performance

The contribution of Argo Spain to extend the international Argo network during 2022 was focused on the Western Mediterranean Sea, deploying a total of one float. This deployment mission was coordinated by the Balearic Islands Coastal Observing and Forecasting System (SOCIB) and the Spanish Institute of Oceanography (IEO-CSIC), and developed by SOCIB.

In November 2022, during the Canales Autumn 2022 oceanographic cruise, Spain launched one Core float from the deck of the vessel R/V SOCIB. The float (WMO 3902467) was deployed in the Mallorca Channel at coordinates 39° 16.30’N and 01° 59.22’E, as shown in Figure 1.

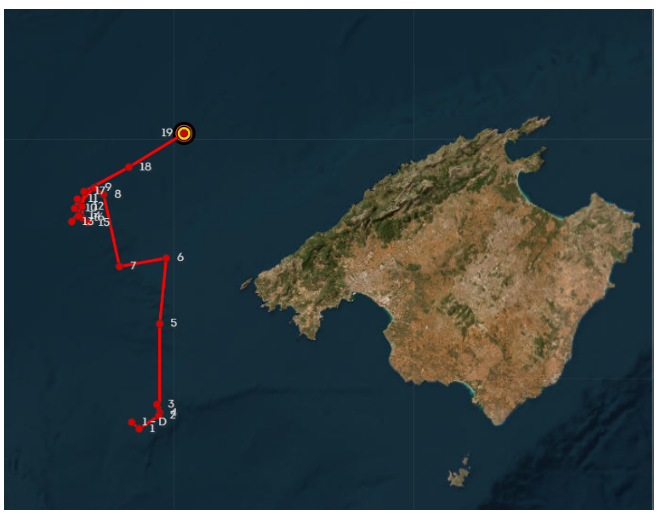


Figure 1. Position of deployment and trajectory of the WMO 3902467 deployed float in the Mallorca Channel in November 2022 (Source: Argo Fleet Monitoring, Euro-Argo).

The deployed float was an Arvor-I platform with an Iridium transmission system. The parking depth was set at 1000 dbar and the profile depth at 2000 dbar. The float works in a 5-day cycle. At the end of 2022 the float transmitted a total of 9 profiles.

In addition, twenty Spanish floats have been active during 2022 in the Western Mediterranean and Atlantic Ocean.

b. technical problems encountered and solved

SOCIB had planned to deploy three floats in 2022, but only one was successfully deployed and remains active as mentioned in the previous section. Unfortunately, the other two floats encountered problems both before and after deployment.

One Core float (WMO 4903635) was deployed during the Canales Summer 2022 oceanographic cruise on board the R/V SOCIB, but it didn't transmit any data since deployment. After 6 months without communication, the status of this float was changed to "closed" (considered dead upon deployment). NKE is taking care of it

The other Core float (WMO 3902466) experienced issues during the pre-deployment testing phase. It is now in the manufacturer's laboratory undergoing diagnostic testing, which has confirmed the need to refurbish the hydraulic group. Transmission testing has shown that it is fully operational, but they also found that the conductivity cell was contaminated and will need to be cleaned following the SBE application note to check if it can be restored to a good state.

The IEO-CSIC planned to send an NKE two Core iridium floats that experienced problems. One of them gave data transmission failures in the pre-deployment phase, while the other one was stranded on a beach; the sensors needed to be cleaned/checked.

c. status of contributions to Argo data management (including status of high salinity drift floats, decoding difficulties, ramping up to include BGC or Deep floats, etc)

After each deployment, detailed technical information is provided to the DAC in charge of the floats (Coriolis) and the AIC. The Argo-Spain program is aware of the changes in the technical and metadata data formats and is providing the necessary information.

d. status of delayed mode quality control process

Argo-Spain mainly deploys floats in the Atlantic Ocean and the Mediterranean Sea. In terms of DMQC, Argo-Spain manages its floats that operate in the Atlantic Ocean and the Instituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) manages all the floats that operate in the Mediterranean Sea, including floats of Argo-Spain. The DMQC of the Argo-Spain floats that operate in the Mediterranean Sea will be assumed by Argo-Spain itself at some point, subject to personnel availability. In successive meetings, a transfer of DMQC knowledge from the IEO-CSIC to the SOCIB will be scheduled so that SOCIB is in charge of the DMQC of the Argo Spain profilers deployed in the Mediterranean.

Argo-Spain fleet is composed of 98 floats deployed so far. A total of 62 floats have been deployed in the Atlantic Ocean and 29 floats deployed in the Mediterranean Sea.

In terms of DMQC, the efforts during 2022 were directed to process the data of 4 Deep Argo floats, according to the requirements of the Deep Argo community. Two of them belonged to Argo Spain (WMO 6901246 and 6901248), while the remaining two were managed by Euro-Argo (WMO 3902126 and 3902127).

2. **Present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo, and funding for sustaining the OneArgo mission: Core, BGC, Deep, Spatial (Polar, equator, WBCs)**

Spain has participated in the international Argo program since its inception and is currently a member of the European Research Infrastructure Consortium Euro-Argo (ERIC). Spanish participation in Argo began in 2002 through a first European project, and a total of 98 Argo profilers have been deployed in the North Atlantic and the Mediterranean Sea since then.

In 2022, the agreement was renovated between the Ministry of Science and Innovation, IEO-CSIC and SOCIB (https://www.boe.es/boe/dias/2022/09/06/pdfs/BOE-A-2022-14622.pdf), assuming the financial commitment that Spain participates as a full member of the ERIC Euro-Argo. The interest in such participation was demonstrated in the process of prioritizing Spain's participation in European research infrastructures, as detailed in the document on the Spanish Strategy for participation in scientific infrastructures and international organizations.

However, the Argo-Spain program does not have proper long-term funding for deployments of Argo floats. The contribution to the Euro-Argo ERIC is secured and sustained, based on IEO-CSIC's access to infrastructures calls from the Spanish Ministry of Science, Innovation, and Universities and from the SOCIB's contribution, which has ensured deployments of at least 3 floats per year since 2015. The IEO-CSIC funds the scientific coordination (1.5 person/month per year) and the transmission costs.

At the end of 2021, SOCIB received funding from NextGenerationEU/PRTR that ensured the purchase and deployment of three floats during 2022.

The personnel of Argo-Spain during 2022 consisted of the following individuals from IEO-CSIC and SOCIB:

IEO-CSIC:

- 1 technician working 50% of their time.
- 1 Principal Investigator (PI) working 50% of their time.

SOCIB:

- 1 full-time technician working on the EA-RISE project
- 1 technician working 15% of their time
- 1 scientific advisor working 15% of their time
- 1 PI working 10% of their time

3. **Summary of deployment plans (level of commitment, areas of float deployment, Argo missions and extensions) and other commitments to Argo (data management) for the upcoming year and beyond where possible.**

   Here is a link to the commitments table at OceanOPS (if the link isn't working, visit OceanOPS and choose 'commitments' from the farthest right icon at the top of the page). If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

SOCIB aims to launch two Core floats in the Mediterranean Sea. To achieve this, a new float to be purchased in 2023 and the float that is currently being repaired at the NKE laboratory will be used.

The IEO-CSIC awaits the imminent reception of a total of twelve (12) new floats by the Ministry of Science and Innovation, which will be launched along different oceanographic cruises during 2023 and 2024. Two (2) of them will be part of the Deep Argo mission and another two (2) of the BGC Argo mission. The rest will be core floats with iridium transmission. The remaining eight (8) floats (iridium transmission system) will contribute to the core mission. Based on scientific requirements, the IEO-CSIC is currently in talks with different PIs, but the deployment areas will focus on the North Atlantic Ocean, with agreed locations such as the Canary Islands region, the Galician Bank or the Gulf of Cádiz. The use of vessels of opportunity to launch floats in the South Atlantic is also contemplated. These plans have already been communicated and registered in OceanOPS.

4. **Summary of national research and operational uses of Argo data as well as contributions to Argo Regional Centers. Please also include any links to national program Argo web pages to update links on the AST and AIC websites.**

Argo is used by many Spanish researchers to improve the understanding of climate and ocean variability. Operational ocean forecast models also use Argo data for model assessments and model improvement through data assimilation (e.g. The Western Mediterranean OPerational forecasting system - WMOP -, the Atlantic-Iberian Biscay Irish-Ocean Physics Analysis and Forecast - IBI-MFC - and Mediterranean Sea Physics Reanalysis - Med MFC -). The web page of the Argo Spain program is: http://www.argoespana.es

5. **Issues that your country wishes to be considered and resolved by the Argo Steering Team regarding the international operation of Argo. These might include tasks performed by OceanOPS, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report. Also, during the AST-24 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.**

No issues.

6. **To continue improving the quality and quantity of CTD cruise data being added to the reference database by Argo PIs, it is requested that you include any CTD station data that was taken at the time of float deployments this year. Additionally, please list CTD data (calibrated with bottle data) taken by your country in the past year that may be added to the reference database. These cruises could be ones designated for Argo calibration purposes only or could be cruises that are open to the public. To help CCHDO track down this data, please list the dates of the cruise and the PI to contact about the data.**

A CTD cast is performed after most of the Argo-Spain deployments.

7. **Keeping the Argo bibliography (Bibliography | Argo (ucsd.edu)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort, please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.**
   There is also the thesis citation list (Thesis Citations | Argo (ucsd.edu)). If you know of any doctorate theses published in your country that are missing from the list, please let me know.

Martínez, J., Gabarró, C., Turiel, A., González-Gambau, V., Umbert, M., Hoareau, N., et al. (2022). Improved BEC SMOS Arctic Sea Surface Salinity product v3.1. *Earth Syst. Sci. Data* 14, 307–323. doi: 10.5194/essd-14-307-2022.

Olmedo, E., Turiel, A., González-Gambau, V., González-Haro, C., García-Espriu, A., Gabarró, C., et al. (2022). Increasing stratification as observed by satellite sea surface salinity measurements. *Sci Rep* 12, 6279. doi: 10.1038/s41598-022-10265-1.

González-Santana, J.A.; Thierry, V.; Amice, M.; André, X.; et al. ASSESSING THE EXTENSION OF THE ARGO ARRAY TOWARDS THE DEEP OCEAN: AN ANALYSIS OF THE LONG-TERM STABILITY AND ACCURACY OF THE SBE61, SBE41 AND RBR SENSORS (2022). Poster communication: hdl.handle.net/10508/16167

Pelegrí, J.L., Hernández-Guerra, A., Vélez-Belchí, P. et al. SAGA: THE SOUTH ATLANTIC GATEWAY. Congress communication: https://bit.ly/3IKYSMj

Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

None.

8. **How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.**

No problems with float's deployment and recovery.

9. **Does your National Program have any deployment plans for RBR floats in the next couple years? If so, please indicate how many floats you will be buying in 2023 and 2024 (if known) and where they might be deployed.**

At the moment, this option is not contemplated in the short term.

U.S. Argo National Report to AST-24, March 2024

Organization of U.S. Argo:

The U.S. Argo Consortium is supported with major funding provided by the National Oceanic and Atmospheric Administration (NOAA), and additional participation of the U.S. Navy. The consortium includes principal investigators from six institutions: Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI), the University of Washington (UW), the Atlantic Oceanographic and Meteorological Laboratory (AOML), the Pacific Marine Environmental Laboratory (PMEL), and the Naval Research Laboratory (NRL/Monterey). Float technology development, production, acquisition, logistics, deployment, array monitoring, and data management functions are distributed among these institutions on a collaborative basis.

In addition to the float-providing and data management activities, the U.S. Argo Consortium works collaboratively with closely related programs including:

- Global Ocean Biogeochemistry array (GO-BGC), supported by NSF to establish the baseline rates of photosynthetic production, respiration, and nutrient supply in present ocean ecosystems.
- Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM), a regional pilot array of BGC Argo floats supported by NSF and NOAA.
- Argo New Zealand is the largest deployer of U.S. Argo floats through designed deployment voyages of RV Kaharoa (jointly supported by Argo USA, New Zealand, and Australia) and deployment opportunities on RV Tangaroa.
- A NOPP project for validation and improvement of the Deep Argo SBE-61 CTD.
- A NOPP project for development of a BGC SOLO float.
- A NOPP project for the development of new BGC sensors and improvement of the SBE Navis platform.
- A partnership of NOAA/PMEL and the Paul G Allen Family Foundation that provided 33 Deep Argo floats and deployments of many of those in the Brazil Basin.
- National Academy of Sciences Gulf Research Program's support for 25 Argo floats in the Gulf of Mexico.
- A cooperatively funded and dedicated Atlantic charter to help ameliorate COVID impacts on vessel access during 2020/2021. Euro-Argo, Argo Canada and US Argo supported the charter, which has deployed ~ 90 floats, mostly into the Southeastern Atlantic.

The contributions of these and other Argo partner projects are gratefully acknowledged.

Another 5-year cycle of U.S. Argo Consortium implementation began in July 2020, and extends through June 2024. The Work Plan for this cycle of U.S. Argo includes milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep international Argo Program termed *OneArgo*.

Objectives:

The U.S. Argo Consortium is funded by NOAA on a year-to-year basis. There is uncertainty in the level of funding that will be available to support the 5-year Work Plan. The projections included in the Plan are optimistic. The assumptions guiding Work Plan scenarios were that (i) Core Argo budgets should increase by 10% per year above the FY2019 institutional funding levels, and (ii) incremental funding of $1M per year will be available for each of the U.S. Consortium Deep and BGC Argo Programs. The increases for Core Argo are meant first to restore a healthy number of deployments for sustaining the Core Argo array, and second to fund coverage increases, beginning with those proposed for high latitudes and the equatorial Pacific. A distribution of institutional effort between the Deep and BGC programs has been planned by the U.S. Argo Consortium institutional partners. All float-providing institutions will participate in both Deep and BGC Programs, and the U.S. Argo DAC will carry out the corresponding data management. Actual funding levels are likely to be less than the ideal scenarios, in which case the highest priority will be sustaining the Core Argo array.

Status of U.S. Core Argo implementation:

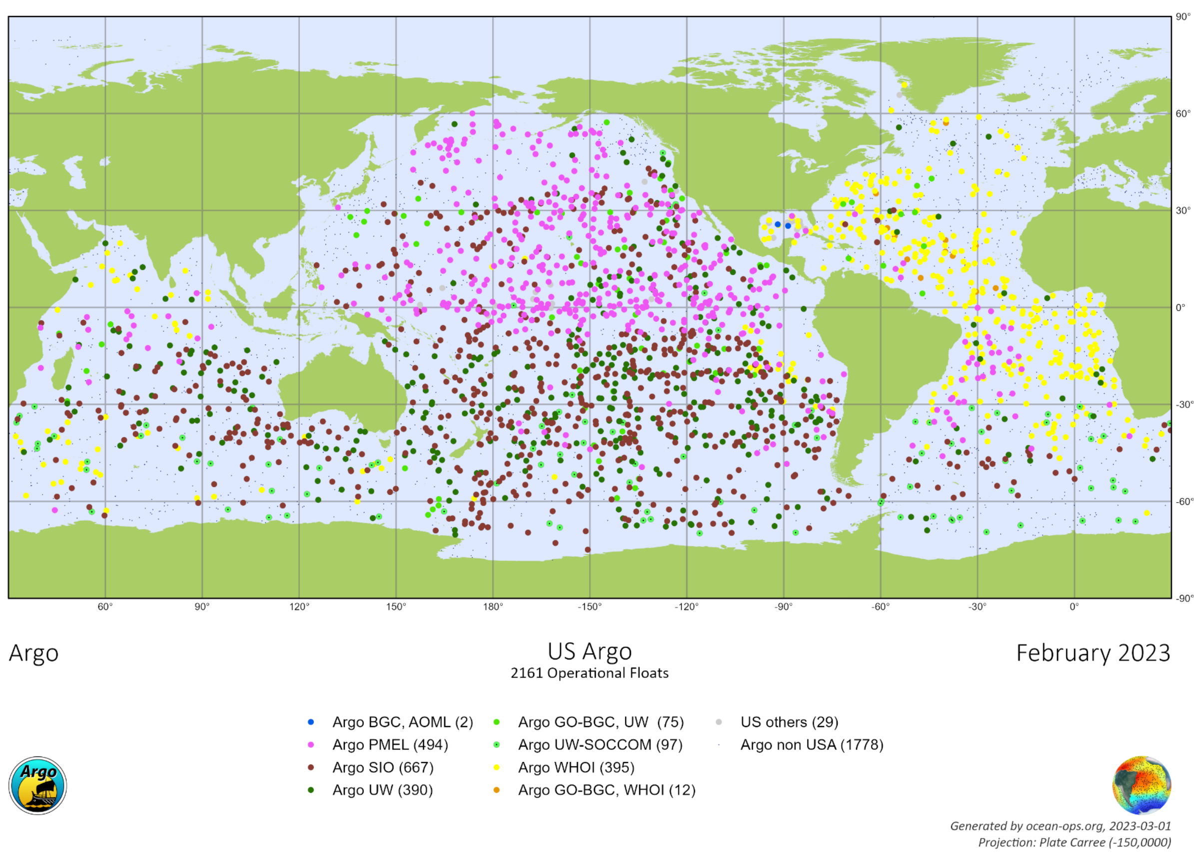


Fig. 1*: Location of operational U.S. Argo Program, SOCCOM, GO-BGC, and other U.S. Argo Equivalent floats as of January 2022 (Source: OceanOPS).*

As of February 2023, there were 2161 operational U.S. Argo floats (Fig. 1), mostly provided by the U.S. Argo Consortium, with substantial contributions from SOCCOM and GO-BGC. Support levels for Core U.S. Argo floats have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have nearly been offset by increases in Core Argo float lifetime, with over 75% of floats deployed as far back as 2016 still operational as of March 2023 (Table 1). Hence the number of operational U.S. Argo floats, which peaked at around 2200 in 2016 and 2017, decreased gradually to about 2150 in 2020, and has been relatively steady since then (Fig. 2).

Further increases in lifetime are expected through continuing identification of short-term and long-term failure modes and improved battery technologies. However, the present number of yearly deployments may not be sufficient to sustain the level of U.S. Argo floats.

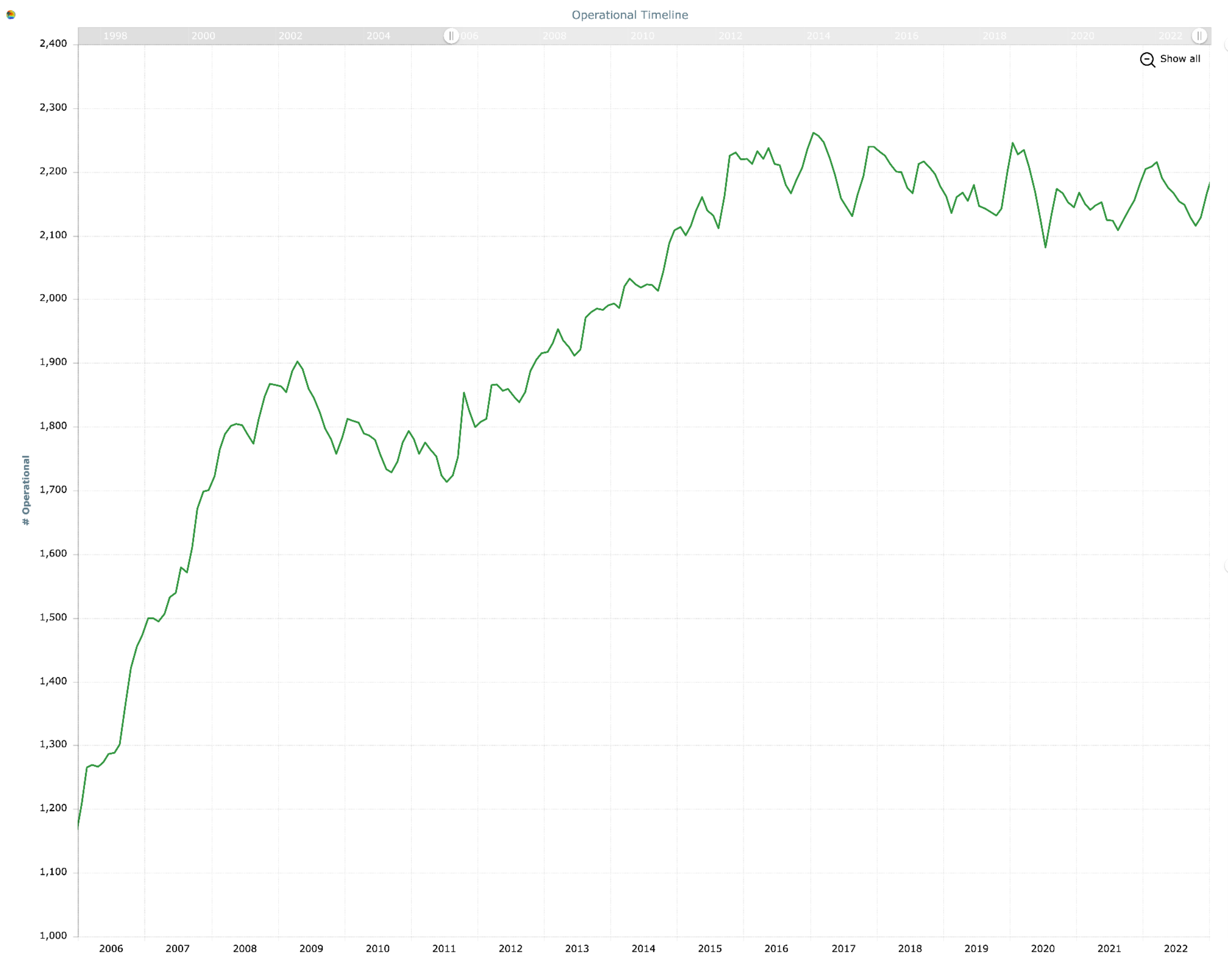


Fig. 2: *Timeline of the number of operational U.S. Argo floats since 2006 as of March 2023 (Source: OceanOPS).*

Year deployed	Number deployed	Number active as of 2/2022	% active (2/2022)
2013	306	2	1%
2014	366	34	9%
2015	335	163	49%

2016	315	236	75%
2017	331	261	79%
2018	256	193	75%
2019	259	213	82%
2020	256	224	88%
2021	257	218	85%
2022	265	214	81%

Table 1: *Number of U.S. Core Argo floats deployed in each year from 2013 through 2022 and the number still active as of March 2023 (Source: OceanOPS). A major focus of the U.S. Argo Consortium is extension of float lifetimes and reduction of early float failures.*

Impacts of the Covid-19 pandemic included limitations on all institutional laboratory activities for physical distancing, a substantial reduction in available deployment opportunities by the research fleet, supply chain difficulties that have adversely affected float manufacture, and sea freight delays. Nonetheless, the relatively long life of Argo floats mitigated the Covid-19 reduction in activities, as illustrated by the continuing nearly-constant number of active US Argo Program floats (Fig. 2). Many of the Covid-19 impacts persist even now, but there were 265 US Argo Program Core Argo floats deployed during 2022 (Table 1, Figure 3), slightly up from the totals of the previous few years.

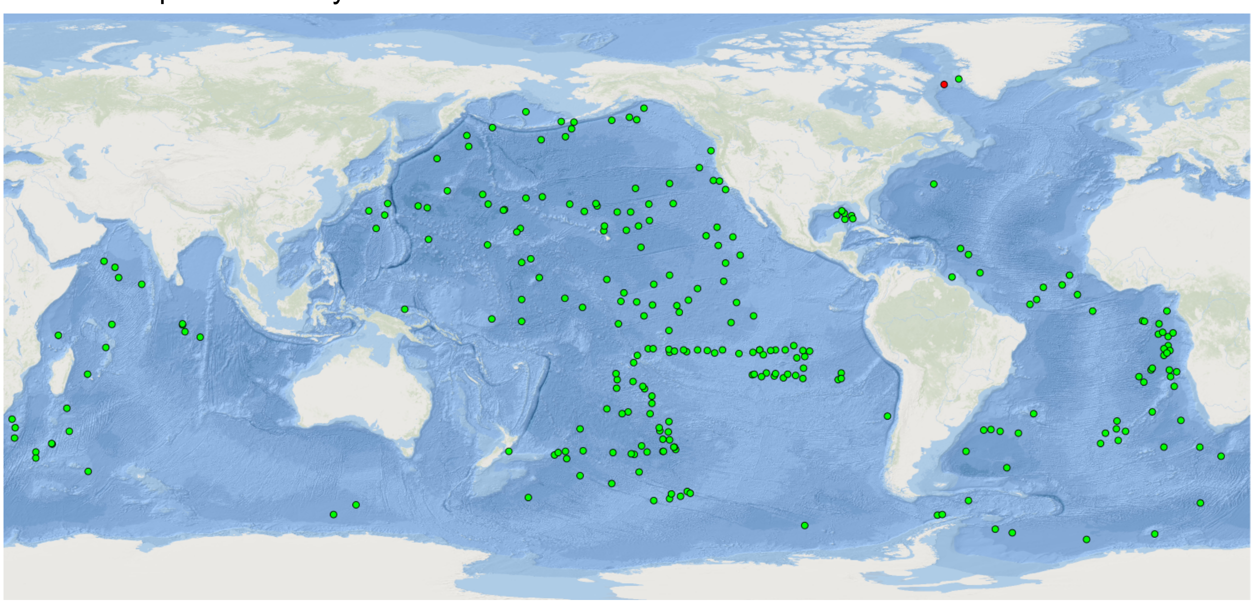


Fig. 3: *March 2023 location of US Argo floats deployed during 2022 (Source: OceanOPS).*

Support for the U.S. Argo Consortium includes float production and deployment; technology improvement; communications; data system development and implementation for real-time and delayed-mode data streams; participation in international Argo coordination, technical workshop, and science workshops; contributions to Regional Centers; and outreach activities. Work is ongoing to assess the accuracy of CTD data used for the core Argo mission. Salinity drift in recent cohorts of Argo floats is being closely monitored collaboratively with the CTD manufacturer. An alternative Core CTD manufacturer is entering pilot status with the intent of limiting risk to the Argo Program. The U.S. Argo Consortium is actively involved in testing, quantifying sensor biases, and contributing to the pilot array of RBR CTD equipped floats.

Deep Argo:

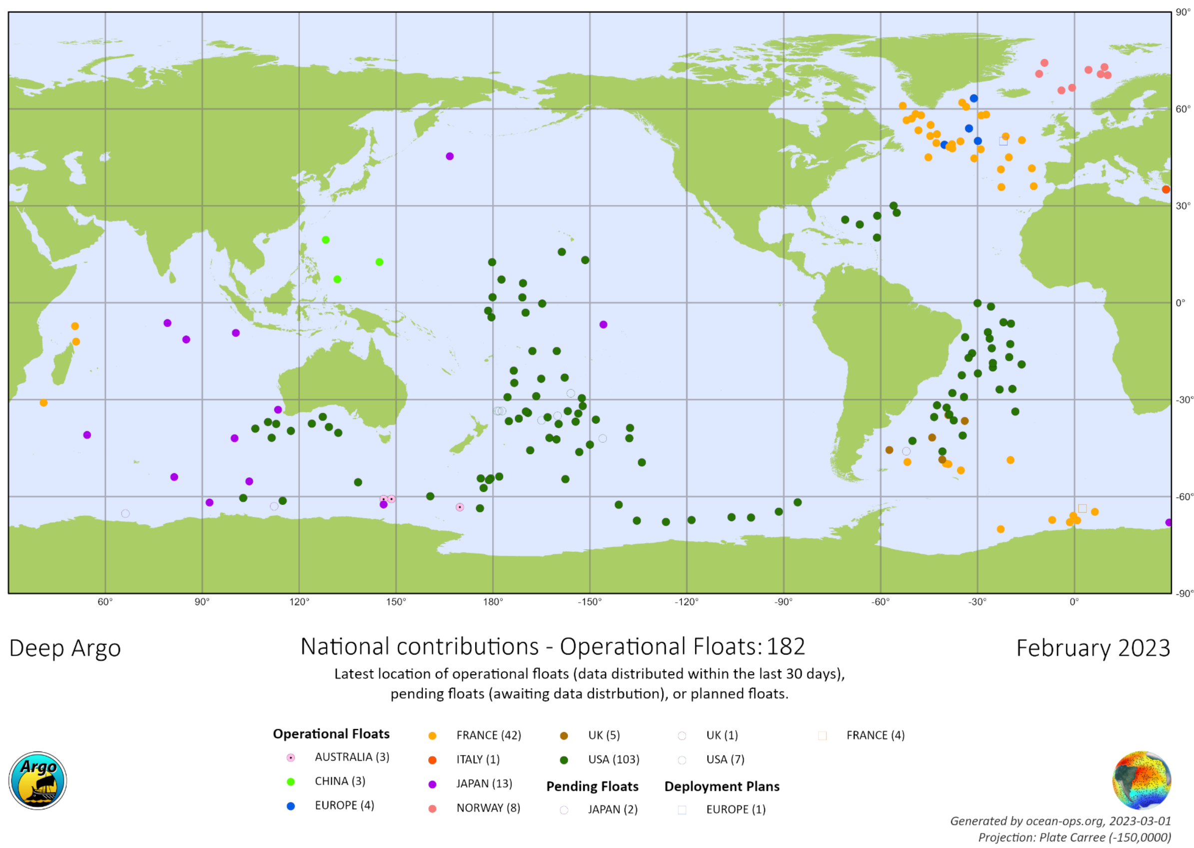


***Fig. 4**: Location of all 182 active Deep Argo floats, as of February 2023, by National Program, with the 103 active U.S. Deep Argo floats indicated by dark green symbols (Source: OceanOPS).*

In 2011–2015, the U.S. Argo Consortium carried out development and testing of Deep Argo floats, with successful prototype float deployments in 2013–2015. U.S. Deep Argo floats profile to pressures as great as 6000 dbar, and recent versions with hybrid lithium batteries are capable of more than 200 cycles. Deployment of U.S. Deep Argo regional pilot arrays began in the SW Pacific Basin in 2016, in the South Australian Basin in late 2016, in the western North Atlantic in early 2017, in the Australian Antarctic Basin in early 2018, in the western South Atlantic in 2019, and in the SE Pacific Sector of the Southern Ocean in early 2023 (Fig. 4).

Testing of Deep Argo float models continues as well as testing of SBE-61 CTD accuracy and stability. The SBE-61 has not yet achieved its aspirational goals of ± .001°C, ±.002 psu, and ± 4 dbar, but is progressing relative to those goals. In partnership with U.S. Argo, a 3-year National Ocean Partnership Program award is funded for improvement of the SBE-61. A collaborative

U.S./New Zealand/SeaBird Scientific cruise on RV Tangaroa will take place in April 2023 for testing/validation of new SBE-61 conductivity and pressure sensors.

BGC Argo:

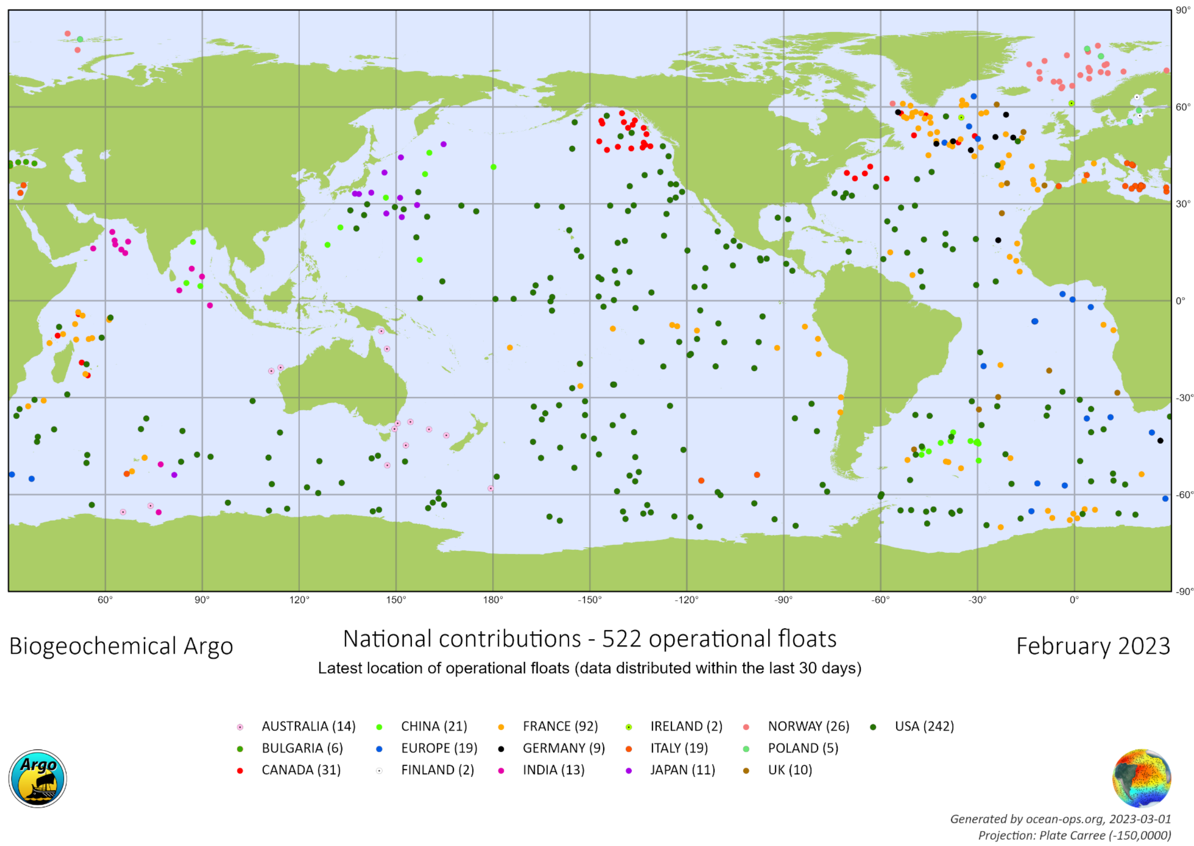


Fig. 5: *Locations of 522 active BGC-Argo floats as of February 2023, including 242 US Argo floats, mostly from SOCCOM and GO-BGC. US BGC floats are indicated as dark green symbols (Source: OceanOPS).*

Since 2012 the U.S. Argo Consortium has carried out testing and deployment of Biogeochemical (BGC) Argo floats. The present versions of these floats cycle 0–2000 m at 10-day intervals and, in addition to the CTD, may carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. A major NSF proposal (SOCCOM) started in 2014 to deploy a 200-float array of BGC floats in the Southern Ocean. A second major NSF proposal (GO-BGC) has recently been funded for global deployments of up to 500 BGC floats over a 5-year period. Two funded NOPP proposals between 2020-2023 have implemented technology improvements to the BGC SOLO and BGC NAVIS Argo float models and have deployed 15 BGC floats in the equatorial pacific. As of February 2023, US BGC floats, mostly from SOCCOM and GO-BGC, with a few US Argo Consortium contributions, number 242 of the total 522 active BGC Argo floats (Fig. 5), of which 192 measure at least five BGC variables.

Plans:

The highest priority for the U.S. Argo Consortium is to sustain the Core Argo array, but maintenance of Regional pilot arrays for Deep and BGC Argo will continue in 2023. Specific plans for float deployments in 2023, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Consortium in FY2023 are not yet finalized but are expected to at least equal FY2022 levels.

Deployments are planned along the new RV Kaharoa delivery voyage from Spain to New Zealand(Fig. 6) tentatively planned beginning in January 2024. The ship will deploy ~150 Argo floats (mostly US floats with some float contributions from Australia) along the transit, including 6 US Deep floats. Since 2004, 25 voyages on RV Kaharoa have deployed at least 2172 Argo floats (Source: OceanOPS).

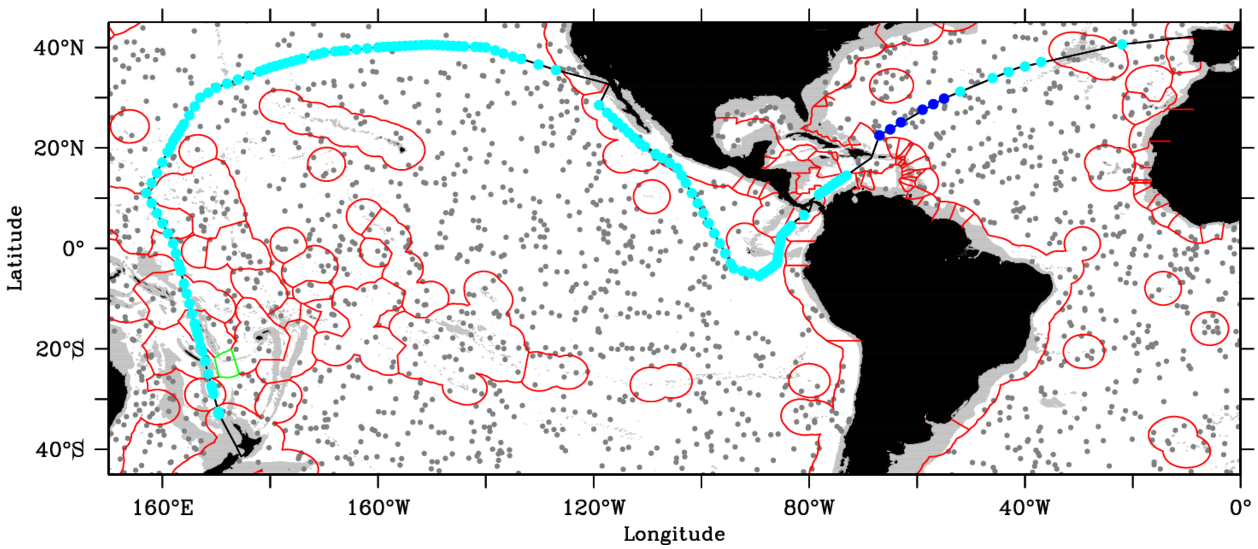


Fig. 6: *Tentative cruise track and deployment plan for the New Kaharoa delivery voyage with planned core (cyan) and Deep (Blue) locations indicated. Existing float locations are shown as gray dots.*

Data management

The U.S. Argo Data Assembly Center (DAC) is based at NOAA/AOML. Real-time data from all U.S. Argo floats are distributed via the GTS and to the Global Data Assembly Centers (GDACs). The systems developed at AOML are operational on a primary server housed at AOML and also run on AOML's Argo mirror server at a cloud service provider. These systems apply internationally-agreed Argo-specific quality control tests and generate data files for the user communities that comply with the Argo standards. The U.S. Argo DAC has expanded its decoding and quality control capabilities to include the full suite of BGC data, currently able to accept BGC data from APEX, NAVIS and SOLO-family floats. Delayed-mode quality control and other data management functions of the core parameters are carried out by the float-providing institutions. The real time and delayed mode adjustment of the BGC parameters for GO-BGC and SOCCOM floats are performed at MBARI. The AOML data center serves as the national focus for data management and is the conduit for delayed-mode data to pass between the PIs and the GDACs.

In addition to the national DAC, a GDAC is run as part of the GODAE server, located at the Naval Research Laboratory, Monterey. The two GDACs at NRL/Monterey and IFREMER/Brest are mirror images in their assemblies of Argo data from all international partners, and are responsible for dissemination of the data. Several U.S. institutions participate in Argo Regional Center activities.

UK ARGO PROGRAMME

REPORT FOR 24TH ARGO STEERING TEAM MEETING MARCH 2023

1. Status of Implementation

Floats deployed and their performance

During 2022 we were able to deploy 32 floats; of these 25 were standard core APEX, six were BGC floats, and one SOLO II Deep float. Deployments have recovered well from 2021, when research cruise schedules remained heavily impacted by COVID-19.

Since the end of 2022, to end February 2023, we have deployed 16 floats: 14 core APEX and two BGC PROVOR floats.

As of 28th February 2023, the UK has 144 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 2.

In addition, we have four floats that are operational, but the real time data processing is not yet set up: two NAVIS BGCi, one BGC PROVOR-Jumbo and one Deep SOLO.

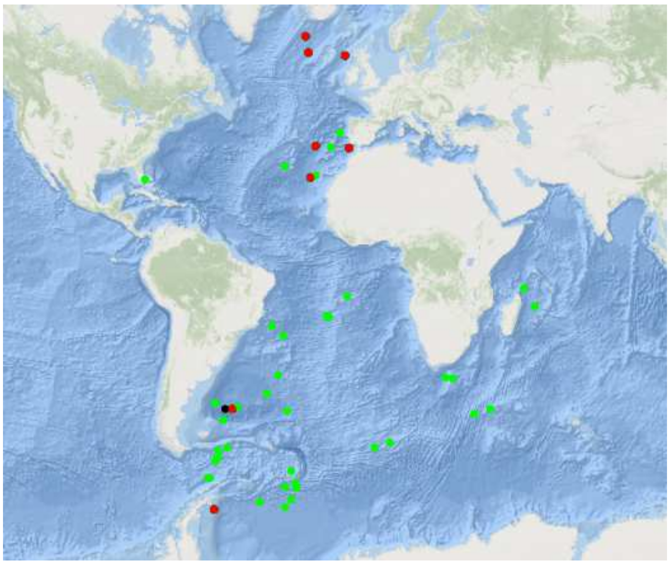


Figure 1. Showing the latest reported locations of 48 UK Argo floats deployed between 1st January 2022 and 28 February 2023, core APEX floats in green (39), APEX-Deep in black (1), BGC floats in red (8).

Of the 48 floats deployed between 1st January 2022 and end February 2023 we have had two float failures: core APEX SN 9194 (6903757) failed immediately after deployment. NAVIS BGC SN F1242 suffered failure of its nitrate sensor immediately after deployment and the float was recovered a few days later. We intend to fix it and redeploy in May 2023 at the PAP mooring site.

At end February 2023 the 144 operational floats returning data include:

- 115 core APEX with SBE CTDs
- 9 core APEX with the RBR sensor
- 1 core NAVIS
- 4 NAVIS with oxygen
- 5 APEX DEEP
- 5 NAVIS BGCi
- 5 PROVOR CTS4s

In addition, as noted above, there are four active floats for which data processing is not yet set up.

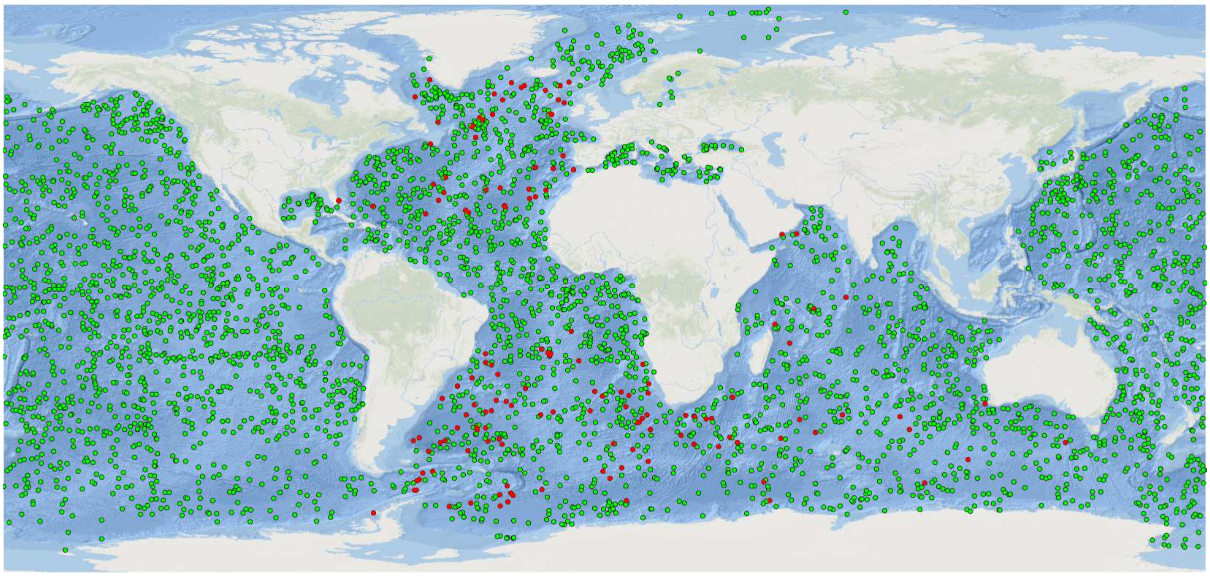


Figure 2. Showing the locations of all UK floats delivering data (144) in red with the global network of 3,936 floats in green, as of 28 February 2023.

Technical problems encountered and solved

APEX Core

We had deployed 16 APEX floats that are at risk of a fast salty drift, these were deployed before the problem was known. Of these 16, eight are no longer operating (at 3rd March 2023). Of the surviving eight, one is on the grey list for PSAL drift, and seven are mostly passing real time QC with flags of 1. We still have five undeployed APEX floats that are at risk of the fast salty drift problem. These have been returned to Teledyne Webb and we are awaiting their repair and return.

For some time, we've noticed that many of our APF11i floats often fail to make a GPS fix when delivering the profile data, but have the second fix, taken prior to diving, reported in the following cycle in 10 days' time. We retrieve this fix to enable us to process the previous profile's data, but it always means that the profile is 10 days late on the GDAC and at the GTS impacting timeliness. It has been noticed that there has been a new aerial design on APF11i floats, and we wonder if the antenna isn't always sufficiently clear of the surface during the time when the GPS fix is being made. At least 12 recently deployed APF11i floats are regularly affected.

APEX floats with RBR CTD

We procured our first six APEX-RBR floats in 2015. Five were deployed with three early failures, the other two failed in July and October 2022, having completed 228 and 241 cycles respectively. Two RBR-L3 replacements for the early failures were provided in 2020 and the third was upgraded to L3, these were deployed in the North Atlantic in December 2020 alongside one new APEX-RBR-L3, all four APEX-RBR-L3 are presently operating normally. We have deployed a further five APEX-RBR-L3 floats since March 2022, all five are operating well,

The data are being made available to Mat Dever at RBR, two of the floats were temporarily put onto 1Hz sampling in the top 100 dbar, to help Mat understand the lag characteristics. These have recently been reverted to normal sampling regimes.

We have nine APEX-RBR-L3 floats scheduled for deployment later in 2023, leaving two in Stores. All nine of our APEX floats currently on order will have RBR-L3 CTDs. After delivery to the UK during March 2023, all nine are allocated to various deployment locations around the Atlantic and Southern Ocean.

APEX Deep

We presently have six deep floats operating in the Argentine Basin region of the SW Atlantic, comprising four APEX Deep deployed in 2021, one APEX Deep deployed in 2020 and one Deep SOLO, deployed in December 2022. There are no plans to buy more deep floats at present. Data processing for the Deep SOLO needs to be set up at BODC, with guidance from Brian King and Colin Sauze (NOC).

Bio-geochemical Argo

We presently have 13 active BGC floats, with only three for which the data processing is not yet set up.

The Navis BGCi that was deployed in November 2020 near the Porcupine Abyssal Plain (PAP) mooring appears to be working well. However, the NAVIS BGCi deployed near PAP in April 2021 failed to report, despite SeaBird engineers clearing the float for deployment. An identical Navis BGCi float was deployed near PAP in May 2022 but was recovered as the nitrate sensor was not working. We will continue to work with SeaBird and attempt to deploy this float again during the PAP cruise in May 2023. Two other Navis BGCi floats were deployed in July 2022, both working normally, for which the data processing is not yet set up. BODC will address this in the coming months.

The 11 PROV-BIO floats purchased by PML in 2013 have all shown good longevity. The last remaining float died in October 2022, having completed 376 cycles. One of the floats from that batch has been recovered and awaiting refurbishment.

We deployed the first of our ASBAN 6-parameter PROV-BIO CTS4 floats in early 2022 with another four deployed up to 28th February 2023. A further eight 6-parameter BGC floats are scheduled for deployment during 2023, leaving two remaining in stock at NOC for future deployments. The ASBAN floats are all performing well so far, as are all of their sensors except for one pH sensor that appears to have failed, returning inconsistent data from the first profile. As part of the UEA PICCOLO project, we attempted to deploy two PROVOR-Jumbo CTS5 floats in the Weddell Sea in February 2023. One failed whilst still on deck and was not deployed. It will be returned to the UK for investigation. The other was successfully deployed and is active, but the data processing is not yet set up.

Status of contributions to Argo data management

Real-time data processing

As of 28th February 2023 the BODC were processing data from 210 floats, comprising 144 active UK floats, 16 Irish floats and 50 Euro-Argo MOCCA floats. Real-time processing is run four times a day with NetCDF files distributed to the GDACs and the Met Office, where the BUFR files are generated and disseminated via the WMO Global Telecommunications System (GTS). The capability now exists to include supplementary profiles and oxygen in the BUFR files. We expect to progress the extension of the BUFR capability to include other biogeochemical variables over the coming months.

BODC data managers and software developers attended the RBR RTQC online training in February 2023 to improve understanding of the corrections needed to be applied to RBR CTDs so that salinity data from BODC RBR floats can be delivered with QC=1. BODC continue to work with RBR on this implementation.

Recently, BODC developed their capacity enabling real-time processing of UK NKE Argo floats to the GDACs by using the Coriolis processing chain. Currently, BODC is processing five 6-parameter ASBAN PROV-BIO CTS4 floats. This development work will allow the data from the remaining ASBANUK floats to be delivered to the GDAC and GTS from deployment. BODC has also developed their capacity to deliver RT-adjustments of the BGC oxygen data. This has been already implemented for the ASBANUK Argo floats.

A focus and high priority for BODC over the coming year are: system development to deliver core Argo parameters for SeaBird Navis floats with N2 controllers, development to process recently deployed NKE PROV-BIO CTS-5 floats, development to process and deliver data from deep SOLO floats.

BODC delivers updated meta and tech files for all floats it processes alongside new core and BGC profile files to the GDACs as part of every processing run.

Delayed mode processing

Core Argo

From March 2022 until the time of writing this report, BODC has analysed and submitted around 3,452 core profiles. This includes profiles from 21 core Argo floats. BODC has also analysed and delivered D-mode data for 5 core Irish Argo floats (337 profiles).

The UK core Argo fleet data went through the international DMQC audit run by external partners from the DMQC core Argo group. The audit was motivated by the fact that a higher percentage of SBE CTDs are now experiencing sensor drifts, which may not be easily identifiable by only examining individual time series. All identified BODC profiles with some issues were reviewed. Any additional revisions or corrections have been completed and re-submitted to the GDACs. BODC was not able to resubmit the few remaining profiles from very old floats from the beginning of Argo project from early 2000s due to technical issues with the float data. Also, during the work undertaken within the SOARC data review in the Southern Ocean region there were some old UK Argo floats identified with incorrectly adjusted D-mode core data, these have been reviewed, improved and resubmitted to the GDAC.

BODC actively contributed to activities related to the Abrupt Salty Drift (ASD) group, focusing on estimating the best practices, guidance and examples of data affected by salinity sensor drift to produce optimal adjustment in delayed-mode. This involved contributing to updating the shared list of floats affected by the salty drift and reviewing documentation related to the draft version of best practices for DMQC operators of core Argo floats.

Deep Argo

NOC and BODC played a key role in coordinating the development of deep Argo mission. This covers contributions in compiling the new procedures for the real-time QC flag scheme and real-time adjustments on Deep Argo vertical profiles and procedures for DMQC of Deep Argo salinity data. Brian King is co-chair of the Deep Argo Mission Team.

BODC has started development work on automatically applying the CpCor correction for pressure effects on conductivity data of deep Argo floats (>2000 dbar) in the real-time QC process which was recommended by the Deep Argo team earlier in 2021. This step is required to perform further analysis of deep Argo floats in delayed mode. Due to very limited resources for data management in BODC, the real-time adjustments and delayed mode procedures has not been implemented in BODC processing workflow yet.

BODC and NOC have been actively involved in the coordination and organisation of DMQC for deep ocean data as a part of the EuroArgo Rise WP3, Task 3.2. This involved organisation and coordination of the intermediate meeting with other European partners within the task and providing a regular update of progress to the reporting body. By December 2022, NOC and BODC have successfully completed all their contributions to the Euro-Argo Rise project related to deep Argo extension (D3.4 and D3.5).

BGC Argo

BODC have developed their capability and upskilled their team at the 1st BGC DMQC workshop (January 2023) to be able to perform DMQC analysis of BGC Argo parameters. From January 2023, BODC have submitted 4,505 BGC oxygen Argo profiles to the GDAC, coming from 13 PROVBIO floats. BODC have successfully completed all of their contributions to Euro-Argo RISE project dedicated to the BGC Argo extension. Additionally, BODC helped in DMQC analysis of oxygen data of BGC Argo Poland fleet.

Southern Ocean Argo Regional Centre (SOARC)

SOARC activity has been limited to efforts towards deliverables in Euro Argo RISE. BODC and NOC have been working to establish a method of regional data quality assessment in the Southern Ocean. They have successfully completed their contribution to the Euro-Argo Rise project dedicated to the extension to the high latitudes.

The developed quality assessment method in the SO uses the pre-classified core Argo float and climatological data belonging to similar water mass regimes using the Profile Characterization Model (PCM) (Maze et al., 2017). The SO assessment software has been developed based on the code created within the Euro-Argo RISE WP2.4 project at Ifremer/LOPS. The output of this software, which is the pre-classified reference data, is further used in the DMQC software - OWC analysis. This method allows the DMQC operator to reduce noise from other water masses leading to a more robust quality control analysis of salinity data in delayed mode.

BODC have represented the works undertaken across other SOARC members at the ADMT23 meeting (December 2023). However, due to very limited resources in BODC they are not able to continue to lead this group.

Argo and the NERC Vocabulary Service (NVS)

BODC Argo has been continuing the work supporting the creation, management and implementation of NVS vocabularies into the Argo data system. This work has been funded under the EU Horizon 2020 ENVRI-FAIR project and is aimed at making Argo metadata interoperable and machine-readable. While the ENVRI-FAIR project is ending, all Argo NVS collections and supporting tools will persist and be actively maintained by the Argo Editors and BODC Vocabulary Management team. New funding opportunities are being sought to develop further FAIR services and enhance interoperability of Argo (meta)data.

2. Funding and human resources

The UK Argo programme is undertaken by a partnership between the Met Office and the National Oceanography Centre (NOC, which includes BODC). The Met Office are responsible for programme management and coordination, procuresment of core floats, organizing float deployments, preparation of floats for deployment, telecommunications (costs) and international funding contributions (OceanOPS and Euro-Argo). NOC and BODC have responsibility for Argo science and data management respectively. NOC have the lead on deep Argo and play a leading role in the expansion of the UK programme into BGC-Argo.

Funding

Argo funding to the Met Office is presently provided directly from the Department for Business, Energy and Industrial Strategy (BEIS) mainly through the Hadley Centre Climate Programme (HCCP), but with an additional contribution through the Public Weather Service Programme. The HCCP workplan and funding for 2021 to 2024, which has been approved by BEIS and Defra (Department for Environment, Food and Rural Affairs) includes UK Argo funding for the period April 2021 to March 2024. In 2022 this funding was only sufficient to order 15 new floats (nine APEX-RBR-L3 and six NKE ARVOR) due to inflation increasing costs.

NERC funding for Argo is primarily directed through NOC under National Capability (NC) funding lines which cover Argo data management (through NC Environmental Data Services funding of BODC) and Argo science. Core BODC Argo national capability funding from NERC remains static for 2022-23 and is therefore decreasing in real terms.

In March 2021, NERC and NOC announced a capital investment of £3.7 million to begin building the UK Atlantic Sector BGC Argo Network (ASBAN-UK) where NOC will deploy six-parameter BGC floats in the Atlantic Ocean over three years as part of UK Argo. The first fifteen were delivered in 2021 and

2022, and six have been deployed, with plans to deploy another seven this year. A second order of ~11 floats will be made in March 2023 with delivery expected by December 2023. BODC secured funding to develop the data infrastructure for NKE BGC floats (ASBAN-UK). Efforts have continued to establish a clear plan for future funding to develop a more sustainable model of UK funding to support the UK contribution to the full-depth multi-disciplinary Argo array, but the funding situation remains challenging.

Non-NC funding is also provided through participation in EU-funded Argo-related projects. The Euro-Argo Research Infrastructure Sustainability and Enhancement (Euro-Argo RISE) project has provided funding for developing core and deep DMQC (Delayed Mode Quality Control), management of BGC (biogeochemical) extensions and regional data quality assessments in the Southern Ocean which was available up to December 2022. Additionally, BODC is funded under the EU H2020 project ENVRI-FAIR to introduce the NVS vocabulary server to support Argo vocabulary management. The ENVRI-FAIR funding is available until June 2023.

BODC has been unable to source sustainable funding to support SOARC functions, so the ARC remains unfunded in the UK to date.

Our aspirations are to contribute 10% of each of the BGC and Deep Argo arrays, and to continue to provide 5% of the Core floats deployed. This could be achieved by deploying 25 BGC floats per year, with a projected lifetime of four years this would lead to a sustained fleet of 100 BGC floats. Deployment of 25 each of Deep and Core floats per year, with a five-year lifetime would ramp up to a sustained fleet of 125 of each float type. The UK would then maintain a fleet of 350 floats (100 BGC, 125 each Core and Deep), about 8% of the total anticipated global fleet. However, funding for this, at around five times the present level, is not in place and would require significant additional investment.

Human resources

Staff members working on UK Argo, their institution and effort on Argo during 2022 are given below. BODC staffing levels have been hit with the long-term absence followed by departure of the Argo lead staff member, which has impacted the team. They have secured some additional short-term time from another NOC team member to help meet priority deliverables, but this has not fully filled the time or skillset gap.

Met Office – 0.8 FTE
Jon Turton, Fiona Carse, John Hankins

NOC, Southampton – 0.7 FTE
Brian King, Nathan Briggs, Darren Rayner

NOC, BODC – 4.1 FTE (March 2022 – March 2023)
Kamila Walicka (1.0), Clare Bellingham (0.85) and Violetta Paba (0.9), with others providing additional support, such as the Juliane Wihsgott (0.33), Clive Neil (0.21), Roseanna Wright (0.08) and the BODC software developer team (0.74).

3. Summary of deployment and data management plans

Deployment plans

As noted earlier, as of 28th February 2023, UK Argo has deployed 16 floats during 2023: 14 core APEX and two PROV-BIO floats. A total of 43 additional floats are scheduled for deployment later in 2023 (figure 3), including:

AMT, March 2023
- 5 APEX SBE core floats
- 1 APEX-RBR-L3 core float
- 5 PROV-BIO 6-parameter floats

NB Palmer, Cape Town to Drake Passage, May 2023

2 APEX SBE core floats
3 APEX-RBR-L3 core float
1 ARVOR core float
PAP mooring cruise, May 2023
2 APEX-RBR-L3 core floats
1 NAVIS BGCi float (if it can be fixed in time)
Florida Straits C-Streams project:
3 PROV-BIO 6-parameter floats
SW Indian Ocean, SEAMester cruise, S.A. Agulhas II, August 2023
4 APEX SBE core floats
NW Atlantic, Discovery passage leg Tromso – St Johns, August 2023
1 APEX-RBR-L3 core float
3 APEX SBE core floats
Discovery passage leg St Johns to Cape Town, November 2023
4 APEX SBE core floats
1 APEX-RBR-L3 core float
1 ARVOR core float
Discovery DY172, SE Atlantic to 60S, December 2023
3 APEX-RBR-L3 core floats
3 APEX SBE core floats

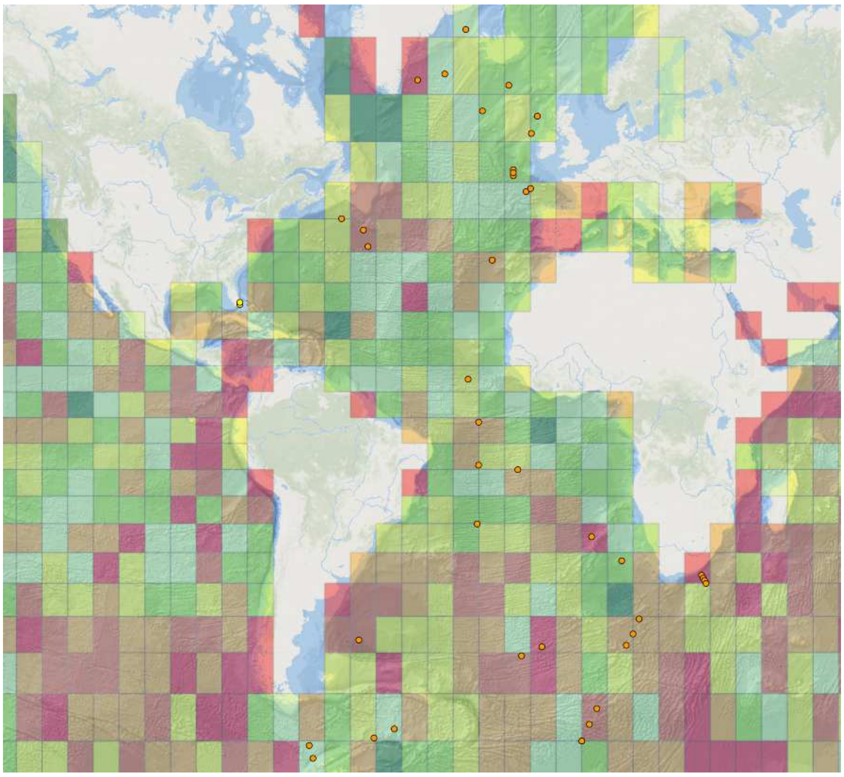


Figure 3. Showing the locations of all UK floats planned for deployment from 1st March to 31st December 2023 (43), coloured boxes are Density/Age vs Argo 2020, as at 28 February 2023.

After the above 43 floats are deployed, we expect to have a total of 26 floats in stock in the UK, comprising

- 20 APEX core floats (including 2 with RBR, and 5 that are very old, ballasted for the Arabian Sea),
- 3 ARVOR core floats,
- 3 BGC PROVOR floats (two ASBAN six-parameter floats and one UEA PROVOR-Jumbo for the PICCOLO project, that failed pre-deployment and will be returned to the UK).

In addition, we have one ARVOR core float at OceanOPS in Brest. It is being kept there for ease of deployment on any passing yacht or other vessel of opportunity.

In summary, a reasonable estimate for UK deployment for the year 2023 would be 50 core floats, 11 BGC floats but no deep floats.

Fiona Carse is leading the Atlantic Deployment Planning group, which was created after AST#23. Discussions at the Atlantic group has already led to some efficient deployment planning of BGC floats in the North Atlantic. The remainder of 2023 looks to be a good year for international co-operation in Atlantic deployments. Fiona also participates in Tammy Morris' Indian Ocean planning group on behalf of UK Argo.

4. Uses of Argo data in the UK

By NOC

Argo data are used widely within NOC, where the science applications include:

- measurement of evolution and drivers of mixed layer processes in the (Indian Ocean);
- inventory and evolution of heat and freshwater establishing controls on budgets (both regional and global);
- deep heat content (N Atlantic).

NOC is currently leading BGC Argo deployments on behalf of the broader UK community. Data are being used in recent, current and upcoming projects for:

- Generating 4D fields of particle size in the ocean for an array of applications including biological pump study.
- Investigating global drivers of variability in ocean carbon storage by sinking organic particles.
- Investigating nutrient transport by the Gulf Stream and its variability
- Tracking the transport of Greenland glacial meltwater into the Labrador Sea via its coloured dissolved organic matter signature.
- Quantifying particle sinking rates and rates of particle fragmentation in the ocean.
- investigating export fluxes and efficiency in hypoxic ocean regions.

At the Met Office

All Argo data are used operationally:

- They are routinely assimilated into its FOAM (Forecasting Ocean Assimilation Model) suite which is run daily and produces 2 analysis days and a 7-day forecast.
- A coupled ocean/atmosphere/sea-ice/land global prediction system has been made operational for producing the main Met Office weather forecasts. This coupled NWP system assimilates data in all components of the coupled model, including Argo data in the ocean component. These data therefore affect both weather forecasts and short-range ocean forecasts. An assessment of the impact of Argo in a lower atmospheric resolution version of that coupled system was detailed in King et al., 2019.
- Initial conditions for coupled monthly-to-seasonal forecasts are taken from the global coupled NWP system so the Argo data are used to initialise these forecasts and are used in ocean reanalyses.
- Argo data are also used in the initialisation of ocean conditions in climate models run to make decadal predictions.
- Near-surface Argo data are used to validate the output from the Met Office's OSTIA (Operational Sea Surface Temperature and Sea Ice Analysis).

Met Office research & development applications (non-operational) which have made significant use of Argo data:

- A paper was published on OSSEs to investigate potential impact of expanding the Argo array (Mao et al., 2020);
- David Ford has done some OSSEs looking at the impact of the planned BGC-Argo array of floats in a global physical-biogeochemical model where he assimilates synthetic versions of the BGC Argo profiles in conjunction with satellite ocean colour data (Ford, 2021);
- A PhD project is currently looking at the impact of real BGC Argo data in a global physical-biogeochemical model. The BGC Argo data are assimilated into the model and the impact on air-sea CO2 fluxes is being investigated.
- A paper was published jointly with the University of Reading on the application of a simple smoother algorithm to make better use of Argo data in ocean reanalysis (Dong et al., 2021).
- A project where we made good use of Argo data was in the assimilation of satellite sea surface salinity data from SMOS, Aquarius and SMAP. The near-surface salinity data from Argo was used to bias correct the satellite salinity data and was crucial for the performance of the assimilation of SSS data. That work is written up in Martin et al., 2019. Another paper was published investigating impact in FOAM and the Mercator system of satellite SSS assimilation which used Argo for assessment (Martin et al., 2020).
- R&D on ocean ensemble forecasting and DA, written up in Lea et al. (2022). The hybrid data assimilation method described in this paper led to improvements in use of observations including Argo.

In the Met Office Hadley Centre for Climate Science and Services, Argo data is in the following products:

- EN4 contains in-situ ocean temperature and salinity profiles and objective analyses. It is updated monthly using real-time Argo profiles and GTSPP data, and annually using delayed-mode Argo profiles (and WOD, GTSPP and ASBO data). EN4 is freely available for scientific research use (see http://www.metoffice.gov.uk/hadobs/en4/). The latest version is EN.4.2.2, which includes a fresh download of all the source data and a substantial update to the XBT/MBT correction schemes. EN.4.2.2 contains four ensemble members where previously there was only two. There is also a new product user guide (based on both the Argo Users' Manual and the HadIOD user guide), including FAQs and example code. EN4 is also forming part of a GEWEX EEI project comparing Ocean Heat Content calculated from reanalyses, in situ data and satellite products (the project website is https://sites.google.com/magellium.fr/eeiassessment/dissemination/documents?authuser=0).
- HadIOD (Hadley Centre Integrated Ocean Database) is a database of in situ surface and subsurface ocean temperature and salinity observations supplemented with additional metadata including bias corrections, uncertainties and quality flags. The dataset is global from 1850-present with monthly updates. The current version is HadIOD.1.2.0.0, the chief sources of data are ICOADS.2.5.1, EN4 and CMEMS drifting buoy data. This product has been available to the public since mid-2020 via https://www.metoffice.gov.uk/hadobs/.

Met Office science uses of the EN4 product include OHC analysis, contributions to BAMS, Ocean Obs'19 White Paper and an Earth Energy Imbalance paper (von Schuckmann et al., 2020).

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5. Issues from UK to be considered by AST

None.

6. Research cruise CTD data

When the UK notifies float deployments with OceanOPS, we include any information about nearby or simultaneous CTD casts if the scientists on board the deploying ship provide this. It is written in the Description free text box in the notification form. Sometimes our floats are deployed from passage legs or ships of opportunity. In these cases, no matching CTD casts are available. All CTD data from UK cruises is best obtained from BODC, using the enquiries@bodc.ac.uk contact address.

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7. Argo bibliography

UK Argo PIs are Jon Turton, Fiona Carse, Brian King, Nathan Briggs, and Giorgio Dall'Olmo (until 2022). The UK last provided a bibliography for AST#21 (in March 2020).

Included below is a list of 76 papers published during 2020 to 2023, with at least one author based at a UK institution. There are 31 papers in 2020, 24 in 2020, and 21 in 2022. The search was carried out using Web Of Science, using keyword "Argo" and refining by country (England, Scotland, Wales, Northern Ireland). PhD theses are not included in this list.

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8. COVID-19 impacts on UK national program

For the year 2022, impacts of COVID-19 have been minimal on deployments. In fact, we have bounced back rather well. There has been no impact on our core floats budget from central government. However, we have been able to buy fewer floats than previous years. This is due to increasing costs being passed on by manufacturers, and an unfavourable USD / GBP exchange rate. We assume the former affects all programmes. On a minor note, Fiona Carse was prevented from attending AST#23 in Monaco due to French entry requirements and COVID-19 in her household!

9. RBR deployment plans for 2023/4

As noted earlier, the UK will receive a delivery of nine APEX-RBR-L3 floats from Teledyne Webb during March 2023. Our current plans for deploying 11 APEX-RBR-L3 floats during 2023 are detailed in Section 3, above. We do not have any plans for 2024 yet.