25th meeting of the International Argo Steering Team

Host: National Oceanography Centre
Southampton, UK
18 - 22 March, 2024

AST-25 Google Drive folder

Link to google spreadsheet for AST-25 Action Items

Contents

Monday: OneArgo

Welcome (Ed Hill, 10 min)

Ed Hill opened the meeting and welcomed Argo, including the six people who were present at the AST meeting held at NOC 24 years ago. He spoke of the history of ocean observations and how Argo is one part of this long history. He recognized NOC and BODC's efforts to support Argo in the UK and wished the AST a successful meeting.

Action item 1: Write a letter of thanks to Brian King and NOC for hosting AST-25. Susan Wijffels

Meeting Goals (King/Wijffels)

Our key challenge remains to work towards the implementation of the new OneArgo design. This requires

1. ongoing technical problem solving, but many issues have been overcome (see below)
2. Continuing to build a unified OneArgo community. This weeks' new integrated meeting format illustrates how we are coalescing into a OneArgo global team - many national programs are now working across the 3 missions. Active BGC/Deep and Polar Mission teams.
3. Securing the ~3x resources to sustainably implement and operate a OneArgo array. This is now our biggest challenge.

Reflecting on the past year, we have solved many technical challenges - fast salty drift, pH sensor production, piloting on-board dynamic corrections on a CTD, new pressure sensors, etc. Argo needs to continue to innovate! We are heartened to see more participation in the RBR deployments in the core array and more national programs moving into a OneArgo 3 mission mode.

While COVID supply chain issues appear to be largely overcome - thanks to our commercial partners, the large price increase of parts is still with us and is impacting national programs on flat funding.

The greater complexity of the OneArgo design, requires greater care in deployment planning. Basin planning meetings appear to be going well and adding a lot of value. We encourage increasing participation by national programs in these meetings and thank the basin coordinators for their leadership of these discussions.

To make the best possible case for increased support we still have some challenges to work on:

1. better demonstrate the value of OneArgo for science and operations: advocacy at international planning meetings, within countries and to entrain our major users as OneArgo champions [G7, WMO, UN Decade etc.]
2. Improve how Argo data are used, particularly through one on one interactions with our super users, and by improving utility for some new application areas (coupled NWP - decrease latency and increase near surface sampling), new products.
3. Continue to improve Argo technology and communicate this work to our funding agencies. To do this we need to continue to strengthen interactions with our commercial partners to expand the vendor choice, increase reliability and drive up the capability and

efficiency of Argo by extending float and sensor lifetimes. To this end we have planned technical workshops and established new technology task teams.

4. Learn what we can do to help DACs deal with the increased complexity of Argo data, and how to modernize our data system. We will hear from ADMT co-chairs about this challenge and discussions around paths forward

It is also crucial that we track our progress towards implementation of OneArgo. What are the major barriers? What is a realistic timeline for full implementation (2030)? How do we measure this and clearly track our progress at OceanOPS?

The next 5 years or so will be crucial for Argo and our ability to implement the OneArgo design. We are poised to be able to implement it but only if funding is forthcoming. Should we seek to re-balance our investments between core/deep/BGC now to enable the new mission arrays to maintain momentum and grow?

- Pros: grow user base of new missions and maintain market for deep and BGC sensors and platforms
- Cons: it will shrink the total array and thus core sampling until new $$s arrive

If insufficient funds are available, when do we reassess (2030). Should we have a plan to refocus on core coverage? As a community we will discuss these choices this week, and in future meetings. The input of our commercial partners as well as funding agencies will also be crucial to how we navigate the next 5-10 years.

Status of Action items from AST-24 (Megan Scanderbeg, 15 min)

https://docs.google.com/spreadsheets/d/1IUW2WXVem_2t5eoGr4-omBo746y5Hqro3Ie4sGc4eSM/edit?usp=sharing

Megan Scanderbeg updated the AST on the number of completed (12), in progress (16) and not done (3) actions from AST-24. She highlighted a few completed actions including the formation of the Polar Argo Mission team complete with co-chairs, terms of reference and an updated webpage (https://argo.ucsd.edu/expansion/polar-argo/). She also thanked Tammy Morris for leading the publication of the core Argo Best Practices paper available in the GOOS repository (https://repository.oceanbestpractices.org/handle/11329/2387) and soon in Frontiers. The other completed actions highlighted included the first 'What's up with Argo data?' slides (https://argo.ucsd.edu/whats-new-with-argo-data/) and the efforts of Peter Oke to get several Argo related abstracts submitted to the 8th WMO Workshop on NWP.

Next, she reported on several actions that were in progress, but which would not be discussed elsewhere in the agenda. The first was action 6: Ask EA Rise to report back to AST on Boundary Current study. A report was written (https://doi.org/10.5281/zenodo.7362265) and examines ways of changing the float's mission to attempt to keep it in Boundary Current regions. The next was 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 the New York Times, Nature, etc. A letter was drafted and sent to the New York Times but was not published. The feedback was that this type of letter should come from outside the Argo community. The authors are still considering submitting it to Nature or another scientific journal. The next set of actions centered on oxygen and while both have not been finished, work is ongoing to further their progress. 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. 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.

Finally, for the actions that were not done, two will be continued (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) and Action 29: Make a OneArgo brochure with help from OceanOPS and the community). For action 31: Work with BGC Argo co-chairs, OceanOPS to identify speakers on sensor issues and data issues at the glider workshop in Sweden June 2024, ideas were submitted, but ultimately not selected to be included in the glider workshop.

OneArgo float commitments for G7 + discussion (Brian King, 25 min)

Brian King started by noting statements from the G7 meeting in November 2023. One stated that G7 members should work with Argo to develop and maintain a clear set of targets for G7 countries to be reviewed annually to track implementation progress. The second was that G7 members should make a strong statement of commitment and forward planning for establishing the global array by 2030 to assure sensor developers of the long-term requirement for their services and to encourage new sensor development. These statements helped formulate the request for each National Program to send in estimates of float deployments by mission type over the next several years.

He next stepped through his choices about the number of floats that need to be deployed per year (250 BGC, 250 Deep, 450 core) to realize the OneArgo array of 1000 BGC, 1250 Deep and 2450 core floats by 2030. Based on the decay rate of floats, he chose an average lifetime of 3.8 years for BGC, 4.75 for Deep and 5.45 for core floats. Noting that some of the choices he made were optimistic, he proceeded to show a series of plots for different scenarios:

1. Business as usual for Japan and USA
2. Scenario 1 with a redistribution of resources to OneArgo proportions
3. As 2 and resources grow by a factor of 2
4. As 2 and resources grow by a factor of 2.5
5. Substantial increases in the USA and Japan

As expected, scenario 2 is chosen, it will result in a decrease in the number of active floats – potentially significantly.

In the discussion, it was noted that it will be important to understand from our manufacturers what is the minimum needed for them to stay in the Argo business. Several suggestions were made to improve/tweak the choices made and Brian agreed to go back, implement them and create a document with the information that can be shared with each National Program. The suggestion is that this document can be used to talk to funding agencies and governments about the funding situation.

Action item 2: In preparation for future AST meetings, ask national programs to continue filling out the deployment spreadsheet implemented this year. Megan Scanderbeg, AST members

OneArgo status and tracking how to communicate progress: overall picture by OceanOPS & discussion (Victor Turpin (25 min), AST co-chairs to lead discussion, 25 min)

In the past 3 to 4 years, spurred by the GO-BGC US project, Argo has transitioned from its original design (Argo Global with 4000 floats, expanded to polar and marginal seas) to OneArgo. OneArgo aims for 4700 floats, with 1200 deep floats and 1000 BGC floats with six variables. OneArgo's progress is measured by the activity and intensity of its three components: 2k floats, BGC Argo, and Deep Argo.

This plot illustrates the evolution of operational floats compared to targets. The declines in 2013 and 2020 align with target changes. Post-2020, the red line representing all floats divides into core (blue), deep (dark blue), and full BGC (green) categories. The plot demonstrates the steady advancement of full Argo BGC implementation alongside a decrease in core floats, balancing these trends to maintain the current array.

So far, the implementation of OneArgo does not affect the current array in terms of operational float at sea.

This plot illustrates float deployment intensity against targets, with intensity goals based on an average fleet performance of 4.1 years. It reveals that annual deployments for each float type fall below what is required to achieve OneArgo. However, the robust longevity of core floats, coupled with progress in full BGC and deep Argo performance, has stabilized the operational float array despite an overall decrease in deployments.

The key message here is that the current Argo array faces significant risk due to the low level of annual deployments and despite improved performance of the global fleet compared to a full core array. The current array is likely to be unsustainable and is expected to decline.

Consequently, OceanOPS is providing recommendation to the AST:

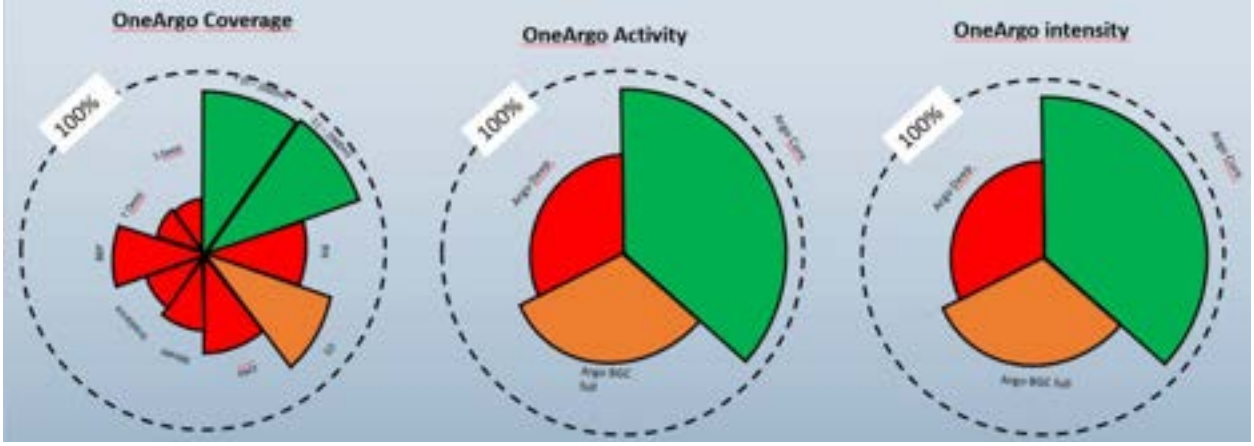
Recommendation 1:
Ensuring the continuity of the current array should be a top priority:

- Annual deployments must stay above 800 to uphold the current array until there is an improvement in float performance.
- The 'float type deployment ratio' should be maintained with over 60% Core floats and less than 40% BGC and Deep floats.

Recommendation 2:
Enhancing float performance is crucial for reaching OneArgo. Core, BGC, and Deep missions should focus their efforts on improving performance.
Adopting the typical OneArgo 'float type deployment ratio' (50% Core, 22% BGC, 28% Deep) without aligning it with increased funding and improved float performance could endanger the program.

Recommendation 3:
Developing a OneArgo implementation roadmap for national programs considering various factors, including the sustainability of the current Argo array, the 'float type ratio,' effective fleet performance, and investment growth.

The OneArgo multiple overlapping missions poses monitoring challenges for clear communication with our funders and stakeholders. The proposed solution, depicted in the following image of 'flower-like' plots, offers a visual tool to swiftly assess our progress towards each target.



To construct a time series, the proposed approach involves computing the OneArgo implementation Key Performance Indicator (KPI) using the following equation.

OneArgo implementation KPI = (deep index + 2k index (~4700 floats) + BGC index)/3.

In the discussion, it was agreed that the community needs to come to agreement on the average life expectancy of floats from each mission in order to compare calculations done by different groups.

Action 3: Come to an agreement on float lifetimes for each mission type in order to improve array projection tools on OceanOPS and Brian's method. Brian King, Victor Turpin, Susan Wijffels

Action 4: Prepare a document that illustrates possible future scenarios of the size of the array with different deployment strategies and funding scenarios. AST co-chairs

OneArgo implementation issues

OceanOPS operational update (10 min – Mathieu)

Mathieu Belbeoch gave an update on OceanOPS of which he is now the lead and sits in the WMO with the Director of Infrastructure, Nir Stav and the Director of WIGOS, Albert Fischer. OceanOPS consists of nine people and is part of the GOOS Management Team. Currently, the system is being migrated into Ifremer IT architecture which should be beneficial in the long run due to the technical expertise available onsite. In the meantime, it highlights the critical needs OceanOPS fulfills: monitoring, metadata flow, WMO/WIGOS allocation, EEZ issues, etc.

OceanOPS is currently in the process of migrating its information system from its previous host, CLS, to Ifremer. This migration was prompted by security requirements at CLS and commenced on February 12th. The transition is ongoing and is expected to be fully completed by the end of June. In the interim, services will be gradually restored from May.

Three essential services for Argo have been identified, and temporary solutions have been provided to the Argo Steering Team (AST).

WMO ID Requests:

For WMO ID requests, please send your email to me or support@ocean-ops.org. Our internal API for WMO ID allocation is operational, and we maintain a reserve of WMO IDs for emergencies.

Deployment Notifications:

To inform all Argo National Focal Points (NFP) of a deployment cruise, please email the 'argo-notif@groups.wmo.int' mailing list. In the absence of the OceanOPS e-notification service and to comply with IOC Res. XX-6, please provide deployment plans. Only members of the argo-st and argo-notif mailing lists can currently send messages to 'argo-notif@groups.wmo.int', but I can extend this authorization upon request. OceanOPS will notify all floats deployed since February 12th once operations are fully restored.

EEZ updates & reminder of who has given concurrence, what countries need to do to grant concurrence (Mathieu 10 min)

EEZ Notifications:

Due to technical challenges with the GIS server, there may be a delay in EEZ notifications. Once the server is operational, we aim to notify all floats meeting EEZ notification criteria either upon reopening or, if feasible, during the shutdown period, in alignment with IOC Res. EC-XLI.4, pending final decision.

Mathieu Belbeoch noted the requirements surrounding EEZs for Argo and non-Argo floats.

In the discussion that followed, it was noted that it is no longer clearly stated on OceanOPS which countries grant concurrence. If interested, please contact OceanOPS directly.

It was also noted that a lack of concurrence hurts deployment opportunities.

Action item 5: OceanOPS is not publishing a list of countries that grant deployment concurrence. If you have questions on concurrence, please contact OceanOPS directly. Float deployers.

Action item 6: Ask Emily Smith & AST to explore discussing difficulties imposed by a lack of concurrence through GOOS. Emily, AST members

AIC, OceanOPS funding (Breck Owens, 10 min)

Nine national programs have continued to provide the same level of funding as they have over the previous decade. This year Monaco also contributed 70,000 € that covered 60% of the salary to hire Orens De Fommervault to support the BGC mission. This support was provided with the understanding that the Argo Program would raise the necessary additional funds to cover the full salary for this position. It was suggested that Argo reach out to France and EuroArgo for this additional support.

Since inflation has decreased the effective support for the positions at OceanOPS, the Argo Executives will reach out to the existing contributing programs to ask them to adjust their support. In addition, a request to all the members of the AST will be sent out to help us fully fund OceanOPS personnel who support OneArgo.

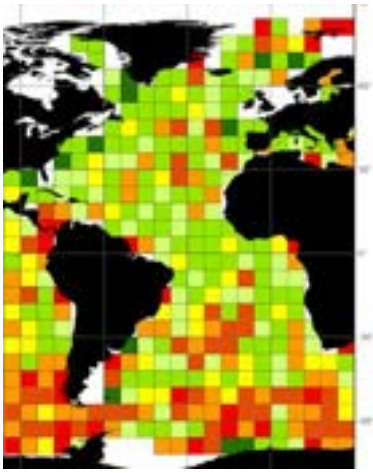
The present Argo support for OceanOPS covers the large number of tasks in support of the Argo Information Center, including monitoring the Argo array for planning and EEZ notification. A proposal to the Observations Coordination Group to reorganize support for OceanOPS using service agreements with the various networks. Argo supports this proposal.

In the discussion, it was noted that some countries have difficulty sending money for technical reasons and Mathieu urged them to reach out to him directly to discuss solutions such as asking countries to earmark money for OceanOPS in their funds sent to the UN.

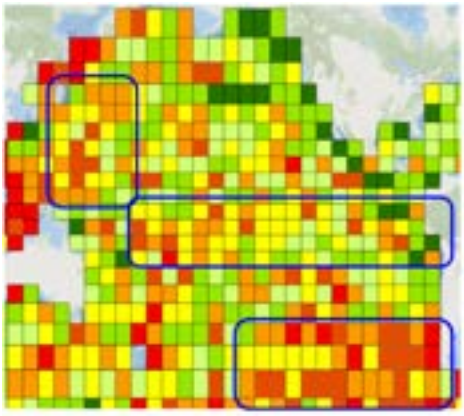
Deployment coordination (Fiona Carse, Tammy Morris, Sarah Purkey, Shigeki Hosoda 10 min)

Since summer 2022, deployment coordination groups have been established for Atlantic, Pacific and Indian ocean basins, including their Southern Ocean and Arctic ‘sectors’. They meet two to four times per year with a simple agenda: review the network status with respect to gaps and discuss deployments from upcoming cruise opportunities. All three groups have excellent support from Victor Turpin at OceanOPS. A very brief summary:

Atlantic: The NA is over-populated, the SA is underpopulated, the balance between the basins has improved recently. The main gaps are the St Helena gap (central SA) and the Southern Ocean sector. (contact Fiona Carse)



Pacific: The Pacific is under target overall, with notable gaps in the NW, tropical and SE. It is hoped that deployment opportunities in the SE will increase with the new vessel Kaharoa II (contact Sarah Purkey and Shigeki Hosoda).



Indian: The Indian Ocean is under target in terms of both activity (85%) and intensity (65%) - deployments are happening but still not enough. We must get floats on as many deployment opportunities as possible (contact Tammy Morris).

Please come and join us if you have floats to deploy or know of ships transiting through gaps in the network.

Near surface sampling audit and recommendation (Brian King, 15 min)

Brian King shared his audit of the shallowest pressure bin sampled by floats over the past years because Argo would like to meet our users' requests for sampling as near to the surface as possible. He noted that over time, floats have begun sampling closer to the surface and in the past year, about 50% of floats sample in the top 2 db. Argo recommends that the technology is mature enough to allow all floats to sample in the top 2 db.

In the discussion, some manufacturers were unaware of this request, and this resulted in the suggestion to discuss it at the Technical workshop in September 2024 and to make a formal suggestion for the standard Argo profiling scheme to share with all manufacturers.

Action item 7: National Programs should specify that floats sample in top 2db. National Programs.

Action item 8: Depending on implementation of sampling up to 1-2db, revisit at AST-26 unpumped CTD measurements near the surface that reside in N_PROF = 2 which don't go out on GTS and may not be picked up by many users. Revisit near surface sampling analysis. AST, Brian King, Fiona Carse

Update on time-of-day sampling (Steve Riser, 15 min)

This talk provided an update on time-of-day sampling used by a number of floats in the Argo fleet. Several years ago, it was found that a significantly high number (> 1000) of floats were configured to sample at the same time of day on each profile. In some cases, this was because the floats were scheduled to surface at noon or midnight on each profile for reasons related to biological or chemical sampling issues. In other cases, this was due to the floats being configured to sample with an integral number of days between profiles. Both of these cases lead to undesirable results, such as creating a bias in the estimation of heat gain in the upper ocean. An ad hoc committee set up to examine this practice strongly recommended that float surfacing be set to a non-integral number of hours for all floats deployed in the future, and that existing floats be reset to this non-integral sampling protocol to the maximum degree possible. A non-integral sampling might consist of a sampling interval of 10.08 days, so that the float will sample at all possible hours of the day over the course of several months. Other acceptable sampling schemes are also possible. Prior to the AST25 meeting, an audit of all floats that had transmitted data in the past 6 months was done. It was found that many DACs had improved the sampling protocols on their floats. However, some of the DACs with the most total floats and the most floats with sampling problems had not yet begun to change their sampling intervals. Overall, this is a serious problem, and it is hoped that considerable effort will go into remedying this issue prior to the next AST meeting.

Action item 9: AST suggests adding a topic to the float technical workshop to consider providing a default Argo mission configuration file, by float type. This could include shallowest pressure bin, high resolution sampling in top 10m, a cycle time of 10.08 days, hourly drift sampling, TSWAIT for SBE CTDs etc. TcoP chairs, float experts, AST members.

Update on interaction with manufacturers to provide float and sensor metadata in a similar JSON format (Brian King, 10 min)

Brian King updated the AST on efforts he led with help from Eric Rehm at SBE and Jean-Michel LeConte from RBR to create a JSON schema for distributing sensor and platform metadata. The schema can be checked for compliance with the NVS Argo reference tables and should

substantially ease the burden on DACs and PIs to access metadata such as calibration coefficients for sensors.
The latest version is not quite ready for release but will be soon. Examples are available on GitHub (https://github.com/euroargodev/sensor_metadata_json/).

RBR has already implemented the draft version. SeaBird has more work to do to implement this due to how they internally save information in their databases, but they are committed to making this transition. Aanderaa already keeps all their sensor data in XML files, so a transition to JSON should be straightforward and they are interested in doing this. Argo plans to contact other sensor manufacturers to ask for their cooperation when the format is operational.

For the platforms, the situation is different, but Argo is eager to reach out and discuss the details more. For example, it would be hugely helpful to have a common format for some of the decoded data provided by float manufacturers. This would include mission config parameters that are platform specific but need to be captured by DACs from the float output, float technical information and even the profiles themselves. Argo is asking for help on defining an end point for decoded data that each platform maker could work towards.

OneArgo data management

Feedback from ADMT-24 (ADMT co-chairs, 30 min)

Megan Scanderbeg presented on behalf of the ADMT executive committee. She began by highlighting the ADMT's efforts to embrace new technologies and the data delivery migrating from FTP to HTTPS with upgraded index lists. She stated that some DACs remain stressed and do not have enough manpower to accomplish their tasks in a timely manner. While DMQC of temperature and salinity data continues, it is more time consuming now due to ASD issues, TBTO contamination and the determination of CPcor for Deep floats, among other extra requests. There is a renewed focus on cleaning up and fully implementing specific metadata fields to make it easier to monitor and identify floats, especially those with special features. She noted that increased communication with users and manufacturers has been beneficial in finding solutions to help DACs create high quality real time files more rapidly.

In terms of the availability of real time data on the GTS, DACs are able to get 80% of data onto the GTS within six hours. If the AST wants this to be faster, it will take work at the DACs to further optimize their systems. The BGC BUFR templates have been developed and are ready for DACs to send adjusted BGC data. Both MEDS and OceanOPS audited the data coming off the GTS each month and found good agreement. To see MEDS audit, click here: ftp://ftp.isdm.gc.ca/pub/staff/tran/gts_bufr_stat/bufr_msg_index.txt.

A prototype of the Argo GDAC is available via the cloud. A working group has been formed to study the best format to store Argo data in the cloud and will report back at ADMT-25.

In order to improve the timeliness of the application of the min/max test results, DACs were asked to automatically implement the results when received. In addition, per user request, a list of questionable floats identified by the min/max tests that have not been greylisted will be made available.

The ADMT has determined how to identify noon time profiles in the data system per the AST's request and it involves using current CONFIG settings in the metadata files as well as adding an alert string to the CONFIG_MISSION_COMMENT.

The ADMT was unable to reach agreement on how to indicate results of the ice avoidance algorithm on floats that are equipped with this firmware and sampling under sea ice over, but the working group remains active and will hopefully present a solution at ADMT-25.

Finally, it was emphasized that the ADMT continues to carefully evolve to handle OneArgo and to modernize its real time processing chain. The ADMT looks forward to the implementation of machine readable sensor and platform metadata and welcomes further interactions with manufacturers to consider developing end point formats for decoders.

Action item 10: AST asks ADMT to rename the greylist to remove any reference to a color and to inform users of change. ADMT co-chairs

Data modernization discussion (ADMT co-chairs introduce, 20 min)

Megan Scanderbeg reported on plans for the ADMT to modernize the serving of Argo data and the real time processing chain. She noted that Argo data has been served in the same format on the same servers for the past 25 years and that it will not be the same for the next 25 years. Instead, Argo needs to decide how to effectively move to serving data from the cloud. Additionally, the GTS is modernizing, and Argo needs to be ready to adapt if needed, although it looks like BUFR will continue for now and National Met Offices should be able to transmit data onto the GTS.

In terms of the real time processing chain, it was noted that DACs remain stressed and are facing real difficulties in implementing the OneArgo data stream due to increasing demands associated with things like:

- Large amounts of metadata associated with BGC sensors
- Large variety of BGC sensors, with new ones being added regularly
- Application of real time adjustments on BGC, Deep, Core and pilot data
- Changing float missions

A series of DAC workshops are being held to (i) investigate creating and deploying containers for the real time processing chain by float type that rely on open-source software and (ii) creating a common end point format for decoded float data that could form the input for the containers. There are clear benefits to these approaches including efficiencies in coding across DACs, faster implementation of new float types throughout the ADMT, etc. However, there are challenges for DACs to adopt and develop these containers and for manufacturers to work with

the ADMT to develop a common endpoint format. The ADMT co-chairs will be meeting with the DACs individually over the next few months to better understand their unique challenges and thoughts about the proposed path forward.

AST members are asked to talk to their DACs and see how they can support them through this transition. Argo wants to reduce the burden on DACs, and we need to work together to identify the best path forward to do this.

Reference data (Sarah Purkey 15 min)

CCHDO is the international hydrographic office responsible for collecting and curating high quality ship based hydrographic survey data. The data is provided to Ifremer to be ingested into Argo reference databases for core, deep and BGC. CCHDO provides public and private data to Argo in its standardized CF-netcdf form ('merged data') for Argo DMQC groups. Typically, when data is submitted to CCHDO, it is posted "as received" within 48 hours, and then "merged" into the standard form based on priorities. Data of high importance to Argo can be requested to be merged quicker by sending a request to CCHDO or communicating these needs with Sarah Purkey. This year, 4920 bottle stations and 661 CTD stations were either updated or added to the public repository but no non-public CTD data for Argo QC only was submitted to CCHDO. The AST is encouraged to remind their colleagues that this is an option.

Turbulence measurements on floats (Bieito Fernandez Castro, 15 min)

In recent years several solutions have emerged for measuring microstructure turbulence onboard profiling floats. Here, we show results from the first test at sea of the integration of a microstructure probe (FloatRider, Rockland Scientific) onto a NKE PROVOR-CTS5 float. The test was conducted for four days in the Mediterranean Sea off Villefranche-sur-Mer in collaboration between the manufacturers, the Oceanography Laboratory of Villefranche (LOV) and the University of Southampton. Test results show the promising quality of microstructure temperature data, from which we retrieved energy and thermal variance dissipation rates via spectral fitting. New deployments are planned in the Mediterranean Sea and Iceland Basin in the coming months.

Float performance update (Brian King, 30 min + 15 min discussion)

Brian King presented float survival rates by mission type in an effort to focus attention on improving float performance and to identify the survival rates of BGC and Deep floats for planning purposes. He noted several choices he made to decide if a float was dead and that he was not trying to embarrass cohorts but to illustrate what can be achieved with best practices. Many float types are performing well, demonstrating what is possible with good technical checkout and practices. He noted that the Float Technical Workshop in September 2024 will

explore how all user groups can get the best performance out of each platform. The AST urges all National Programs to ask their technical people to engage in the workshop.

Procurement (Vicky Savage, 5 min)

Brian King shared with the AST that NOC will be adding sustainability to all of its tenders, including for Argo floats soon. The plan is that NOC procurement will assess the sustainability of supply chains to potential suppliers. If your institution is also considering this, please let Brian King know.

Looking for float procurement efficiencies (Peter Oke, 20 min)

Peter Oke presented efforts to improve float procurement, especially for small purchases. One possibility identified was to have WMO purchase the floats and then Argo members would receive, prepare and operate the floats. WMO already does this for weather stations and drifters. Potentially, this could benefit manufacturers and Argo groups, but it needs to be further investigated. Concerns include the service that manufacturers may or may not be able to provide through a WMO purchase, and the potential challenges related to transferring funds from national programs to the WMO. A few countries are interested and during discussion, it was suggested to follow up with DBCP and others within WMO to learn more about how the existing avenues work for purchasing equipment.

Action item 11: Peter Oke, Victor to explore using WMO to purchase floats on behalf of smaller countries to improve float purchasing efficiencies. Report back at AST-26. Peter, Victor

Tuesday: BGC Argo

BGC-Argo Introduction and status (Hervé + Ken + Orens): 10 min

The introduction gives a quick overview of the achievement of the BGC-Argo mission over the previous year. Overall, the BGC-Argo is progressing well, with an increasing number of floats with six variables. Map of density /coverage of BGC-Argo shows under-sampled regions (South-East Pacific; Eastern part of the Subtropical South Atlantic; Subtropical Indian). Qualification of data in DM is improving, especially for O2, NO3 and pH. The documentation for processing and QCing data is now available for all six variables. More than 550 papers have been published so far with the top three journals being JGR, FMARS & GRL. The BGC-Argo Technological Task Team (TTT) has been launched to provide expertise and recommendations for BGC-Argo sensors. Finally, the membership of the BGC-Argo mission team has evolved, taking account of the emergence of the TTT and the inclusion of new young members.

BGC implementation (1.5h)

National reports (1 slide / 18 countries): 40 min National PI

National representatives of each country involved in the BGC-Argo mission were invited to report on their national activities related to Data management, DAC, communication & outreach, issues etc.

- Australia:

- Data management: ALL RTQC and adjustments up to date except for BBP (not yet implemented), with regular updates of adjustment coefficients at least every 6 months. Updated the nitrate calculation based on the latest temperature coefficients. Planned improvements (over the next 6 months): RTQC of BBP, produce the new trajectory files and then start in-air oxygen DMQC (currently using WOA2018 for oxygen adjustments).
- Communication & Outreach :UTAS social and traditional media posts on float recoveries in April and November attracted significant interest (8,000 views for one post).
- Others : Tom Trull retired. Christina Schallenberg is the CSIRO representative, Pete Strutton at U Tasmania. We recovered three floats! Two off the east coast of Tasmania in April (social media post >8K views), one in the Southern Ocean in November. Significant media around each event. Australia's BGC-Argo program is funded as a *sub-facility* (under the Argo *facility*) in Australia's Integrated Marine Observing System. We were recently re-funded through 2027 at about the same level as 2019-2023. Working on at least one grant to fund more floats and pursuing philanthropic funding. Trying to increase the size of our program.

- Canada:

- Data management: Anh Tran and Chris Gordon have been working hard to integrate CTS5 floats into data flow.
- Others : Looking forward to integration of the RBR tridente sensor on NKE CTS5.

- China:

- Data management: Two BGC-Argo floats with rechargeable batteries were deployed in the Northwest Pacific, However, these two floats faced ballasting issues, preventing them from descending beyond 400 meters. CSIO is actively exploring opportunities to retrieve and re-ballast these floats for redeployment.
- Communication & Outreach: CSIO has successfully organized a 6-day BGC-Argo training course in Hangzhou on November 15-20, 2023. This training was supported by POGO, with 19 trainees from Bangladesh, Egypt, India, Malaysia, Morocco, the Philippines, Saudi Arabia, and China.

- Europe, Bulgaria, Finland, Polan, Spain:

- Data management: DMQC done on a best effort basis but needs to be further organized.
- Communication & Outreach : European funding for BGC-Argo (lobbying towards the European Commission & discussions with the operational community - Copernicus). Comics “Journey with Ocean Observers” in collaboration with OceanOPS.
- Others: EU projects: GEORGE [2023-2026] - Sensor developments (pCO2) and integration, in collaboration with other EU Research Infrastructures. DOORS EU project [2021-2025] - 2 BGC floats deployed in the Black Sea.

- France:

- Data management: UVP : Data pipeline towards Coriolis AUX finalized (Deployment of 26 floats with UVP over the last two years). Ed/Lu hyperspectral sensors : Data pipeline towards Coriolis AUX : ongoing (deployment of 10 floats).
- Communication & Outreach : BGC-Argo website administration and update + newsletter…: https://biogeochemical-argo.org. Release of the new « adopt a float » website (90 classes; resources translation) : https://adoptafloat.com.
- Others : Development of a micro sonar (micronekton: 1mm – 5 cm). PIANO Ifremer funding. First test on CTD-Rosette expected by the end of 2024.

- Germany:

- Data management : Wimart-Rousseau et al. (2024). Technical note on float-pH data quality control methods. *Biogeosciences* (in press). With the present BGC-Argo pH DMQC methods, we fail to achieve a pH accuracy near the stated 0.01 pH in the subpolar northwest Atlantic. Differences between reference algorithms regionally amount up to 0.02 pH alone.
- Communication & Outreach : Deployed 2 APEX BGC-Argo floats with polar explorer/ writer Arved Fuchs in the Baltic Sea (1 failed upon deployment).
- Others : Cooperation with Norwegian Polar Institute to study Biogeochemistry in Eastern Weddell Gyre (deployment of BSH BGC floats on the Troll Transect).

- India:

- Data management: QC of Doxy and Chla are implemented as per the ADMT. BBP700 profiles with QC flags are being pushed to GDAC. DOXY: SAGE software is being used for adjusting gain factor and populating the adjusted fields. Chla: QC of Chl-a profiles done, adjusted fields generated and being updated to GDAC. Agreeing for the gridded Alpha and Beta values for real-time corrections (Agreed after the BGC working group meeting). Nitrate: RTQC is being tested for profiles from Nitrate floats.
- Communication & Outreach: Data awareness activities wrt BGC profiles are undertaken. Supporting the profiles to students and researchers for their R&D work. BGC data usage was propagated during ITCOO training programs.
- Others: Data gridded product for the northern Indian Ocean available on INCOIS Live Access Server (LAS).

- Italy:

- Data management:•Hiring one BGC DMQC operator to deal with core+DOXY and BGC floats. Submitted proposal including task to develop DMQC methods for BBP.

- Communication & Outreach: Trieste Next: Argo outreach activity (Sept 2023). Adopt-a-float in Trieste (3 schools signed up). Two seminars (1 nursery + 1 high school).
- Others: Projects using BGC-Argo data: PNRR ITINERIS, ESA CAREHeat, ESA 4DMED-SEA; ESA SCOPE; ESA COLOR, HEU AtlantECO, HEU OceanICU, NERC MicroRespire. Testing alternative BGC sensors: 2 floats with OPUS + SUNA in order to be deployed in the oligotrophic Med Sea, 19 floats with OPUS, 21 floats with RBR Tridente. Med Sea Core-Argo fleet to be equipped with DOXY sensors to support operational BGC modelling.

- Japan:

- Data management: DAC & RTQC: Japan Meteorological Agency (JMA). DMQC: Japan Agency for Marine-Earth Science and Technology (JAMSTEC). JAMSTEC will begin submitting BD files to GDAC in March 2024. Additionally, JAMSTEC has evaluated the performance of ARO-FT and AROD-FT and corrected the DOXY profiles for ARO-FT. JMA decodes all the variables of active BGC-Argo floats in Japan. JMA has been developing a program for RTQC of each parameter and conducted RTQC for O_2 with adjustments based on WOA. Additionally, JMA has introduced the adjustment for NO_3 based on WOA in February 2023.
- Communication & Outreach : The super lesson was held during JpGU2023, explaining the contents and characteristics of BGC-Argo data and how to use it.
- Others : Issue : Due to the announcement of a pH sensor error by SBS on May 25, 2023, JAMSTEC suspended floats equipped with a pH sensor. JAMSTEC has asked SBS to replace the pH sensor with the updated version mounted on floats, but SBS has not done so yet. Since 2021, JAMSTEC has been developing the NINJA float equipped with ARO-FT and a fast repetition rate fluorometer (FRRF). Furthermore, beginning in 2024 and over a three-year plan, JAMSTEC will develop a power-saving and compact FRRF, supported by CREST, JST. WPI-AIMEC, a collaborative research institute of Tohoku Univ. and JAMSTEC, was established in 2024 to understand and forecast the response and adaptive mechanisms of marine ecosystems to Earth system dynamics. As part of WPI-AIMEC, one BGC-Argo float will be deployed in the North Pacific. The new mid-term research project "hotspot3“, funded by JSPS, has been accepted and will start in April 2024. The research aims to understand mechanisms of physical-biogeochemical processes in the atmosphere and ocean, with a plan to deploy 5-10 BGC-Argo floats.

- Norway:

- Data management :Do DMQC of oxygen, pH, nitrate, and Chl-a.
- Communication & Outreach : A national Argo BGC-workshop was held in Bergen, Norway in November with almost 30 participants.
- Others : A proposal for five years funding (2025-2029) was submitted to the Research Council of Norway. Funding for total 55 floats + DMQC: 17 core, 20 core+DO, 6 Deep+DO, 12 BGC (4+ bgc variables).

- USA:

- Data management: MBARI Data Center manages ~300 active and ~200 inactive BGC floats. AOML also manages a smaller set (~7) of BGC floats. The MBARI Data Center updated manuals for nitrate and pH and published an improved temperature correction algorithm for nitrate (Plant et al., 2023).

- Communication & Outreach: GO-BGC sponsored a BGC-Argo data workshop at UMass Boston in August. A workshop for educators will be held in June 2024. The Adopt-A-Float program continues a strong effort with 70 floats adopted in 2023. GO-BGC sponsored a profiling float component in the MATE ROV Challenge.
- Others: Several sensor and float issues were resolved in 2023. MBARI scientists worked closely with Sea-Bird to resolve early failures in pH sensors. Extremely inconsistent calibrations in CDOM sensors were found and project scientists worked closely with Sea-Bird to resolve the issue. UW staff identified a problem with air bladders on Apex floats and worked with Teledyne Webb to resolve the problem. Testing 2 new, 6-parameter float models: MRV BGC-S2A/SIO BGC-SOLO II (5 total deployed, ~8 to 16 total in 2024) & Sea-Bird Navis Nautilus. 2 total deployed, ~5 to 10 total planned in 2024.

13. UK:

- Data management: RT data delivery for 13 BGC floats. RTQC automatic adjustments for DOXY (11 PROVOR III), CHLA and BBP (11 PROVOR III and 2 PROVOR V), NITRATE (11 PROVOR III). From March 2023 up to date of writing this document BODC undertook DMQC Adjustments for 2 DOXY floats (PROVOR III). Internal DMQC training in BODC on BGC QC processing to BODC Argo team members to improve the NOC capacity in undertaking Argo data analysis. Currently the team is upskilling and preparing for the DMQC of Nitrate. Design of the CTS5 delivery and delivery of data from PICCOLO project. Upgrade of the Coriolis processing chain allowing new functionality of automatic RTQC of BBP and Nitrate from ASBAN UK floats.
- Others: Issues : CTS4 deployed in Florida Straits failed to surface, CTS4 near Portugal stuck at surface, CTS4 failed checkout due to bad connection with sim card. Temporal disruptions in RT data delivery due to internal BODC software updates.

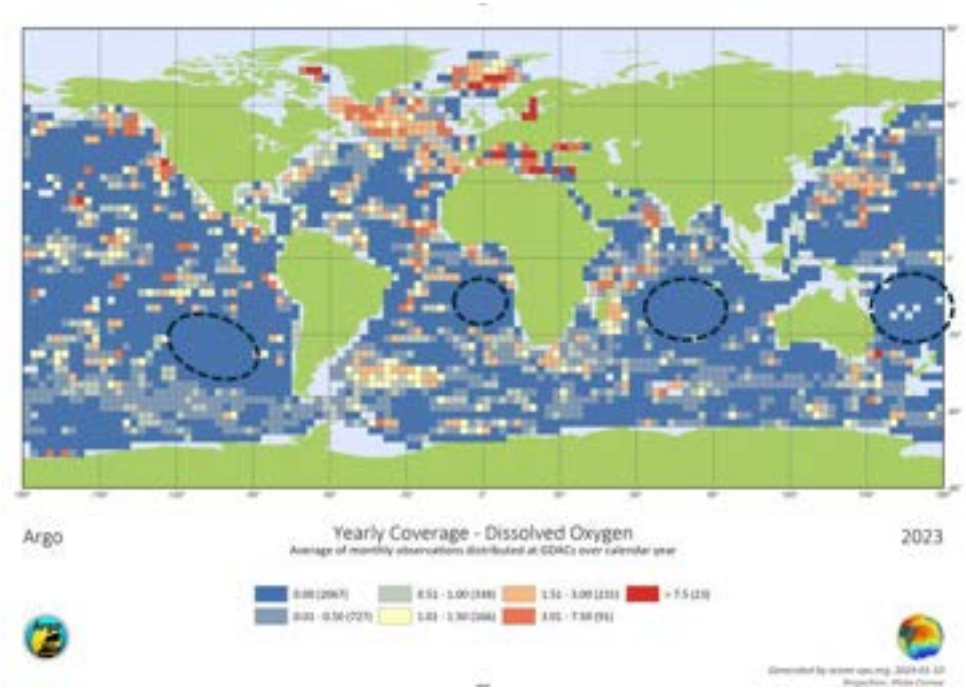
General assessment of near term deployments: Orens - 10 min

Based on information collected from national representatives, an assessment of BGC-Argo float deployments conducted in 2023 was carried out. A total of 168 BGC-Argo floats were deployed (excluding floats measuring only temperature, salinity, and oxygen), with approximately 50% of the contribution coming from the USA. Sixty-six percent of the deployed floats were equipped with the full suite of sensors (5-6 parameters), although there were notably fewer irradiance sensors compared to others. Many deployments were made with non-official BGC-Argo sensors, indicating the dynamism of R&D projects in addition to operational aspects. National representatives also provided deployment plans for 2024, 2025, and beyond. Most countries have commitments for the coming years, which is a positive signal. A large contribution from the

USA is still expected, and there may be an increase in contributions from Italy and Norway due to structural funding. It is likely that BGC-Argo will reach its deployment intensity target in 2024. Thanks to the efforts of the main contributing countries, a significant increase in radiometric measurements is also anticipated.

Priority areas: Orens - 10 min

Areas with few floats were identified by examining float density/coverage and its evolution over the past year. Four regions were found to have a recurrent float deficit: the Gulf of Guinea, the Indian Ocean, the Western Pacific, and the Southeastern Pacific. While several deployments are planned, particularly by the USA, they are expected to be insufficient to fill the gap in these oceanic regions. Therefore, the community must strengthen its efforts, and deployment in these areas must be considered a priority.



Long term funding (USA Ken and others) 10 min

US BGC-Argo is contributing about half of the BGC floats and about 70% of the multi-sensor floats. These contributions are funded primarily by two NSF science programs, SOCCOM and GO-BGC. SOCCOM ends in 2024 and a renewal proposal has been submitted. GO-BGC will formally end in late 2025, but deployments will continue to late 2026. Discussions among US Federal agencies on mechanisms to renew GO-BGC are underway, but no clear path exists yet.

Strategy towards space agencies (Hervé) 10 min

Among the six core BGC-Argo variables, three of them are “bio-optical variables”: Chla, suspended particles (bbp) and radiometry (presently PAR, Ed380; Ed412; Ed490). The same variables can also be measured or derived from space through Ocean Color Radiometry (OCR)

sensors. The progressive densification of the BGC-Argo array as well as the development of refined methods for QC now produce an interoperable global database for these variables that is unique with respect to space applications. Three area of interaction between BGC-Argo and ocean color can be envisaged:

(1) The synergistical use of BGC-Argo and satellite data to generate, thanks to machine learning method, 3D/4D gridded products for Chla, bbp /POC & radiometry, with some of them being distributed by Copernicus marine service (https://data.marine.copernicus.eu/product/MULTIOBS_GLO_BIO_BGC_3D_REP_015_010/description). These products can be used for a range of applications from supporting data quality control (through audits) to reference measurements to initialize / validate BGC-models to cite a few.

(2) The use of BGC-Argo bio-optical data for the validation of optical products derived from satellite measurements. There is a growing body of literature taking advantage of this unique dataset for validation of Chla or bbp of derived variables from radiometry (e.g. diffused attenuation coefficient). BGC-Argo data present additional advantages with respect to historical optical data as they are more representative of bio-optical conditions in open ocean and also more consistent and interoperable.

(3) Finally with the emergence of new sensors taking hyperspectral measurements of both Ed and upwelling radiance (Lu) new perspectives emerge with respect to application for the Ocean satellite community. The recent launch of the PACE hyperspectral satellite offers the chance for rapidly developing dense reference datasets of BGC-Argo floats carrying sensor platforms for the open ocean that can support validation for new types of products. Additionally, to the extent that all the uncertainties linked to radiometric measurements by floats are well characterized, BGC-Argo floats could be used, in the future, in synergies with reference optical moorings to the so-called Fiducial Reference Measurements (FRM) that are key to adjust the gain of satellite sensors over their lifetime and as such contribute to calibration activities.

As a conclusion, more formal exchanges between space agencies and BGC-Argo should be undertaken in view of common interests. The International Ocean Color Coordinating Group (IOCCG) that previously sponsored the Bio-optical sensors on Argo floats working group could be the place for such constructive discussions.

Action 12: BGC-ARGO to attend and be represented in IOCCG meetings. Herve Claustre

Revisiting the implementation plan (Ken + Hervé) 10 min

1. What is a BGC float (5 or 6 param?) ....
2. Role of O2 only floats
3. New sensors

The BGC-Argo Science and Implementation Plan was written in 2016. While it has been successful, it is also aging and needs to be updated. Topics that need updating include:

- The role of 5 vs 6 sensor floats
- The role of O2 only floats

- Defining the BGC-Argo float mission cycle. how to address floats that cycle at short (e.g. daily) cycle times
- Updating processes for integration of new sensors
- Updating the section on float and program cost.

The BGC-Argo Mission Team will begin this process.

BGC sensors including Q & A with manufacturers (2:05)

TTT/WG Intro (Edouard/Yui 10min)

The creation of the new BGC Argo Technological Task Team (TTT) was decided at the last AST. It was set up in June 2023 and is co-chaired by Yui Takeshita (MBARI) and Edouard Leymarie (LOV) with the help of Orens Pasqueron de Fommervault. This team is becoming important as more new sensors become available to measure both standard and new variables. This will bring resilience to the program, a potential reduction in the price of sensors, but also a potential difficulty in maintaining database homogeneity when using sensors from different manufacturers. The composition of the group and the terms of reference are available on the BGC Argo website.

The group has met 3 times and the following decisions have been taken:

- Work with OceanOps and ADMT for tracking current sensor's performance (dedicated presentation)
- Integrate TTT activities into the annual ADMT to present and discuss technical issues (exact format TBD)
- Creation of 3 working groups to work on sensor interoperability by variable within specialized groups: Fluo-Chla, Backscattering and Radiometry. These groups are introduced in the dedicated presentations of this session.

OceanOPS monitoring: Orens - 10 min

In the context of OneArgo and the anticipated increase in diversity of BGC sensors within the network, tracking sensor performance at OceanOPS is considered a priority. Currently, such an analysis is conducted by MBARI for GO-BGC and SOCCOM floats only. OceanOPS has begun implementing this method for the entire Argo fleet and producing a plot showing the fraction of sensors surviving at certain cycle numbers. This work is based on Stoer et al. (2023) method and relies primarily on the BGC-Argo quality flag system. Simultaneously, the OceanOPS metadata database has been reviewed and curated to correct inconsistencies (missing metadata, erroneous metadata, duplicates). A metadata inventory was also conducted to assess available information and determine if certain fields must be mandatory or added in the future (e.g., Batch number). Developments will continue to address specific cases and provide an operational tool to the community. Additional metrics and charts should be developed based on the requirements expressed by the AST and the ADMT.

New chlorophyll sensors + WG (Julia/Antoine: 10min: 5 min sensor + 5 min WG + 5 Q&A)

The context for the chlorophyll fluorescence working group (FluoWG), established in the framework of the BGC-Argo TTT, is twofold. First, in addition to historic SeaBird ECO fluorometers, new sensors are becoming available for deployment on BGC-Argo. In this context, the FluoWG recommends that the manufacturers share as much information as possible (calibration, sensor specifications) and will provide recommendations for standard calibration procedures and methods to ensure the interoperability of data from different sensors (manufacturers/makes). Second, new fluorometers with 2 excitation channels at 435 and 470 nm (instead of just the 470 nm) have been deployed to explore ways of reducing the variability of the fluorescence-to-chlorophyll a (Fluo:Chla) ratio. The WG will seek to provide recommendations for processing of data from the 435 nm channel and investigate the hypothesis that the Fluo:Chla ratio shows a similar level of variability for both the 435 and the 470 nm channel. One option to explore the response of the different sensors under different oceanic conditions as well as the variability of Fluo:Chla is to merge in situ reference databases, comprising shipborne concomitant fluorescence and HPLC pigment measurements.

Our group at LOV has started to merge such a database, with fluorescence measured with a 2 excitation channel ECO sensor concurrently with HPLC pigment determinations, collected during four field cruises in the Labrador Sea, Equatorial Atlantic, Subtropical Indian Ocean, and Southwest Indian Ocean. A preliminary analysis of this database indicates that, to first order, the Fluo:Chla ratio shows as much variability for the 435 than the 470 nm channel. Yet, further investigations are needed to conclude, in particular on the role of NPQ, CDOM and/or phytoplankton community composition. Importantly, we suggest that merging reference databases with fluorescence and HPLC pigment measurements collected by other groups would be an efficient way to provide a more definitive assessment of the 435-nm channel. Such analysis could be conducted within the framework of the FluoWG.

New BBP sensors + WG (Giorgio: 10 min – 5 min sensor + 5 min WG + 5 Q&A)

A summary of the first activities of the TTT BBP group was presented. The main objective of these activities was to understand how to best integrate new BBP sensors (e.g., RBR Tridente) into the existing BGC-Argo dataset. Two calibration methods were proposed for BBP sensors to be installed on BGC-Argo floats: (i) the "gold reference standard" where each BBP sensor is calibrated using NIST-traceable beads, preferably of 0.1-um size to minimize uncertainties, and (ii) a "secondary calibration" where a few "gold" sensors are first calibrated using method (i) and then used to cross-calibrate many other sensors. Method (i) is advantageous because it relies on a reference standard that is traceable and reproducible and thus can be adopted by different companies. Method (i) is also expected to be more accurate than method (ii). We also presented ideas on how to verify that the existing and new BBP sensors deliver consistent datasets. First an analysis of BBP data in stable ocean regions (e.g., deep waters in oligotrophic gyres) similar to that conducted by Poteau et al., (2017) was recommended. Second, a ship-

based intercalibration exercise was discussed where different sensors from each manufacturer could be compared simultaneously (intercalibration of the CHLA channels could be achieved at the same time). These two methods provide complementary advantages, and the initial conclusion of the working group is that we may have to adopt both of them. The next steps will be to define what uncertainties are needed for BGC-Argo BBP data, to engage with manufacturers to better understand their calibration procedures and to analyze existing BBP data.

New radiometer sensors + WG (Edouard: 10 min – 5 min sensor + 5 min WG + 5 Q&A)

Three radiometers are currently available on profilers. The historical OCR504 from SBS is now available on almost all BGC profilers. The Ramses hyperspectral sensor from TriOs is available on the Provor CTS5 and Apex platforms. Finally, Biospherical's MPE-PAR is a monospectral (PAR channel) high-dynamic sensor available on Provor CTS5 only. The CTS5 can also be fitted with two Ramses for measuring downward irradiance and upward radiance, for use in the calibration or validation of satellite products. New sensors, in particular RBR's Quadrente, will soon be available. A comparison of the three sensors on the same float shows a significant difference in sensitivity between the three sensors. An intercomparison of the sensors is presented. On the one hand, using a profiler in the Mediterranean Sea equipped with an OCR and a Ramses, and on the other, using a profiler in Baffin Bay equipped with an OCR and an MPE. Intercomparison is studied by looking at three quantities: the value extrapolated to the surface, the depth at which we measure 1% of the surface signal and finally the depth at which we measure PAR=15. In particular, there is a significant difference between Ramses and OCR for values extrapolated to the surface. This difference can probably be reduced by working on the Ramses data extrapolation method. In the polar zone of Baffin Bay, OCR cannot always measure the 1% depth, due to a lack of sensitivity in low light conditions. Further intercomparisons are necessary to continue this work.

The radiometry working group will aim to improve sensor interoperability, taking into account not only primary data ('irradiance') but also derived products such as the extrapolated surface value or the 1% depth. This interoperability depends not only on the sensors, but also on the profilers and the way in which the data is acquired. The group is made up of four people, and volunteers are still being called for.

pH availability and reliability (Yui 10min + 5 Q&A)

The status of pH sensor availability from SeaBird was first presented. Honeywell announced the discontinuation of their ISFET chips (core technology for the Deep-Sea-DuraFET (DSD) pH sensors on floats) in June 2022. They agreed to restart production in Dec 2022 after pressure from the US government. Since then, SeaBird has received two batches of ISFETs from Honeywell, and the performance of the new chips is good. They are experiencing good yields in their calibration now, and they have resumed production at rates similar to pre-June 2022.

A brief history of the reliability issue with SeaBird pH sensors, and steps taken to remedy it were presented. In 2021, high failure rates of SeaBird pH sensors were observed, caused by a faulty reference electrode. The symptoms are that the diagnostic values (Ik and Ib) remain good, but VRS (sensor signal) starts to decrease. The shape of the profile looks OK for a while, but then typically leads to a more erratic profile shape. These symptoms typically appeared in the first couple of months of deployment, but the sensors that survived >1 year were typically OK. In response to this, MBARI and SeaBird collaborated to identify 2 issues with their mechanical design. First, the durometer was increased for the O-ring that seals the reference electrode. Second, the method to prepare the reference electrode was refined. Extensive cross-calibration was conducted between MBARI and SeaBird, and as a result, significant improvement in SeaBird pH reliability was observed. For sensors deployed between March 2022-2023, SeaBird pH sensors had a 36% failure rate in the first year (n=45), whereas sensors deployed between March 2023-2024 had an 8% failure rate in the first year (n = 62). Given this evidence that SeaBird pH sensor reliability has significantly improved, GO-BGC and SOCCOM projects plan to continue deploying a majority of SeaBird pH sensors moving forwards.

Finally, updates on the development of two potential pH sensor alternatives were presented: the Pyroscience Pico-pH optode, and a pH sensor using an ISFET from LioniX International. We tested both sensors on a Spray underwater glider down to depths of 1000 m. The standard sensing foil for the Pico has a response time that is too long to make it viable for profiling applications, but the fast-response version that was developed recently at Pyroscience showed significant improvement in its ability to capture fine scale vertical variability. However, a large shift in calibration was observed for this deployment with unknown cause, which was troubling. On the other hand, the LioniX pH sensor showed good performance on our mission, and we plan on continuing development. SeaBird and MBARI are pursuing parallel designs for this sensor and are in close communication with their results to maximize the chance of development for a successful sensor.

New oxygen sensors (Yui : 10 min + 5 Q&A)

Four new or improved oxygen sensors were presented.

1. SBS83: This is a new oxygen optode that can be pumped for improved response time, but also is capable of air-calibration. It is a mechanical repackaging of the SBS63; thus, similar performance is expected. Three triple-O2 floats, equipped with an Aanderaa 4835, SBS63, and SBS83 were deployed in the Pacific to assess the performance of the SBS83. Based on these floats, the SBS83 had better precision (calculated as 1 standard deviation of the 8 measurements made in air each time it surfaces) than the Aanderaa by about 50%. Furthermore, surface O2 agreed to better than 1% between the Aanderaa and SBS83 after they were individually air-calibrated. Response time of the SBS83 was characterized in the lab and showed slightly faster response time compared to the SBS63. There are 13 SBS83 deployed on floats currently, with all sensors functioning properly. We plan to procure ~70 floats equipped with SBS83's through the GO-BGC program over the next year.

2. RBR ODO: Improvement in performance of the RBR ODO|slow sensor was presented. First, the resolution of the ODO sensor was improved from ~1 umol/L to < 0.1 umol/L with an increase in energy requirement (36 to 60 mJ/sample). New hardware and firmware are required for this upgrade. Their calibration protocol for the ODO has been improved and is capable of an accuracy of +/- 2 umol/L over a range of temperature and O2 concentration.
3. JFE AROD-FT: The mechanical design of the AROD-FT was updated to improve air-calibration. The optical foil sat in a small recess in the previous design, thus, likely trapping seawater on the foil during air-calibrations. To address this, the optical foil now sits flush, thus, no seawater should pool on top of the optical foil. This new version will be tested on a double DO sensor Deep-Arvor float.
4. Aanderaa FOD701: A new foil that has notable improvements to the commonly used Pst3 foil was presented. The main improvements are: Lower storage drift (~50% of Pst3), lower pressure coefficient (1-2% / 1000 dbar), better resolution at low O2 conditions (15nM), and lower pressure conditioning drift. To obtain the most accurate and consistent measurements at depth, each sensor will likely need to be calibrated individually for its pressure response. Preliminary, raw data from a dual-optode APEX float (two Aanderaa 4835 with a Pst3 foil and a FOD701 foil) deployed in the Eastern Tropical North Pacific was presented. These preliminary results suggested that the FOD701 had lower storage drift and smaller pressure coefficient relative to the Pst3 foil, but further analysis is required.

Action item 13: Form an oxygen working group to tackle oxygen bias issue and to report back at AST-26. Virginie Thierry, Yui Takeshita, Henry Bittig to lead.

Alternative nitrate sensor supplier (Henry : 5 min + 5 Q&A)

In line with other activities to increase sensor diversification and reduce single points of failure for the BGC-Argo mission, Henry Bittig presents work to qualify an alternative nitrate sensor. Traditionally, the SBS DeepSUNA sensor, a 2000 dbar rated UV spectrophotometer, is the only available sensor used on BGC-Argo for nitrate measurements. As an alternative, the TriOS OPUS-DS sensor is a 6000 dbar rated UV spectrophotometer first commercialized in 2014. It has been used previously for various monitoring tasks, but also for surface underway measurements (often coastal), deep CTD casts (up to 4000 dbar), or a profiling coastal mooring.

Within the BMBF-funded DArgo2025 project the TriOS OPUS-DS sensor:

(a) was integrated into the NKE BGC-Argo float platform CTS5, becoming a commercially available option in 2022.

(b) characterized in the lab against the SUNA sensor, where power consumption per sample was found to be ca. +25 % elevated for the OPUS-DS compared to a SUNA, which is apparently linked to a substantially elevated base current draw of the OPUS so that total on-time per sample dominates the power budget. The present commercial version of OPUS provides several additional functionalities (e.g., Ethernet interface, on-board calculations) not used on Argo floats but likely responsible for this elevated base

consumption. I.e., with optimizations for Argo (similar to those done to the SUNA sensor over the past 20 years), there is good potential for a better energy budget.
(c) tested in the field alongside the SUNA sensor with two dual-nitrate floats deployed in the Baltic Sea. Both floats have been recovered prior to battery exhaustion at about 200 cycles with more than 100 sensor sampling points per profile (i.e., operated in intensive testing mode). Shipboard reference sampling was performed 4x or 5x times, respectively, during both deployments.

To both sensors, standard BGC-Argo nitrate processing (TCSS-algorithm) and adjustment (offset) were applied. Due to Baltic Sea specifics, an adapted approach for the reference level (otherwise based on CANYON-B/ESPER based GLODAPv2 regression) had to be used (Bittig, unpubl.), being the same for both sensors. The OPUS data shows somewhat elevated scatter than the SUNA, but comparison to bottle data did show no difference between OPUS-DS and SUNA performance (ca. N=75 per float and sensor), both yielding unbiased data after QC with an RMSE around 1 µmol/L.

The OPUS-DS sensor is commercially available on an established BGC-Argo float platform (CTS5) and, based on the (limited) DArgo2025 field results, shows similarly accurate data after DMQC as the SUNA. At the same time, the OPUS-DS price tag is significantly less than the DeepSUNA sensor. To solidify results, further field tests like within the Argo Italy ITINERIS project (planning to deploy 19 OPUS-equipped and 2 dual OPUS/SUNA-equipped floats in the Med Sea) are to be encouraged across the OneArgo community. Similarly, OPUS sensor optimization by TriOS for Argo use (e.g., improved energy budget) would be a promising route for wider adoption of this alternative nitrate sensor.

Underwater Vision Profiler (Hervé : 5 min + 5 Q&A)

The UVP6 with embedded taxonomy identification operates successfully. Thirty-two floats with UVP6 have been deployed so far and four will be deployed in 2024 (Icelandic Basin and Costa Rica Dome) by five countries (France, Norway, Germany, Italy, Australia). The data pipeline is being implemented at Coriolis and RT QC methods begin to be discussed between specialists (e.g. use of the slope of the particle size distribution). The UVP6 sensor addresses 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. Following the framework for accepting new BGC-Argo variables (IOC recommendations), UVP6 has the potential to become a new variable of the BGC-Argo array.

Common themes from WG, Manufacturers feedback (10 min Q&A)

Common themes that have emerged from our first WG meetings for CHLA, BBP, and Irradiance were presented: 1) all WGs need to engage with manufacturers as they will be key partners for this work; 2) we would like the manufacturers to publish calibration protocols for their sensors and make them publicly available; 3) we would like technical specifications for the sensors that are relevant to their performance/inter-calibration; and 4) we need to establish an intercalibration in the laboratory and field to verify comparable sensor performance across

different manufacturers. This short discussion was designed to start a conversation with the manufacturers.

Action item 14: Ask manufacturers to share their calibration protocols and sensor specifications with the BGC Argo TTT.

BGC data management and products (2.5 h)

Data Management Task Team summary (Catherine/Tanya: 20 min)

First, we would like to remind everyone of the BGC data management task team mandate which is to drive and enhance the development of BGC data management procedures following the scientific guidance of the BGC-Argo Mission Team. All DACs pushing BGC-Argo data to the GDAC should be represented in the task team and the representative commits to attending all the planned meetings or to nominating a proxy in order to make timely decisions and take action (to the best of their ability, with support from the group) so as to not hold up goals.

Last year, we dedicated a lot of time to update the BGC documentation: release of the BBP QC document, updates of the CHLA QC document, updates of the Nitrate processing document with the new temperature correction, and to insert GTS buffer sequences into the BGC-QC cover document.

During ADMT-24, a potential bias in the DOXY_ADJUSTED concentration was presented in two presentations (V. Thierry, X. Xing). A group was formed to investigate this issue, some discussions have started, and some ideas are suggested, but as it is a small bias, it is difficult to trace. Tanya and Catherine think that a coordinated effort is needed to address this point as this may be explained at different levels: technical, processing (DAC) or DM (DM operators).

After Eric's Rehm presentation on three different issues for the CDOM sensors, the data management team expects feedback from the BGC AST on how to cover the topic regarding the QC flag assignment in order to protect the users.

We are presently working on reporting the status of action for all the DACs regarding the BGC data management in a stoplight chart, following what is done for the core mission. We circulated it last week and we will present the action status this way at the next ADMT.

Presently, we are working on defining a detailed implementation of the RT_CHLA Slope across DAC (Raphaelle's presentation).

Some feedback is also requested for ways forward to serve PAR, for floats no longer equipped with PAR sensor (4 wavelengths instead of 3 wavelengths+PAR)

We are also planning to organize a second BGC DMQC workshop in 2025 as the first one was really appreciated.

BGC Product: Example of the PAR – will computed PAR be considered an Argo parameter when calculated. Should we have product files (Pprof with derived products) (Herve/Ken, others: 15 min)

This presentation follows two main objectives. The first part of the presentation introduces the so-called SOCA-light (Renosh et al. 2023; DOI: 10.3390/rs15245663) to model a vertical profile of PAR, Ed380; Ed412 & Ed490 in the absence of OC4 sensor. This neural network-based method, trained on the radiometry BGC-Argo data set, relies on the same principle and inputs than similar SOCA methods developed for Chla or bbp : the retrieval of the vertical radiometric profiles make use of satellite Ocean Color Remote Sensing Reflectance, the hydrological vertical structure and the geolocation of the profile. Such modeled vertical profiles could support a variety of applications in particular for any BGC-Argo float, the computation of the euphotic zone or the diffuse attenuation coefficient Kd.

The second part of the presentation is linked to the recent recommendation from a BGC Argo working group to standardize the wavelengths used in radiometers. They recommended replacing the PAR channel on the radiometer with a 555 nm channel as preliminary investigations indicated that PAR could be computed accurately from 380, 443, 490 and 555 nm radiometer bands. The equation format for the calculation was not finalized. A small, ad-hoc group is now working on this. The remaining question, of whether or not to report PAR in the B and Sprof files, will then be addressed once any limitations in computing PAR are available and well tested. Nitrate serves as a precedent for reporting PAR that is computed from individual wavelength bands. The nitrate sensor measures light absorption at a number of wavelengths and then computes nitrate concentration, which is reported.

How to produce a more uniform CHLA data set (Raphaëlle / Catherine 20 min)

This presentation aimed to suggest the use of a new adjustment to obtain a more uniform chlorophyll-a concentration dataset from the Argo data stream. For this, we suggest the use of a look-up table of slopes varying across regions to be used in Real-Time (RT) that is more in agreement with the slopes suggested to be used in Delayed-Mode (DM) by C. Schmechtig (presented during the 23rd ADMT in Miami). This is crucial because CHLA adjusted both in DM and in RT fill the same CHLA_ADJUSTED fields. The main issue is that users are far from always checking the data mode of the variable but use all the CHLA_ADJUSTED data. By using the SOCA climatologies of CHLA_ADJUSTED and ED490, we computed the slope from radiometry-based methodology (from Morel at al. 2007), satellite-based and Uits et al. (2006) based. We evaluated the accuracy of the datasets adjusted from each methodology using a machine learning-based workflow allowing comparison against HPLC reference measurements. The result is that the radiometry-based slopes (both used in RT and DM) return unbiased and more accurate Chla at a global scale. The use of these new RT slopes will (1) improve the accuracy of the CHLA_ADJUSTED dataset of ~15 % at a global scale and >100 % for the

Southern Ocean (>45°S) and (2) allow to push CHLA_ADJUSTED in delayed-mode without having significant differences between data adjusted in real time and in delayed mode.

Action item 15: Ask Raphaelle Sauzède & Catherine Schmechtig to move forward with documenting the procedure to get an improved 'slope' factor for chla and consider changing terminology from 'slope'. Raphaelle, Catherine

Action item 16: Ask DACs to begin testing implementation of improved chla 'slope' factor using look up table from Raphaelle Sauzède & Catherine Schmechtig. DACs

Secondary corrections to data - deep oxygen (500 – 2000m) analysis (Yui)

A summary of studies and presentations that compared float O2 data to shipboard data (e.g. GLODAP, WOD, or regional analysis) were presented. All seven studies demonstrated a small negative bias in the float data below ~1000 m, of -1 to -4 umol/kg. Based on these studies, it is likely that there is a small negative bias of float data at depth. A group of researchers familiar with this topic met at the Ocean Sciences meeting in 2024 to discuss potential issues, and next steps.

What is BGC delayed mode? (DM report) 20 min

Goal of DMQC is to remove spurious sensor drifts and errors from the Argo data stream and to bring the entire set to a uniform (if possible) and known (labeled error estimates) quality. As the techniques for the DMQC of BGC parameters evolves, more intercomparisons between newly deployed and aged sensors should be encouraged and overall consistency checks put in place. A key aspect of this endeavor is to alert our user community of these evolving efforts, and hopefully increasing accuracy of the DMQC'd data set

Basic data system structure, many BGC-DACs vs a few (Euro-Argo…Claire/ Yann-Hervé) 20 min

Delayed Mode Quality Control of BGC data must become as seamless as DMQC on Core, since data quality has always been key in Argo. Key features expected from DMQC are:

- Interoperability: already ensured by sharing procedures and software, a step forward is underway within the EU Envri-Fair project that builds a GUI enabling the co-working of experts on the same profile;

- Sustainability: duplication of efforts must be avoided, in order to overcome overwhelming cost;

- Timeliness: operational users need DMQC data in a precise time-frame, especially for validation, and Service Level Agreement might be put in place to ensure the provision of DMQC data;

- Diversity: the confrontation of scientific approaches is always needed, especially for new variables, moreover due to progress in understanding data error and biases, DMQC is not meant to be performed only once.

At the European level, after concertation in the framework of the Euro-Argo RISE project, a distributed organization in line with these principles is proposed, coordinated by Euro-Argo ERIC for its members. Although it still needs to progress and to prove itself, the ERIC should provide in this organization:

- a continuously updated list of skilled personnel/teams among the members;
- the list of floats/profiles of the members to be DMQCed;

- the connection between teams, helping to contract if needed (since DMQC operation could be charged).

- solutions to overcome excess workload by subcontracting or hiring, ensuring training is received beforehand.

- facilitation in the establishment of “service level agreements” expected by some agencies.

This presentation opened the discussion on how, at the global level, collaboration in this spirit might avoid much waste of time, money, and even of goodwill.

Wednesday: Deep Argo & Polar Argo

Deep Argo

Deep Argo implementation (1 hour 30 minutes)

Status of the global Deep Argo array, Deep Argo objectives and scientific value (20-min, Nathalie and Virginie)

Although the need to implement the global Deep Argo array is recognized at the international level, only 16% of the targeted 1200 float array is funded. Significant support is urgently needed from international agencies. Growing literature has shifted from demonstrating Deep Argo technological capacity to showing its scientific value. Most (86%) near real time and delayed mode quality control Deep Argo data are now corrected for CPcor. Tentative deployment rate for 2024 is 95 (to be confirmed) Deep Argo floats, a value about 2 times higher than 2023, thanks to the commitment of international partners. Recommendations are to start the global implementation of the Deep Argo array with deployments in unsampled key regions. The DAMT is asking OceanOPS to generate density maps in order to build a deployment strategy. The Deep Argo implementation paper entitled “Observing the full ocean volume using Deep Argo floats” was published in 2023 https://doi.org/10.3389/fmars.2023.1287867.

Contribution from the national programs (50-min, 10 countries x 5-min talks from each national program)

i. Canada: Ocean Networks Canada (ONC) was successful in obtaining funding from the Canadian Foundation for Innovation (CFI) to procure 18 Deep Arvor floats (all with oxygen sensors). These floats were delivered in early 2023. Five of the floats were deployed in the Northeast Pacific in 2023 and two additional floats were deployed in the Southern Ocean in January 2024. All floats are operating properly and RTQC is being managed by the MEDS DAC. The plan for 2024 is to deploy an additional six floats in the Northeast Pacific to expand the spatial coverage. The remaining five floats will be deployed in 2025. There is no long-term funding for this project, but we will be exploring options over the coming year.

ii. Australia: 3 deployments of MRV Deep Solos in 2019 with floats lasting between 2, 4 and 5 years (1 still alive). 2 deployments of MRV Deep Solos in 2021 with 1 float at 2.5yrs and still alive. The other float had bad salinity data from cycle 10 and went to the surface in emergency mode from cycle 40 (after the second deep cycle). There was a jump in relative humidity over the last 9 cycles. The float was recovered and found to have a cracked glass sphere and the CTD was lost. In January 2024, 8 deep floats were deployed; 5 are operating well, 2 lost early after 6 and 18 cycles and 1 float is erratic with buoyancy issues (possibly a pump leak). Another 4 Deep SOLO's will be deployed in the 2024/2025 Austral summer.

iii. Japan: JAMSTEC deployed 2 Deep NINJAs equipped with dissolved oxygen sensors (RINKO AROD-FT manufactured by JFE-Advantec) in the North Pacific and Southern Ocean in 2023. 2 RINKO-equipped Deep NINJAs are planned for deployment in the Southern Ocean in 2024. Additional funding was obtained in 2023 for 10 deep Argo floats with RINKO AROD-FT, which will be deployed in the Pacific Ocean or Southern Ocean in 2025. As part of the development of a new float platform, experimental observations of 3 MOBY floats were conducted in collaboration with OSEAN in France and ESO member Princeton University researchers. All MOBY floats are equipped with SBE61 CTD, two of which are capable of detecting seismic waves with hydrophone sensors. The obtained data have not yet been provided to GDAC, but will be improved to apply in Argo data flow.

iv. China: In June 2023, there were 2 floats (Xuanwu) deployed in the Kuroshio Extension region but 1 missing and 1 only survived for 14 cycles less than 2000m (WMO: 2902889). In December, 6 floats, including 1 HM4000 float (2902895) and 5 Xuanwu floats (WMO: 2902888, 2902890, 2902891, 2902892, 2902894) were deployed in the Philippine basin. It should be noted that after deployment of each float, a concurrent CTD cast and on-board salinity measurements were conducted. Until very recently, there are over 200 profiles that reached 5000-m depth and 24 profiles that reached 6000-m depth. The cycle period of two floats (2902888 and 2902890) has been set to 10 days and the other floats are set to profile with a fast sampling phase, i.e., 2-day or 3-day to further examine the profiling ability of platforms as soon as possible. Supported by China Deep Argo Pilot Network project,

which aims to deploy 60 floats by the end of 2025, we plan to deploy 20 Xuanwu floats (10 in the Kuroshio Extension region and 10 in the Philippine basin) in 2024.

v. Italy deployed 9 Deep-Argo floats in the Mediterranean Sea from 2016 to 2023. The typical configuration adopted is a cycle time of 5 days (10 days was used for the last deployments and this will be the standard cycle time from now on) and a deep park pressure (3500-3800 dbar) to try to keep the float in the deepest area for a longer time. There are two Italian Deep-Argo active as of March 2024. We experienced several failures at the beginning of the Italian Deep-Argo program but now the fleet is performing well. OGS has a yearly national contribution that is mainly dedicated to developing the core Argo activity and a small percentage of this fund is used for the extension of Argo. In 2022, the Italian Ministry of Research has funded a 2.5-year grant (ITINERIS project) to purchase 12 Deep floats. They will be deployed in the Mediterranean Sea from 2025 to 2027 in targeted deep areas. We aim at demonstrating the importance of deep measurements to investigate the heat content stored in the deepest layers of the water column.

vi. France deployed 4 floats in 2023 in the North-Atlantic Ocean and purchased 12 Deep-Arvor-O2 floats. As of today, 33 French Deep-Arvor floats are actives (about 67% of European fleet, 17% Deep-Argo fleet). Perspectives: 17 Deep-Arvor should be deployed in 2024: 12 in the North-Atlantic, 4 in the Southern Ocean (already deployed) and 1 in the Pacific Ocean near Costa-Rica; 2 of the floats are double DO sensor (AROD-FT and Aanderaa). The development of a Deep-6k float model is ongoing (Ifremer PIANO project). Funding is secured to buy about 11 Deep-Argo floats (4k and 6k after 2025) per year until 2027 (ObsOcean and Argo-2030 projects + IR* Argo-France). No secure funding beyond 2027.

vii. The U.S. deployed 26 Deep Argo floats in 2023. Deployment plans in 2024 include 32 Deep SOLO floats: 1 WHOI Deep SOLO in the Irminger Sea, 7 Scripps Deep SOLO in the Northwest Atlantic, 2 PMEL Deep SOLO in the Argentine Basin, 3 (maybe 7 TBC) Deep SOLO and 2 (TBC) WHOI Deep SOLO along A16S in the Southwest Atlantic, 1 WHOI Deep SOLO along A13.5S in the Southeast Atlantic, 15 Scripps Deep SOLO in the Southwest and Southeast Pacific Basins, and 1 PMEL Deep SOLO in the South Pacific. SIO is continuing research and development work in collaboration with SeaBird Scientific to finalize the implementation of the Keller pressure sensor on the SBS61 CTD (new Deep Argo 6000-m CTD model from SeaBird to replace the SBE61 CTD), assess the performance of the RBR CTD sensor to 6000 m depth, and has collaborated with NIWA and Argo DO sensor providers to collect comparisons from several optodes based on bottle comparisons to 6000 m depth.

Discussion (20-min) on the factors limiting the implementation of Deep Argo

During the discussion, it was agreed that more interactions with the modeling community would be helpful to learn where Deep Argo data coverage would be most helpful and to ensure they are using the Deep Argo data properly. SynObs is interested in partnering with Argo and the

DAMT agreed to think carefully about what they might want tested. There were differing opinions on whether the Deep Argo Mission Team should shift to a more global deployment strategy and the team agreed to discuss this more internally and interact with users to decide on the best strategy.

Action item 17: DAMT to define as a group the best way to transition from regional arrays to global implementation based on (i) current float deployment rates and (ii) feedback from the modeling community and report results to the AST-26.

Deep CTD sensors (1 hour 40 minutes)

RBR CTD and comparison with extended-depth SBE-41 and SBE-61 (15-min, Virginie)

The presentation provided results from the intercomparison of the SBE61, SBE41CP and RBRargo|deep6k on two-headed and three-headed Deep-Arvor floats deployed in 2020 and 2022. Pressure and temperature sensor differences are within sensor's accuracy and in agreement with the Deep-Argo target accuracy (±3 dbar and ± 0.001°C). Low top to bottom mean values of the pressure sensors difference (<2 dbar) hide a vertical structure of the difference ranging from about zero near the surface to about 5 dbar at 4000 dbar – hysteresis of the pressure sensor is clearly seen. The intercomparison reveals that 1 dbar pressure difference can lead to 0.01°C temperature difference where vertical gradient is 0.01°C/dbar (shallow layers). Pressure sensor accuracy is critical for upper layer heat content measurements (1 dbar accuracy would be great). For all sensors, salinity / conductivity data needs to be corrected by comparison to reference cast : pressure dependent bias (CPcor or X2/X3/X4) for all + Offset/drift (OWC) in some cases. However, the two-steps Deep-Argo salinity DMQC procedure works well. After correction, salinity differences between the sensors are within ± 0.004. Remaining errors are projected toward the surface layers. The DMQC procedure probably compensates from pressure or temperature errors. Deep-Argo salinity quality should not rely on the availability of reference data, but on the intrinsic quality of the CTD probes.

Progress on estimation at SeaBird of CPcor for individual SBE61s (20-min, Nathalie)

Validation of laboratory measurements at SeaBird of CPcor using shipboard salinity samples show that lab estimates provide an improvement over nominal CPcor of -9.57e-8. Lab estimates of SBE61 CPcor are lower in magnitude than either direct field measurements or statistical estimation indicating a need for further development of the lab method. Results indicate that 46% of SBE61s and SBE41s would be within ±0.002 PSS-78 by adopting a better nominal CPcor value. Future work includes relating optimized Cpcor to information provided by Argo: date and coordinates of deployment, method used to optimize Cpcor, and group who conducted the Cpcor correction to identify dependency to storage, location of profiles (test relationship to temperature?), method, and QC group. Future work also includes relating optimized Cpcor to

information provided by SeaBird: date of calibration of conductivity cell to relate CPcor to age of the conductivity cell.

In the following discussion, many questions were raised around what will happen with Cpcor going forward, how this will be recorded in the data stream and what to do with past data. The suggestion is that the ADMT be made aware of the implementation of a new Cpcor value and to begin preparing for the eventuality.

Action item 18: Ask the existing small working group to continue studying Cpcor on deep floats and report back to ADMT-25 on recommended value(s) to use. Nathalie Zilberman, Dave Murphy, Cecile Cabanes.

Sampling procedure from the SBE41CP and SBE61, including pumping and timing (15-min, Rob Ellison)

SeaBird is working on a document describing the sampling procedure from the SBE41CP and SBE61, including pumping and timing. This document will be finalized by the end of 2024 and will be shared with the Argo community and discussed at the Float Technical Workshop in September 2024.

Action item 19: AST suggests discussions around best practices for programming TSWAIT time for each SBE CTD type, float type and mission. Could this be discussed at the Technical workshop or elsewhere? TcoP chairs.

Update on development progress of the SBS61 a.k.a SBE61 with Keller pressure sensor (15-min, Rob Ellison)

The operational Deep Argo CTD from SeaBird, SBE61, is equipped with a Kistler 7000 dbar pressure sensor that has an accuracy of ±4.5 dbar/7000m (0.6% FS). Feasibility work at SeaBird to improve pressure accuracy since 2021 has involved field tests of several alternative pressure sensors. SeaBird is moving forward with the Keller Series 20 sensor. Ongoing work consists of conducting pressure hold experiments to further examine; 1) the relationship between pressure error and parking depth, and 2) the rate of recovery or relaxation of the surface measurement. SeaBird is studying design & manufacturing process optimization with Keller to further improve stability at deep parking depth. Prototype builds of Deep Argo CTDs called SBS61 (SBE61 with Keller sensors) are underway with improved Keller sensors. Keller and SeaBird's objective is to complete the evaluation of benefits of external DAkkS calibration in 2024. Sea-Bird will be prepared to move Keller design into production when Deep Argo completes validation based on comparisons with Quartzdyne measurements on Deep Argo floats in the field.

Update on the laboratory and field performance of the RBRargo|deep6k (15-min, Mat)

A 15 minute presentation was given to provide the latest developments in the both the RBRargo|deep6k and RBRargo|deep6k.trans CTDs. It covered the results from several laboratory and field experiments to validate the accuracy of the CTDs. In situ accuracy was verified against both a float equipped with several CTDs (collaboration with IFREMER) and a shipboard CTD (collaboration with Scripps). The presentation also included the characterization and field validation of dynamic corrections for both CTD models. Finally, additional topics covering the performance of the RBRtridente in the field all the way to 6000 dbar and the latest developments on pressure sensor and pressurized calibration at RBR were also included.

Discussion on Deep Argo CTD performance (20-min)

Deep DO sensors (30 min)

Report on the RBR, Rinko, Aanderaa, and SeaBird Deep DO performance from the Tangaroa cruise (15-min, Nathalie, Phil and Denise with feedback from the Aanderaa, Rinko, RBR and SeaBird)

Deep Argo DO sensors were tested against bottle measurements during a research cruise northeast of New Zealand, May 2023 on NIWA's Tangaroa vessel. Results among all sensors show accuracy of 2-10 μmol/liter between 0-6000 m depth. The current status of sensor performance leads to a heavy workload on data quality control which relies on the availability of reference data. Results from the Tangaroa cruise have provided a roadmap for how Deep Argo oxygen sensors can be improved. In order to resolve the deep ocean DO signal, manufacturers need to (i) refine high hydrostatic pressure characterization, (ii) improve accuracy and precision from the surface to 6000-m, and (iii) increase stability and lower drift of the sensors.

Discussion on Deep Argo DO performance (15-min)

Deep data management (15 minutes)

Progress on identification of Deep Argo data on the GDAC (5-min, Megan)

Megan Scanderbeg presented on the motivation for identifying Deep Argo floats and profiles in the Argo data stream and then the proposed solution. Two needs were recognized by the community with one being the need to identify Deep Argo floats for monitoring purposes and the second being the need to identify only profiles that are deeper than a desired pressure level. In order to accommodate those, the ADMT agreed to create a Deep Argo index list with the max

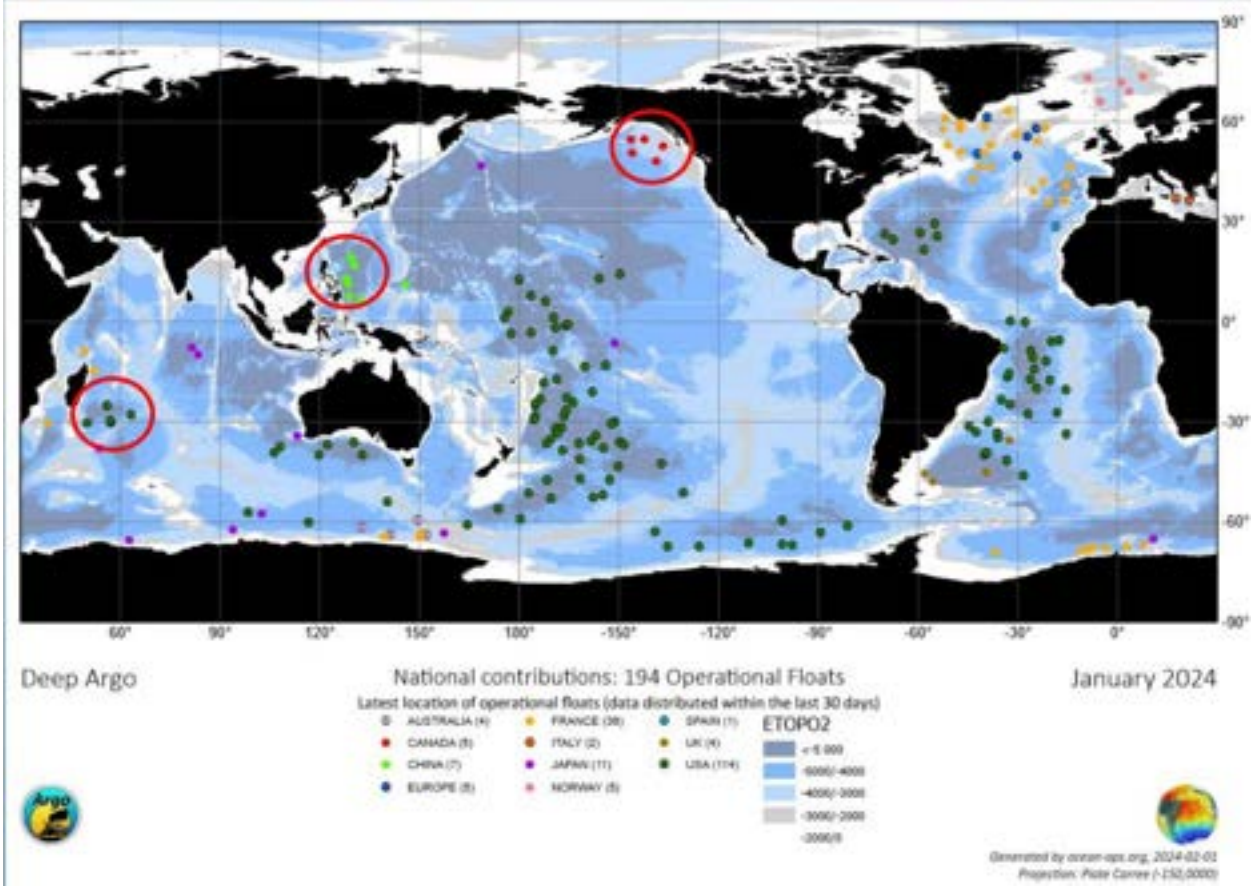
pressure reached during each profile. The list will contain all Deep Argo floats and will also contain the parameters measured by each float to easily identify oxygen measurements. The hope is that this will be implemented by ADMT-25.

Discussion (10 min)

Deep monitoring (30 minutes)

Update on Deep Argo fleet monitoring from OceanOPS (15-min, Victor)

Deep Argo is continuing to expand regionally with new regional arrays being deployed this year and committed to be sustained and supported while previously implemented regional array are maintained operational. It is noticeable that the Argentine Basin Array is getting old and likely to decline in the next year.



The implementation of Deep Argo is progressing steadily but slowly. Over the past three years, 11 countries have been involved in deploying deep floats, demonstrating ongoing internationalization efforts. However, the United States and France remain the primary supporters of Deep Argo, collectively owning about 80% of the fleet.

Three major float models—SOLO_D, SOLO_D_MRV, and ARVOR_D—drive the implementation of Deep Argo. Their performance is promising, with SOLO_D exhibiting capabilities comparable to a standard core Argo float.

Recent deployments of APEX_D and NINJA_D are lacking, and the new deep float model developed by China, Xuanwu, is currently undergoing active testing. Therefore, providing performance indicators for these models is not pertinent at this time.

The key takeaway regarding the status of Deep Argo is the increased participation of 11 national programs over the past three years. However, sustained support from national programs is crucial. Diverse platform and sensor models are essential for program robustness. With three to four reliable platform models driving implementation and ongoing testing of a new model (Xuanwu), along with two sensor manufacturers, the deep program exhibits resilience. Improved performance of the deep fleet and ongoing basin implementations indicate readiness for larger-scale expansion.

During the AST 25th meeting in Southampton, commitments from various countries underscored growing interest in Deep Argo.

Action item 20: DAMT co-chairs to work with Victor to continue developing Deep Argo KPIs and Deep density maps.

Discussion on Deep Argo fleet status and evolution (15-min)

Deep pilot measurements (30 min)

Progress on deep ocean mixing measurements from Deep Argo floats (10-min, Arnaud Le Boyer)

Progress on the development of the Scripps Deep Argo based bathymetry product (10-min. Nathalie, Megan, Kevin, Esmee)

Over 10,000 Deep Argo based bathymetry measurements have been collected between 2017-2023. Deep Argo bathymetry comparisons with multibeam data show great agreement with limited rms difference of 165 m, high correlation of 0.96, and limited averaged horizontal error of 1.4 km. The main source of error in Deep Argo bathymetry is the float horizontal displacement between grounding and GPS positioning at the surface. GLORYS ocean reanalysis predictions show widespread ocean regions where horizontal error is limited (< 2 km). Larger error values (2-8 km) are found at ocean boundaries, near the Equator, and in the Antarctic Circumpolar current. Deep Argo has the capacity to rapidly improve GEBCO grids on a global scale. A new product is under development at Scripps Institution of Oceanography that will provide global

bathymetry estimates using Deep Argo float measurements and associated horizontal error estimates derived from GLORYS analysis. A companion paper is in preparation.

Discussion (10-min)

Polar Argo Mission

Polar Argo implementation (60 minutes) Nicholas, Esmee

Status of the Polar Argo array, scientific value, challenges (15 mins)

The Polar Argo Mission Team began in 2023, we have 27 members from 12 countries.

The terms of reference are available here: https://argo.ucsd.edu/expansion/polar-argo/

We aim for quarterly meetings with a mix of technical, implementation and scientific discussions, with three meetings held in 2023/2024.

Status Update:

Arctic basin and surrounding seas: 11 Countries and 10 PI's. There are 79 floats active (102 north of 60N) from a target of 69 floats in the OneArgo design. Deployments between 15-20 per year, with floats living on average 3.6 yrs, to a max of 8 years.

Southern Ocean: 11 Countries and 18 PI's. 254 floats active in the Southern Ocean basin (288 active south of 60S) from a target of 376. Deployments average around 45 per year. Float lifetime on average is 4.8 years (equivalent to core) with maximum longevity of 10 years. 5 Nations sustain > 80% of the polar arrays in both hemispheres, we need to diversify and increase float contributions to polar regions. The Southern Ocean is the least well sampled basin with ~70% design density. Is it time to review the OceanOps grid and targets for Polar Argo? Discussion to be held within the community and with OceanOps. Many regions are currently excluded, i.e. parts of Ross, Weddell, ice-covered Arctic, Barents, Beaufort and parts of Baffin Bay. Most polar floats now sampling on a 5 day mission on the continental shelves. Many groups are deploying floats that are parked on the bottom of continental shelves, and these have been very successful. Impact of polar Argo data is shown by the increase in coverage in the seasonal circumpolar ice zone and the positive impact this data has on new climatology and Ocean State Estimates.

National contributions (deployments 2023/2024 and expected float commitments 2024/2025) (25 mins)

11 countries have reported deployments and plans for 2023/2024 and ongoing:

- **Australia** : Argo Australia has deployed 9 core floats (Arvor and APF11) and 8 deep (SOLO MRV) in 2023/24. For 2024/2025, 4 core and 4 deep (SOLO MRV) are planned to be deployed, mainly near the Antarctic shelf off Australia. Argo Australia has reported new activities such as trialing ice hardware (pole and eggbeater) on 4 floats to collect measurements of ice draft in 2024/2025. They also contribute to IBACO bathymetry dataset from grounded Argo profiles. Argo Australia has reported challenges such as flat funding and price increases that reduce the procurements from 6 to 3-4 floats per year. Also, fewer deployment opportunities with lack of opportunities from Australian marine science cruises for the past 5 years. They gratefully rely on the international colleagues (Italy, NZ, Germany, Japan) to get floats in the water. Eventually, they report long delays in shipping (~8 weeks to get floats to Australia) and some issues with float performance in recent years.
- **Canada** : in 2023/2024, Argo Canada has reported 2 deployments of core floats in the Beaufort Sea (Arctic) and 5 core floats in the Ross Sea (Antarctica, 1 has failed after deployment likely due to freezing CTD cell). They have reported ISA tuning for both deployment regions. In 2024/2025, they plan to deploy 2 core floats in the Beaufort Sea and 2 core floats in the Ross Sea again, but with a mix of RBR and SBE CTD.
- **Finland** : Argo Finland has deployed floats in the Barents Sea, but not since 2022. The 2022 floats disappeared under the ice the first winter, then never reappeared. Further deployments are planned in the Barents Sea but are not secured yet. Argo Finland also deployed in the Baltic Sea, which is not formally in the Argo Arctic design, but is seasonally covered by the ice. This is a test bed for the ISA system. At least one float is planned to be kept for 2024/2025 in the Baltic Sea where recovery is easy during the summer season.
- **France** : Argo France has deployed 3 Arvor floats North of the Svalbard in the Arctic Nansen basin in 2023 (ArcticGO project, PI: C. Lique). 1 float was equipped with RBR with vertical sampling up to the surface, 1 float was equipped with SBE CTD with ISA turned off, 1 float was lost just after deployment for unknown reasons. Floats with ISA turned off have been allowed to send profiles up to early February 2024 while the other has disappeared under the ice in October 2023. In 2025, 2 Arvor floats are planned to be deployed in the same area (MadStrat project). In the Southern Ocean, 5 deep Arvor floats will be deployed (in the framework of the EURECA project, PI: JB Sallée) in the Ross (Weddell) Sea. 4 will be deployed (delayed deployment) from ASFAR frame in both areas.
- **Germany** : In 2023/2024, BSH has deployed 3 BGC floats (full BGC except Nitrate sensor) in the Eastern Weddell Sea, in cooperation with the Norwegian Polar Institute (NPA), to study the biogeochemistry and circulation of the Eastern Weddell Gyre. A longer cooperation with the NPA is considered for annual deployment along the Troll Transect supplying the Norwegian Antarctic Station. AWI has deployed 4 core floats in the Prydz Bay on the PolarStern 140 cruise in the framework of Ocean:Ice project (HE

UE project funded by the EU Concil and UKRI). The floats will intend to ground at the bottom at each profile. In the Arctic, in 2023, BSH has deployed 2 Arvor floats on the AWI Arcwatch cruises on the PolarStern : one in the Nansen Basin North of the Svalbard and one in the Eastern Amundsen Basin. They have reported 2 floats that have reemerged in the Eastern Amundsen Basin after a long journey under the ice (2 winters). However, issues concerning the functionality of the ISA have been reported (emergency ascends, transmission of stored data), that need to be discussed with NKE.

- **Italy** : In 2023/2024, 8 floats (1 core + 7 TS-DO) have been deployed around the Ross Sea shelf. In winter 2025, 12 floats will be deployed on the Ross Sea shelf in the framework of the GLOB (**GLO**mar **C**hallenger **B**asin) project, funded by PNRA.
- **Japan** : In 2023/2024 1 deep Argo has been deployed by JAMSTEC near the Antarctic continent in the framework of the Japan Antarctica Expedition (JARE65) on the TR/V Umitaka-maru. In 2024/2025, 2 core floats (maximum, TBD) will be deployed by the icebreaker Shirase and 2 deep floats (~110°E) by the TR/V Umitaka-maru in the framework of JARE66.
- **New Zealand** : in 2022, 2 Apex floats funded by the Antarctic Science Platform (ASP) have been deployed (~77°S). 1 float has stopped reporting after 9 cycles. 1 works perfectly after 2 ice-seasons. In 2023,1 float from British Antarctic Survey (ARVOR I NAOS) has been deployed at ~78˚S, 174˚W; and 5 floats from Fisheries and Oceans Canada (ARVOR I NAOS) has been deployed from Laura Bassi (same floats that are reported in the Canada bullet above). In 2025, 1 Apex float will be deployed from the Tangaroa in the Ross Sea. 1 BGC float will be deployed in the Ross Sea (ASP) to study under ice phytoplankton blooms and oxygen changes in deep water formation region. (RV Tangaroa will deploy ~12 floats in the Southern Ocean (SOLO 2 and Deep SOLO) but most north of 60˚S). Temperature/comms issues have been reported on recent deployments of NKE ARVOR floats in the Ross Sea (C. Stewart).
- **Poland** : IOPAN has deployed 2-3 floats since 2009 in the Greenland Sea and Norwegian Seas in the framework of IOPAN AREX cruises in the Arctic (survey between BSO and Fram Strait). The deployment activities under Euro-Argo have been funded by the Argo Poland program (second period 2022-2026). Since 2023, 1 Argo float has been deployed in the Svalbard Fjord Hornsund. For 2023/2024/2025, annual deployments in the Nordic Seas (2) and Hornsund Fjord (1) are planned.
- **UK** : In 2023/2024, BAS has deployed 3 floats in the Amundsen Sea (West Antarctica), 1 Arvor floats deployed in the Ross Sea as part of the Italy/NZ effort. In 2024 and onward, 6-8 floats will be deployed in the Brandsfield Strait near the Antarctic Peninsula as Ukraine component (coll. with BAS) in the framework of UE OCEAN:ICE project. 3 ALAMO floats will be air-deployed in East Antarctica, opportunity field season 2024-25 (UE OCEAN:ICE project). In the framework of the BAS PRESCIENT project, 4 Arvor floats will be deployed in the Amundsen Sea, West Antarctica between April 2024 - March 2029 with opportunity for deployment in ~ Jan 2026, Jan 2027 and/or Jan 2028. BAS Pushing the Frontier project plans to air-deploy 4 ALAMO profilers in shelf seas in East Antarctica. Eventually, the WingRacers project aims to develop air-deployment capability for ALAMO type profilers.

- **USA**: Engineering work is on-going to integrate WHOI Acoustic Communications Group's Low-Power Detector (LPD) into the MRV ALTO float platform. The LPD listens for acoustic transmissions from ice buoys that are part of the ONR-sponsored Arctic Mobile Observing System. The acoustic transmissions along with a precise clock onboard the float enable geolocation of the floats under sea ice. On-going work to improve ice avoidance autonomy on ALTO floats is reported. In summer 2024, 4 floats equipped with acoustic receivers will be deployed in the Beaufort Gyre. Funding from NOAA forthcoming to eventually deploy BGC floats (also equipped with LPD) in the Beaufort Gyre. USA Polar Argo Science activity is also reported: Profiling floats were deployed in the Beaufort Sea under ONR-sponsored research initiatives. Under the Stratified Ocean Dynamics of the Arctic, floats were deployed in the Barents Canyon and in the open Arctic Ocean. Observations are used to understand how heat entering the Arctic through the Bering Strait impacts sea ice and Arctic ecosystem. Floats were deployed for the Arctic Heat Open Science Experiment, (primary focus is Chukchi Sea) in collaboration with NOAA/PMEL. The goal of the program was to develop real-time observing capabilities with the National Weather Service in Alaska.

ISA Tuning (5 mins)

Operating floats in a sea ice environment can damage the floats when surfacing. ISA (Ice Sensing Algorithm; Klatt et al., 2007) is an ice avoidance strategy that relies on a temperature criterion in the near surface layer to detect the presence of ice at the surface. A tradeoff between maximizing the float emergence and minimizing the risk of damage is to be determined. In the Arctic, tools for decision on ISA tuning and proposed regional setting has been proposed in the framework of EARise EU project. In the Southern Ocean, T. Kobayashi (JAMSTEC) has studied the ISA performance based on in situ data (Argo and marine mammals) and SIC satellite data. He has found a relative homogeneity of the ISA choice for different regions and proposes a T_{ISA} around -1.5°C as an optimal temperature criteria. However, more feedback on ISA tuning and float behaviors from float recently deployed in Arctic and Southern Ocean is needed (unexpected behaviors, missing profiles: memory issues, false ice detection …). ISA discussion with manufacturers should continue (NKE).

Under Ice Positioning/Navigation (5 mins)

There are now a number of published methods to estimate location of under-ice profiles in post-processing :
Yamazaki et al. 2020 doi: 10.1029/2019jc015406
Oke et al. 2022 doi: 10.1029/2022EA002312
Wallace et al. 2020 doi: 10.1029/2020GL087019

In general, these methods will all do a better job over small gaps < 10 cycles, be aware that for long under-ice periods, the errors may be large (~100's kms). Need to assess floats on a case-by-case basis, methods will work well for some floats/regions, not so well in others. For RAFOS-equipped floats in the Weddell Gyre there is now new Artoa4Argo software to determine locations of under-ice profiles. See Hancock and Boebel (2024). JAOT, 41. DOI: 10.1175/JTECH-D-23-0020.1 This method improves on the Kalman Smoother (Chamberlain et al., 2022). The new method first corrects for clock offset and drifts and then estimates positions using RAFOS sound signals. It then uses the Kalman smoother technique to fill any remaining

gaps. In the Weddell Gyre, the RAFOS sound sources will be refurbished and moved to the Weddell continental slope and 18 new floats deployed in Jan-Mar 2025 to track deep water pathways.

Ice hardware options (5 minutes)

There are now Ice guards available for Ice floats to both protect sensors and may provide estimates of sea ice draft (see James Girton talk). A Working group is working on improving ice-related information in the Argo netcdf files.

Reporting of under ice data (ice evasion status) (5 mins)

All DACs should fully implement the ice algorithm config in the meta and tech files. At the moment, this data is not well populated. Working on a new variable in the trajectory file to convey ice-related info. Aim to create a summary index file for users to identify ice algorithm status on each profile. Additional hardware specifications can be stored in the Configuration parameters.

Summary and conclusion of Argo Polar Mission presentation:

Polar Argo is now measuring regions previously out of reach, e.g., circumpolar SIZ, shallow shelf, under ice shelves and measuring new properties (e.g. sea ice draft). Southern Ocean float lifetimes now equivalent to core Argo (4.8 yrs). Arctic float lifetimes are close to core Argo ~ 1 year less (3.6 yrs). The challenge is to sustain and grow the Polar Argo array. A handful of countries/programs sustain bulk of the polar arrays, we need to diversify/increase float contributions. Issues are a lack of sustained funding, sometimes limited deployment opportunities, significant price increases for floats meaning less are deployed, supply chain issues and other factors that have affected float reliability and timelines and anecdotal reports of an increase in float issues in recent years. The Polar Argo Mission team is sharing information and technical knowledge to try to improve this.

Action item 21: Ask Polar AMT to develop a Best Practices document for polar Argo float deployments and link to Float Deployment webpage on AST website. Polar co-chairs, Megan Scanderbeg

Action item 22: Gather useful links to documents such as ISA tunings for regions, etc. to add to Polar AMT webpage. Polar co-chairs, Megan Scanderbeg

Science Talks:

Technologies for sustained, autonomous polar observing: acoustic navigation, networked autonomous systems, gliders and floats. Craig Lee (10 mins)

Craig Lee updated the AST on Polar observing plans for the next several years. Several platforms with different acoustic navigation and comms systems are planned for continued observation in the Polar regions. The plan is for basin-scale acoustic geolocation for gliders, floats, and UUVs. It is expected that floats will carry low power and low cost receivers but could consider moving to the more capable MicroModems. Gliders have shown promising results in the region and the hope is that adapted floats will as well. In addition to the SOLO-II floats, Apex floats and the MRV Alamo floats will also be deployed in the region.

Measurements of sea ice draft from floats. James Girton TBC (10 minutes)

SOCCOM under-ice performance. Steve Riser (10 min)

This talk summarized recent results from the SOCCOM (Southern Ocean Carbon and Climate Observations and Models) project. The goal of this project is to deploy an array of 200 biogeochemical floats in the Southern Ocean in both open water and ice-covered regions and to analyze the data from these floats. This work is an important part of BGC-Argo. SOCCOM is now in its tenth year and has deployed nearly 300 BGC floats in the Southern Ocean during this period. Roughly 160 of the floats are operational in the Southern Ocean at the present time. In recent years data from approximately 30 under-ice floats has been received annually, including data from more than 400 profiles per year. In early 2023 five SOCCOM floats were deployed in shallow water (< 500 m) on the Ross Sea Shelf in an attempt to assess how well such a region could be sampled with float technology, since this is a likely area for dense water formation and strong seasonality, with important BGC implications. The five floats disappeared under the ice just a few weeks after deployment. Four of the five floats appeared in early January of 2024 and transmitted nearly one year's worth of BGC under-ice profiles from the ice zone on the shelf. The data are presently being analyzed. This is the first time that this has been done with BGC floats in such a shallow region, and plans are underway for possible future deployments in other shallow, ice-covered regions of the Southern Ocean.

Ice floats beneath ice shelves. Pierre Dutrieux/Pierpaolo Falco (15 mins)

Pierre Dutrieux: In Antarctica and Greenland, interactions between Oceans and Ice sheets are crucial to the regulation of the global overturning circulation and the current acceleration of ice flow into the ocean and associated global sea-level rise. Satellite and moored ocean observations demonstrate with increasing temporal and spatial resolution that the interaction is complex and occurs on broad ranges of scales. But the establishment of clear relationships

between ocean and ice sheet will remain elusive until we obtain direct, sustained in-situ observations beneath and near the ice shelves. Four acoustically geo-located EM-APEX floats sampled oceanic properties near and under the Dotson ice shelf in West Antarctica in January 2018, with observations continuing through the winter into summer 2018/2019, covering several hundreds of kilometers under the ice shelf. Observed water properties generally confirm expected features of under ice shelf circulation, with deep inflowing warmer water on the eastern side of the cavity and shallower outflowing meltwater on the western side. Initial analysis also reveals new and potentially important features for ice/ocean interactions: (i) bathymetric inversion from airborne gravity observations are significantly improved by using in-situ constraints; and (ii) a float slipped through a wide gap between Dotson and Crosson ice cavities, implying broader connectivity between basins, with potential implications for ice dynamics. The technology used for this project offers tantalizing prospects for future explorations.

Thursday (closed morning):

Float technical updates

Core floats (10 min each)

APEX (Steve Riser)

This was a talk that summarized the recent performance of Apex floats. The core Apex floats discussed here were produced at the University of Washington, and the BGC Apex floats were produced jointly by the University of Washington and MBARI. In the past year a problem with air bladders on these floats has been identified and fixed, after several years of trying to remedy this problem. This is good news and will lead to considerably longer lifetimes of Apex floats, including both the UW and Teledyne/Webb versions. Additionally, there is increasing evidence that an electrical problem in UW/MBARI BGC-Apex floats that caused many floats to die prematurely (at around 150 profiles) has been fixed. This implies a new average lifetime for these floats of more than 200 profiles. The success of this fix should become more pronounced after another year of profiles. There have been several new prototypes of the UW/MBARI BGC-Apex floats deployed in the past year, including floats with a new multi-channel chlorophyll/backscatter sensor, an upward-looking 3 channel radiometer, and a new oxygen sensor, all manufactured by SeaBird. These prototypes are all working well (more than 6 months after deployment), and it is expected that more floats will be deployed with these sensors in the future.

ALTO (Steve Jayne):

The ALTO float from MRV is their development platform for new sensors and mission sets. During the last year, significant fixes and improvements have been made to the firmware addressing issues including a Bluetooth power drain, bugs in the ice avoidance algorithm, and the RBR CTD's corrected salinity channel. WHOI is currently testing v10.7.1 in the 10-meter tall tank. Ice avoidance seems to be working as expected. WHOI has deployed 7 ALTO floats since 2023, and they are working nominally, though 1 has shown a leaky valve. Developments for the ALTO float include: integration of the Rockland Scientific Instruments turbulence sensors on the microALTO float; integration of passive acoustics for geolocation in the Arctic Ocean; an ALTO equipped with the biogeochemical sensor suite; and a completely new firmware called the Flight Control Software.

SOLO-II (Nathalie Zilberman)

SOLO-II floats show great performance with a small (12%) overall failure rate (sum of float and CTD) over the past 7 years. Scripps is investigating cases of flooding in collaboration with SeaBird. A new antenna design (collaborative work between IDG and Maxtena) is under testing to reduce cases of float failure. Scripps is planning to run an analysis of the rate of float failure versus age (hazard rate) in order to further increase the SOLO II performance.

Arvor (Romain Cancouët)

The Arvor float manufactured by nke instrumentation (France) is the float model most deployed in 2023, from a large number of implementers (16 countries). It now counts more than 900 active floats, about 25% of the whole Argo array. It operates in most areas (open ocean, marginal seas, under-ice, tropics).

Arvor floats survival rates should be decomposed between the ARGOS model, the ARGOS LIGHT model with lighter battery capacity, the IRIDIUM model, and the model with an additional optode. The lifetime of the core IRIDIUM float, the most deployed one, is very good as 80% of the units reach 5 years.

The Arvor float enables the RBR CTD integration, and 54 floats have been deployed in this version. A firmware update enables 1 Hz raw data collection, and the latest version also allows the capability to perform onboard dynamic correction. Some teams have faced recent early failures of this Arvor RBR version. This is still unexplained, and this is a concern.

Some ARVOR floats have been identified drifting at the surface at the end of their lives, after several years of functioning and an expected normal death after battery exhaustion. This is not the behavior expected and preconceived knowledge of Argo groups, and this represents an issue as some floats then beached to shore, especially in marginal seas. Our analysis showed that ~30% of the inactive ARVOR floats having exhausted their batteries have finished their lives at the surface (reporting positions for ~15 days). A projection of the issue on the active ARVOR fleet shows that ~65% of the 900 active Arvor floats will work until battery exhaustion, and that ~30% of these will likely end up drifting at the surface. This represents 175 floats, and we urge the manufacturer to implement corrective firmware, as the attempts to scuttle the floats have up to now failed.

Other technical issues on Arvor floats have been reported, including some unexpected or very complicated cases with the ISA behavior, some grounding/difficulty to dive events under extreme density conditions, and missing data on shallowest part of the profiles under specific density conditions.
The technical support is currently slow and limited, and requests to scale it with respect to the current number of active floats and Argo Programs deploying Arvor floats have been made.

MRV S2A (Pelle Robbins)

The S2A is a clone of the IDG SOLO-II, manufactured by MRV Systems. Over 800 S2A have been deployed starting in 2011 and 55% of deployed S2A are still reporting. Prior to deployment, the WHOI lab inspects each instrument and conducts a series of tests. These inspections sometimes reveal components which require additional work. Over the past 3 years, 17% of floats have required additional attention from the manufacturer after delivery. Since January 2023, PMEL and WHOI have deployed 95 S2A. Of these, about 10% developed some sort of problem soon after deployment. The most frequently observed problems are associated with the hydraulic valve of the buoyancy engine and manifest as inability to hold consistent park pressure. Problems with the hydraulic valve seal can increase energy consumption by 10% to 300% depending on severity. If a float survives the first few months in the ocean, then it will generally last for several years. About 80% of S2A exceed a 5-yr lifetime. Transition to the newer Tadiran battery packs have improved long-term energy management and should provide power for up to 390 dives to 2000dbar, or 10.6 year longevity on a standard Argo 10-day period.

Navis (Gregory Johnson)

PMEL remains the major deployer of Core Navis floats. Of the 60 deployed in 2022, eight have stopped reporting and several others have issues. PMEL deployed 15 units in 2023, of those, one failed on deployment, another reported one profile successfully and then failed, another was misballasted (too light to profile all), and a fourth often misses GPS fixes. Issues with recent deliveries include mis-ballasting, a compromised O-ring, and a float obviously opened after “final testing”. Recommendations include: Do final testing at SeaBird after the final seal. Ensure customer support knowledge is sufficient to recognize that repairs are necessary. Provide repair reports for RMAs that document diagnostic testing done to confirm issues, actions taken to resolve issues, and post-repair testing done to verify full functionality of the repaired float.

Deep floats (10 min each)

Deep SOLO (Nathalie Zilberman)

Deep SOLO floats show great performance with float-related failure rates similar to SOLO II over the past 7 years. Overall (SBE61+float) failure rate over the past 7 years of the Deep SOLO is 19%, close to the SOLO II (12%). Sources of failure of the SBS61 CTD (with Keller) are well understood. Recommendation for SeaBird is to install a humidity sensor on the SBE61

and SBS61 to better understand causes of CTD failure. Scripps is planning to deploy 3 Deep SOLO floats in 2025 with improved Keller and better integration on the SBS61. IDG is working on the implementation of a glass radome on Deep SOLO antennas to increase float longevity under ice.

Deep Arvor (Xavier André)

A total of 134 Deep-Arvor (4,000m profiling floats) have been deployed, that is to say one third of the Deep-Argo network. 55 floats are active, and more than 50 floats will be deployed by France, Canada and Euro-Argo in 2024. The number of cycles available greatly depends on its configuration : it ranges from 206 theoretical cycles in spot sampling without DO optode, to 125 in continuous pumping with an additional optode (93% of Deep-Arvors are delivered in this later configuration). Work has been done by NKE to reinforce the pump, which had to be returned to NKE after tests in hyperbaric tanks 20% of the time. Now, with the reinforced pump, on the last 42 units tested in hyperbaric tank, 100% were operational and have not had any issues.

Two Deep-Arvor with both Aanderaa 4330 and JFE Advantech Rinko AROD-FT optodes will be deployed this summer. Deployment had to be delayed in 2023 to change the upper part of the AROD-FT to avoid water remaining on the foil during the in-air measurements.

The four Deep-Arvor that have been deployed on a bottom structure in 2022 are all operating well and have spent one winter under ice. All data have been recovered.

MOBY/OSEAN (Shigeki Hosoda)

The MOBY float is a deep Argo-type platform developed by OSEAN in France, which is capable of measuring hydrographic and/or seismic waves with CTD and/or hydrophone to a depth of 4000 m. The original MOBY model, named Mermaid, is equipped with a hydrophone and capable of observing to a depth of 2000 m and was modified by OSEAN. With the cooperation of Princeton University, JAMSTEC deployed 3 MOBYs equipped with SBE61 CTD sensors during the Shisei-maru cruise of JAMSTEC in the summer of 2023. The purpose of the deployment of the MOBY floats was to test the capability of the MOBYs to operate, control by command transmission, ground on the sea bottom, and continuously acquire CTD data following the Argo observation mission to a depth of 4000 m. After setting up a two-day interval observation mission for two weeks as a trial, we shifted to observations every 10 days to a depth of 4000m. As of February 2024, all MOBYs were in good condition and had already acquired more than 30 profiles of data, but one of them was missing due to too much grounding in the shallower region. Based on various technical data obtained from MOBY, it is recognized that the hardware performance is sufficient for a deep Argo platform. We will continue to improve the data to match Argo's data flow and confirm the long-term stability.

Xuanwu (Zhaohui Chen)

The main progress of Xuanwu floats in 2023 is that we have updated the current version of Xuanwu (V1.0) to Xuanwu (V2.0). The differences between the two versions are the estimated profiling counts supported by an advanced battery capacity (216Ah). Another change is the CTD

installation for the new version of horizontally mounted, compared with the older version (vertically mounted). The most striking progress for Xuanwu V2.0 is that we included a buoyancy compensation module with 6 elastic elements. The buoyancy compensation module can store the seawater pressure difference energy in the form of potential energy in the elastic element, which is a passive buoyancy regulation system, without the consumption of system energy, and can reduce the power consumption of the active buoyancy regulation system. We have tested the two floats with/without the buoyancy compensation module and found that the module can save ~20% energy consumption for each cycle. We also found there was a large discrepancy in water depth between ETOPO2 and actual calculated depth using CTD on a float. Further improvements are still needed in the lifetime, reliability and parking accuracy of the Xuanwu float.

BGC floats (10 min each)

PROVOR (Edouard Leymarie)

The Provor product range now includes the CTS4, CTS5 and CTS5 Jumbo. The difference between CTS5 and CTS4 is related to more recent electronics, enabling advanced functionalities such as the integration of new sensors or the use of a graphic interface (GUI) for deployment planning and communication with the float. The Jumbo version offers a 60% increase in battery capacity for 18cm extra float length. In 2023, as many CTS5s (+ Jumbo) were deployed as CTS4s, showing the gradual shift to this new version of Provor. To date, 70 CTS5s (+ Jumbo) have been deployed. 41 (59%) are still active (mean cycle = 54, max = 192). 7 (10%) are under ice (mean cycle = 74, max = 290). 14 (20%) have been recovered (mean cycle = 140, max = 295) and finally 8 are dead (min cycle = 4, mean = 60, max = 154). Of all the floats lost, at least 2, if not 3, were due to a water leak in one of the sensors. We consider these results to be good overall, given the large number of CTS5 floats used in riskier prototype applications. The graphical user interface (GUI) is presented. It enables secure programming and estimates energy and communication consumption. A 2-year ice application in Baffin Bay is presented. The CTS5 allows configuration changes under ice using dated commands in a script. A real-time estimate of energy consumption is presented, using this under-ice float as an example. We can see the difference in consumption per profile between the period under ice, the first profiles with communication and conventional/summer operation. Finally, future developments will include: passive acoustics, Linux core, micro-sonar, and integration of RBR-Tridente sensors and turbulence sensors.

BGC Navis (Steve Riser)

This was a talk about BGC-Navis floats. Most of the discussion was about a new BGC-Navis prototype known as Navis/Nautilus. This float is a redesigned BGC-Navis with an improved buoyancy pump, redesigned internal layout, increased battery capacity, an upward looking radiometer, and improved communications firmware. These floats were jointly developed with funds from a NOPP grant, by the University of Washington, MBARI, and SeaBird Scientific. Three prototypes of the Nautilus have now been produced at SeaBird and deployed near

Hawaii. The first float failed after 21 profiles due to a leak. The other two floats are performing well, with one of the floats now having completed 156 profiles. All systems and sensors are working well on these 2 prototypes, and it is likely that this float model will become the BGC-Navis of the future. Several more have already been ordered by UW and WHOI and will be deployed as part of the GO-BGC program (a component of BGC-Argo) in the coming year.

BGC SOLO (Sarah Purkey)

The BGC SOLO is a six 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 and has since been licensed to MRV systems to be built and sold commercially. To date, 4 SIO built and 4 MRV built floats have been deployed and are performing well overall, with the first float having completed over 300 cycles. MRV is ramping up production and has plans to produce 8 a quarter (32 total) this year.

Under-ice floats

SOLO Arctic float (Craig Lee, Dan Rudnick 10 min)

Craig Lee presented an update on the adaptations being made to the SOLO-II float for Arctic deployments. He recalled that a modem, hardened antenna, ice avoidance mast and a hydrophone port were added to the SOLO-II to ready it for deployments in the Arctic. The software needed to be updated to interface with the acoustic controller as well as to update the handling of backlogged data. Finally, the acoustic payload had to be integrated. The first deployment through an ice hole took place within the past few days and is expected to return data in the summer when the ice opens up. Two more floats are expected to be deployed as part of AMOS2024 summer field work with an additional 26 floats to be fabricated for 2025 and 2026 deployments.

ASD update (Delphine Dobbler/Birgit Klein, 15 min)

An updated status of the Abrupt Salinity Drift is presented, showing that the situation has been stable since the last ADMT. The error rate (percentage of CTD having reached an unadjustable state, computed by batch of 300) now reaches a similar 40% in the 3 ranges (6300-6600, 8100-8700 and the warranty range 10482-11252) The slight decrease in percentage of PSAL profile QC F for 2023 is confirmed (15.6% to compared with 16.2% in 2022), 3 more floats are drifting early in the warranty range 10482-11252 (183 in total) and 2 more floats (26 in total) with CTD sensor serial number after 11252 (i.e. after the manufacture change in 2018) are declared as ASD. Warranty certificates have been received by most partners, but it is ongoing for CSIRO. The UK has already used theirs in their last purchase and Germany and CSIRO are planning to use them on their next purchase.

Core CTD Sensors

SBE (Nathalie Zilberman, 10 min)

Missing parts and mounting mistakes were detected in recent SBE41 orders received at Scripps Institution of Oceanography. The recent uptick in missing screws and accessories at SeaBird is largely attributable to a gap in SBE's standard work for assembling and servicing these instruments. SeaBird work instructions were not specific enough to cover every variant currently built.
"SeaBird is updating both work instructions and process for training new associates, namely how they check the work of people who are interacting with a new variant of instrument for the first time."

Action item 23: Ask Nathalie for SBE CTD S/Ns for poorly manufactured sensors to SIO. Megan will send to AST members. Request full range of affected CTDs from SBE and alert the AST. Nathalie, Megan.

RBR (Mat Dever via video, Gregory Johnson (PMEL), 25 min)

A recorded presentation was provided by Mat Dever to review the performance of the onboard dynamic corrections algorithm on two different floats recently deployed (WMO4903508 and WMO3902254). The presentation also included the recommended dataflow for the raw and corrected salinities.

Gregory Johnson noted that PMEL deployed WMO 4903508 in the Bering Sea in August 2023, an MRV Systems ALTO float equipped with an RBR CTD. It was the first RBR CTD with onboard sensor response corrections. It took a little while to get the float configured so that it was correcting onboard and sending back all the desired data streams. The CTD will not correct onboard unless the sampling rate is at least 1 Hz. Profiles 35-63 reported 1 Hz CTD data from the upper 100 dbar, including profiling through a very sharp thermocline into a strong mixed layer for a few profiles, which allowed evaluation of the corrections. The onboard corrections clearly improve the data quality substantially. While they are not perfect, we should not expect them to be.

Action item 24: Ask ADMT to consider if and how to implement correction in salinity computation for RBR CTDs affected by the square root code error. Ask RBR when they start correcting this (identify by S/N). RBR, Annie Wong, ADMT co-chairs.

Thursday afternoon

This session is open and will feature vendor presentations.

Discussion on how to implement new process for issuing float stickers (Mathieu/Victor, 15 min)

Manufacturers presentations per invitation from AST co-chairs

Platforms (SBE, TWR, MRV, NKE – 20 min each)

1. Questions to all: float sticker email address, end of life management, JSON metadata

CTD Sensors (SBE, RBR – 30 min each)

1. Questions to all: JSON metadata

The presentation by RBR was given by Jean-Michel Leconte and Greg Johnson. It included a review of the "RBR Argo offer", that is: the current status of the RBR argo fleet, recent field Service Bulletin and Notice of Revisions, the next generation (Gen4) of sensors and loggers, as well as the internal Argo monitoring system used to ensure a healthy RBR argo fleet and a fast response to failures.

BGC Sensors (Trios, Aanderaa, JFE, SBE, RBR 15 min each)

Trios:

TriOS has briefly presented the company's history, capabilities and premises. The product portfolio was mainly developed for industrial applications except for the hyperspectral radiometer RAMSES that was developed for science, where TriOS is rooted in 1998 as a spin-off from the University of Oldenburg.

Because of the growing interest in RAMSES and the hyperspectral UV-photometer OPUS, those two sensors were presented in more detail, highlighting future possibilities with regard to the JSON schema and less energy consumption on OPUS. Lead times are typically below 4 weeks.

The RBR presentation covered the characteristics and field performance of its suite of BGC sensors: the RBR*tridente* (fluorescence and backscatter), the RBR*quadrante* (radiometer), and the RBR*coda* T.ODO (oxygen optode). It focused on the improved performance of the RBR*coda* T.ODO, as well as full-depth (6000 dbar) field validation of the RBR*tridente* and RBR*coda* T.ODO.

Action item 25: Ask Jochen Klinke to report on the sampling for BGC CTDs to ensure that the flow path is clear. Jochen Klinke

Action item 26: Ask for point of contact at manufacturers to coordinate discussions, AST and ADMT involvement, etc. Megan Scanderbeg

Action 27: At the Technical Workshop, consider talking to all manufacturers about including firmware to address end of life where floats could be programmed to descend and stay there until dead. TcoP chairs.

Action item 28: AST exec to consider best path to discuss Argo's needs in next 5- 10 years with manufacturers. If possible, plan for discussion. AST exec

Friday

Demonstrating OneArgo's value

Argo communication, websites updates, bibliography & BGC-Argo initiatives (Megan Scanderbeg, Orens de Fommervault, 30 min)

Megan Scanderbeg started the session with a series of webpages that have been added to the AST website over the past year including:

- A float deployment best practices page
- A page describing what makes a float part of Argo
- A page on the newly formed Technical Community of Practice
- New videos added over the past year including one aimed at 8 – 13 year olds, an ocean heat content animation and more

In terms of the bibliography, over 500 papers continue to be published each year and a new country was added – Benin. The other bibliography stats continue to grow at similar rates. Statistics were shown on the GDAC DOI data downloads and referring websites with similar patterns to previous years.
Finally, Megan ended by sharing resources available to AST members including a collection of talks from previous members that can be accessed when needed. New this year is a spreadsheet with upcoming international meetings and who will be submitting abstracts and attending the meetings on behalf of Argo.
https://docs.google.com/spreadsheets/d/1xoTDysJ4cwJWyrNVxMI_fLlF2qVZfxWB8U5BmLF1NVQ/edit?usp=sharing AST members are encouraged to add conferences they know of or are planning to attend.

BGC-Argo communication and outreach activities were presented by Orens de Fommervault. Regarding the website, it was emphasized as a communication hub for the BGC-Argo mission, with over 5,000 users from 40 countries. Web developments conducted in 2023 included improvements to the program history menu, updates to meetings, team members, and bibliography, redesign of the latest deployment menu, and rewriting of the participating countries sections. It was also noted that BGC-Argo communication is active through regular publication of newsletters, with a target of 3-4 releases per year and an aim to reach an increasing

audience (currently 350 subscribers). Orens de Fommervault reminded the AST that the newsletter is open for contributions from everyone and covers a wide range of topics including science, outreach, papers, and meetings. Communication on social networks (X, formerly Twitter) was also discussed. Despite positive numbers (25 tweets in 2023, 1,100 followers, and 50,000 views), the growth of the @biogeochemical_argo account appears relatively stagnant. It was suggested to explore extending communication to other platforms such as LinkedIn. OceanOPS communication material was also introduced, highlighting dissemination of information on Argo and BGC-Argo through the GOOS Bulletin and Report Card to high-level stakeholders, decision-makers, and member states, complementing other communication channels. The presentation concluded with a brief description of two outreach projects: Adopt a Float and Ocean Voyager.

Action item 29: Add new webpage with clear resources to get started using Argo data, including videos. Megan Scanderbeg

Action item 30: Add new webpage with updates for current users. Megan Scanderbeg

Action item 31: Add on the official Argo website (argo.ucsd.edu) and other platforms (Euro Argo, others?) a recommendation to acknowledge Deep Argo use (not just Argo) to help track Deep Argo use in publications and build Deep Argo bibliography. Megan Scanderbeg

Action item 32: Track the number of papers per year that cite the Argo data paper. Megan Scanderbeg

Action item 33: Include map of locations of profiles that have changed in past XX months/years in 'What's up with Argo?' and elsewhere on websites. Argo data comms working group.

OneArgo as part of UN Ocean Decade (Megan Scanderbeg, Orens de Fommervault, 20 min)

Megan Scanderbeg presented work done by various AST members over the past year to interact with some identified programs and projects. It is becoming clear which are active, and which are not, and she will update the spreadsheet accordingly. She also reported on meetings she and Claire Gourcuff had with different aspects of the Decade to figure out how best to make Argo data available through Decade portals. It looks like ODIS and Ocean InfoHub 2030 are good candidates and they will continue working towards getting Argo into these systems. Next, she explained the distributed leadership structure of the UN Ocean Decade. There are Decade Collaborative Centers (DCCs) and Decade Coordination Offices (DCOs) to which actions can officially join and then report back to each year. Each of these DCCs and DCOs must also run a Community of Practice (CoP) to which anyone can affiliate with. She presented on the status of the three identified DCCs and DCOs that would be most relevant to OneArgo. The first was the DCO for Ocean Observing which our parent program is already attached and the CoP is active, so she did not recommend officially attaching. The next one was the DCO for Ocean Data Sharing which she and Claire met with to discuss how OneArgo might fit best. They were

welcoming to OneArgo and seemed to suggest that we would be a role model for data management as much of their work is focused on lifting up actions that are just starting a data management system. The CoP is active and the ADMT co-chairs are still considering a formal attachment. The other DCC was for Ocean Prediction and is not yet active, so she suggested waiting. Finally, she reported on how the OneArgo yearly report due 10 May 2024 will be compiled with the help of Orens and the AST.

Action item 34: Ask AST to respond to spreadsheet by 15 April for UN Ocean Decade report: https://docs.google.com/spreadsheets/d/1Ldg2CsIyOpnWxOtF05dXD5Hx9wjsT-VBaV5ngh2e7-8/edit?usp=sharing

Action item 35: AST asks ADMT co-chairs to continue pursuing adding Argo data to ODIS with help from OceanOPS.

OneArgo communication efforts - brochures, etc (EuroArgo 15 min)

Action item 36: Make a OneArgo brochure with help from EuroArgo, OceanOPS and the community. EuroArgo, OceanOPS, Fiona Carse, Blair Greenan, Nicolas K, Breck Owens

Interactions with super users

SynObs presentation (Elisabeth Remy, 30 min), Discussion 15 min

Explanation of CORA update process (Tanguy Szekely, 15 min)

Explanation of EN4 update process (Rachel Killick, 15 min)

EN.4.2.2 is the most up to date version of the Met Office Hadley Centre's EN series of subsurface temperature and salinity datasets. We take data from four sources: Argo, Arctic Synoptic Basin wide Oceanography (ASBO), the Global Temperature and Salinity Profile Program (GTSPP) and the World Ocean Database. Where Argo data is in more than one of these sources, we prioritise data from the GDAC. Argo is a key data source for EN4, without it our ocean coverage would be much sparser, with impacts on those who use EN4 internally and externally for model validation, initial conditions and OHC time series estimation, amongst other things. The current version of EN4 is updated on a monthly basis with a fresh download of source data from Argo and GSTPP for the current and previous month. We seek to do a full re-processing of the dataset (and version number update) once a year, doing a full re-download of source data from start to present day, updating code and addressing user feedback. We take into account the Argo QC for the _ADJUSTED Argo variables, but do not currently take the QC flags for the unadjusted variables, instead doing our own QC checks and using grey lists and altimetry QC lists. This is something we are likely to change in the next version of EN4 (partly as a result of feedback gathered during this presentation!). We are incredibly grateful for the

resources Argo provides in terms of documentation, user guides, FAQs, user support and other tools. Argo is a vital part of our work, and it would be great to keep it in the spotlight by having regular presentations at science meetings such as EGU, AGU and Ocean Sciences.

Action item 37: Ask Elisabeth Remy and Yosuke Fuji for detailed responses to OceanPredict survey results and share with AST. Megan Scanderbeg

Action item 38: Ask SynObs to consider identifying people to sit on the Deep Argo Mission Team, BGC Argo Mission Team and Polar Argo Mission Team meetings to help improve communication and develop requests to study. Mission team co-chairs, Yosuke Fuji, Elisabeth Remy

Action item 39: Identify a small group to interact with SynObs to devise Deep Argo distribution strategies to test and report results at AST-26. Virginie Thierry, Nathalie Zilberman, Peter Oke, Greg Johnson

Action item 40: Form joint working group between OceanPredict – Argo to have regular discussions on BGC data in particular, but also touching on Deep Argo and Polar Argo missions, with the goal of learning how to assimilate data into operational systems. Consider an in-person workshop to kick off the working group activities. Ask Katja Fennel if she can lead Argo part. See if Peter can identify OceanPredict lead. Ask Katja Fennel, BAMT co-chairs, Yann-Herve

Upcoming International science workshops (40 min)

See all meetings listed here: https://docs.google.com/spreadsheets/d/1xoTDysJ4cwJWyrNVxMI_fLlF2qVZfx

UN Ocean Decade, June 2025 in France : (https://oceandecade.org/news/united-nations-general-assembly-adopts-resolution-confirming-2025-edition-of-un-ocean-conference-in-france/) Virginie *Thierry, Herve Claustre to lead* d*iscussion 30 min*

Action item 41: Develop a session proposal between Argo and satellite partners when UNOC 2025 call comes out. AST co-chairs.

Action item 42: Set meeting with AST exec, Pierre Bahurel and Pierre-Yves LeTraon to better understand how to interact with the UNOC 2025 meeting in France and blue zone, green zone, etc. AST exec.

UN Ocean Decade in Barcelona, 10 - 12 April 2024 (https://oceandecade-conference.com/2024-ocean-decade-conference-launch-of-calls-for-posters-and-oral-presentations.php) *Orens de Fommervault, 5 min*

The UN Decade Conference in Barcelona was briefly introduced. It is an in-person event held in Barcelona, Spain, from April 8 to April 12, 2024, and organized by IOC-UNESCO. 1,500 attendees are expected, including heads of state, leaders of UN agencies, and scientists. The main conference will take place over two days (April 10-12), with satellite events occurring throughout the entire week. Susan, Tammy, and Orens will attend the meeting, and 1 abstract has been submitted by Megan.

US Clivar: pathways connecting climate changes to the Deep Ocean work, 23 - 25 April 2024 in Delaware, US (Pathways Connecting Climate Changes to the Deep Ocean: Tracing Physical, Biogeochemical, and Ecological Signals From Surface to Deep Sea | US CLIVAR) Nathalie Zilberman, Sarah Purkey attending

OCG-15, 15 - 17 May 2024 in Canada (https://www.goosocean.org/index.php?option=com_oe&task=viewEventRecord&eventID=3981)

8th WMO Workshop on the Impact of Various Observing Systems on Numerical Weather Prediction and Earth System Prediction, 27 - 30 May 2024 in Sweden (https://community.wmo.int/en/meetings/8th-wmo-impact-workshop-home) Peter Oke, Virginie Thierry, Joellen Russell attending

International Sea Level Workshop, 4 – 6 June 2024 in Brest, France (2024 Sea Level Workshop - Sciencesconf.org), Virginie Thierry attending

30 Years of Progress in Radar Altimetry, 2 - 6 September, 2024 in Montepelier, France (https://www.altimetry2024.org/), Nathalie Zilberman attending

PICES meeting, 6 Oct - 1 Nov, 2024 in Honolulu, Hawaii, USA (https://meetings.pices.int/meetings - pices-2024)

Action item 43: Update PICES community on the progress and potential of BGC Argo. Expect first request in June from PICES. Toshio Suga, BGC co-chairs.

OceanPredict Symposium, 18 Nov – 22 Nov, 2024 in Paris, France

Action item 44: Ocean Predict , Paris, Nov 2024:Identify Argo person to submit abstract and attend meeting. Brian King

Future Argo Meetings

Technical Workshop, September 2024 in Seattle (Pat McMahon, 5min)

Action item 45: AST requests that Argo National Programs send their technical people to the technical workshop in September 2024.

ADMT-25, 20 - 25 October, 2024 in Trieste, Italy

AST-26, proposed by Scripps to host the week of: 14 – 18 April 2025

Action item 46: Invite fisheries person/people to AST-26 to give presentations. Ask Blair Greenan and Andrea Fassbender for suggestions.

AST membership & other business

Registrants

	First Name	Last Name	Affiliation (ie Scripps Institution of Oceanography)
1	Xavier	ANDRE	Ifremer
2	Mathieu	Belbeoch	OceanOPS
3	Clare	Bellingham	NOC/BODC
4	Henry	Bittig	Leibniz Institute for Baltic Sea Research Warnemünde (IOW)
5	Charles	Branham	Sea-Bird
6	Jodi	Brewster	UMiami/NOAA/AOML
7	Nathan	Briggs	National Oceanography Centre

8	Hendrik	Bünger	Institute for Chemistry and Biology of the Marine Environment
9	Cecile	Cabanes	CNRS
10	Romain	Cancouët	Euro-Argo ERIC
11	Magdalena	Carranza	Monterey Bay Aquarium Research Institute
12	Fiona	Carse	Met Office
13	Thierry	Carval	Ifremer
14	Pasquale	Castagno	University of Messina, Italy
15	Zhaohui	Chen	Ocean University of China
16	Marialena	Christopoulou	Sea-Bird Scientific
17	Hervé	CLAUSTRE	LOV - CNRS
18	Sophie	Clayton	NOC
19	Didier	Clec'h	RBR
20	Louis	Clement	National Oceanography Southampton
21	Beth	Curry	MRV Systems LLC
22	Giorgio	Dall'Olmo	OGS
23	Yann-Hervé	De Roeck	Euro-Argo ERIC
24	Yves	Dégrés	Nke instrumentation
25	Mathieu	Dever	RBR
26	Delphine	Dobler	Euro-Argo
27	Catia	Domingues	NOC
28	Clara	Douglas	University of Southampton, National Oceanography Centre
29	Pierre	Dutrieux	British Antarctic Survey
30	Heather	Eberhart	Sea-Bird Scientific
31	Rob	Ellison	Sea-Bird Scientific
32	Tony	Escarcega	TSK
33	Pierpaolo	Falco	Marche Polytechnic University of Ancona
34	Andrea	Fassbender	NOAA PMEL
35	Katja	Fennel	Dalhousie University
36	Denise	Fernandez	NIWA
37	Bieito	Fernández castro	University of Southampton
38	Hartmut	Freznell	UW/PMEL
39	Yosuke	Fujii	Meteorological Research Institute/ Japan Meteorological Agency
40	Tetsuichi	Fujiki	JAMSTEC
41	Antonella	Gallo	National Institute of Oceanography and Applied Geophysics - OGS
42	ZHIYUAN	GAO	University of Southampton
43	Jillian	Garabedian	Teledyne Marine
44	John	Gilson	SIO
45	James	Girton	UW
46	Judah	Goldberg	Rockland Scientific

47	Christopher	Gordon	Fisheries and Oceans Canada
48	Claire	Gourcuff	Euro-Argo ERIC
49	Alison	Gray	University of Washington
50	Blair	Greenan	Fisheries and Oceans Canada
51	Nicola	Guisewhite	MBARI
52	Takuya	HASEGAWA	JAMSTEC
53	Franck	HIERAMENTE	OSEAN
54	Mizue	Hirano	Japan Agency for Marine-Earth Science and Tecnology
55	Kato	Hiroharu	JFE Advantech Co., Ltd.
56	Shigeki	Hosoda	JAMSTEC
57	Jostein	Hovdenes	Aandera, Xylem
58	Genevieve	Howell	Sea-Bird Scientific
59	Yibin	Huang	Xiamen University, China
60	Clara	Hulburt	Teledyne Webb Research
61	Steven	Jayne	WHOI
62	HyeongJun	Jo	Korea Meteorological Administration(KMA)/National Institute of Meteorological Sciences (NIMS)
63	Kenneth	Johnson	MBARI
64	Gregory	Johnson	NOAA/Pacific Marine Environmental Laboratory
65	Greg	Johnson	RBR
66	Colette	Kelly	Woods Hole Oceanographic Institution
67	Rachel	Killick	Met Office Hadley Centre
68	Baek-Jo	Kim	National Institute of Meteorological Sciences
69	Brian	KING	National Oceanograophy Centre, Southampton, UK
70	Birgit	Klein	Bundesamt fuer Seeschifffahrt und Hydrographie
71	Jochen	Klinke	Sea-Bird Scientific
72	YUSUKE	KOJIMA	TSURUMI-SEIKI CO.,LTD
73	Nicolas	Kolodziejczyk	University of Brest/Argo France
74	Sven-Erik	Krause	TriOS Mess- und Datentechnik GmbH
75	Meredith	Kurz	U.S. NOAA
76	Arnaud	Le Boyer	Scripps Institution of Oceanography
77	Jean-Michel	Leconte	RBR
78	Craig	Lee	Applied Physics Laboratory, University of Washington
79	Brian	Leslie	Teledyne
80	Edouard	Leymarie	Laboratoire d'Oceanographie de Villefranche (LOV)
81	Hua	Li	JFE Advantech Co., Ltd
82	Zenghong	Liu	Second Institute of Oceanography, MNR
83	Meike	Martins	Bundesamt für Seeschiffahrt und Hydrographie (BSH) Hamburg, Germany
84	Tanya	Maurer	MBARI
85	Pat	McMahon	CSIRO

86	Milena	Menna	National Institute of Oceanography and Applied Geophysic (OGS=
87	Melissa	Miller	Scripps Institution of Oceanography, GO-BGC
88	Kjell Arne	Mork	Institute of Marine Research
89	Tammy	Morris	SAEON
90	Markus	Motz	RBR Ltd.
91	Dave	Murphy	SBE
92	Nguyen	Ngoc-Son	Keller
93	David	Nicholson	Woods Hole Oceanographic Institution
94	David	Nogre	Nke instrumentation
95	Giulio	Notarstefano	Istituto Nazionale di Oceanografia e di Geofisica Sperimentale - OGS
96	Peter	Oke	CSIRO
97	Emanuele	Organelli	CNR - National Research Council of Italy
98	Emily	Osborne	AOML
99	Breck	Owens	Woods Hole Oceanographic Institution
100	Violetta	Paba	NOC
101	Matt	Palmer	Met Office Hadley Centre / University of Bristol (UK)
102	Orens	Pasqueron de Fommervault	OCEANOPS - IOC/UNESCO
103	olivier	PHILIPPE	OSEAN
104	Josh	Plant	MBARI
105	Noé	Poffa	Ifremer
106	Antoine	Poteau	Sorbonne University
107	Sarah	Purkey	Scripps Institution of Oceanography
108	Pattabhi	Rama Rao	INCOIS
109	Eric	Rehm	Sea-Bird Scientific
110	Elisabeth	REMY	Mercartor Ocean
111	Clark	Richards	DFO/BIO
112	Steve	Riser	UW
113	Pelle	Robbins	Woods Hole Oceanographic Institution
114	Dean	Roemmich	Scripps Institution of Oceanography
115	Harald	Rohr	TriOS Mess- und Datentechnik GmbH
116	Tetjana	Ross	Fisheries and Oceans Canada
117	Edward	Ryan	AOML
118	Dan	Ryan	Teledyne
119	Jerome	Sagot	Nke instrumentation
120	Kanako	Sato	JAMTEC
121	Raphaelle	Sauzede	CNRS - Institut de la Mer de Villefranche
122	Megan	Scanderbeg	Scripps Institution of Oceanography
123	Catherine	schmechtig	CNRS
124	Claudia	Schmid	NOAA/AOML
125	Dan	Shropshire	Teledyne
126	Emily	Smith	GOOS

127	Peter	Strutton	University of Tasmania
128	Toshio	Suga	Tohoku University & JAMSTEC
129	Phil	Sutton	NIWA
130	SHINICHI	TAKAI	JFE Advantech Co.,Ltd.
131	Yui	Takeshita	MBARI
132	Lynne	Talley	Scripps Institution of Oceanography
133	Anders	Tengberg	Aanderaa-Xylem, Bergen, Norway
134	Virginie	thierry	LOPS/Ifremer
135	Victor	Turpin	OceanOPS/WMO
136	Jonathan	Turton	Met Office
137	Julia	Uitz	Laboratoire d'Océanographie de Villefranche
138	Esmee	van Wijk	CSIRO Environment, Australia
139	Susan	Wijffels	WHOI
140	Annie	Wong	Scripps Institution of Oceanography
141	Xiaogang	Xing	Second Insitute of Oceanography, MNR, China
142	Ya	Yang	FIO/MNR
143	Nathalie	Zilberman	Scripps Institution of Oceanography

National Reports

Argo Australia - 2024

Submitted by: Peter Oke, CSIRO

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)
    a. floats deployed and their performance

        Since March 2023, Argo Australia has deployed 34 floats, including:

        - 20 floats south of 55S;
        - 5 floats in the Tasman Sea; and
        - 9 floats in the Indian Ocean.

        This includes 3 BGC floats and 8 Deep floats.

    b. technical problems encountered and solved

        Several of the Deep floats deployed in the Southern Ocean (perhaps 3 out of 8) seem to have failed early. We do not yet know the cause of the 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)

        The Australian DMQC Operators continue to engage in the DMQC Discussion forum (https://www.marine.csiro.au/argo/dmqc/html/ArgoDM-Disc.html) to help promote best practice and to consult with other DMQC Operators regarding difficult floats.

    d. status of delayed mode quality control process

        A high level of DMQC has been maintained. DDMQC has been performed on 353 floats since last March 2023.

        Transition to sftp caused some problems for the Australian DMQC team. This is now solved.

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)

    Argo Australia secured a new 4-year contract with IMOS, sustaining funding for Core and BGC, and expanding funding to include Deep Argo. This contract funds about 6.5 FTE, including funding for technical support, real-time data processing, delayed-mode quality control, and leadership. IMOS funds are also sufficient to fund about 17 Core floats, 3 BGC floats, and 3 Deep floats each year; and to cover operational costs (e.g., telecommunications) for the program.

Funding to support from BoM continues, covering costs for about 0.5 FTE for real-time data processing, and core floats each year.

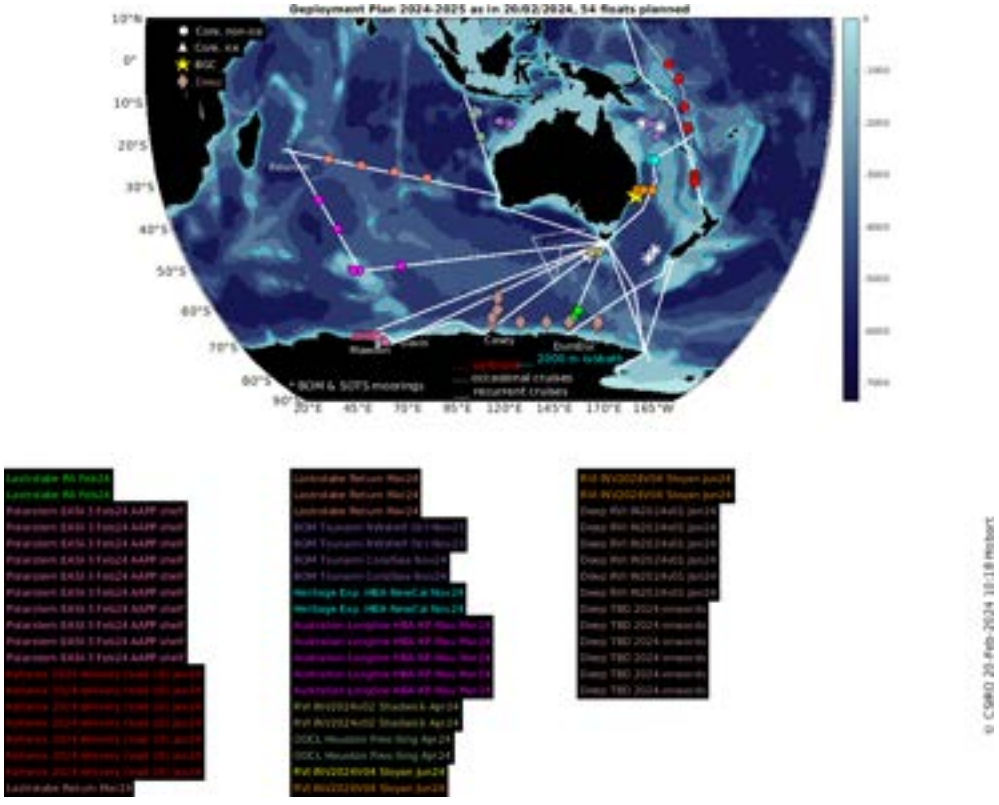
Funding from AAPP continues until 2027, covering costs for about 0.5 FTE and 3-4 core floats per year. AAPP funds also covered costs for 8 Deep Argo floats in 2023.

Funding from the Australian Geospatial Organisation is assessed annually. AGO have agreed to provide funding for 5 core floats this year.

Funding for floats from CSIRO is assessed annually. This is historically enough to fund 10 core floats each year. This year, CSIRO only contributed funds for 2 core floats.

3. Summary of deployment plans: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be **returned separately ASAP** to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.

   Argo Australia maintains an active deployment plan at: http://www.marine.csiro.au/~sem018/Argo/deployment_planning/. This is adjusted as deployment opportunities come and go (see below for the latest map of planned deployments).



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.

   Version 2023 of the Bluelink ReANalysis (BRAN 2023) is underway. BRAN2023 assimilates Argo data, altimetry, and satellite SST data, plus other in situ data sources. The main improvement in BRAN2023, compared to previous versions, is the inclusion of biogeochemistry. BRAN2023 should be completed by mid-2024.

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-25 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

   nil

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.

   Several cruises have been undertaken that have included deployment of Argo floats and collection of reference CTD.

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.

Australian contributions to the Argo bibliography appears to be up to date.

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

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 2024 and 2025 (if known) and where they might be deployed.

   Yes. We have two Altos with RBR CTDs that are yet to be deployed.

ARGO National Report 2023: Bulgaria

Violeta Slabakova and Atanas Palazov

Institute of oceanology – BAS

February 2024

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 15 floats under the BulArgo programme, which is the Bulgarian contribution to the Euro-Argo ERIC infrastructure. The floats have provided more than 2500 profiles out of which 1467 include DOXY measurements (Fig.1). Currently the number of active floats in the Black Sea is 14 out of which 9 are operated by Bulgaria.

Figure 1. Profiles of the BulArgo programme (2011-2023)

a) Floats deployment and their performance

During 2023, two BulArgo floats were deployed in the Black Sea under the framework of the MASRI project. One of the floats WMO 3902461 is ARVOR - DO and float WMO1902575 is ARVOR T/S. Both floats integrate Iridium satellite telemetry system which provides a dual

telecommunication capability allowing modification of the configuration in real-time. Prior deployments the floats were tested in the IO-BAS technical laboratory. The BulArgo floats (WMO 1902575 and 3902461) were deployed on 30th of November 2023 and 14th of December in Bulgarian Black Sea EEZ at depth 1200 m. 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 2023 is presented on Table 1.

In the framework of H2020, DOORS- Developing Optimal and Open Research Support for the Black Sea project, the BuArgo technical team deployed, two BGC ARGO floats (WMO 7901065 and WMO 4903711, model PROVOR CT4 floats (provided by IO-BAS and Euro- Argo ERIC) 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, DOORS project). The floats were deployed in the Romanian EEZ from the board of the R/V Mare Nigrum. 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. (Table 1).

Table 1. Status information for the floats deployed in the Black Sea during 2023

Model	WMO	Deployment date	Deployment time	Latitude, N	Longitude, E	№ of Cycles	Status
ARVOR-DO	3902461	14/12/2023	15:03:00	42°15 '	28°44’	6	active
ARVOR- I	1902575	30/11/2023	2:25:00	43°09'	28°59'	7	active
PROVOR-III (CT4)	7901065	15/05/2023	09:09:00	43.6768	30.521	28	active
PROVOR- III (CT4)	4903711	11/05/2023	10:47:00	43.87	30.8349	27	active

b) Technical problems encountered and solved

No technical issues have been found regarding the float 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 centre (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. Three persons from IO-BAS are working on the Euro- Argo and BulArgo activities. They do so besides their other duties.

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)**

In 2024, IO-BAS plans to deploy:

- ARVOR -DO float in the Georgian Black Sea waters during H2020 DOORS cruise #3
- ARVOR – DO and ARVOR- (RBR) in the Bulgarian Black Sea waters

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

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.**

4.1. Operational and scientific use of Argo data

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 researchers from the Black Sea countries to improve the understanding of Black Sea physical and biogeochemical properties. In the end of 2022 BulArgo programme has launched its web page: https://bulargo.io-bas.bg/ that demonstrates and promotes Argo, Euro- Argo and BulArgo activities. The BulArgo webportal provides information and data access from all floats operating in the Black Sea and presenting all Bulgarian Argo activities, news and data from Argo floats. A continuous upgrade is ongoing integrating more images and videos from floats deployment activities.

4.2. Dissemination activities of the BulArgo programme

Within 2023 several dissemination activities were carried out by the BulArgo programme such as the participation of 2023 Researchers Night and the educational activities for high school students organized by IO-BAS.

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

NON.

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.**

At all deployment locations a deep CTD station was taken. The ship-data will be sent to Argo (Reference Database).

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

Planned in 2024.

8 .Ago bibliography

1. Dymova, O., and N. Markova (2023), Numerical Estimation of the Black Sea Circulation near the Continental Slope Using SKIRON and ERA5 Atmospheric Forcing, *Environmental Sciences Proceedings*, *25*(1), 61, doi: https://doi.org/10.3390/ECWS-7-14305
2. Grégoire, M., et al. (2023), Monitoring Black Sea environmental changes from space: New products for altimetry, ocean colour and salinity. Potentialities and requirements for a dedicated in-situ observing system, *Frontiers in Marine Science*, *9*, doi: https://doi.org/10.3389/fmars.2022.998970
3. Markova, N. V. (2023), The Black Sea Deep-Water Circulation: Recent Findings and Prospects for Research, in *Processes in GeoMedia—Volume VI*, edited by T. Chaplina, pp. 553-564, Springer International Publishing, Cham, doi: https://doi.org/10.1007/978-3-031-16575-7_49
4. Markova, N. V., and O. A. Dymova (2023), Conditions of Deep-Water Undercurrent Generation in the North-Eastern Black Sea, *Fluid Dynamics*, *58*(5), 852-863, doi: https://doi.org/10.1134/S0015462823600591
5. Silvestrova, K., S. Myslenkov, O. Puzina, A. Mizyuk, and O. Bykhalova (2023), Water Structure in the Utrish Nature Reserve (Black Sea) during 2020 - 2021 According to Thermistor Chain Data, *Journal of Marine Science and Engineering,* *11*(4), doi: https://doi.org/10.3390/jmse11040887.
6. Suslin V.V., Slabakova V., Martynov O.V., Kryl M.V., Yushchenko S.A., Pryakhina S.F., Golovko N.I.. Light backscattering by suspended particles at 700 nm in the Black Sea water layer of 0-1000 m: Bio-Argo floats data. 12780, Society of Photo-Optical Instrumentation Engineers (SPIE), 2023, ISBN:978-151066809-6, ISSN:0277786X, https://doi.org/10.1117/12.2686000

Argo Canada – Report of Activities for 2023

Submitted by: Blair Greenan, Katja Fennel, Tetjana Ross, Clark Richards, Chris Gordon, Anh Tran, Roberta Hamme, Kohen Bauer and Marcel Babin

25th meeting of the Argo Steering Team (AST-25)

Location: Hybrid (Southampton & Virtual)

18-22 March 2024

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)
    a. floats deployed and their performance

As of 25 January 2024, there are 166 operational floats in the Argo Canada program.

From January to December 2023, Argo Canada deployed at total of 33 floats in the following Basins, managed by the MEDS DAC:

- Pacific Ocean (12 floats):
    - 1 NKE ARVOR floats (SBE CTD)
    - 4 NKE ARVOR floats (SBE CTD + O2)
    - 2 NKE PROVOR CTS4 floats (SBE CTD, O2, Chla, backscatter)
    - 5 NKE Deep-ARVOR floats (SBE CTD + O2)
- Atlantic Ocean (19 floats):
    - 11 NKE ARVOR floats (5 SBE CTD, 6 RBR CTD)
    - 2 NKE ARVOR floats (SBE CTD + O2)
    - 3 NKE PROVOR CTS4 floats (SBE CTD, O2, Chla, backscatter)
    - 1 NKE PROVOR CTS4 float (SBE CTD, O2, Chla, backscatter, pH)
    - 2 NKE PROVOR CTS5 floats (SBE CTD, O2, Chla, backscatter, radiometry)
- Arctic Ocean (2 floats):
    - 2 NKE Arvor floats (SBE CTD)

In the fall 2023, the Takuvik lab (Université Laval) carreid out the following floats in Baffin Bay (CCGS Amundsen), managed by the Coriolis DAC:

- 2 BGC floats (model JUMBO, developed by H. Claustre)
- 2 BGC NAOS floats have were recovered in central Baffin Bay

To improve communication among the groups within Canada that are deploying Argo floats, a tracking system has been developed which provides information on completed and upcoming deployments, as well as existing inventories at each facility. The website is available at: Argo Canada Development Blog: Deployment Planning with a summary for 2023 available at: Argo Canada Development Blog: 2023

b. technical problems encountered and solved

One each of NKE ARVOR and NKE PROVOR CTS4 floats had elevated vacuum pressures indicative of a bladder problem. These floats were not deployed and will likely require return to manufacturer for repair. It should be noted, however, that these floats failed this test in September 2023 and at the time of writing this report we have not been given instructions from the manufacturer on what to do with them.

NKE ARVOR floats equipped with RBR CTD sensors delivered in 2023 have upgraded firmware that allowed the float to sample and transmit CTD at a frequency of 1Hz over a segment of the water column up to 200m. Two floats (4902670, 4902671) deployed in the Labrador Sea had this feature activated in mid-October 2023, collecting 1Hz data in the top 200m. One lesson learned from operating these floats is that because of how the float slows down as it approaches the sea surface, data volume in the top 5-10dbar is significantly greater than expected.

In addition to 2023 floats being delivered with this upgraded firmware, NKE ARVOR floats with RBR sensors delivered in 2022 were also able to be upgraded. 3 floats (4902617, 4902618, 4902619) were upgraded to have this capability and deployed in the South Atlantic off Western Africa, however their 1Hz capability has not yet been activated. 1 of these 3 floats (4902617) failed upon deployment and is currently in end-of-life mode, drifting at the surface. We continue to await a response from NKE since initially inquiring following the float's deployment in early December 2023 to see if it is possible to fix this float remotely.

1 refurbished NKE ARVOR float was deployed this year but failed before reporting a profile. This float was originally recovered after it beached due to drifting at the surface because of a sensor failure (RBR CTD).

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 179 Argo floats of which 5 floats have had trouble reporting in the last 2 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.

From January 2023 to January 2024, on average, 429 messages per month were issued to the GTS in BUFR format, of which 84% of the data were available within 12 hours of the float reporting.

Since AST-24, the following tasks have been completed:

- Develop and implement the modules to decode PROVOR CTS5 and to create the meta, profile and technical NETCDF files for GDACs submission.
- 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
- RTQC of backscatter data has been updated to comply with tests published by Dall'Olmo et al. 2023 (https://doi.org/10.12688/openreseurope.15047.2)
- All eligible floats are surfacing at varying local times of day in accordance with recommendations by the Argo Sampling Committee

d. status of delayed mode quality control process

Delayed mode QC has resumed at MEDS, with 1,105 profiles processed since last year. Approximately 71% of eligible profiles have been DMQC'd at least once, and 72% of eligible floats have been DMQC'd at least once for salinity, while 53% of floats have been DMQC'd at least once with both salinity and pressure. The DMQC process is sporadic because of short staffing. MEDS is looking into filling the staff's shortage to address the backlog of DMQC of core floats and monthly anomaly reports and OCEANOPS altimetric checks .

Of all BGC floats, currently 2034 of 7545 profiles (27%) are in delayed mode. 1374 profiles (18%) are adjusted.

As of the DOXY audit published in October 2023, 8 Canadian floats were flagged as containing potentially bad data. 5 of 8 of these floats have since been DMQC'ed and

hence should be resolved. The remaining 3 floats (4900637, 4900883, 4901786) are actively being worked on and should be resolved shortly.

All DOXY DMQC was done using the python tool developed by Argo Canada (https://github.com/ArgoCanada/bgcArgoDMQC). While to WOA method for calculating DOXY gain is quite robust, in-air calculations remain under active development and should be used with close attention.

Changing historical DOXY_QC flags from 1 to 3 is an immediate priority.

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. The Iridium SBD and RUDICS services are provided by MetOcean Telematics, which has a contract to supply Iridium services to the whole of the Government of Canada.

Ongoing capital for float purchases has not been identified, so it remains necessary to request capital resources annually to obtain the funding required to purchase new floats. The Government of Canada (DFO and Department of National Defence – DND) committed $337k CAD for purchases of core NKE Arvor-I (SBE CTD) floats in the Fiscal Year 1 April 2023 to 31 March 2024. The funding will result in the acquisition of 13 core Argo floats. This represents a significant reduction in DFO procurements relative to the preceding 5 years when additional funding was made available to initiate development of the BGC-Argo program in Canada.

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 delivered to date, and two of these floats were deployed in the Labrador Sea in December 2023.

CFI funding held jointly by the Universities of Victoria and British Columbia (C-PROOF, see details in Section 4) that has been providing BGC sensors for floats deployed in the Northeast Pacific. In March 2023, floats were delivered with four O2 sensors (purchased by UVIC) added to DFO Arvor floats and five SUNA (nitrate) sensors plus the jumbo option (purchased by UVic) added to DFO Provor floats. In addition, two Provor floats (oxygen, nitrate, irradiance, chlorophyll, and backscatter sensors) were purchased by UVic and delivered in October 2023.

In 2023, Ocean Networks Canada (ONC) received 18 NKE Deep ARVOR floats, which can profile to 4000 m and carry a dissolved oxygen sensor. Five of these floats were successfully deployed in the NE Pacific in the summer during DFO led cruises. An additional 2 floats are anticipated to be deployed in the Southern Ocean sometime before the end of January 2024, during an ongoing cruise in the Drake Passage.

Since 2016, Takuvik has deployed 24 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)
- 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, Argo Polar Task Team member, 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 people, 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 meets 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: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be **returned separately ASAP** to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.

In 2024, Argo Canada plans to deploy approximately 38 floats in the Northeast Pacific, North/South Atlantic, and in polar regions:

- 15 Core
- 4 Core + O
- 6 BGC (2-3 sensors)
- 7 BGC (4-6 sensors)
- 6 Deep + O

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. This includes providing lateral open boundary conditions 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. The C-PROOF project ended in 2023.

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-25 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 once again 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

Fu, Y., et al. (2023), Seasonality of the Meridional Overturning Circulation in the subpolar North Atlantic, Communications Earth & Environment, 4(1), 181, doi: https://doi.org/10.1038/s43247-023-00848-9

Greenan B. J., A. P. Wong, T. Morris, E. A. Smith and M. Bollard (2023), Keeping an Eye on Earth's Oceans With Argo Robots, Front. Young Minds. 11:943491. doi: https://doi.org/10.3389/frym.2023.943491

Li, M., Y. He, and G. Liu (2023), Atmospheric and oceanic responses to Super Typhoon Mangkhut in the South China Sea: a coupled CROCO-WRF simulation, Journal of Oceanology and Limnology, 41(4), 1369-1388, doi: https://doi.org/10.1007/s00343-022-1328-6

Neukermans, G., L. T. Bach, A. Butterley, Q. Sun, H. Claustre, and G. R. Fournier (2023), Quantitative and mechanistic understanding of the open ocean carbonate pump – perspectives for remote sensing and autonomous in situ observation, Earth-Science Reviews, 239, 104359, doi: https://doi.org/10.1016/j.earscirev.2023.104359

Stoer, A. C., et al. (2023), A census of quality-controlled Biogeochemical-Argo float measurements, Frontiers in Marine Science, 10, doi: https://doi.org/10.3389/fmars.2023.1233289

Wang, B., and K. Fennel (2023), An Assessment of Vertical Carbon Flux Parameterizations Using Backscatter Data from BGC Argo, Geophysical Research Letters, 50, e2022GL101220. doi: https://doi.org/10.1029/2022GL101220

Ph.D./M.Sc. Thesis

Adam Stoer, ESTIMATING MARINE PHYTOPLANKTON BIOMASS AND PRODUCTIVITY FROM AUTONOMOUS PROFILING FLOATS, Dalhousie M.Sc. thesis, 2023

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 2023 were not impacted by COVID-19 restrictions. DFO is still experiencing research vessel availability issues. The primary platform for oceanographic research on the east coast of Canada (CCGS Hudson) was decommissioned in January 2022. A replacement research vessel is scheduled to be in service in 2026. In the intervening period, we are reliant on vessel charters, which presents challenges for Argo float deployment planning in the Atlantic.

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 2024 and 2025 (if known) and where they might be deployed.

Argo Canada is committed to deploying additional floats equipped with RBR CTDs. The procurement plan for 2024 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. This change in the capability of the Arvor float has been implemented and we have deployed most of these floats that are in our inventory.

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 25th Argo Steering Team Meeting, Southampton, March 18-22, 2024

Argo Chinese National Report 2023

Zenghong Liu[1], Xiaogang Xing[1], Zhaohui Chen[2,3], Fangli Qiao[4], and Fei Chai[5]

1 State Key Laboratory of Satellite Ocean Environment Dynamics, the Second Institute of Oceanography, MNR, Hangzhou 310012, China

2 Ocean University of China, Qingdao 266100, China

3 Laoshan Laboratory, Qingdao, 266237, China

4 The First Institute of Oceanography, MNR, Qingdao 266061, China

5 Xiamen University, Xiamen 361102, China

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)

a. floats deployed and their performance

In 2023, China deployed 13 floats in the western Pacific, including 1 HM4000, 6 XUANWU, 2 PROVOR_CTS5, 2 PROVOR_CTS4 and 2 NAVIS floats. The details of these floats are shown in Table 1.

Table 1. Details of the floats deployed in 2023

Float model	Number	Sensor	Region	Owner
HM4000	1	RBRargo^3 deep 6k	Philippine Sea	Laoshan Lab
XUANWU	6	SBE61	5 in Philippine Sea, 1 in Kuroshio Extension	Laoshan Lab
PROVOR_CTS5	2	SBE41, Aanderaa 4330, ECO_FLBB2, OCR504, SUNA, SeaFET	NW Pacific	Ocean University of China
PROVOR_CTS4	2	SBE41, Aanderaa 4330, ECO_FLBBCD, OCR504, SUNA	NW Pacific	CSIO, South China Sea Institute of Oceanology,

				CAS
NAVIS (with rechargeable battery)	2	SBE41, SBE63, MCOMS_FLBBCD, SUNA, SeaFET	NW Pacific	CSIO

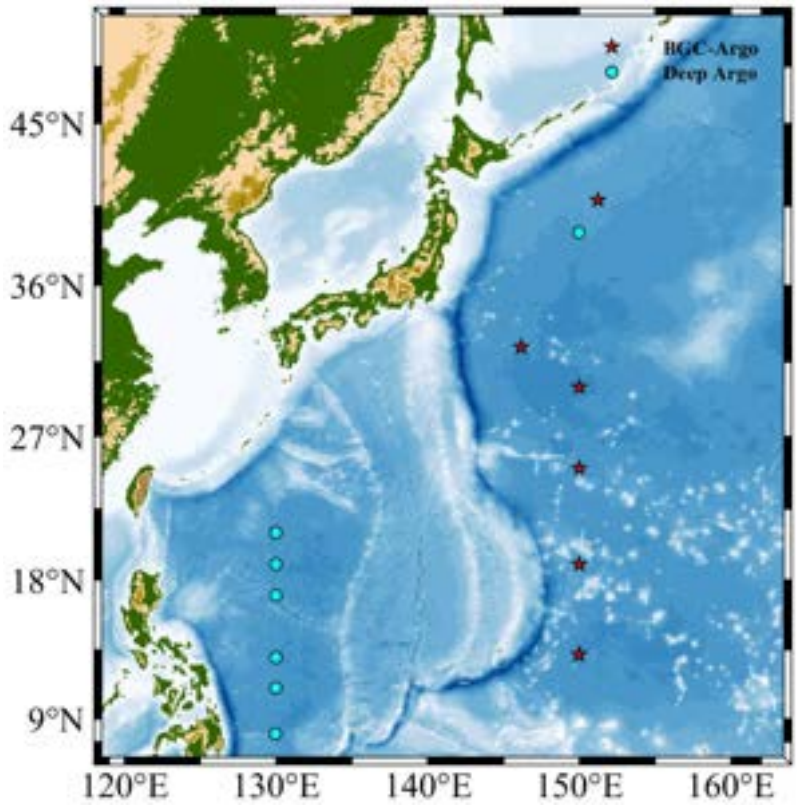


Fig.1 Launch positions of the Chinese floats in 2023

One XUANWU float (WMO: 2902889) deployed in May 2023 only survived 14 cycles with maximum profiling depth only 1500 m. The manufacturer then investigated the possible reason and made improvement in the solenoid valve. In December 2023, Laoshan Laboratory deployed the first batch of Chinese-made deep float in Philippine Sea, including 5 XUANWU and one HM4000 floats. Until now, these floats have been able to profile up to their nominal profiling depth and are all alive.

Two NAVIS floats with SeaTrac rechargeable battery deployed by CSIO have the ballasting problem after the extra BGC sensors were added onto the float, which resulted in the too shallow profiling depth. Therefore, the floats cannot harvest much energy from the less temperature difference and may not survive much cycles as expected.

b. technical problems encountered and solved

One HM4000 float (2902895) equipped with RBRargo[3] deep 6k CTD sensor deployed in December 2023 has been found a systematic salinity bias comparing with the shipboard CTD cast. The reason is that the coating of the conductivity cell had been broken when the float manufacturer conducted field testing. Fortunately, a shipboard CTD cast and bottle data were obtained at the float deployment, so that we can correct the salinity observations using an estimated conductivity slope.

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 2023 CSIO received 2,847 core profiles plus 902 DOXY, 493 CHLA, 806 BBP, 180 CDOM, 648 IRRADIANCE, 369 NITRATE and 272 pH profiles from 73 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.

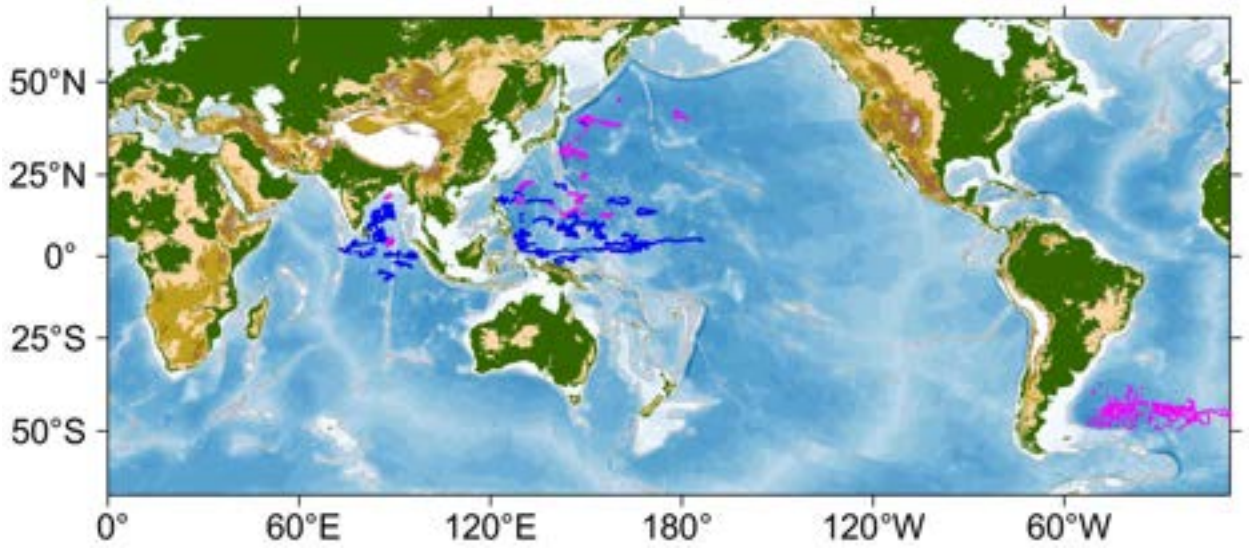


Fig.2 Positions of core (blue) and BGC (red) profiles.

d. status of delayed mode quality control process

Last year CSIO had sent about 7, 249 D-files of Core Argo to GDACs. In total, about 78% R-files has been DMQC'd. With the help from CSIRO DMQC team and Dr. Mathieu Dever (from RBR LTD), we've updated the DMQC system which now can process the data that collected by RBR CTD sensor. Meanwhile, our DMQC operator is also learning the BGC-Argo data processing under the instruction from Tanya Maurer.

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)

Unfortunately, the national funding for China Argo has not been secured. Until now, no projects or special funds have been granted as a contribution to OneArgo. The deployment of float still relies on research and special programs undertaken by institutions and universities. Although 30 COPX floats were deployed in Indian Ocean last year, their data have not been agreed to submit into GDAC because these floats were sponsored by a special program. 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 will 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.

In 2024, China plans to deploy 4 BGC-Argo floats in the western Pacific, 2 in the Northwest Pacific (Kuroshio Extension region) during the summer-autumn cruise of RV DONGFANGHONG 3, and the other 2 in the tropical west Pacific during the summer-autumn cruise of RV KEXUE. Laoshan Laboratory plans to deploy 20 deep floats (XUANWU) in the Philippine Basin and Kuroshio Extension regions. Currently the floats are ready to be assembled, but the purchase process of SBE61 CTD is behind the schedule. It is expected that SBE61 CTD can be ready by the end of September and 20 floats can be deployed by RV KEXUE by the end of 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 T/S profiles have become the most important data in the 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. A deep-Argo web app is being developed by

CSIO, which provides an interactive map interface that features deep-Argo float metadata and technical data but also float locations, trajectories and figures.

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.

6 full-depth CTD casts obtained from the deployments of deep Argo 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

Wang, M., D., Wang, Y., Xiang, Y., Liang, R., Xia, Yang, J., F., Xu, and X., Huang (2023), Fusion of ocean data from multiple sources using deep learning: Utilizing sea temperature as an example. Frontiers in Marine Science, https://doi.org/1.3389/fmars.2023.1112065

Yang, G., Q., Zheng, X., Xiong (2023), Subthermocline eddies carrying the Indonesian Throughflow water observed in the southeastern tropical Indian Ocean, Acta Oceanologica Sinica, 42(5), https://doi.org/10.1007/s13131-022-2085-2

Wang, H., J., Song, C., Zhao, X., Yang, H., Leng, N., Zhou (2023), Validation of the multi-satellite merged sea surface salinity in the South China Sea, Journal of Oceanology and Limnology,41(6), https://doi.org/10.1007/s00343-022-2187-x

Liu, Z., F., Chai, X., Xing, Z., Chen, L., Cheng, D., Chen, J., Xu (2023), Perspectives for China Argo ocean observarion network, The Innovation Geoscience, 1(1), https://doi.org/10.59717/j.xinn-geo.2023.100012

Chen, W., K., Ren, Y., Zhang, Y., Liu, Y., Chen, L., Ma, S., Chen (2023), Reconstruction of the Sound Speed Profile in Typical Sea Areas Based on the Single Empirical Orthogonal Function Regression Method, Journal of Marine Science and Engineering, 11(4), https://doi.org/10.3390/jmse11040841

Argo National Report 2023 – 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 to oceanic operations, 37 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.

In 2023 FMI deployed total of 4 floats. One Apex float was deployed on Gotland Deep (WMO 3902579), one in Northern Baltic Proper (WMO 4903714) and two in Bothnian Sea (WMOs 3902531 and 2903899)

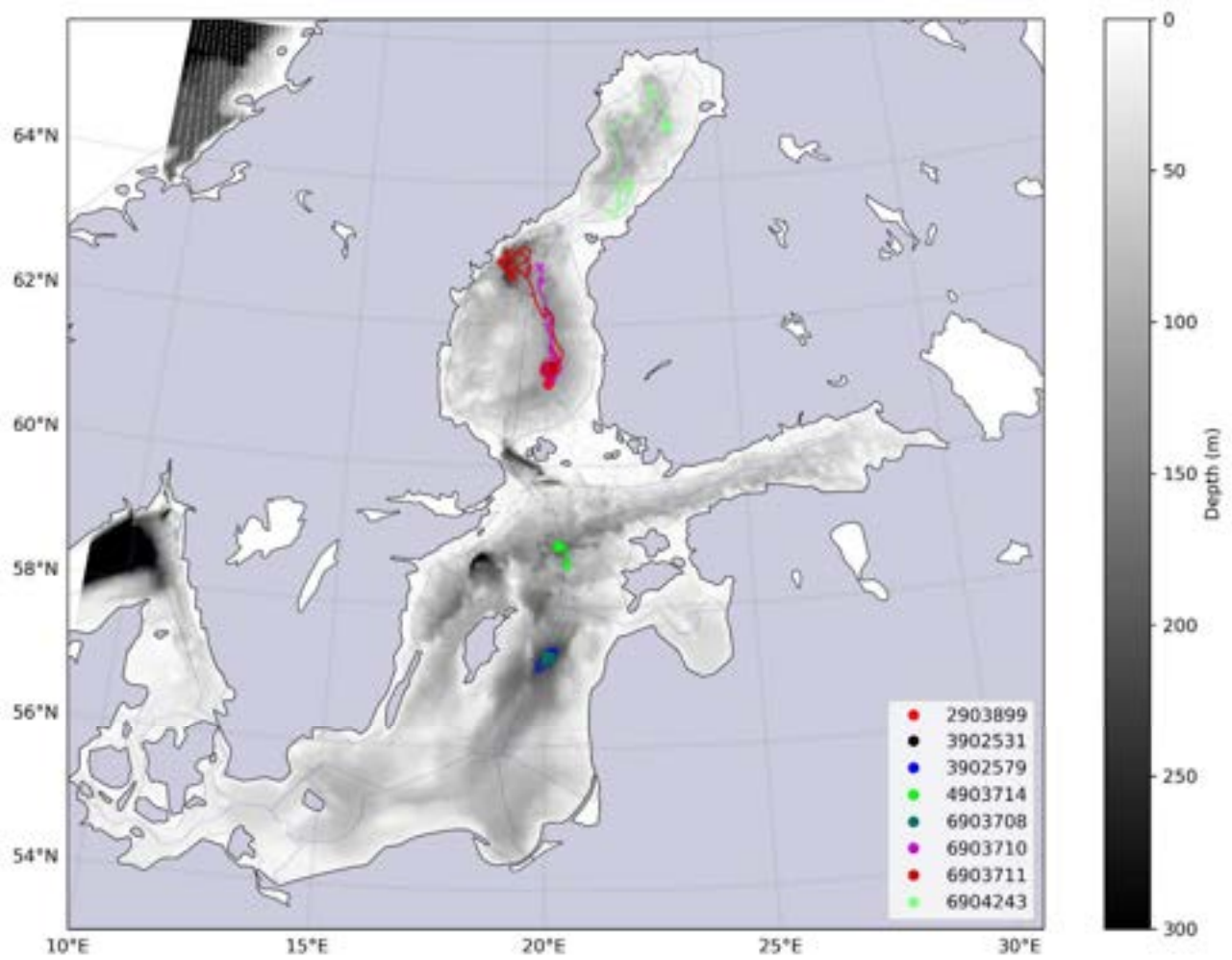


Figure 1, Routes of FMI Argo floats which operated in the Baltic Sea in 2023. Dots indicate the deployment location. Crosses indicate the recovery point or latest measurement for each Argo float. Light blue lines indicate the borders of national EEZ.

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 made it possible to increase the total person months used in Argo activities closer to 12 in earlier years. 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 2015-2016. 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 successfully measured for two winters and is currently under ice. The two Barents Sea floats deployed in 2022 are as of writing yet to resurface.

3. **Summary of deployment plans**

FMI plans to deploy at least 3 floats in 2024. 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 important 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.

Roiha P, Siiria SM, Haavisto N, Alenius P, Westerlund A, Purokoski T. 2018. Estimating currents from Argo trajectories in the Bothnian Sea, Baltic Sea. Frontiers in Marine Science. 5:308. Available from: https://www.frontiersin.org/article/10.3389/fmars.2018.00308.

Roiha P 2019 Dissertation, Advancements of operational oceanography in the Baltic Sea, Finnish Meteorological Institute Contributions 157, http://hdl.handle.net/10138/308506

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 acquire more floats with RBR sensors to further continue operations with RBR sensors in addition to the SeaBird models, when manufacturers can provide models with both Oxygen sensor and RBR.

German National Report 2023 for the Argo Steering Team Meeting AST25

Submitted by Birgit Klein and Meike Martins on behalf of Argo Germany

The AST requests a National Report from each country involved in implementing the Argo array prior to the yearly AST meetings. These reports help inform all Argo participants of the status of each National Program and help guide the AST meetings. Please use the questions below to help produce your report and send it to Megan Scanderbeg two weeks prior to the annual AST meeting or drop it into the National Reports folder here: https://drive.google.com/drive/folders/1VdEKiReuFglprqUXSpChB-fmpfeE-gK1?usp=drive_link .

1. **The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)**
    a. **floats deployed and their performance**

    On the total, 38 Floats were deployed by Argo Germany, mainly in the Atlantic Ocean. 32 were purchased from the operational budget at the BSH funded by the BMDV, 3 were deployed and funded from institutional funds by the AWI, 1 BGC Float was financed and deployed by IOW with the RV Elizabeth Mann Borgese, 2 by the ICBM with the Dagmar Aaen.

    In December 2023, Polarstern expedition PS140 deployed a series of 4 Arvor floats in Prydz Bay, East Antarctica. The floats, operated through AWI and the EU-project OCEAN:ICE, are intentionally-grounded under the sea ice of the continental shelf, in order to provide year-round profiles from one of the key Antarctic dense water formation sites. The Polarstern team also deployed 4 floats from BSH on the same cruise in the Southern Ocean. Additional 7 BSH floats were deployed on 2 other Polarstern cruises earlier in 2023, 2 in the Arctic Ocean and 5 in the Atlantic. 8 BSH floats were deployed on a Meteor cruise in the Atlantic, and other 10 floats stored at the south African hub with Tammy were deployed on a transittour of the US RV Revelle by American colleagues. 2 BGC floats were deployed during a Maria S. Merian cruise in the end of 2023 in the Labrador Sea and a 3rd one in the Northwest Atlantic on the SOOP line.

    The low number of float results from delays in cruise until 2024.

    b. technical problems encountered and solved

    The 3 BGC floats deployed in December in the Labrador Sea and NW corner are equipped with pH sensors shipped after June 2022, which according to the community notice issued by SBS, still showed an elevated risk of early failure. Due to project constraints the floats had

to be deployed anyway in 2023 but all floats so far behave well and the first 20 to 30 cycles of these floats show reasonable data. We will closely monitor the floats during coming months.

Three older pH sensors which have been sent back to the manufacturer are still a point of concern, because we have received no delivery date yet for the return. These floats would be needed for a cruise in summer 2024.

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 status of the ASD floats from the German program has been documented in the joint excel spreadsheet curated by Coriolis until November 2023. No more new incidences were encountered in the past year. The European fleet which is partly handled by BSH did show however a few more cases, which will be discussed with SBS at the end of the year. There is a small delay in core float dmqc since then due to lack of personal resources. Ramping up to include BGC floats has also been hampered by the short personal resources. In the second half of 2023 the workforce for Argo Germany was reduced to half due to sickness and termination of contracts.

Certificates for 5.5 CTDs related to the ASD issue were issued by SBE for installation on future float procurement.

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 core floats is good, but decreased a bit compared to previous years. The national report will be updated as soon as the OceanOps webpage is online again and statistics can be calculated.

Delayed mode quality control of floats in the Baltic were discussed during a workshop in Sopot (18.04-19.04.2023) and a following workshop in Bergen (16.10-19.10.2023). During the hands-on workshops all groups with floats in the Baltic were present and a processing chain developed by IMR was provided. This close cooperation will be continued in 2024 and extended to the BGC parameters, in a first phase to the oxygen data.

Due to the lack of personal resources, BSH is behind schedule of DMQC, especially concerning BGC floats. 2 persons dealing mostly with the logistical and technical matter were ill or changed the position so that the remaining team had to take over their duties. However, close collaborations between the German institutes has been established, e.g. the deployments of the 3 BGC Floats were prepared according to the needs of the future pH data quality control.

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 BMDV (Federal Ministry for Digital and Transport) has approved to increase the budget for 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 was 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. For 2024 and following 4 years, BSH has established a tender with 2 manufacturers, NKE and Bornhöft (TWR), in order to ease the procurement of floats.

   GEOMAR is continuing the 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. A new pH sensor from Pyroscience has been installed on the SOOP line and shows promising results. ICBM is continuing to redeploy its floats with hyperspectral radiometers, while IOW is experimenting with the pCO2 sensor. Unfortunately, one of the floats carrying a pCO2 sensor has been lost in 2023 for unknown reasons. The remaining float had been sent to NKE for checks and will be back in March 2024 for deployment in spring 2024.

   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 joined the BSH Argo team in January 2023 and is presently working 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 until February of 2023. 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 (only until Feb 2023)
Simon Tewes (BSH)	Technician, technical support, and performance monitoring (only until September 2023)
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring (only half of the time)
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 (, C-Scope), BGC group, DMQC expert (BGC sensors)
Oliver Zielinski (ICBM)	Research scientist, BGC group, now at Institute of Baltic Research Warnemünde (IOW)
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC expert radiometry (BGC sensors)
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: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be **returned separately ASAP** to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.

Deployment year:	2024					
Float Type:	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
A. Funded	27		3	**6**	0	0
B. Business as usual/Reasonable expectation		15				
C. Proposed, with a reasonable chance of success				1		
D. Aspirational						
E. Other			3			
Totals	27	15	6	7	0	0

Further plans to deploy floats in 2025 to 2027:

Deployment year:	2025						2026						2027					
Float Type:	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
A.	25				0	0					0	0						
B.	20	20	8	3			20	18	8	3			20	18	8	3		
C.				1													1	
D.							6											
E.																		
Totals	45	20	8	4	0	0	26	18	8	3	0	0	20	18	8	3	1	0

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 and updating the Argo Germany web site. 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. 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 and other operational forecasting systems. 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 2023 was held as a hybrid event on 20.06.2023. 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-25 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% 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 high 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.

   During some of the deployments organized by the BSH reference CTD profiles were taken, the principal investigators are asked to provide the data as soon as they are calibrated. We will then exchange them with Coriolis.

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.

- Dall'Olmo, G., U. Bhaskar TVS, **H. Bittig**, E. Boss, J. Brewster, H. Claustre, M. Donnelly, T. Maurer, D. Nicholson, V. Paba, J. Plant, A. Poteau, R. Sauzède, C. Schallenberg, C. Schmechtig, C. Schmid and X. Xing (2023). Real-time quality control of optical backscattering data from Biogeochemical-Argo floats. Open Res. Europe 2: 118, doi: 10.12688/openreseurope.15047.2

- **Ismail, M. F. A**., **Karstensen, J.** , Ribbe, J., Arifin, T., Chandra, H., Akhwady, R., Yulihastin, E., Basit, A. und Budiman, A. S. (2023) Seasonal mixed layer temperature and salt balances in the Banda Sea observed by an Argo float. Open Access Geoscience Letters, 10 (1). Art.Nr. 10. DOI 10.1186/s40562-023-00266-x.

- Purwandana, A., **Ismail, M. F. A.,** Nugroho, D., Atmadipoera, A. S. und Kampono, I. (2023) Hydrography and turbulent mixing in the Banda Sea inferred from Argo profiles. Open Access IOP Conference Series: Earth and Environmental Science, 1251 (1). Art.Nr. 012007. DOI 10.1088/1755-1315/1251/1/012007.

- **Roch, M., Brandt, P. und Schmidtko, S.** (2023) Recent large-scale mixed layer and vertical stratification maxima changes. Open Access Frontiers in Marine Science, 10 . Art.Nr. 10:1277316. DOI 10.3389/fmars.2023.1277316.

- **Roch, M. (**2023) On the Changing Upper-Ocean Stratification: Trends and Variability of the Upper-Ocean Structure during the Argo Observation Period. Open Access (PhD/Doktorarbeit), Christian-Albrechts-Universität zu Kiel, Kiel, Germany, 169 pp.

- Stoer, A. C., Y. Takeshita, T. L. Maurer, C. Begouen Demeaux, H. C. **Bittig**, E. Boss, H. Claustre, G. Dall'Olmo, C. Gordon, B. J. W. Greenan, K. S. Johnson, E. Organelli, R. Sauzède, C. M. Schmechtig and K. Fennel (2023). A census of quality-controlled Biogeochemical-Argo float measurements. Front. Mar. Sci. 10: 1233289, doi: 10.3389/fmars.2023.1233289

Wimart-Rousseau, C. , Steinhoff, T., Klein, B., Bittig, H., and Körtzinger, A. (2023): Technical note: Enhancement of float-pH data quality control methods: A study case in the Subpolar Northwest Atlantic region, BG Discussions, https://doi.org/10.5194/bg-2023.

Schoderer, M**., Steinhoff, T., Bittig, H., Klein, B.**, Haegle, R., Arne, and Hornidge A.-K. (2024), It takes thousands of dots to paint a picture – Structures and practices for integrated marine carbon observations and vulnerabilities in the observation network Contribution to "Knowledge Integration in Ocean Governance" edited by Dorothea and Annegret Kuhn, in preparation.

Krissy Anne Reeve, Torsten Kanzow, **Olaf Boebel,** Myriel Vredenborg, Volker Strass, and Rüdiger Gerdes (2023), TheWeddell Gyre heat budget associated with the Warm Deep Water circulation derived from Argo floats, July 2023, Ocean Science 19(4):1083-1106,DOI: 10.5194/os-19-1083-2023

Maike Sonnewald, **Krissy Reeve,** Redouane Lguensat, (2023) A Southern Ocean supergyre as a unifying dynamical framework identified by physics-informed machine learning, Communications Earth & Environment, 4(1), DOI: 10.1038/s43247-023-00793-7.

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 Impact.

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 2024 and 2025 (if known) and where they might be deployed.

Yes, BSH is cooperating with RBR for deployments of the RBR CTD sensors. In 2023, several RBR sensors were deployed: 10 floats, i.e. 5 equipped with a SBE CTD and 5 with a RBR CTD were deployed as buddies, along the transittour through the South Atlantic of the Revelle by American colleagues. 3 other RBR floats were deployed in late 2023 in the South Indian Ocean, one of them has severe problems after the 7th cycle, analysis of the failure reasons are on-going. 5 floats with an RBR sensor wait in Lisbon to be deployed with the Portuguese Navy, one will be deployed south of Portugal, in March 2024. 2 floats equipped with RBR sensors will be deployed in August 2024 in the Eastern subtropical North Atlantic. Further plans to buy floats equipped with RBR CTD in 2024 and 2025 are not finalized yet, however, RBR CTD sensor are included in the tender with both manufacturers (see above) and BSH plans are to purchase 10% of the CTD sensors from RBR.

GREEK ARGO PROGRAMME

PRESENT STATUS AND FUTURE PLANS

D. Kassis and G. Korres
HCMR
March 2024

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 2023, two (1) 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, one (1) Italian float, Deep Arvor-I, 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 (see Table 1). Regarding the Greek float, it was deployed in the South Aegean during the Greek WFD network maintenance. The float 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	ARVOR I	1902582	AI2600-21GR003	29/03/2023	21:35	36.83	23.91	69	Active
2	DEEP Arvor-I	3902483		25/10/2023	14:40	36.48	21.59	19	Active

All floats have been integrated in the MedArgo project. 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 2023.

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 was expected, postponed currently for 2024. Under this, we envisage the purchase of 6 additional floats to cover the needs until 2025. 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 2024 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2024 is to continue the efforts for a sustainable funding scheme for the Greek-Argo infrastructure in accordance with the Euro-Argo infrastructure. In 2024, 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:

Ntoumas, M., Perivoliotis, L., Petihakis, G., Korres, G., Frangoulis, C., Ballas, D., ... & Stamataki, N. (2022). The POSEIDON Ocean Observing System: Technological Development and Challenges. *Journal of Marine Science and Engineering*, *10*(12), 1932.

Potiris, M., Mamoutos, I. G., Zervakis, V., Tragou, E., Kassis, D., & Ballas, D. (2023). Record-high salinity and interannual dense water formation variability in the Aegean Sea coincide with reduced inflow of Black Sea Water (No. EGU23-13363). Copernicus Meetings.

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

Kassis, D., Korres, G., Perivoliotis, L., 2016. Sub-mesoscale features of the Eastern Ionian Sea as derived from Argo floats operating during 2014-2015, in: Submesoscale Processes: Mechanisms, Implications and New Frontiers. Presented at the 48th Liege Colloquium, University of Liege, Liege, Belgium.

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

Kassis, D., Notarstefano, G., Ruiz-Parrado, I., Taillandier, V., Díaz-Barroso, L., et al.. 2021. Investigating the capability of Argo floats to monitor shallow coastal areas of the Mediterranean Sea. p. 110 – 117. In: *Proceedings of the 9th EuroGOOS International Conference. 3 – 5 May 2021, Online Event 2021, EuroGOOS. Brussels, Belgium. https://archimer.ifremer.fr/doc/00720/83160/*

Notarstefano, G., Kassis, D., Palazov, A., Tuomi, L., Walczowski, W.,, et al., 2021. Extension of Argo in shallow coastal areas and expansion of the regional communities (EURO-ARGO RISE project). p. 375 – 381. In: *Proceedings of the 9th EuroGOOS International Conference. 3 – 5 May 2021, Online Event 2021, EuroGOOS. Brussels, Belgium. https://archimer.ifremer.fr/doc/00720/83160/*

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 (2024)

(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

INCOIS has made a total contribution of 538 floats to the international Argo programme so far. During the 2023-24 period, INCOIS deployed 44 Argo floats in the Indian Ocean, of which 40 are Core Argo floats and 4 are BGC floats. Presently, 73 Argo floats are active and transmitting data. All the active float data are processed and sent to GDAC.

1.1b Performance Analysis of Floats Deployed

Of the 538 floats deployed so far, 73 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 has deployed 538 floats so far (till Feb 29, 2024). Out of these, 73 floats are active. All the active float 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 (73) data are subject to real-time quality control and are being sent to GDAC.

- **Web pages**

  INCOIS continued maintaining a Web-GIS-based site for the Indian Argo Program. It contains the entire Indian Ocean float data along with profile position. Further details can be obtained by following the link: http://www.incois.gov.in/Incois/argo/argo_home.jsp. Apart from the floats deployed by India, data from floats deployed by other nations in the Indian Ocean are received from the Argo Mirror and made available in the INCOIS website. User can download the data based on his requirement.

- **Statistics of Argo data usage**

  Statistics of Indian and Indian Ocean floats are generated and maintained on the INCOIS website. The density maps for aiding people with new deployments are made available on a monthly basis. For full details, visit the following link:

  http://www.incois.gov.in/Incois/argo/argostats_index.jsp.

- **Products generated from Argo data.**
  1. INCOIS continued to generate value-added products using all Argo data (both national and international). Continued to use variational analysis method (DIVA) while generating value-added products. Many products are generated using Argo temperature and salinity data. The Argo T/S data are first objectively analysed, and this gridded output is used in deriving value-added products.

2. DVD on “Argo Data and Products for the Indian Ocean” is discontinued, and is being made available via INCOIS and UCSD websites. However, the older version of the same is still available for download.

Fig: Web page of the Argo data viewer.

3. Argo value-addedd products are continued to be made available through INCOIS LAS. For further details, visit http://las.incois.gov.in.

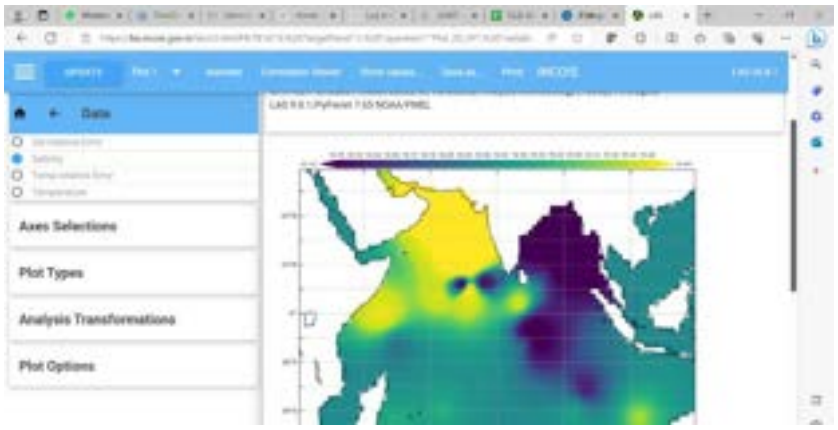


Fig: Screeshot of the LAS page for Argo value added products.

4. Continued to provide the Argo and value-added products derived from Argo data through ERDDAP.
5. Argo data and products are made available through Digital Ocean. For more details, users are requested to visit: http://do.incois.gov.in

1.4 Status of Delayed Mode Quality Control process

In total, ~49% of the eligible profiles for DMQC are generated and uploaded to GDAC. Floats identified and notified through the ocean-ops are passed through DMQC and submitted to GDAC. Some more floats are grey-listed, and the list is updated on GDAC.

1.5 Trajectory files status:

INCOIS continued generating Ver 3.1 trajectory files and uploaded them 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 has 06 BGC Argo floats (all 06 with CTD, DO, FLBB and pH sensors, and two floats with additional nitrate sensors) in stock, received in February 2024, and will be deployed in the coming months in the Indian Ocean. In March 2024, INCOIS placed a purchase order for 50 Argo floats (40 CORE and 10 BGC floats) for deployments in the Indian Ocean. Once these floats are received, INCOIS will make the deployment planning across various sectors of the Indian Ocean, including the Bay of Bengal, Arabian Sea, Equatorial Indian Ocean, and Southern Ocean (depending on ship-time availability)

Supporting the Indian Argo Project is a dedicated team of four scientific and technical personnel responsible for tasks such as float deployment, 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 plans to address the data gaps across different sectors of the Indian Ocean by deploying more Argo floats. However, the final decision on deployment locations depends on getting cruise approvals or chances to collaborate with other research institutions to plan cruises in those data gap regions. Moreover, the availability of approved funds is also crucial in determining the final number of Argo floats. Presently, INCOIS placed a purchase order for 50 Argo floats in March 2024, consisting of 40 core floats and 10 BGC floats.

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. The Indian MET department utilizes this analysis for initializing the coupled ocean-atmosphere forecast of the Monsoon. Since 2011, India has been providing seasonal Monsoon forecasts using a dynamic 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

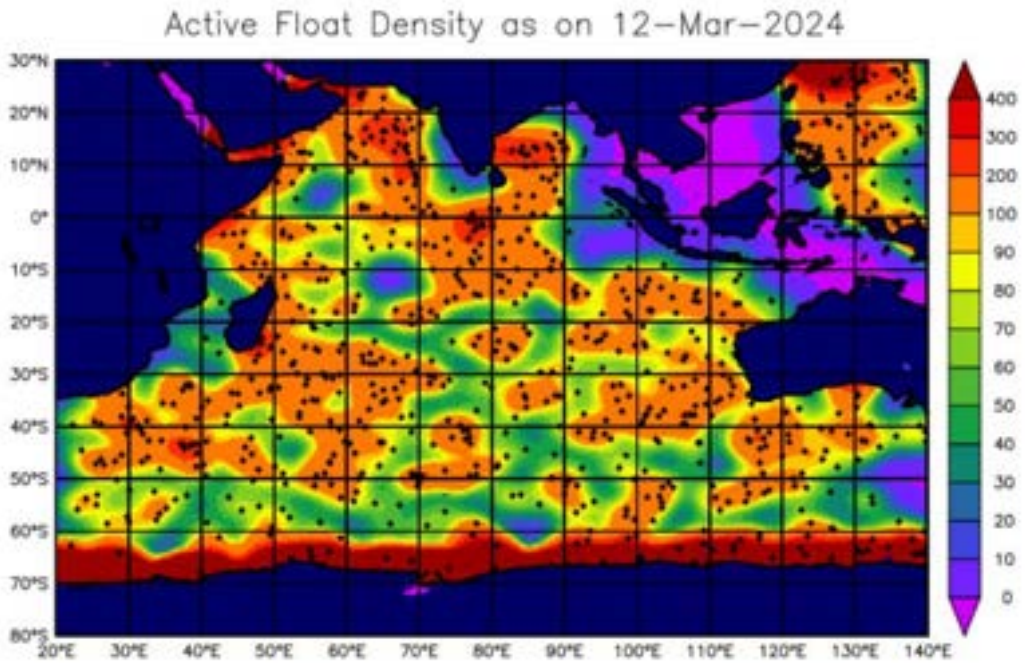
(http://www.incois.gov.in/argo/ARDCenter.jsp)

- 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 March, 2024 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.

INCOIS is not getting ship time for float deployments in the Southern sector of the Indian Ocean. If AST could help INCOIS get cruise plans from other Argo member countries, INCOIS can collaborate with them to deploy floats in those regions.

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, wherever possible. 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:

1. Akhil, V. P., M. Lengaigne, K. S. Krishnamohan, M. G. Keerthi, and J. Vialard (2023), Southeastern Arabian Sea Salinity variability: mechanisms and influence on surface temperature, Climate Dynamics, doi: https://doi.org/10.1007/s00382-023-06765-z.
2. Anjaneyan, P., J. Kuttippurath, P. V. Hareesh Kumar, S. M. Ali, and M. Raman (2023), Spatio-temporal changes of winter and spring phytoplankton blooms in Arabian sea during the period 1997–2020, Journal of Environmental Management, 332, 117435, doi: https://www.sciencedirect.com/science/article/pii/S0301479723002232.
3. Bhattacharya, T., K. Chakraborty, P. K. Ghoshal, J. Ghosh, and B. Baduru (2023), Response of Surface Ocean pCO2 to Tropical Cyclones in Two Contrasting Basins of the Northern Indian Ocean, Journal of Geophysical Research: Oceans, 128(4), e2022JC019058, doi: https://doi.org/10.1029/2022JC019058.
4. Chacko, N. (2023), On the rapid weakening of super-cyclone Amphan over the Bay of Bengal, Ocean Dyn., 73(6), 359-372, doi: https://doi.org/10.1007/s10236-023-01555-x.
5. Jha, R. K., and T. V. S. U. Bhaskar (2023), Generation and Assessment of ARGO Sea Surface Temperature Climatology for the Indian Ocean Region, Oceanologia, 65(2), 343-357, doi: https://doi.org/10.1016/j.oceano.2022.08.001.
6. Konda, G., V. S. Gulakaram, and N. K. Vissa (2023), Intraseasonal variability of subsurface ocean temperature anomalies in the Indian Ocean during the summer monsoon season, Ocean Dyn., 73, 165-179, doi: https://doi.org/10.1007/s10236-023-01547-x.
7. Maneesha, K., S. Ratheesh, and T. V. S. U. Bhaskar (2023), Impact of the Upper Ocean Processes on Intensification of Cyclone Amphan, Journal of the Indian Society of Remote Sensing, 51(2), 289-298, doi: https://doi.org/10.1007/s12524-022-01592-x.
8. Mohanty, S., V. S. Bhadoriya, and P. Chauhan (2023), Upper Ocean Response to The Passage of Cyclone Tauktae in The Eastern Arabian Sea Using In Situ and Multi-Platform Satellite Data, Journal of the Indian Society of Remote Sensing, 51(2), 307-320, doi: https://doi.org/10.1007/s12524-022-01621-9.
9. Mohanty, S., M. Swain, R. Nadimpalli, K. K. Osuri, U. C. Mohanty, P. Patel, and D. Niyogi (2023), Meteorological Conditions of Extreme Heavy Rains over Coastal City Mumbai, Journal of Applied Meteorology and Climatology, 62(2), 191-208, doi: https://doi.org/10.1175/JAMC-D-21-0223.1.
10. Prasanth, R., V. Vijith, and P. N. Vinayachandran (2023), Formation, maintenance and diurnal variability of subsurface chlorophyll maximum during the summer monsoon in the southern Bay of Bengal, Prog. Oceanogr., 212, 102974, doi: https://doi.org/10.1016/j.pocean.2023.102974.
11. Rahaman, H., L. Kantha, M. J. Harrison, V. Jampana, T. M. B. Nair, and M. Ravichandran (2023), Impact of initial and lateral open boundary conditions in a Regional Indian Ocean Model on Bay of Bengal circulation, Ocean Model., 184, 102205, doi: https://doi.org/10.1016/j.ocemod.2023.102205.

12. Thandlam, V., H. Rahaman, A. Rutgersson, E. Sahlee, M. Ravichandran, and S. S. V. S. Ramakrishna (2023), Quantifying the role of antecedent Southwestern Indian Ocean capacitance on the summer monsoon rainfall variability over homogeneous regions of India, Scientific Reports, 13(1), 5553, doi: https://doi.org/10.1038/s41598-023-32840-w.
13. Thoppil, P. G. (2023), Enhanced phytoplankton bloom triggered by atmospheric high-pressure systems over the Northern Arabian Sea, Scientific Reports, 13(1), 769, doi: https://doi.org/10.1038/s41598-023-27785-z.

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 COVID-19 pandemic-related constraints, INCOIS was not able to procure any floats during the 2019-2022 period. However, INCOIS procured 50 Argo floats during the 2022-23 period, and 44 of them were deployed. Additionally, INCOIS placed a purchase order for another 50 floats during March 2024.

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.

INCOIS, so far, only deployed pumped CTD-based Argo floats and do not have any immediate plans to procure RBR unpumped CTD floats due to a reported salinity bias issue (Dever et al. 2022). However, INCOIS welcomes a wide range of sensor and float manufacturers to promote competitive pricing and meet the global requirements and timelines in the current international supply chain situation following the Covid-19 pandemic. INCOIS requests that AST come up with a detailed plan and recommendations for using unpumped CTDs in Argo floats.

Argo National Report 2023: Ireland

1) The status of implementation (major achievements and any issues in 2023):

a) Irish Argo float Overview

In 2023, although Ireland did not deploy any Argo floats, Ireland procured six floats through Euro-Argo ERIC for deployment in 2024

The Marine Institute had intended to deploy a TWR/APEX BGC float, WMO:6901936 in Q.4 of 2023. 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. A repair was carried out to the float CTD and was returned to TWR in December of 2023. Unfortunately, as of March 2024 the float has yet to be returned as it has once again failed its pre-deployment testing in TWR.

Marine Institute Argo Float Overview (2023)					
Operational Floats (2023)					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901921	7243	TWR/APEX	23/03/2016	OPERATIONAL
2	6901922	7242	TWR/APEX	14/04/2016	OPERATIONAL
3	6901924	7240	TWR/APEX	10/02/2017	OPERATIONAL
4	6901925	7841	TWR/APEX	11/02/2017	OPERATIONAL
5	6901926	7842	TWR/APEX	20/05/2017	OPERATIONAL
6	6901928	7844	TWR/APEX	12/02/2018	OPERATIONAL
7	6901929	AI2600-17EU001	NKE/ARVOR	12/02/2018	OPERATIONAL
8	6901930	AI2600-17EU002	NKE/ARVOR	27/03/2018	OPERATIONAL
9	6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
10	6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
11	6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL
12	6901934	AI2600-18EU030	NKE/ARVOR	31/08/2020	Under Ice
13	6901935	AI2600-18EU032	NKE/ARVOR	10/09/2020	OPERATIONAL
14	6901937	AI2600-18EU031	NKE/ARVOR	05/09/2020	OPERATIONAL
15	6901938	AI2600-18EU029	NKE/ARVOR	07/03/2021	OPERATIONAL
16	6901939	AI2632-18EU039	NKE/ARVOR	08/03/2021	OPERATIONAL

Floats to be deployed in 2024					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	TBC	AI3500-23EU008	NKE ARVOR RBR	TBC	TBC
2	TBC	AI3500-23EU009	NKE ARVOR RBR	TBC	TBC
3	TBC	AI3500-23EU010	NKE ARVOR RBR	TBC	TBC
4	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 and 2023. 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). Carried out by BODC for the Marine Institute (Ireland). In the case of new RBR version ARVOR floats this will be carried out through Coriolis.

d) Status of delayed mode quality control process

Carried out by BODC for the Marine Institute (Ireland). In the case of new RBR version ARVOR floats this will be carried out through Coriolis.

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 National level funding has been received to procure 3 core floats per year on an ongoing basis. The Marine Institute has received 3 RBR ARVOR floats, procured through the Euro-Argo ERIC, for deployment in 2024 with another 3 RBR ARVOR floats on order through Euro-Argo ERIC. The Marine Institute will procure/deploy additional floats where funding allows and will also assist the ERIC in deploying project specific floats where appropriate.

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 2024 consist of the deployment of 3 core ARVOR floats with RBR CTD sensors in the North East Atlantic with the first earmarked for a cruise to the Rockall Trough in April. These 3 floats will be the first RBR ARVOR floats deployed by the Marinre Instiute. If the ongoing issues with the TWR APEX BGC float can be resolved, this float will also likely be deployed in 2024.

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.

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.**
The Marine Institute procured 6 RBR ARVOR floats in 2023 through Euro-Argo ERIC and intend to procure another 3 RBR ARVOR floats through Euro-Argo ERIC in 2024.

Submitted by: G. Notarstefano (OGS), E. Mauri (OGS), Giorgio Dall'Olmo (OGS), Massimo Pacciaroni (OGS), Antonella Gallo (OGS), Emanuele Organelli (CNR-ISMAR) and Giovanni La Forgia (CNR-ISMAR)

Report on the Italian Argo Program for 2023

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)

a. Floats deployed and their performance

A total of 18 Italian floats were deployed in 2023 (see Tables 1 and 2 for details). These floats were Arvor-I, Arvor-Ice, Provor CTS4, Provor CTS5, and Deep-Arvor designs manufactured by NKE (France). All floats transmit data via Iridium telemetry.

Mediterranean and Black Sea deployments

Ten units were released in the Mediterranean (Table 1). The Core-Argo floats have a park pressure at 350 dbar and maximal profiling depth at 2000 dbar. Bio-Argo floats have a park pressure at 1000 dbar and the maximal profiling pressure was set to 2000 dbar. One Arvor-I float (WMO 4903680) was deployed in the Sicily Channel and parked on the sea bottom to limit horizontal displacement and to sample that shallow area: the cycle time was set to 5 days and the parking depth was adjusted in order to be always greater than the maximum bathymetry. The Provor V Jumbo float was deployed in the Ionian Sea in November hosting 4 key BGC variables plus the UVP6 - underwater vision profiler to acquire particle size distribution and zooplankton taxonomy.

Most floats were deployed from research vessels of opportunity (i.e., R/V Atalante, R/V Aegaeo, R/V Gaia Blu, Speedboat (Malta), fishing vessel (Cyprus) and R/V Laura Bassi for the Mediterranean and R/V Agulhas II and Laura Bassi for the South Atlantic and Southern Ocean with the help of colleagues from France, Greece, Malta, Italy and Cyprus.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor- T/S Diss. Oxy	7901019	02-Mar-2023 10:07	33.90	33.00	2	08-Mar-2023 07:44	33.84	33.29	D	5
Arvor - T/S Diss. Oxy	2903795	24-Apr-2023 17:08	40.94	4.26	195	04-Feb-2024 22:09	41.31	03.61	A	5
PROVOR CTS4	1902605	28-Apr-2023 22:04	42.14	07.48	152	05-Feb-2024 12:05	42.17	07.27	A	5
Arvor - T/S Diss. Oxy	3902500	05-May-2023 04:08	40.84	04.95	152	04-Feb-2024 07:44	41.58	08.23	A	5
Arvor - T/S Core	4903680	08-Jul-2023 08:50	35.70	14.41	33	18-Dec-2023 22:09	36.34	14.04	D	5
Arvor – I DEEP	3902483	25-Oct-2023 14:46	36.50	21.58	16	02-Feb-2024 06:11	36.53	21.48	A	5
PROVOR V Jumbo	2903797	20-Nov-2023 14:40	35.86	17.80	33	03-Feb-2024 10:00	36.26	17.46	A	5
Arvor - T/S Diss. Oxy	4903679	25-Nov-2023 22:47	38.99	15.20	15	05-Feb-2024 09:49	39.19	14.54	A	5
Arvor – I DEEP	5906993	26-Nov-2023 12:56	37.06	17.88	8	30-Jan-2024 23:04	37.03	17.44	A	10
PROVOR CTS4	5907088	26-Nov-2023 13:16	37.06	17.89	16	02-Feb-2024 11:26	36.11	17.15	A	5

**Status in early February 2024: A = active, D = dead*

***Cycle: Length of cycle in days*

Table 1. Status information for the 10 Italian floats deployed in the Mediterranean Sea during 2023.

South Atlantic, South Pacific and Southern Ocean

With the help of Italian colleagues onboard the R/V Laura Bassi: a total of 5 Arvor-I equipped with ice-detection software were deployed, three along the Ross Ice Shelf (6903831, failed due to the lack of communication with the SBE41 probe, 6903832, and 6903833 re-deployed as WMO 6903810), two during the crossing the Circumpolar Current (6903829, 6903830). 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). One float (6903794) was recovered for maintenance purposes.

In collaboration with the *Parthenope* University, three Arvor-I with ice detection were deployed in the southern Atlantic sector (5906980, 5906979, 4903650).

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-T/S ICE	6903829	09-Jan-2023 20:00	-63.02	172.73	40	05-Feb-2024 01:44	-63.98	-169.51	A	10
Arvor-T/S ICE	6903830	10-Jan-2023 13:02	-65.03	176.15	39	29-Jan-2024 03:22	-64.83	164.59	A	10
Arvor-T/S ICE	**6903831**	**26-Jan-2023 15:05**	**-77.16**	**168.90**	**2**	**03-Feb-2023 05:45**	**-77.04**	**168.93**	**D**	**7**
Arvor-T/S ICE	**6903832**	**27-Jan-2023 08:16**	**-77.41**	**174.38**	**56**	**04-Feb-2024 05:46**	**-76.67**	**173.84**	**A**	**7**
Arvor-T/S ICE	**6903833**	**29-Jan-2023 17:15**	**-77.96**	**-160.23**	**60**	**31-Jan-2024 16:42**	**-77.47**	**-163.21**	**recovered**	**7**
Arvor-T/S ICE	5906980	08-Feb-2023 03:07	-50.37	-0.29	-	08-Feb-2023 03:07	-50.37	-0.29	D	10
Arvor-T/S ICE	5906979	08-Feb-2023 16:52	-48.04	-0.98	37	05-Feb-2024 23:35	-53.93	36.39	A	10
Arvor-T/S ICE	4903650	08-Feb-2023 16:52	-48.05	-0.98	37	05-Feb-2024 23:51	-53.16	38.00	A	10

**Status in early February 2024: A = active, D = dead*

***Cycle: Length of cycle in days*

Table 2. Status information for the 8 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2023.

Overall status at the end of 2023

In summary, at the end of 2023, the Argo-Italy program had a total of 86 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 48 in the South Pacific, South Atlantic, and Southern Oceans (south of 60°S, see Figure 2).

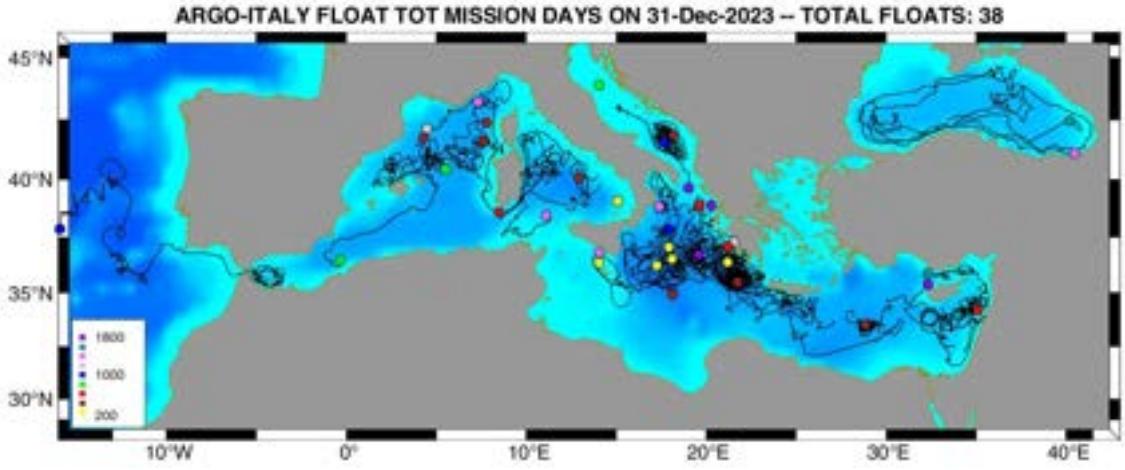


Figure 1. Trajectories and positions (circle symbols) on 31 December 2023 of the 38 Argo-Italy floats active in the Mediterranean and Black Sea (one float escaped in the Atlantic Ocean). Circles are color coded as a function of float age in days.

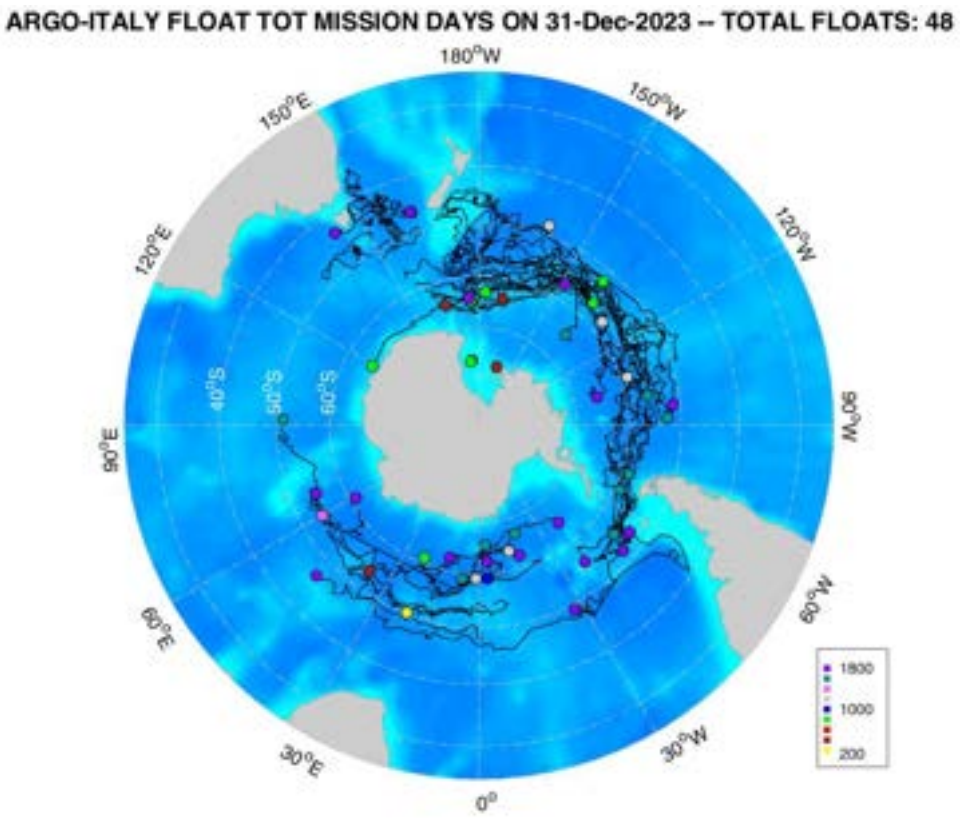


Figure 2. Trajectories and positions (circle symbols) on 31 December 2023 of the 48 Argo-Italy floats in the South Pacific, South Atlantic and Southern Oceans. Circles are color coded as a function of float age in days.

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 2012-2023. The float population in 2023 is in the range 80-90 active instruments. In 2023, the number of dead floats is well balanced by new deployments.

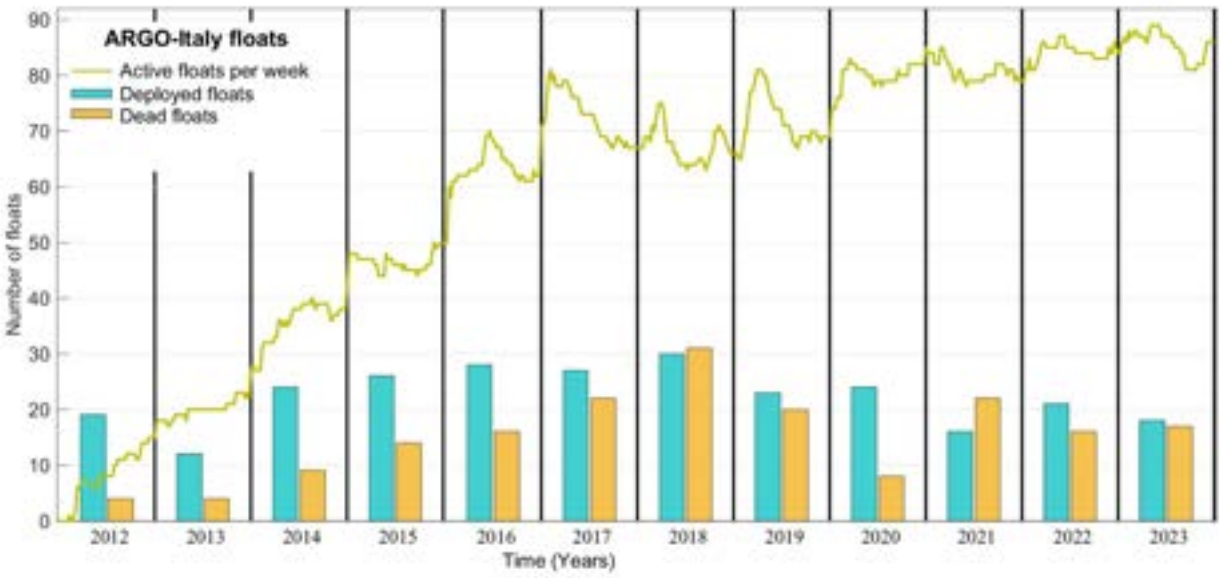


Figure 3. Temporal evolution of the number of Argo-Italy active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of 268 Argo-Italy floats have been deployed, 157 in the Mediterranean and Black Seas and 111 in the Southern Hemisphere oceans. Over a 12 year period, they have provided about 43000 CTD profiles. The histogram of the number of floats in selected CTD profile classes is shown in Figure 4. The number of float profiles sorted by the main floats types shows the evolution in time of the Italian fleet (Figure 5). In this diagram, Core and Core DO floats are grouped; Bio floats are intended as floats equipped with sensors for measuring 2 to 6 BGC parameters. The spatial coverage provided is quite uniform (Figure 6) in the Mediterranean Sea with the exception of a small region in the Balearic sub-basin where a more intensive sampling took place as planned in the BIOSWOT Project.

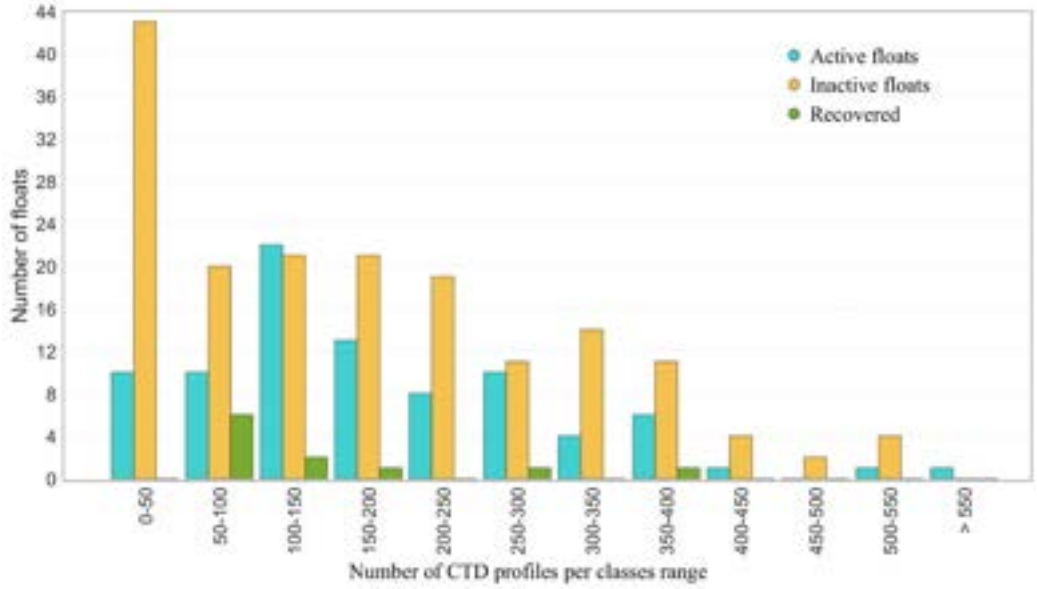


Figure 4. Histogram of the number of floats in selected CTD profile classes at the end of 2023 (orange: dead float, cyan: alive at the end of 2023, green: recovered).

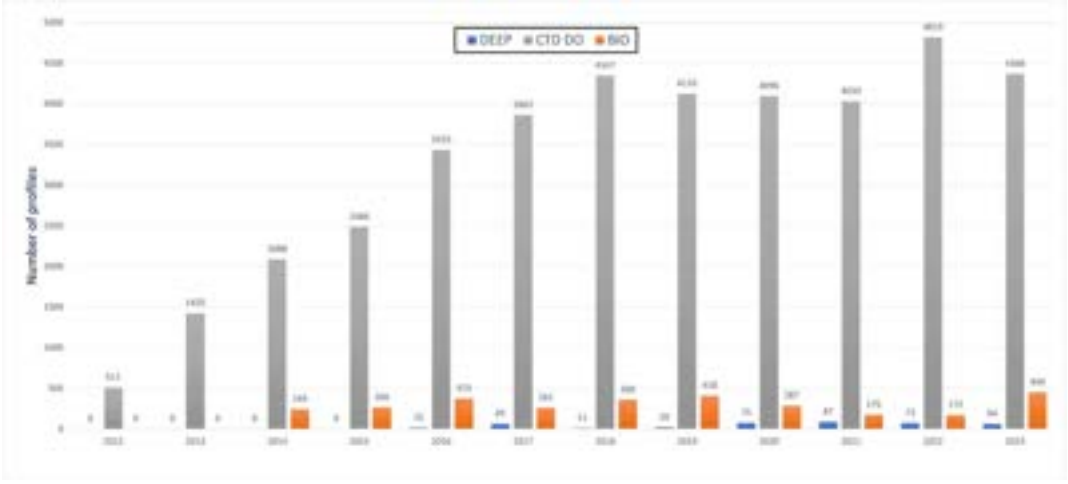


Figure 5. Number of float profiles from 2012 to 2023 sorted by main float types (orange: Bio floats, blue: Deep floats, grey: core and core DO floats).

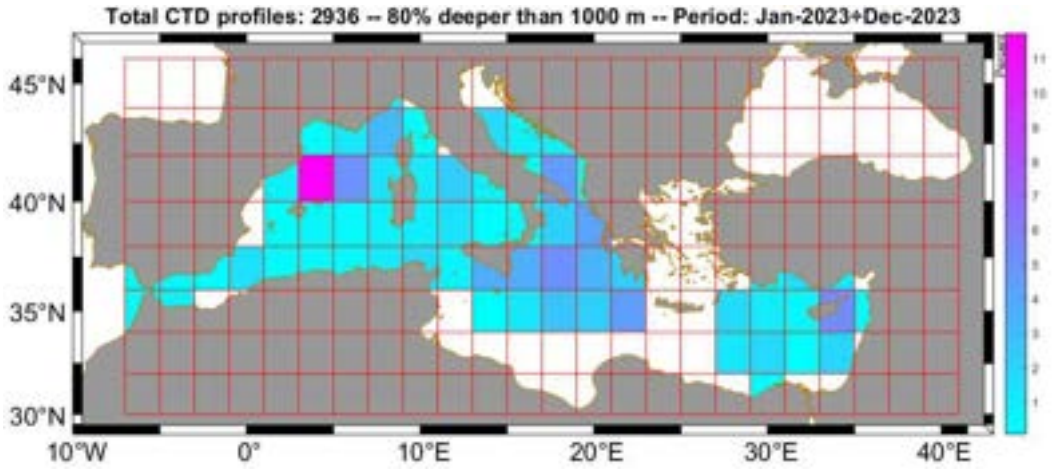


Figure 6. Density map of CTD profiles in 2023.

b. Technical problems encountered and solved

Mediterranean Sea

The Arvor DO 7901019 failed after 2 cycles due to a lack of communication with SBE41.

The Provor V Jumbo 2903797 stopped transmitting UVP data after the first few profiles. Anyway, it is still acquiring data. This will be investigated once the float will be recovered.

Global Ocean

The Core Arvor 5906980 failed after deployment for unknown cause.

Southern Ocean

The Core Arvor 6903831 failed after 2 cycles due to a lack of communication with the SBE41 probe.

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 was done for approximately 76,4% of eligible floats (191 out of 250 eligible floats) deployed between 2010 and 2022 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. Furthermore, we started to implement the PCM (Profile Classification Model) method in the Mediterranean Sea. This approach allows a selection of reference data belonging to a similar water mass regime even though data are older with respect to the float profile. For some sub basins, the reference data are quite old and this method should be useful to solve this problem. The DMQC analysis was also conducted on the shallow-coastal floats deployed in the Mediterranean Sea, in the framework of the European H2020 Euro-Argo RISE project. In addition to the qualitative analyses, as comparisons between floats profiles and CTD at deployment or nearest CTD in space, the procedure developed for the Baltic sea has been adapted to the Adriatic Sea in order to improve the qualitative analysis. This analysis is under development and no D-files are produced at the moment.

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.

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 27 floats in 2023, including 15 Core-Argo with dissolved oxygen sensors, 2 Deep-Argo with dissolved oxygen sensors, 9 Core-Argo with dissolved oxygen sensors and with Ice Detection Algorithm implemented, and 1 Core-Argo equipped with the RBR CTD. 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 2023. It is expected that the same level will be maintained in 2024, including the procurement of about 8 additional Core-Argo with dissolved oxygen sensors. The Italian Ministry of Research has committed to provide funds in order to sustain the Italian contribution to Argo beyond 2024 (when a new five-years plan will start) as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to Italian national funding, in 2023 OGS received funding from the Italian PNRA (Programma Nazionale di Ricerche in Antartide) for personnel (about 6 man months) dedicated to activities related to Argo. CNR-ISMAR has purchased one BGC-Argo float that has been 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/Deep floats (34 units by OGS and 9 units by CNR) to be deployed mainly in the Mediterranean and in key regions of our open seas. The scientific aims span from biogeochemical to bio-optical issues related to climate change as well as a modelling component. Furthermore, the deep data will be used to study the heat storage in the deepest layers of the water column particularly in the Mediterranean Sea. Our overall strategy will be to explore the key areas of the Mediterranean with BGC floats and also equipped with bio-optical sensors to characterise and provide new information to both experimental and modelling scientists. These new floats, together with previous ones, will provide the opportunity to quantitatively assess the importance of these measurements and better calibrate future funding in BGC, bio-optical, and Deep Argo in the Mediterranean Sea and in areas of multi-year interest. In doing so, we aspire to secure sustained, long-term funding for the BGC and Deep extensions of the Argo array. To realise this strategy, we are strengthening the interactions between the Italian observational Argo teams (OGS and CNR), the national and the European satellite community, and the biogeochemical modelling group at OGS. The ITINERIS floats are expected to be deployed in 2024-2026.

3. **Summary of deployment plans: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be returned separately ASAP to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.**

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 from 2024 to 2028 have been provided as a separate contribution at https://drive.google.com/drive/folders/1a_hOVSpGMKajxd91Lv_fmP4IsmMnouNM, as requested. The main areas of interest are the Mediterranean and the Southern Oceans. 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.

Over a longer time frame, Italy is primarily interested in maintaining mainly its contributions to the Core mission and supporting the Bio/BGC and Deep Argo missions as long as funds are available for these extensions.

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 used for assimilation and forecast validation into the operational Mediterranean marine forecasting center (Med-MFC) run by the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC) and the National Institute of Oceanography and Applied Geophysics (OGS). Med-MFC provides 3D daily physical and biogeochemical fields of the Mediterranean that are available on the Copernicus Marine Service at https://data.marine.copernicus.eu/products?facets=areas%7EMediterranean+Sea. Assessments done by the Med-MFC have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions.

Specifically for the biogeochemical operational component, work done by OGS during 2023 included: (i) the inclusion of the assimilation of O2 profiles in the biogeochemical component of the Med-MFC (Amadio et al., 2023), (ii) the development of novel Neural Network applications for the reconstruction of synthetic biogeochemical profiles using Argo and BGC-Argo data (Pietropolli et al., 2023a and 2023b), and (iii) the development of novel ensemble data assimilation schemes for BGC-Argo profiles in the Mediterranean biogeochemical model (SEAMLESS H2020 project Cossarini et al., 2023) to foster the exploitation of BGC-Argo information with a focus on carbon sequestration, oxygen dynamics, eutrophication and plankton dynamics.

Additionally, new skill performance metrics of the Med-MFC biogeochemical predictions have been implemented using BGC-Argo data and are published regularly in the OGS webpage of the operational results (medeaf.ogs.it).

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 , as well as to develop and validate new satellite products .

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/.

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-25 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-ISMAR)

Bibliography (2023):

- Amadio, C., Teruzzi, A., Pietropolli, G., Manzoni, L., Coidessa, G., Cossarini, G., 2023. Combining Neural Networks and Data Assimilation to enhance the spatial impact of Argo floats in the Copernicus Mediterranean biogeochemical model. EGUsphere 1–28. https://doi.org/10.5194/egusphere-2023-1588

- Cossarini, G., Skakala, J., Wakamatsu, T., Teruzzi, A., Spada, S., & Yumruktepe, C. (2023). Guidelines on space-in situ data assimilation (D5.1). Deliverable report of project H2020 SEAMLESS. Zenodo. https://doi.org/10.5281/zenodo.7684591

- Gonzalez-Santana A., Oosterbaan M., Clavelle T., Maze G., Notarstefano G., Poffa N. and Velez-Belchi P., (2023). Analysis of the global shipping traffic for the feasibility of a structural recovery program of Argo floats. Front. Mar. Sci. 10:1161580. doi:10.3389/fmars.2023.1161580

- Kubin E., Menna M., Mauri E., Notarstefano G., Mieruch S. and Poulain P.-M. (2023). Heat content and temperature trends in the Mediterranean Sea as derived from Argo float data. Front. Mar. Sci. 10:1271638. doi:10.3389/fmars.2023.1271638

- Menna, M., Martellucci, R., Reale, M. et al. A case study of impacts of an extreme weather system on the Mediterranean Sea circulation features: Medicane Apollo (2021). Sci Rep 13, 3870 (2023). https://doi.org/10.1038/s41598-023-29942-w

- Pietropolli, G., Manzoni, L., Cossarini, G., 2023a. PPCon 1.0: Biogeochemical Argo Profile Prediction with 1D Convolutional Networks. EGUsphere 1–23. https://doi.org/10.5194/egusphere-2023-1876

- Pietropolli, G., Manzoni, L., Cossarini, G., 2023b. Multivariate Relationship in Big Data Collection of Ocean Observing System. Applied Sciences 13, 5634. https://doi.org/10.3390/app13095634

- Uitz, J., Roesler, C., Organelli, E., Claustre, H., Penkerc'h, C., Drapeau, S., et al. (2023). Characterization of bio-optical anomalies in the Kerguelen region, Southern Indian Ocean: A study

based on shipborne sampling and BioGeoChemical-Argo profiling floats. Journal of Geophysical Research: Oceans, 128, e2023JC019671. https://doi.org/10.1029/2023JC019671

- Stoer, A.C., Takeshita, Y., Maurer, T.L., Begouen Demeaux, C., Bittig, H.C., Boss, E., Claustre, H., Dall'Olmo, G., Gordon, C., Greenan, B.J.W, Johnson, K.S., Organelli, E., Sauzède, R., Schmechtig, C.M., and Fennel, K. (2023) A census of quality-controlled Biogeochemical-Argo float measurements. Front. Mar. Sci. 10:1233289. doi: 10.3389/fmars.2023.1233289

- Li M., Organelli E., Bellacicco M., Landolfi A., Serva F., Pisano A., Marullo S., Santoleri R. (2023). BGC-Argo floats and Earth Observation to assess the impact of Marine Heat Waves on phytoplankton communities in the NW Mediterranean Sea (The CAREHeat project). EC-ESA Joint Earth System Science Initiative, 22-24 November, Frascati (Italy). Poster.

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 2024 and 2025 (if known) and where they might be deployed.**

   OGS bought one Arvor I equipped with the RBR sensor in April 2023 and the float will probably be deployed in the Southern Adriatic in 2024.

References

- Cossarini, G., Mariotti, L., Feudale, L., Mignot, A., Salon, S., Taillandier, V., Teruzzi, A., d'Ortenzio, F. (2019). Towards operational 3D-Var assimilation of chlorophyll Biogeochemical-Argo float data into a biogeochemical model of the Mediterranean Sea. Ocean Modelling, 133, 112-128

- Cossarini, G., Feudale, L., Teruzzi, A., Bolzon, G., Coidessa, G., Solidoro, C.,Di Biagio V., Amadio C., Lazzari, P., Brosich Al., Salon, S. (2021). High-resolution reanalysis of the Mediterranean Sea biogeochemistry (1999–2019). Frontiers in Marine Science, 8, 1537.

- Salon, S., Cossarini, G., Bolzon, G., Feudale, L., Lazzari, P., Teruzzi, A., Solidoro, C., Crise, A. (2019). Novel metrics based on Biogeochemical Argo data to improve the model uncertainty

evaluation of the CMEMS Mediterranean marine ecosystem forecasts. Ocean Science, 15(4), 997-1022.

- Terzić, E., Lazzari, P., Organelli, E., Solidoro, C., Salon, S., d'Ortenzio, F., & Conan, P. (2019). Merging bio-optical data from Biogeochemical-Argo floats and models in marine biogeochemistry. Biogeosciences, 16(12), 2527-2542.

- Teruzzi, A., Bolzon, G., Feudale, L., & Cossarini, G. (2021). Deep chlorophyll maximum and nutricline in the Mediterranean Sea: emerging properties from a multi-platform assimilated biogeochemical model experiment. Biogeosciences, 18(23), 6147-6166.

Argo-KOREA Annual Report 2023

by National Inst. of Meteorological Sciences/KMA

25th Argo Steering Team Meeting (AST-25)
Southampton, UK, 18-22 March 2024

1. Status of Implementation

The National Institute of Meteorological Sciences of the Korea Meteorological Administration (NIMS/KMA) has deployed **264** Argo floats around the Korean Peninsula and the North Pacific Ocean since 2001, including eight active floats as of March 2024. In 2023, NIMS/KMA deployed six Argo floats in the East China Sea (ECS) and Yellow Sea (YS) (Fig. 1). Five floats were deployed in the ECS from July 13 to 16, 2023, with a parking depth of 60m and a one-day or two-day profiling scheme, and one float was in the YS on November 26, 2023, with parking depth of 60m and a two-day profiling scheme for shallow sea observation. All floats deployed using the GISANG 1, the KMA's research vessel, could obtain the profile from the starting day.

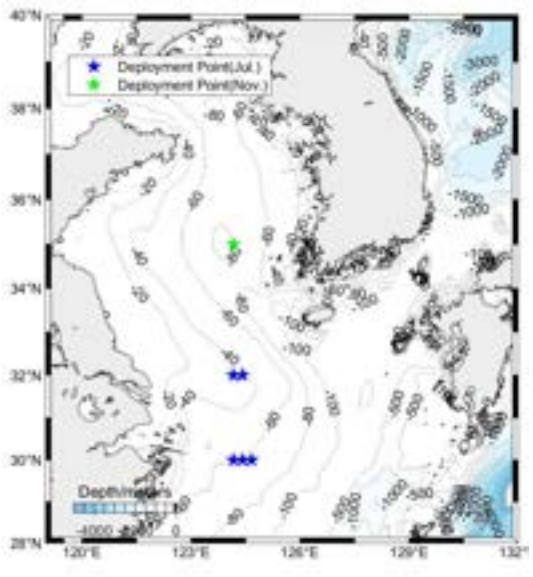


Fig. 1. Deployment points of Argo floats in the East China Sea and Yellow Sea in 2023.

- Status of contributions to Argo data management

- A total of 828 profiles were collected from January through December 2023 and sent to the Global Data Assembly Center (GDAC) after undergoing Real-Time Quality Control (RTQC) procedure.
- Data re-submission to GDAC was conducted by applying the Warning Objective Analysis Report.
- The RTQC procedure for shallow sea profiles and grey-listed ones has been updated.
- The RTQC procedure has also been updated for the global range test for the North Pacific Ocean and the East Sea.
- Some missing files, such as "Tech.nc" and "Meta.nc", were found on the KMA Data Center server. This issue may be related to an unexpected failure of FTP data transmission to GDAC. A fix is currently in progress and will be implemented soon.

- Delayed Mode QC

- A total of 652 profiles (446 profiles from the East Sea, and 206 from the Yellow Sea) were processed by the Delayed Mode QC (DMQC) procedure. These profiles were observed from early September 2022 to early September 2023. The D-files were successfully sent to the Ifremer GDAC on June 29, October 19, and November 9, 2023, in NetCDF format. The Delayed Mode T/S Audit Report was answered on November 9 with 664 profiles included: 238 profiles from the East Sea, 420 profiles from the North Pacific Ocean, and 6 from the Yellow Sea.
  The profiles of this year will be DMQCed based on KMA DMQC procedure and OWC 3.0.0. The D-files will be sent to the Ifremer GDAC in June and October 2024 in NetCDF format.
  We are in the process of effectively addressing the CTD duplicated S/N issue and the file reject warning issue regarding metadata format.
- Constant salinity offsets were identified in several shallow ARGO floats right after their deployments in the Yellow Sea by using shipboard CTD data. Since the floats in the Yellow Sea observed for a relatively short period of time (due to shallow parking depths of less than 100m and short cycle times of about a day), they usually have initial salinity offsets rather than salinity drift. Additionally, given that the Yellow Sea is a wide continental shelf area, its temporal and spatial scale of salinity variability is much smaller than those in the open ocean. Therefore, the only available shipboard CTD data collected at similar time and location to the Argo floats were utilized as a reference for OW.
- The identified offset for PSAL evaluated based on the shipboard CTD data is

adjusted by using LAUNCH_OFFSET in "MAIN_write_dmqc_files" (matlab code). We plan to make further enhance DMQC progress for the shallow Argo floats by collecting more precise CTD data in the future.

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

We successfully deployed six floats in the sea around the Korea Peninsular in 2023. In 2024, we plan to deploy seven Argo floats, with a different deployment strategy from last year, targeting the Northwestern Pacific (NWP) Ocean and the ECS. The following people contribute to the Argo-Korea program.

- Baek-Jo Kim, Hyeong-Jun JO (NIMS/KMA)
- Kyung-Hee Oh, Hyuk-Min PARK (KIOST)
- Jong-Jin PARK, Yumi SONG (KNU)

3. Summary of deployment plans

NIMS/KMA has a deployment plan for seven floats in 2024: three floats will be deployed at the NWP to keep the observation network and four floats at the ECS to continue the shallow sea observation scheme in the marginal ocean. The KOREA-Argo observation program will be preformed to examine the variation of the ocean environment (Fig. 2).

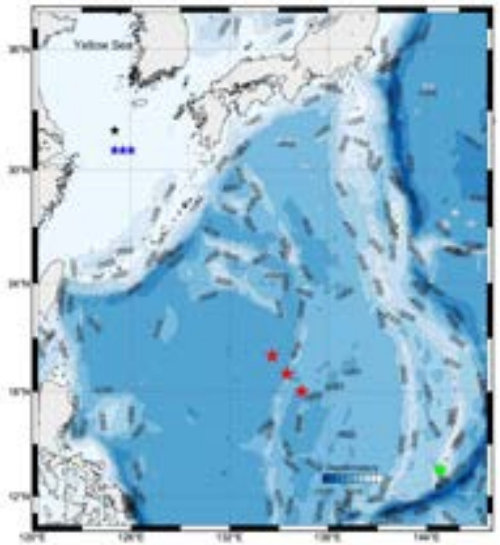


Fig. 2. NIMS/KMA's deployment point for 2024

4. Summary of National Research and Operational Uses of Argo data as well as contributions to Argo Regional Centers.

In 2023, Argo float observations were conducted in the shallow sea, such as the deployment of six floats in the ECS and YS. Through Argo float observations, the decrease of sea temperature and salinity during typhoon passage, as well as the descent of thermocline layer due to coastal upwelling have been revealed. NIMS/KMA will maintain a continuous Argo float observation network along the typhoon northward-moving path.

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

- No CTD data has been uploaded to the CCHDO website.

7. Bibliography

- Baek-Jo Kim, Hyeong-Jun Jo, KiRyong Kang and Chul-Kyu Lee, 2023; Current status and future direction of the NIMS/KMA Argo program. Atmosphere. Vol. 33, No 5, pp.1-10, doi:10.14191/Atmos.2023.33.5.1

8. Effects of COVID-19

- The deployment was impacted by the rapidly changing exchange rate between the US dollar and the Korean won. Because of the unfavorable exchange rate, we performed the procurement process twice, creating a delay of at least three months. The total period from contract to arrival at our institute took about five months, which was two-months longer than normal. Due to these impacts, we delayed the float deployment from November 2022 to July 2023.

9. RBR CTD piloting and deployment plans

- Not planned yet

<The End>

ARGO National Report 2024 – 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:
   - 119 floats have been purchased since 2004
   - 41 are working
   - 6 are ordered for 2024 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.
   Presently, the Netherlands only contributes to the core mission.
   One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.
   Together with the NIOZ (Netherlands Institute for Sea Research), KNMI is working on a restructuring of the Netherlands Argo contribution.

3) **Summary of deployment plans.**
   Six 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**
   Not any more.

9) **RBR sensors**
   10 floats with RBR CTDs have been deployed so far. Results are positive.
   Floats ordered for 2024 will have RBR sensors, too.

Argo New Zealand National Report, March 2024.

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 2023)

a. floats deployed and their performance:

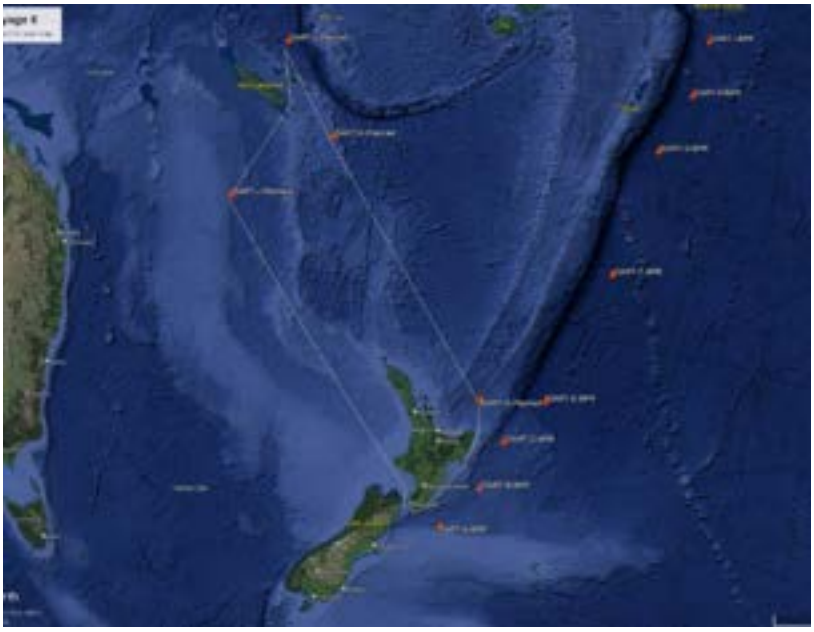
2 Solo2 floats are in the process of being purchased this financial year. These floats will be deployed on the Kaharoa II deployment voyage (starting March 2025- see later).

2 Apex floats funded by the Antarctic Science Platform were deployed in the Ross Sea (~77˚S) in January 2022 from vessel San Aotea II. Unfortunately, one of the floats went under the ice sheet after 9 profiles and has not reported since.

1 further Apex float was purchased by the Antarctic Research Programme for deployment in the Ross Sea in summer 2023/2024. Unfortunately, its delivery was too late to be deployed this Antarctic field season: it will be deployed next Southern Hemisphere summer.

New Zealand also facilitated the deployment of floats from other countries:

11 SIO Solo2 floats were deployed during a Tsunami monitoring buoy servicing (DART) voyage in May 2023:



DART voyage track

Four SIO Deep Solo floats were deployed during a Deep Argo sensor development voyage (see later):

Deep Solo deployments

SIO float number	WMO number	Deployment date	Deployment lat	Deployment lon
6103	5906932	04/05/2023	35.02°S	179.43°W
6104	5906933	04/05/2023	35.01°S	179.43°W
6102	5906931	07/05/2023	34.50°S	179.21°W
6105	5906934	07/05/2023	34.50°S	179.21°W

Deploying Deep Solo serial number 6102. Photo: Steve Diggs (SIO).

One British Antarctic Survey (BAS) ARVOR I NAOS (PI: Pierre Dutrieux) was deployed at ~78˚S, 174˚W from Laura Bassi icebreaker. The NIWA contact is Craig Stevens.

Five floats from Fisheries and Oceans Canada (PI: Chris Gordon) ARVOR I NAOS were deployed from the Italian icebreaker Laura Bassi: one near the ice shelf front, one on the central Ross Sea continental shelf, three on the slope current. NIWA contact Craig Stevens and Denise Fernandez.

ARVOR BAS float deployed in the Ross Sea. Photo: Craig Stewart (NIWA).

b. technical problems encountered and solved:

The NZ Solo2 floats from previous years deployments are functioning well. The first Antarctic deployment (7900924) stopped transmitting after 9 cycles, but it was deployed very close to the ice shelf edge and it is assumed it went under the ice cavity.

A temperature/comms issue with the recent deployment of NKE ARVOR floats in the Ross Sea was reported by Craig Stewart: "The issue we experienced with NKE ARVOR float startup was failure of the final step – the beeping which confirms satellite communications and final internal checks. Both floats had made the initial two checks – i.e. the 5 clicks and the 5 pump activations after magnet removal (we didn't add water to the CTD intake for concerns on freezing). Both floats were used from cold (i.e. deck temperature – possibly around -5˚C). I suspected that the lack of beeping may be a cold related issue, so on a subsequent deployment attempt an hour later I allowed both floats to warm towards room temperature over a 20-minute period before starting. Both floats worked perfectly after this. In retrospect I should have warmed all floats to at least above ~0˚C to minimise ice forming on the float before the first dive after deployment."

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 Solo2 floats is performed by Scripps Institution of Oceanography (John Gilson).
DMQC on the NZ Apex float in the Ross Sea is performed by CSIRO (Esmee van Wijk).

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)

NIWA New Zealand Argo float funding continues on a year-to-year basis at the level of two core floats per year. There is increasing local interest in BGC floats, but feedback has been that BGC purchases will take the place of Core purchases, with limited additional funding. The intention is that the interested scientists set the priorities.
This past year has seen another New Zealand group purchase and deploy floats. The Antarctic Science Platform (ASP) purchased and deployed two Apex floats in the Ross Sea. A further Apex float has been purchased but will not be deployed until next Southern Hemisphere summer. The ASP hopes to purchase a 4-parameter BGC float in 2024.

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.

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.**

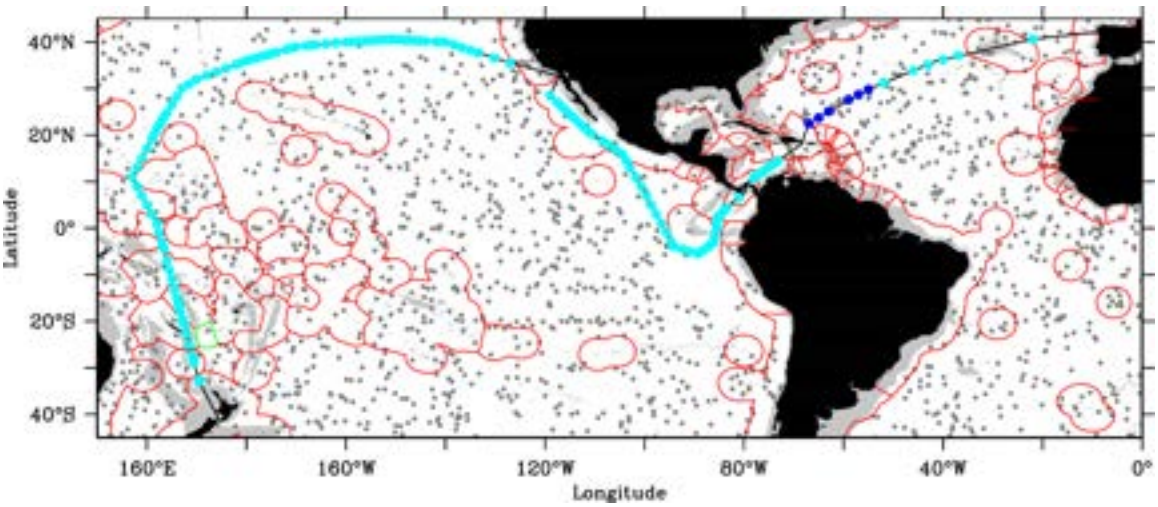
New Zealand floats: planned purchase and deployment of 2 Solo2 floats in the South Pacific as part of the Kaharoa II delivery voyage.

Deployments for other countries:

a) Kaharoa II delivery voyage.

Kaharoa II in final build stages. Photo: Greg Foothead.

There is a large deployment voyage planned in conjunction with the Kaharoa II delivery voyage. This voyage will deploy 58 Core floats and 6 Deep floats on the first leg and a further 88 Core floats on the second leg. Floats are supplied by SIO, UW, WHOI, CSIRO and NIWA (NZ).



Delivery voyage deployment plan. (John Gilson, SIO).

Total Floats = 143

Core: (123)

UW 46

SIO 53

WHOI: 15

CSIRO: 7

NZ: 2

Deep: (7)

SIO 7

BGC: (13)

WHOI: 2

SIO: 2

UW: 9

b) **R/V Tangaroa Tsunami servicing voyages** (southwest Pacific): June/July 2024. SIO is planning deployments.

c) **R/V Tangaroa Ross Sea voyage** January/February 2025. There is interest from SIO in deploying ~12 Core floats and 4 Deep floats. Also interest from Canada about deploying 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 data and products are routinely used in research, including physical oceanography, marine ecosystems, climate and fisheries.

Deep Argo Development Voyage 3.

An R/V Tangaroa research voyage focusing on Deep Argo sensor development and the SW Pacific Deep western Boundary Current was completed in May 2023. The work was a collaboration between NIWA (New Zealand), Scripps Institution of Oceanography, NOAA and Sea Bird Scientific.

Details:

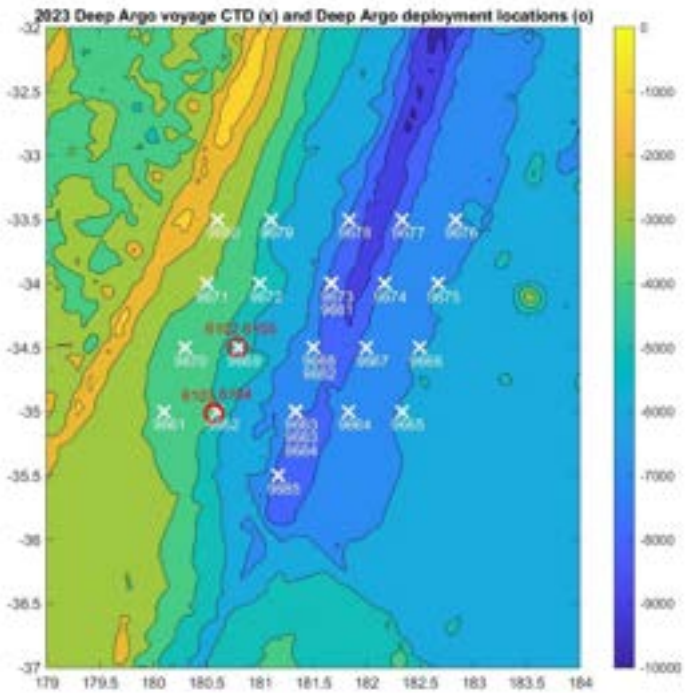
TAN2307: Deep Argo 2023 (Deep Western Boundary Currents) 2 – 16 May 2023

Lead organisation: NIWA

Funding: NIWA SSIF, NOAA

Collaboration: Scripps Institution of Oceanography (Nathalie Zilberman), Sea Bird Scientific Dave Murphy), NOAA

Voyage Leaders: Phil Sutton/Denise Fernandez (NIWA)

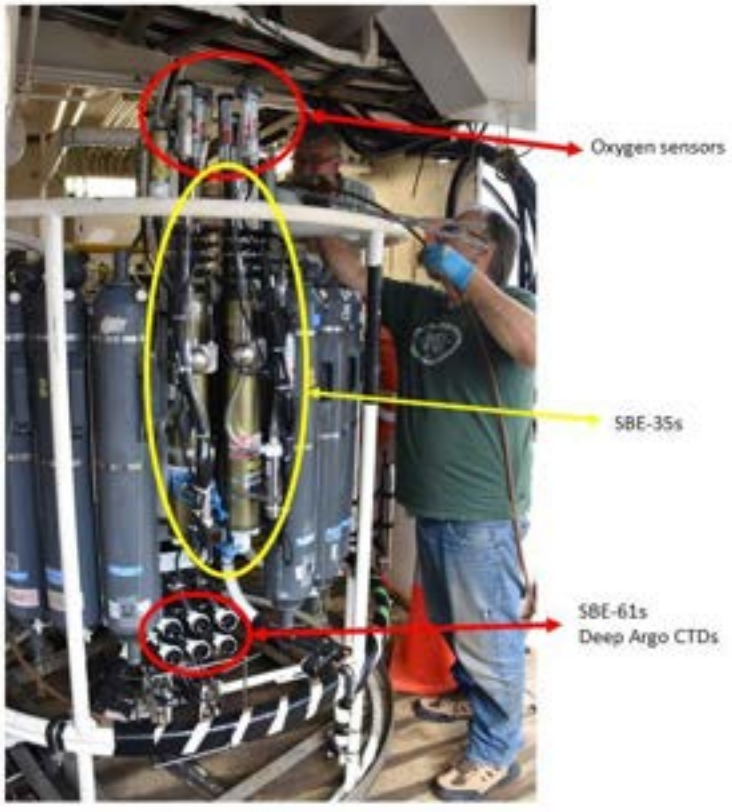


The station locations (white x) and Argo float deployment locations (red circles) overlaid on bathymetry.

Deep Argo target sensor accuracies are ±0.002 PSS-78 (salinity), ±0.001°C (temperature) and ±3 dbar (pressure) (Roemmich et al., 2019b; Zilberman et al., 2023). While present sensors are meeting these requirements, there is still room for improvement, in particular for the conductivity and pressure sensors. The study region is ideal for sensor development work because the ocean properties are relatively constant and stable below 4000m.

There were two initiatives targeting core sensor improvement on this voyage:

A) Sea-Bird Scientific (SBS) is presently the sole manufacturer of 6000m Deep Argo sensors. SBS personnel participated in the voyage testing prototype equipment. Six experimental Deep Argo CTD packages were attached to the shipboard carousel for intercomparison tests and individual experimental conductivity cells were installed in place of the shipboard secondary conductivity cell on selected CTD casts.



Matt Walkington (NIWA) preparing the CTD package. Two SBE-25s with dissolved oxygen sensors were mounted in two Niskin Bottle locations. Six experimental SBE-61s were mounted horizontally above the 9plus to place their seawater intakes close to that of that of the shipboard unit. Photo: Steve Diggs (SIO).

B) Two RBR Deep CTD packages were mounted on the CTD carousel for intercomparison and testing.

RBR CTD equipped with two RBR dissolved oxygen sensors. Photo: Steve Diggs, SIO.

Dissolved oxygen has not been one of the core Deep Argo measured parameters to date. However, deep dissolved oxygen would be very useful for studying deep water mass property and age changes. In pursuit of this goal, Nathalie Zilberman (SIO) arranged for all of the major dissolved oxygen sensor manufacturers to provide sensors for intercomparison.

All of the sensor work (pressure, conductivity and dissolved oxygen) was predicated on highly-accurate data being collected by the shipboard CTD. This was achieved by calibrating all of the shipboard sensors both before and after the voyage and also through on-board conductivity calibrations to correct the shipboard CTD conductivity sensors and chemical Winkler titrations to calibrate the shipboard CTD dissolved oxygen sensors.

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.

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. We are waiting on a post-voyage pressure sensor calibration.

7. **Argo bibliography (Bibliography | Argo (ucsd.edu))**

Costa Santana, R. 2022. Intra-annual variability in the East Auckland Current and its impact on cross-shelf exchange (Thesis, Doctor of Philosophy). University of Otago. http://hdl.handle.net/10523/1377

Dunn MR, Finucci B, Pinkerton MH, Sutton P and Duffy CAJ (2023) Increased captures of the critically endangered leatherback turtle (Dermochelys coriacea) around New Zealand: the contribution of warming seas and fisher behavior. Front. Mar. Sci. 10:1170632. doi: 10.3389/fmars.2023.1170632

Han, C., Bowen, M., Sutton, P. 2023. The response of the upper ocean to tropical cyclones in the South Pacific. Journal of Geophysical Research. Submitted.

Salinger, M.J., Diamond, H.J., Bell, J., Behrens, E., Fitzharris, B.B., Herod, N., McLuskie, M., Parker, A.K., Ratz, H., Renwick, J., Schofield, C., Shears, N., Smith, R.O., Sutton, P.J., Trought, M.C.T. 2023. Coupled Ocean-Atmosphere Summer Heatwaves in the New Zealand Region: an update. Weather and Climate. 42 (1).

Zilberman, N., Thierry, V., King, B., Alford, M., André, X., Balem, K., Briggs, N., Chen, Z., Cabanes, C., Coppola, L., Dall'Olmo, G., Desbruyères, D., Fernandez, D., Foppert, A., Gardner, W., Gasparin, F., Hally, B., Hosoda, S., Johnson, G.C., Kobayashi, T., Le Boyer, A., Llovel, W., Oke, P., Purkey, S., Remy, E., Roemmich, D., Scanderbeg, M., Sutton, P., Walicka, K., Wallace, L., van Wijk, E.M. 2023. Observing the full ocean volume using Deep Argo floats. Frontiers in Marine Science. Volume 10 – 2023. https://doi.org/10.3389/fmars.2023.1287867.

Santana, R., MacDonald H., O'Callaghan, J., Powell, B., Wakes, S., Suanda, S. 2023. Data assimilation sensitivity experiments in the East Auckland Current system using 4D-Var. Geoscientific Model Development 16 913) 3675-3698 https://doi.org/10.5194/gmd-16-3675-202

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 substantial covid issues in the past year. There are still covid requirements for using NIWA vessels, although these are being relaxed.

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 New Zealand-Wellington local school participated in a hands-on experiment consisting of decorating Styrofoam cups which were taken onboard R/V Tangaroa and deployed on deep CTD casts. After the voyage the cups were returned to the class and the students found out the effect of water pressure on the cups: the pressure of the water expelled the air out of the foam and shrank the cups. Students learned about that, as a contrast with the floats and other hard solid instruments deployed in the deep ocean, animals are adapted to the environment they live in and some of them, like whales and seals, have the ability to dive deep by safely collapsing their lungs and drawing oxygen from the blood and muscles.




Argo National Report March-2024 – 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 2023)

   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 2023, Norway deployed **8 Argo floats**:
      - 2 BGC-floats (6 bgc-variables + transmissometer (CROVER) and UVP6)
      - 2 BGC-floats (4 bgc-variables = Bio)
      - 2 core+DO floats
      - 2 core floats

      Since 2018, Norway has in total deployed 67 floats (table) and at present has 37 operative floats that include Deep, BGC, and core.

	Deep	BGC	Bio	Core+DO	core	SUM
2018					5	5
2019	2	3	3		6	14
2020	4	1	5		2	12
2021	1	1	3	4	5	14
2022	3	4	2	2	3	14
2023		2	2	2	2	8
SUM	**10**	**11**	**15**	**6**	**23**	**67**

Table 1. Number of deployed Norwegian floats per year since 2018.

   b. technical problems encountered and solved

      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. 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)

4 floats deployed 2019-2020 had fast salinity drift (ASD). SBE will grant warranty credit (100%) for these floats.

d. status of delayed mode quality control process

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 DMQC of temperature/salinity for most of our floats deployed in 2019 and later (67 floats). Exceptions are 2 floats that 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 (37 of 44 floats), nitrate (6 of 11 floats) and pH (4 of 11 floats). DMQC of Chl-a for some floats are done (we need that someone approve the files). 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 Research Council of Norway (RCN, 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, a new project proposal is submitted to the RCN.

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.

3. Summary of deployment plans: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be **returned separately ASAP** to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.

In 2024, we will deploy 5 Argo floats in the Nordic Seas: 2 BGC (6 bgc-var.), 2 BGC (4 bgc-var) and 1 Deep+DO.

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.

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-25 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 2024 and 2025 (if known) and where they might be deployed.

   No RBR-floats will be deployed this year, but we plan to purchase some floats with RBR-sensors in the next order.

Argo-Poland National Report 2023

Małgorzata Merchel, Waldemar Walczowski

IO PAN, Sopot, Poland, 24.01.2024 r.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)

Argo-Poland is carried out by the Institute of Oceanology of the Polish Academy of Sciences (IOPAN). Since 2009 the Institute has deployed forty-one floats. Twenty-three of them were launched in the Nordic Seas from the board of *r/v Oceania* and three in the same region aboard *r/v Horyzont II.* Since November 2016, also aboard *r/v Oceania*, IOPAN has launched fifteen floats in the Baltic Sea.

a. floats deployed and their performance

In 2023 Poland launched 6 floats from the board of Institute of Oceanology Polish Academy of Sciences (IO PAN) vessel *r/v Oceania*. Five floats were deployed under the Argo-Poland program, which is Polish contribution to the Euro-Argo ERIC infrastructure, one float was deployed under the EU MOCCA project.

Two Argo floats (WMO 3902119, 3902118) were deployed in the Nordic Seas at the end of June 2023 at positions 75.00 °N, 08.44 °E and 75.00 °N, 15.42 °E respectively (Figure 1). Both instruments are the NKE manufactured ARVOR floats with Iridium transmission system and ice avoidance algorithms. The parking depth was set at 1000 dbars and the profiling depth at 2000 dbars. The floats have cycles of 10 days. In addition to standard CTD measurements, the floats also have taken measurements of dissolved oxygen. The first float (WMO 3902119) was operated for the whole of 2023 and has sent 19 complete sets of hydrographic data (CTD, O_2) by the end of the year. The second float (WMO 3902118) stopped sending data on October 18. Most likely, the float drifted under the sea ice.

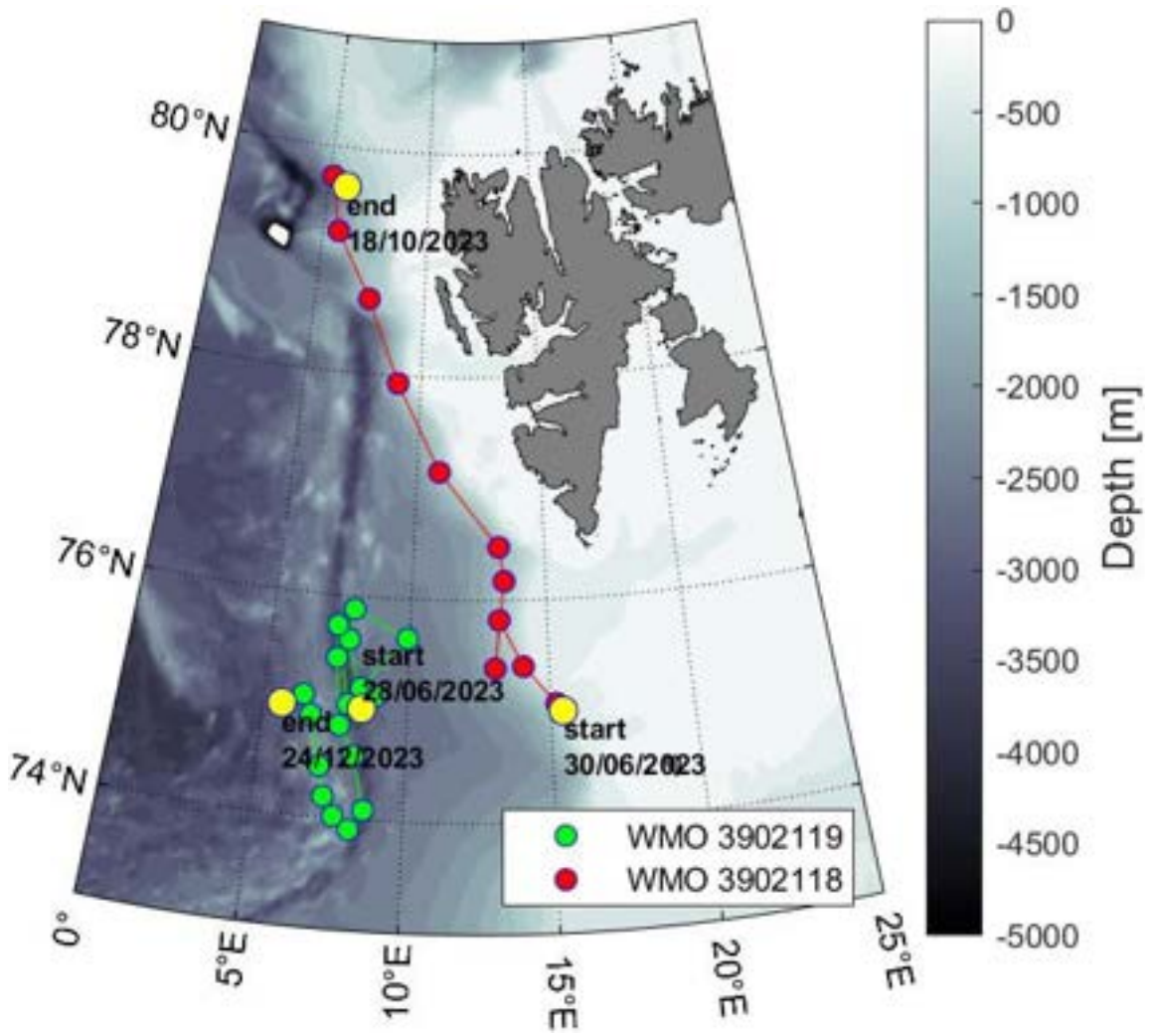


Figure 1. Positions of deployment and trajectories of two Argo floats deployed in the Nordic Seas by Argo-Poland program in June 2023.

Four Argo floats were deployed in the Baltic Sea from the board of *r/v Oceania* in 2023. In February 2023, during a standard hydrodynamic cruise, IO PAN recovered the Argo float (WMO 3902115) from the area of the Slupsk Furrow. After recovering, the float was transported to the Bornholm Basin, assigned a new WMO 3902117 number, and redeployed at position 55.23 °N, 16.04 °E (Figure 2). The float was operated for the whole of 2023 and has sent 280 complete sets of hydrographic data (CTD, O_2) by the end of the year. The second Baltic float (WMO 7901091) was launched in the Gdansk Deep (54.83 °N, 19.33 °E) in May 2023 (Figure 2). The device is the ARVOR type with the Iridium transmission system and performs standard CTD measurements. In 2023 it transmitted 53 complete CTD data sets. The float was deployed under the EU MOCCA project.

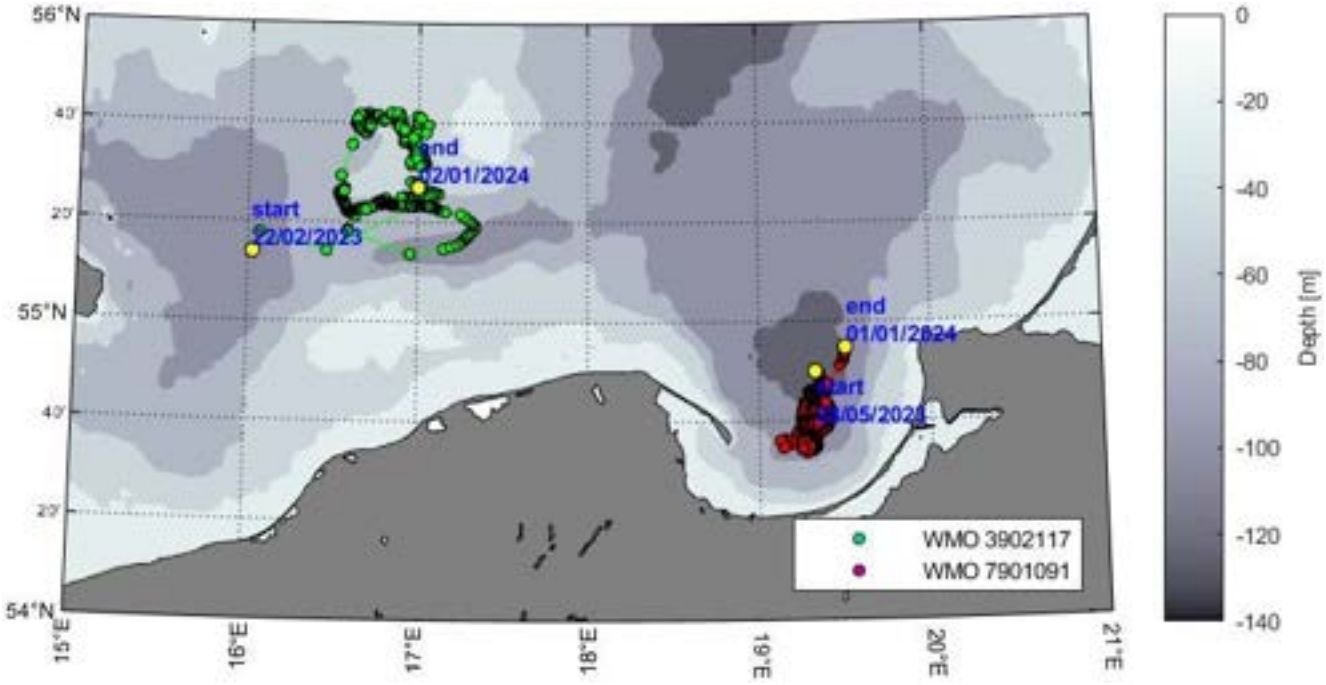


Figure 2. Positions of deployment and trajectories of two Argo floats deployed in the Baltic Sea by Argo-Poland program in February and May 2023.

Two more Baltic floats were launched in September 2023. On September 22, the Argo float (WMO 1902682) was deployed in the Bornholm Deep (55.22 °N, 15.90 °E) (Figure 3). The float is the ARVOR type with an Iridium data transmission system. In addition to standard CTD measurements, the float will also measure dissolved oxygen content in the water. By the end of the year the device has sent 53 complete sets of hydrographic data (CTD, O_2). On September 24, the Argo-Poland consortium deployed Biogeochemical Argo (BGC Argo) (WMO 1902683) for the first time. In addition to standard CTD measurements, our BGC Argo measures four additional seawater properties: dissolved oxygen concentration, chlorophyll-a concentration, irradiance and CDOM. The float was deployed in the Gdansk Deep at the position 54.85 °N, 19.23 °E (Figure 3). The device is the PROVOR type with the Iridium data transmission system. The float was operated for the whole of 2023 and has sent 82 complete sets of BGC data by the end of the year. All four Baltic floats have been working in 1- or 2-day cycles. In all devices, the parking depth has been set deeper than the bottom depth to keep the floats in a limited area and use them as a virtual moorings.

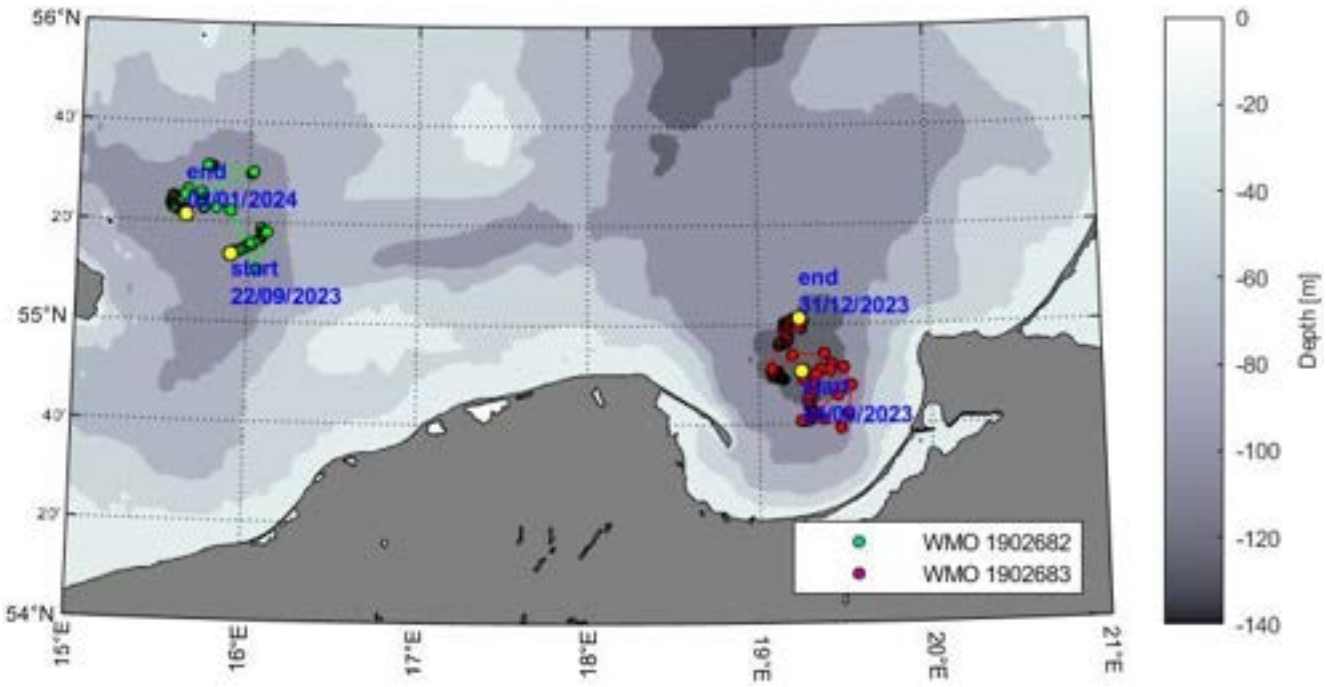


Figure 3. Positions of deployment and trajectories of two Argo floats deployed in the Baltic Sea by Argo-Poland program in September 2023.

b. technical problems encountered and solved

The Arctic and Baltic floats were 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 floats.

c. status of contributions to Argo data management.

Data from the Arctic floats 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

IOPAN has been performing delayed mode quality control (DMQC) on data from Arctic floats deployed since 2018. Argo Poland also actively participates in the creation of DMQC procedures

for data from Argo floats launched in the Baltic Sea. DMQC on the data from Arctic floats deployed before 2018 is performed by BSH (Hamburg, Germany).

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 deploy at least 3 floats per year. Two floats will be deployed in the European Arctic and at least one float in the Baltic Sea.

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 2023 two Polish floats were deployed during IOPAN Arctic cruise AREX, when about 200 CTD profiles have been done. Four floats were launched in the Baltic Sea, during the Baltic cruises. The CTD stations were also performed just before the floats deployment. IOPAN can provide the data from this six stations to compare it with Argo floats.

Rest of the data from the Nordic Seas and the Baltic Sea will be available via IOPAN database. Contact point: Waldemar Walczowski, walczows@iopan.pl.

7. **Argo blibliography**

Merchel M., Walczowski W., Rak D., Wieczorek P., 2024, The use of Argo floats as virtual moorings for monitoring the South Baltic Sea, Oceanologia, in press.

Two other scientific papers using data from Argo floats are in preparation.

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

No problems with floats deployment and recovery.

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

There are plans to buy one RBR float if it has an oxygen sensor.

SAPRI
South African Polar Research Infrastructure

NRF National Research Foundation | SAEON South African Environmental Observation Network

South African National Report - AST25

Southampton, UK, 18-22 March 2024

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2023)

    a. Floats deployed and their performance

    Floats deployed on behalf of the UK, Germany and US teams

    b. Technical problems encountered and solved

    None

    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

    None

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)

    Tamaryn Morris (SAEON) for Core Argo, with interest in WBC expansion for deployments. This is being explored further through the GOOS Co-Design Boundary Current Exemplar Programme. SAPRI is looking to employ a technician to work with Argo floats and gliders, which will include setups and data (metadata) management.

    Sandy Thomalla (CSIR SOCCO) for BGC Argo.

    With the implementation of SAPRI (South African Polar Research Infrastructure), we would be keen to become more involved with the Polar deployment mission of OneArgo.

    Thomas Mtontsi and Tamaryn Morris (SAEON) for Ocean Observing outreach activities, including a South African “Adopt-a-Float” programme.

3. Summary of deployment plans

   SAEON and SAPRI are procuring six Core Argo Floats fitted with RBR CTD sensors and these should arrive ~August 2024. Deployment plans are provisional.

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.

   Research related to Boundary Currents (especially Agulhas Current) using Argo float technology.

   No operational uses at this time.

   No Argo webpage for South Africa at this time.

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-25 plenary, each national program will be asked to mention a single highlight or issue via a very brief oral report.

   No specific issues. We do need to work with a DAC for our incoming six Core Argo floats this year and will discuss at AST-25 which DAC may have capacity to assist us. Ideally we would like to work on our float data ourselves, but we do not yet have that capacity.

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.

   None at this time.

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.

   Core Argo Best Practice - https://repository.oceanbestpractices.org/handle/11329/2387

   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.

   None

   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.

As above - Tamaryn Morris (Core) and Sandy Thomalla (BGC).

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.

   None

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 2024 and 2025 (if known) and where they might be deployed.

   South Africa is procuring six Core Argo floats with RBR CTD sensors. Deployments will be in the South Atlantic, Southern and South Indian Oceans, however exact coordinates have not been decided yet.

Argo-Spain National Report 2023

Lara Díaz-Barroso (SOCIB), Alberto González (IEO-CSIC), 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 2023)

a. floats deployed and their performance

Argo Spain contributed to extending the international Argo network during 2023 deploying floats in the Atlantic Ocean and Mediterranean Sea. These deployment missions were coordinated by the Spanish Institute of Oceanography (IEO-CSIC) and the Balearic Islands Coastal Observing and Forecasting System (SOCIB). The specifications of the deployments by area are shown below.

Atlantic Ocean

Within the framework of the biannual oceanographic cruises RAPROCAN2304 and RAPROCAN2312, together with the collaboration of other IEO-CSIC scientific teams, a total of 6 floats were launched in the Atlantic Ocean by IEO-CSIC (Table 1). All of them were deployed in the Canary basin, except the first BGC-Argo float of Argo Spain, deployed in the Cantabrian Sea mid-year during RADPROF2304 cruise. The remaining 5 floats corresponded to 4 core Argo and 1 Deep Argo.

Western Mediterranean Sea

In November 2023, during the Canales Autumn 2023 oceanographic cruise, Spain launched 2 core Argo floats from the deck of the vessel R/V SOCIB (Table 1). These cruises are part of the SOCIB 'CANALES' endurance line, which aims to further deepen the knowledge of the state and variability of the Balearic Sea, consolidating and further developing scientific research.

WMO	Deployment date	Deployment location	Cruise
4903713	16/04/2023	29°14.772' N, 15°50.508' W	RAPROCAN2304
3902506	02/07/2023	44°19.998' N, 5°40.002' W	RADPROF2304
6990625	12/12/2023	29°9.282' N, 15° 30.258' W	RAPROCAN2312
2903822	14/04/2023	29°10.002' N, 18°10.002' W	RAPROCAN2304
4903712	10/12/2023	29°10.056'N, 18°29.928' W	RAPROCAN2312
2903823	17/04/2023	28°56.472' N, 14°22.542' W	RAPROCAN2304
3902466	07/11/2023	39°15.486' N, 1°58.890' E	Canales Autumn 2023
6990533	08/11/2023	39°00.024' N, 0°44.256' E	Canales Autumn 2023

Table 1, Deployment information related to Spanish deployed floats during 2023. The BGC Argo float was registered as 3902506 and the Deep Argo as 4903712.

Different preset configurations were used before each mission. On the one hand, all Core Argo floats and the BCG float were configured to dive up to 2000 dbar and 1000 dbar of parking depth. On the other hand, the Deep Argo float was set to dive up to 4000 dbar and 1000 dbar of parking depth. All floats worked in cycles of 10 days in the Atlantic Ocean and 5 days in the Mediterranean Sea.

Active Spanish floats in 2023

In summary, 19 Spanish floats have been active during 2023 in the Atlantic Ocean and the Western Mediterranean Sea.

b. technical problems encountered and solved

During 2023, the IEO-CSIC sent to the manufacturer NKE 2 Core Argo floats from previous batches that experienced problems. One of them failed in data transmission in the pre-deployment phase, while the other was stranded on a beach; the sensors needed to be cleaned/checked. A response is still being awaited. Regarding the batch of floats received in 2023, 2 Core Argo floats experienced problems. One of them apparently failed in data transmission in the pre-deployment phase. And the last one did not pass the checklist on land. These 2 floats are planned to be shipped to NKE during 2024 to be repaired.

Although SOCIB initially planned to deploy 3 floats, only 2 were eventually deployed. This decision was made to ensure the deployment scheduled for 2024 by SOCIB in the Mediterranean, as part of their agreement within the Euro-Argo ERIC (Disposición 14622 del BOE núm. 214 de 2022). The adjustment was needed by considerations related to the budget allocated for future purchases by the center.

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 (DMQC) process

Argo-Spain mainly deploys floats in the Atlantic Ocean and the Mediterranean Sea. In terms of DMQC, Argo-Spain, through IEO-CSIC, 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.

In terms of the floats for which Spain is responsible for the DMQC process, 53 out of the 71 Atlantic floats have been processed, including 2 (WMO 6901262 and 6901264) in the year 2023. There are plans to achieve a processing rate of 12 floats per year in the upcoming 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)

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 since then, a total of 108 Argo floats have been deployed. Among these, 71 floats have been deployed in the Atlantic Ocean, and 37 floats have been deployed in the Mediterranean Sea. Additionally, 4 floats have been donated to other countries: 2 floats to Costa Rica, 1 float to Morocco, and 1 float to Mexico.

In 2022, the agreement was renovated between the Ministry of Science and Innovation, IEO-CSIC and SOCIB (Disposición 14622 del BOE núm. 214 de 2022), 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 currently lacks proper long-term funding for the deployment of Argo floats. The contribution to the Euro-Argo ERIC is secured and sustained through membership payments from the Spanish Ministry of Science, Innovation, and Universities, as well as SOCIB. Additionally, the availability of extra funding relies on access to infrastructure calls. Both IEO-CSIC and SOCIB are committed to ensuring deployments of at least 3 floats per year, and its transmission costs. Also, IEO-CSIC funds the scientific coordination (1.5 person/month per year).

At the end of 2021, SOCIB received funding from NextGenerationEU/PRTR to ensure the purchase and deployment of floats in the Mediterranean Sea during the next few years.

The personnel of Argo-Spain during 2023 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 technician working 50% of their time.
- 1 technician working 10% of their time
- 1 PI working 5% of their time

3. **Summary of deployment plans: please see the separate documents explaining the longer term outlook this year as a response to G7 requests. This spreadsheet is to be returned separately ASAP to help prepare for the meeting. It can be sent to Megan or dropped in the folder link containing the instructions.**

This information is included in the European deployment planning statistics for subsequent years, which is located in the "national_dpeloyment_information" folder of the AST25. However, we attach below individually the theoretical contribution of Argo-Spain for the coming years (Table 2).

SPA	2024						
	Total	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
Nordic Seas	0						
Mediterranean Sea	2	1					
Black Sea	0						
Baltic Sea	0						
Southern Ocean	0						
Arctic Ocean	0						
Global Ocean	4	2		1		1	
Total	**5**	3	0	1	0	1	0
SPA	**2025**						
	Total	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
Nordic Seas	0						
Mediterranean Sea	0	3					
Black Sea	0						
Baltic Sea	0						
Southern Ocean	0						
Arctic Ocean	0						
Global Ocean	10	7	1			2	
Total	**13**	10	1	0	0	2	0
SPA	**2026**						
	Total	Core	Core + O	Core + 2-3 BGC	Core + 4-6 BGC	Deep	Deep + O
Nordic Seas	0						
Mediterranean Sea	0	3					
Black Sea	0						
Baltic Sea	0						
Southern Ocean	0						
Arctic Ocean	0						
Global Ocean	10	8	2				
Total	**13**	11	2	0	0	0	0

Table 2, Potential deployments of Spanish floats (float types and corresponding quantities) projected for the coming years as part of Euro-Argo ERIC

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-25 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.

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.

González-Santana, A., Oosterbaan, M., Clavelle, T., Maze, G., Notarstefano, G., Poffa, N., et al. (2023). Analysis of the global shipping traffic for the feasibility of a structural recovery program of Argo floats. *Front. Mar. Sci.* 10, 1161580. doi: 10.3389/fmars.2023.1161580

Olivé Abelló, A., Pelegrí, J. L., and Machín, F. (2023). A Simple Method for Estimating Horizontal Diffusivity. *Journal of Atmospheric and Oceanic Technology* 40, 739–752. doi: 10.1175/JTECH-D-22-0097.1

Jiménez-Rincón, J.A., Cianca, A., Ferrero-Martín, C., Izquierdo, A. (2023) A Glider View of the Spreading and Mixing Processes of Antarctic Intermediate Water in the Northeastern Subtropical Atlantic. *J. Mar. Sci. Eng. 11*, 576. https://doi.org/10.3390/jmse11030576

Olivé Abelló, A. (2023). Transformations and pathways of Southern Ocean waters into the South Atlantic Ocean. **Thesis**: http://hdl.handle.net/2445/204661

Chevillard, C. (2023). Assessment of the ocean state, variability and changes in the northwestern Mediterranean Sea from multi-platform observations in the context of climate change. **Msc Thesis**

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 2024 and 2025 (if known) and where they might be deployed.**

At the moment, this option is not contemplated in the short term.

UK Argo Report for Argo Steering Team meeting (March 2024)

1. One Argo implementation status

a. Floats deployed and their performance

During 2023 we deployed 58 floats; of these 46 were core floats and 12 were BGC floats. No deep floats were deployed.

From 1 January 2024 to 27 February 2024, we deployed a further 11 floats: five core APEX, five core ARVOR (four of the ARVORs were purchased by BAS and have been adopted by UK Argo) and one PROV-BIO (CTS5).

Figure 1 shows UK floats deployed since the start of 2023.

As of 6 March 2024, the UK has 145 operational floats (i.e. for which real-time data have been made available during the previous month), as shown in Figure 2.

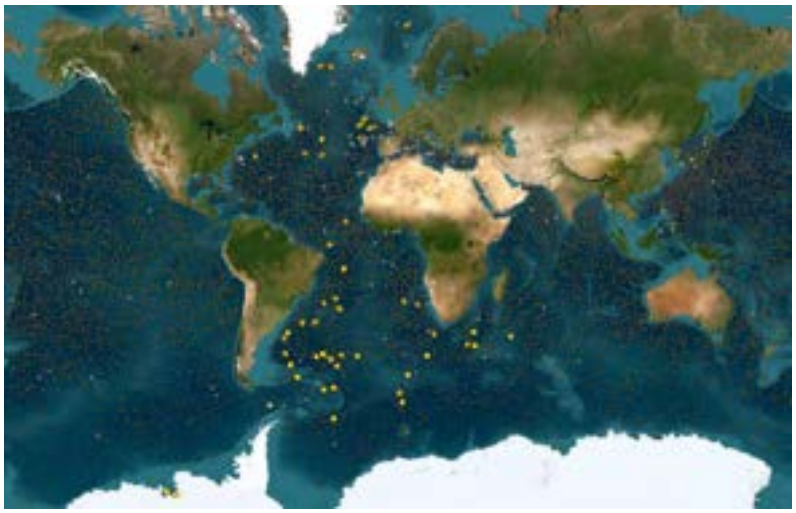


Figure 1. Showing the latest reported locations of the 69 UK Argo floats deployed between 1 January 2023 and 28 February 2023.

The 145 operational floats returning data include:

- 98 core APEX with SBE CTD
- 17 core APEX with RBR CTD
- 7 core ARVOR with SBE CTD
- 1 core NAVIS
- 2 NAVIS with oxygen
- 3 NAVIS BGCi
- 11 6-parameter PROV-BIO CTS4
- 2 5-parameter PROV-BIO CTS5
- 4 APEX DEEP

In addition, we have one float that is active, but the real time data processing is not fully set up:

- Deep SOLO float in the South Atlantic, Argentine Basin (WMO ID 2903791)

Figure 2. Showing the locations of all 145 UK floats delivering data in yellow as of 6 March 2024.

b. Technical problems encountered and solved

Float failures

Of the 56 standard core floats deployed between 1 January 2023 and end February 2024 we have had 2 float failures:

- Core APEX-RBR 9622 (1902098) deployed in Drake Passage in March 2023 transmitted near empty science files that did not contain any profile data.
- Core APEX-RBR 9626 (1902093), deployed in Drake Passage in February 2023 has been inactive since 09/03/23 having performed 4 cycles. It is assumed to have died.

Also, ARVOR 22UK006 (6990631) that was deployed in January 2024 appears to be stuck in 'end of life' mode and we have not yet been able to put that float into mission mode.

During the period we also deployed 12 BGC floats, comprising nine 6-parameter CTS4 PROV-BIO, two 5-parameter CTS5 PROV-BIO and one 4-parameter NAVIS BGCi. Of these the following have failed:

- CTS4 deployed in Florida Straits failed to surface (WMO 6990515)
- CTS4 near Portugal stuck at surface (WMO 3901579)
- CTS5 (WMO 6990516) deployed during PICCOLO cruise in Weddell Sea during February 2023 is assumed to have failed, the last profile received in March 2023.

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, nine are no longer operating (as at 6 March 2024). Of the surviving seven, three are on the grey list for PSAL drift, and five are mostly passing real time QC with flags of 1. We had five undeployed APEX floats that were at risk of the fast salty drift problem, these have since been returned after repair but have not yet been deployed. We have also received two free CTDs under SeaBird's ASD warranty, which have been offset against our recent order with Teledyne Webb.

For some time, we've noticed that some 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. At least 22 recently deployed APF11i floats are regularly affected, a significant increase since our report in March 2023, when this number was 12. This appears to be an ongoing problem with Apex core floats. The table below shows Apex serial number, WMO ID and deployment date of the affected floats.

SN	WMO	Deployed
8571	1901920	18/01/2020
8572	1901921	19/01/2020
8977	3901563	03/01/2021
8979	3901568	19/05/2022
8980	1902094	22/02/2023
8981	1901924	08/10/2020
8982	1901933	08/10/2020
8983	3901573	13/12/2022
8985	6903726	21/10/2020
8988	3901569	19/05/2022
9007	1901928	21/02/2021
9189	6904180	03/03/2022
9196	6903761	14/10/2021
9197	1901934	06/12/2021
9198	1901935	07/12/2021
9199	3901570	20/05/2022
9200	3901571	21/05/2022
9201	1902081	17/05/2022
9203	1901936	13/02/2022
9204	1901937	13/02/2022

9205	1901938	14/02/2022
9469	5906967	28/03/2023

It has been noticed that there has been a new aerial design on APF11i floats, and that some APEX-deploying groups have found a 'sticky bladder' problem, resulting in insufficient buoyancy to obtain a surfacing GPS fix. We asked CLS whether they can provide a separate 'Iridium fix' position that we could use instead, but they are unable to do so for RUDICs floats. Unfortunately, all the affected floats use RUDICs communications. CLS proposed a solution, involving adding an Argos back up system to the float (a small Linkit device) but this does not help where floats are already deployed.

APEX floats with RBR CTD

We procured our first six APEX-RBR floats in 2015 and since then have deployed 26 APEX-RBR, 15 of these in 2023 and 2024. As of 6 March 2024, there are 17 APEX-RBR delivering data to the GDACs and GTS. One of the APEX-RBR deployed in 2023 failed to report any profiles: APEX-RBR 9622 (1902098) transmitted nearly empty science files that did not contain any profile data.

We presently have 13 APEX-RBR floats in stores with some of them scheduled for deployment later in 2024.

APEX Deep

We presently have five deep floats operating in the Argentine Basin region of the SW Atlantic, comprising three APEX Deep deployed in 2021, one APEX Deep deployed in 2020 and one Deep SOLO, deployed in December 2022.

Data processing for our Deep SOLO has recently been set up at BODC, with some data now available at the GDAC and on the GTS. Full automation of this processing will be completed soon. There are no firm plans to buy more deep floats at present. However, we aspire to buy and deploy 15 deep floats (without oxygen sensors) between 2026 and 2030.

Bio-geochemical Argo

We presently have 13 active BGC floats. Real-time data processing is fully set up for all BGC float types.

The Navis BGCi (F0660, 6903751) that was deployed in November 2020 near the Porcupine Abyssal Plain (PAP) mooring appears to be working well. However, the NAVIS BGCi F1241 (6903756) deployed near PAP in April 2021 failed to report, despite SeaBird engineers clearing the float for deployment. An identical Navis BGCi float (F1242, 4903670) was deployed near PAP in May 2022 but was recovered as the nitrate sensor was not working and redeployed in May 2023 during the May 2023 cruise. Two other Navis BGCi floats were deployed in July 2022, both working normally, for which the data processing has recently been set up (F1101, 6904191; F1102, 6904192).

We have now deployed 13 ASBAN six-parameter CTS4 floats (9 in 2023). Two of the floats have failed post deployment: one is drifting at the surface after repeatedly aborting its descents; another, deployed

in shallow water in the Florida Straits, failed to surface. An additional float failed checkout prior to deployment due to a sim card connection issue, and has now been repaired. We have two remaining ASBAN CTS4 floats in stock and, in March 2024, received a delivery of 11 additional ASBAN CTS5 6-parameter floats. The ASBAN floats are all performing well so far, except for the pH sensors, which have had a high failure rate. As part of the NERC-funded PICCOLO project, we attempted to deploy two PROV-BIO Jumbo CTS5 floats in the Weddell Sea in February 2023. One failed whilst still on deck and was returned to the UK and later repaired by NKE. It was subsequently deployed in February 2024 and is operating well.

c. Status of contributions to Argo data management

BODC has enabled several software developments this year to allow for the data delivery of recent core Arvor, Provor CTS5 and the core data from BGC Navis floats. BODC also delivers real-time data for 50 remaining MOCCA floats. Several RTQC test updates have been implemented.

BODC endeavors to address any QC changes needs identified by the Objective Analysis reports and Altimetry QC issued by Ifremer and OceanOps on a regular basis and made updates to the meta files following reports from the GDAC file checker. Additionally, BODC is undertaking visual inspection of the core Argo parameters from core, deep and BGC float types of all profiles which then undergo further DMQC analysis.

BODC actively contributed to activities related to the Abrupt Salty Drift (ASD) group, focusing on estimating the best practices, guidance and examples on how to treat salinity data that are affected by sensor drift to produce optimal adjustment in d-mode. This involved actively contributing to updating the shared list of floats affected by the salty drift and reviewing best practices and procedures for DMQC operators of core Argo floats.

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 and any additional corrections have been completed and re-submitted to the GDACs.

The strategy adopted to deliver the support to national programs focused on ensuring a high-quality approach and the progressive enhancement of expertise. This supports OGS in implementing the DMQC-PCM software, contribution to the working groups.

d. Status of delayed mode QC process

Core Argo

From March 2023 to March 2024 BODC Argo submitted to GDAC 28 core Argo floats with ~6230 core profiles in D-mode. This includes 8 Argo floats (with ~380 new D-mode profiles) DMQC-ed and received from the external European partner - BSH.

BGC Argo

BODC has adopted the procedures and SAGE_O2Argo software for estimates of the Gain of the DOXY parameters of Argo floats. Additionally, we also implemented the procedures from https://github.com/catsch/DM_FILLER allowing applying corrections in D-mode BGC floats, generation and population of the D-mode NetCDF files.

The BODC Argo team has greatly expanded their knowledge of the QC analysis of BGC Argo floats. Through the updates of the Coriolis processing chains in BODC, we have started delivery of automatic RTQC adjustments of Chlorophyll A, Nitrate and BBP to the UK active PROVOR floats. Additionally, BODC is regularly providing the RTQC adjustments to DOXY for UK active PROVOR floats.

From March 2023 to March 2024 BODC Argo undertake the DMQC analysis of 2 Argo BGC floats with ~249 profiles of DOXY parameter and submitted to GDAC. The DMQC analysis for DOXY and Nitrate BGC Argo floats for Argo PROVOR is planned to be undertaken in March 2023.

2. Funding levels

The UK Argo programme is undertaken through a partnership between the Met Office (which is an Executive Agency owned by the Department for Science, Innovation and Technology, DSIT) and the National Oceanography Centre (NOC, which includes BODC, is an independent self-governing organisation). The Met Office are responsible for programme management and coordination, procurement 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.

Met Office

Argo funding to the Met Office is mainly provided from the Department for Energy Security and Net Zero (DESNZ) through the Hadley Centre Climate Programme (HCCP), but with an additional contribution from the Department for Science, Innovation and Technology (DSIT) through the Public Weather Service Programme. The HCCP workplan and funding for 2021 to 2024, which was 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 FY2023 this funding was supplemented by some additional end-of-year monies sufficient to order 19 floats (11 APEX-RBR-L3, four APEX-SBE and four NKE ARVOR-SBE). We had originally intended to procure more ARVOR but a delay in providing the order to NKE meant this had to

be reduced due to delivery constraints. The regular Argo budget for FY2024 is expected to remain level and should allow for a similar number of floats to be procured as we would expect to procure mainly ARVORs.

NOC

NOC funding for Argo is primarily from NERC (Natural Environment Research Council) under National Capability (NC) lines which cover Argo data management (through NC Environmental Data Services funding) and Argo science. Core BODC Argo national capability funding from NERC remains static for 2022-23 and is therefore decreasing in real terms. The current level of funding cannot cover all the increasing, mandatory demands for One Argo.

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 was placed during 2023, with delivery in early March 2024. BODC secured funding to develop the data infrastructure for NKE BGC floats (ASBAN-UK). The ASBAN funding finishes on 31/03/24, with no further BGC funding in the pipeline at present. 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.

BODC was funded under the EU H2020 project ENVRI-FAIR to introduce the NVS vocabulary server to support Argo vocabulary management. The ENVRI-FAIR funding was available until June 2023.

The UK Argo contributed to the Euro Argo One proposal which will be submitted in March 2024. The Euro Aro One funding will allows to UK Argo to contribute to developing more automatic and modular software for real-time processing of Argo system and improve the FAIRness of Argo (meta) data workflows and system. This project will allow to enhance and deploy in BODC the QC procedures for trajectory files and deep Argo data not available before in BODC and increase the availability of high-quality Argo data in high latitudes by implementing software to improve data quality control. Moreover, this project will improve the Argo structuration by helping BODC to maintain the existing Argo data stream tools and software at the open-source platform, improve organisation and coordination of BGC DMQC and update UK Argo national programme website. For the first time, BODC Argo will be able to much broader contribute to Argo outreach in the local UK schools and share the knowledge about the significance of OneArgo program for the study of the global ocean and its role in the climate system.

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 2023 are given below.

Met Office – 0.93 FTE (calendar year 2023)
Jon Turton, Fiona Carse, John Hankins

NOC, Southampton – 0.7 FTE (March 2023 - March 2024)
Brian King, Nathan Briggs, Darren Rayner

NOC, BODC – 1.5 FTE (March 2023 – March 2024)
Emma Gardner, Kamila Walicka, Clare Bellingham, Katy Baldwin, Roseanna Wright and Violetta Paba.

The BODC development team also provides support.

3. Deployment plans

The Met Office aims to buy and deploy around 25 core floats per year, based on our sustained but flat government funding. For BGC and deep floats, the amounts of floats bought and deployed remain dependent on project-based research funding. We have submitted the spreadsheet showing expected deployments out to 2030, as requested.

As noted earlier, as of 28th February 2023, UK Argo has deployed 11 floats during 2024: five core APEX, five core Arvor, and one Prov-Bio (CTS5).

We aim to deploy a total of 22-26 core and five BGC floats later in 2024 and in early 2025, including:

Core floats

NE Atlantic, DY174 Discovery RAPID East mooring cruise, April 2024:
    2 core APEX-SBE
European Shelf / NE Atlantic, JC264 James Cook Met Buoy Servicing cruise, June 2024:
    2 core Arvor-SBE *[set to rapid cycling]*
North Atlantic Ellett Line ~ 60 N, DY181 Discovery, June 2024:
    2 core APEX-SBE
NW Atlantic near Iceland/Greenland, DY183 Discovery passage leg, August 2024:
    0 - 2 core APEX-SBE
Atlantic at 20 S, AMT[1], JC272 James Cook, November 2024:
    2 core APEX-SBE
Brazil Basin, JC273 James Cook, December 2024:

[1]It is not yet clear if the 2024 AMT will be a science cruise or a passage leg

2 core APEX-SBE
Atlantic at 20 N, DY189 Discovery passage leg (Guadeloupe to Greece), February 2025:
2 core Arvor-RBR
Atlantic at 25 S, JC275 James Cook, February 2025:
2 core APEX-RBR-L3
SW Atlantic, Argentine Basin, Sir David Attenborough, November 2024:
2 core APEX-SBE
2 core APEX-RBR
Southern Ocean / Drake Passage, Sir David Attenborough, December 2024:
4 core APEX-SBE

In addition, we aim to send 4-6 core floats to Tammy Morris in Cape Town, if she has suitable opportunities.

BGC floats

North Atlantic, Iceland Basin, Discovery BIO-Carbon spring cruise, June 2024
1 ProvBio CTS4 six-parameter (ASBAN, NOC floats)
North Atlantic, PAP cruise, James Cook, May 2024:
1 ProvBio CTS4 six-parameter (ASBAN, NOC floats)
North Atlantic, Iceland Basin, Discovery BIO-Carbon autumn cruise, Sept 2024
1 ProvBio CTS5 six-parameter (ASBAN, NOC floats)
Labrador Sea, REBELS cruise, James Cook, August 2024
1 ProvBio CTS5 six-parameter (ASBAN, NOC floats)
Atlantic Ocean (unspecified region and cruise)
1 ProvBio CTS5 six-parameter (ASBAN, NOC floats).

In addition, five ASBAN six-parameter PROVOR BGC floats will be deployed during 2025, and a further three during 2026. All will be deployed in the Atlantic, exact locations are not yet decided.

4. National research and operational uses of Argo data

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).
- Data product produced using Argo data: At NOC we produce a 4-D global map of Argo T and S data at 2 degree lat and long resolution from 60S to 60N. The data are gridded in 10-day windows using objective mapping on sigma-1 or neutral density levels and then interpolated back to 20 dbar vertical resolution. This is generally updated towards the end of each calendar year. A time series of global heat content is calculated and reduced to annual averages and then incorporated into the synthesis of global heat content calculations led by K von Schuckmann. The full 4-D gridded fields can be made available by contacting Brian King at NOC.

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.
- GLOBESINK and BIO-CARBON: A two-year NOC-led project called GLOBESINK started in August 2022 to generate a global dataset of particle size and downward particulate organic carbon flux from BGC Argo measurements of optical backscattering. This dataset contributes to the wider NERC BIO-CARBON programme, which aims to improve our ability to predict changes in biological carbon update by the oceans. One output of the project will be a publicly available particle dataset using BGC Argo data through 2022 (to be delivered in 2024). NOC aims to maintain this product in the future through single center NERC bid AtlantiS. New BIO-CARBON projects PARTITRICS and IDAPro, led by NOC and University of Southampton, will deploy two UK BGC Argo floats and fund their data delivery and QC, and also deploy three French BGC Argo floats. The float data will be used for estimates of primary production, net community production, and downward POC flux as part of 2024 BIO-CARBON fieldwork.
- PhD studentships: Currently, three NOC-led PhD projects have a large component utilizing BGC Argo data. One focuses on net community production in the Weddell Gyre, another is exploring methods to optimally interpolate subsurface chlorophyll data, and a third is looking into the drivers of variability in the remineralization depth of sinking organic carbon in the ocean. A fourth NOC-based project led by the University of Southampton will develop methods to QC and correct pH data from BGC Argo.

By 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, and into the 1.5 km high-resolution North-west European Shelf Seas model (AMM15).
- Since June 2022 the Met Office has run a global coupled ocean-atmosphere NWP (numerical weather prediction) model that assimilates ocean temperature and salinity profiles. The high-resolution UK area atmospheric NWP model takes time-varying sea surface temperature fields from AMM15. Hence the temperature and salinity profile data impacts both weather forecasts and short-range ocean forecasts.
- 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).

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 Ocean Heat Content (OHC) analysis, contributions to BAMS, Ocean Obs'19 White Paper, an Earth Energy Imbalance paper (von Schuckmann et al., 2020), and an Indicators of Global Climate Change paper (Forster et al., 2023).

References are listed in section 7. Pre-2023 references are listed in the Argo bibliography in the UK's report to AST#24.

5. Issues for AST for consider

The core Argo Best Practices document [link at https://argo.ucsd.edu/float-deployment-best-practices/] recommends an ascent rate of 20 cm/s (0.2 dbar/s) for floats with the RBR sensor. This has been questioned by Teledyne Webb who consulted RBR who responded that they do not believe this should be the recommendation and will be asking to have the document revised. Based on their discussion with RBR they (Teledyne Webb) recommend the default ascent rate of 0.08 dbar/s for APEX-RBR floats. We would like AST clarification on this. We can also ask RBR during their session on Thursday 21st March.

Reference CTD data – with increasing international coordination, how do (should) deployment CTDs reach the national DM operator of the float owner (mostly relevant for core floats).

Sticky Apex bladders… has there been any progress or new advice to Apex float deployers. Perhaps this a question for Tech Workshop in Sepember?

6. 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.

7. 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#24 (in March 2023).

Included below is a list of 25 papers published since 1st January 2023, with at least one author based at a UK institution. The search was carried out using Web Of Science, using keyword "Argo" and refining by country (England, Scotland, Wales, Northern Ireland). Note there are 25 papers 2023 and none yet in 2024. PhD theses are not included in this list.

Coggins, A; Watson, AJ; Schuster, U; Mackay, N; King, B; McDonagh, E; Poulton, AJ
Surface ocean carbon budget in the 2017 South Georgia diatom bloom: Observations and validation of profiling biogeochemical argo floats

DEEP-SEA RESEARCH PART II-TOPICAL STUDIES IN OCEANOGRAPHY, 209, doi: 10.1016/j.dsr2.2023.105275

Cox, I; Brewin, RJW; Dall'Olmo, G; Sheen, K; Sathyendranath, S; Rasse, R; Ulloa, O
Distinct habitat and biogeochemical properties of low-oxygen-adapted tropical oceanic phytoplankton
LIMNOLOGY AND OCEANOGRAPHY, 68, 9, doi: 10.1002/lno.12404

Forster, P. M., Smith, C. J., Walsh, T., Lamb, W. F., Lamboll, R., Hauser, M., Ribes, A., Rosen, D., Gillett, N., Palmer, M. D., Rogelj, J., von Schuckmann, K., Seneviratne, S. I., Trewin, B., Zhang, X., Allen, M., Andrew, R., Birt, A., Borger, A., Boyer, T., Broersma, J. A., Cheng, L., Dentener, F., Friedlingstein, P., Gutiérrez, J. M., Gütschow, J., Hall, B., Ishii, M., Jenkins, S., Lan, X., Lee, J.-Y., Morice, C., Kadow, C., Kennedy, J., Killick, R., Minx, J. C., Naik, V., Peters, G. P., Pirani, A., Pongratz, J., Schleussner, C.-F., Szopa, S., Thorne, P., Rohde, R., Rojas Corradi, M., Schumacher, D., Vose, R., Zickfeld, K., Masson-Delmotte, V., and Zhai, P. (2023)
Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence
Earth Syst. Sci. Data, 15, 2295–2327, https://doi.org/10.5194/essd-15-2295-2023, 2023.

Fu, Y; Lozier, MS; Biló, TC; Bower, AS; Cunningham, SA; Cyr, F; de Jong, MF; deYoung, B; Drysdale, L; Fraser, N; Fried, N; Furey, HH; Han, GQ; Handmann, P; Holliday, NP; Holte, J; Inall, ME; Johns, WE; Jones, S; Karstensen, J; Li, FL; Pacini, A; Pickart, RS; Rayner, D; Straneo, F; Yashayaev, I
Seasonality of the Meridional Overturning Circulation in the subpolar North Atlantic
COMMUNICATIONS EARTH & ENVIRONMENT, 4, 1, doi: 10.1038/s43247-023-00848-9

Ghosh, R; Putrasahan, D; Manzini, E; Lohmann, K; Keil, P; Hand, R; Bader, J; Matei, D; Jungclaus, JH
Two Distinct Phases of North Atlantic Eastern Subpolar Gyre and Warming Hole Evolution under Global Warming
JOURNAL OF CLIMATE, 36, 6, doi: 10.1175/JCLI-D-22-0222.1

Good, S; Mills, B; Boyer, T; Bringas, F; Castelao, G; Cowley, R; Goni, G; Gouretski, V; Domingues, CM
Benchmarking of automatic quality control checks for ocean temperature profiles and recommendations for optimal sets
FRONTIERS IN MARINE SCIENCE, 9, doi: 10.3389/fmars.2022.1075510

Henson, S; Bisson, K; Hammond, ML; Martin, A; Mouw, C; Yool, A
Effect of sampling bias on global estimates of ocean carbon export
ENVIRONMENTAL RESEARCH LETTERS, 19, 2, doi: 10.1088/1748-9326/ad1e7f

Johnson, ER; Crowe, MN
Oceanic dipoles in a surface quasi-geostrophic model
JOURNAL OF FLUID MECHANICS, 958, doi: 10.1017/jfm.2023.87

Johnson, GC; King, BA
Zapiola Gyre, Velocities and Mixing, New Argo Insights
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, 128, 6, doi: 10.1029/2023JC019893

Jones, SC; Fraser, NJ; Cunningham, SA; Fox, AD; Inall, ME
Observation-based estimates of volume, heat, and freshwater exchanges between the subpolar North Atlantic interior, its boundary currents, and the atmosphere
OCEAN SCIENCE, 19, 1, doi: 10.5194/os-19-169-2023

Lacour, L; Llort, J; Briggs, N; Strutton, PG; Boyd, PW
Seasonality of downward carbon export in the Pacific Southern Ocean revealed by multi-year robotic observations
NATURE COMMUNICATIONS, 14, 1, doi: 10.1038/s41467-023-36954-7

Momin, IM; Mitra, AK; Waters, J; Martin, MJ; Lea, D; Bhatla, R
Evaluation of global ocean analysis and forecast system in the Tropical Indian Ocean
JOURNAL OF EARTH SYSTEM SCIENCE, 132, 3, doi: 10.1007/s12040-023-02118-w

Ni, QB; Zhai, XM; LaCasce, JH; Chen, DK; Marshall, DP
Full-Depth Eddy Kinetic Energy in the Global Ocean Estimated From Altimeter and Argo Observations
GEOPHYSICAL RESEARCH LETTERS, 50, 15, doi: 10.1029/2023GL103114

Ni, QB; Zhai, XM; Yang, ZB; Chen, DK
Generation of Cold Anticyclonic Eddies and Warm Cyclonic Eddies in the Tropical Oceans
JOURNAL OF PHYSICAL OCEANOGRAPHY, 53, 6, doi: 10.1175/JPO-D-22-0197.1

Orúe-Echevarría, D; Polzin, KL; Garabato, ANC; Forryan, A; Pelegrí, JL
Mixing and Overturning Across the Brazil-Malvinas Confluence
JOURNAL OF GEOPHYSICAL RESEARCH-OCEANS, 128, 5, doi: 10.1029/2022JC018730

Quartly, GD; Aiken, J; Brewin, RJW; Yool, A
The link between surface and sub-surface chlorophyll-a in the centre of the Atlantic subtropical gyres: a comparison of observations and models
FRONTIERS IN MARINE SCIENCE, 10, doi: 10.3389/fmars.2023.1197753

Renfrew, IA; Huang, J; Semper, S; Barrell, C; Terpstra, A; Pickart, RS; Vage, K; Elvidge, AD; Spengler, T; Strehl, AM; Weiss, A
Coupled atmosphere-ocean observations of a cold-air outbreak and its impact on the Iceland Sea
QUARTERLY JOURNAL OF THE ROYAL METEOROLOGICAL SOCIETY, 149, 751, doi: 10.1002/qj.4418

Romero, E; Tenorio-Fernandez, L; Portela, E; Montes-Aréchiga, J; Sánchez-Velasco, L
Improving the thermocline calculation over the global ocean

OCEAN SCIENCE, 19, 3, doi: 10.5194/os-19-887-2023

Ryan-Keogh, TJ; Thomalla, SJ; Monteiro, PMS; Tagliabue, A
Multidecadal trend of increasing iron stress in Southern Ocean phytoplankton
SCIENCE, 379, 6634, doi: 10.1126/science.abl5237

Serra-Pompei, C; Hickman, A; Britten, GL; Dutkiewicz, S
Assessing the Potential of Backscattering as a Proxy for Phytoplankton Carbon Biomass
GLOBAL BIOGEOCHEMICAL CYCLES, 37, 6, doi: 10.1029/2022GB007556

Terrats, L; Claustre, H; Briggs, N; Poteau, A; Briat, B; Lacour, L; Ricour, F; Mangin, A; Neukermans, G.
BioGeoChemical-Argo Floats Reveal Stark Latitudinal Gradient in the Southern Ocean Deep Carbon Flux Driven by Phytoplankton Community Composition
GLOBAL BIOGEOCHEMICAL CYCLES, 37, 11, doi: 10.1029/2022GB007624

Turner, KE; Smith, DM; Katavouta, A; Williams, RG
Reconstructing ocean carbon storage with CMIP6 Earth system models and synthetic Argo observations
BIOGEOSCIENCES, 20, 8, doi: 10.5194/bg-20-1671-2023

Wang, A; Huang, BX; Yang, J; Chen, G; Radenkovic, M
SCMNet: Toward Subsurface Chlorophyll Maxima Prediction Using Embeddings and Bi-GRU Network
IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS AND REMOTE SENSING, 16, doi: 10.1109/JSTARS.2023.3325922

Xu, WL; Wang, GF; Cheng, XH; Xing, XG; Qin, JH; Zhou, GD; Jiang, L; Chen, BZ
Mesoscale Eddy Modulation of Subsurface Chlorophyll Maximum Layers in the South China Sea
JOURNAL OF GEOPHYSICAL RESEARCH-BIOGEOSCIENCES, 128, 11, doi: 10.1029/2023JG007648

Zilberman, NV; Thierry, V; King, B; Alford, M; André, X; Balem, K; Briggs, N; Chen, ZH; Cabanes, C; Coppola, L; Dall'Olmo, G; Desbruyéres, D; Fernandez, D; Foppert, A; Gardner, W; Gasparin, F; Hally, B; Hosoda, S; Johnson, GC; Kobayashi, T; Le Boyer, A; Llovel, W; Oke, P; Purkey, S; Remy, E; Roemmich, D; Scanderbeg, M; Sutton, P; Walicka, K; Wallace, L; van Wijk, EM
Observing the full ocean volume using Deep Argo floats
FRONTIERS IN MARINE SCIENCE, 10, doi: 10.3389/fmars.2023.1287867

8. COVID-19 impacts

Nothing to report.

As for the year 2022, impacts of COVID-19 have no discernable effects on UK deployments or data processing activities during 2023. 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 unfavorable USD / GBP exchange rate. We assume the former affects all national programmes.

9. RBR deployment plans

The Met Office received delivery of eleven APEX-RBR-L3 floats from Teledyne Webb in early March 2024 and expects to receive four Arvor-RBR-L3 floats from NKE before the end of March 2024. Many of these floats will be deployed during 2024. Our current plans for deploying core floats with RBR CTDs are detailed in section 3, above. We do not yet have deployment plans beyond February 2025.

U.S. Argo National Report to AST-25, 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:

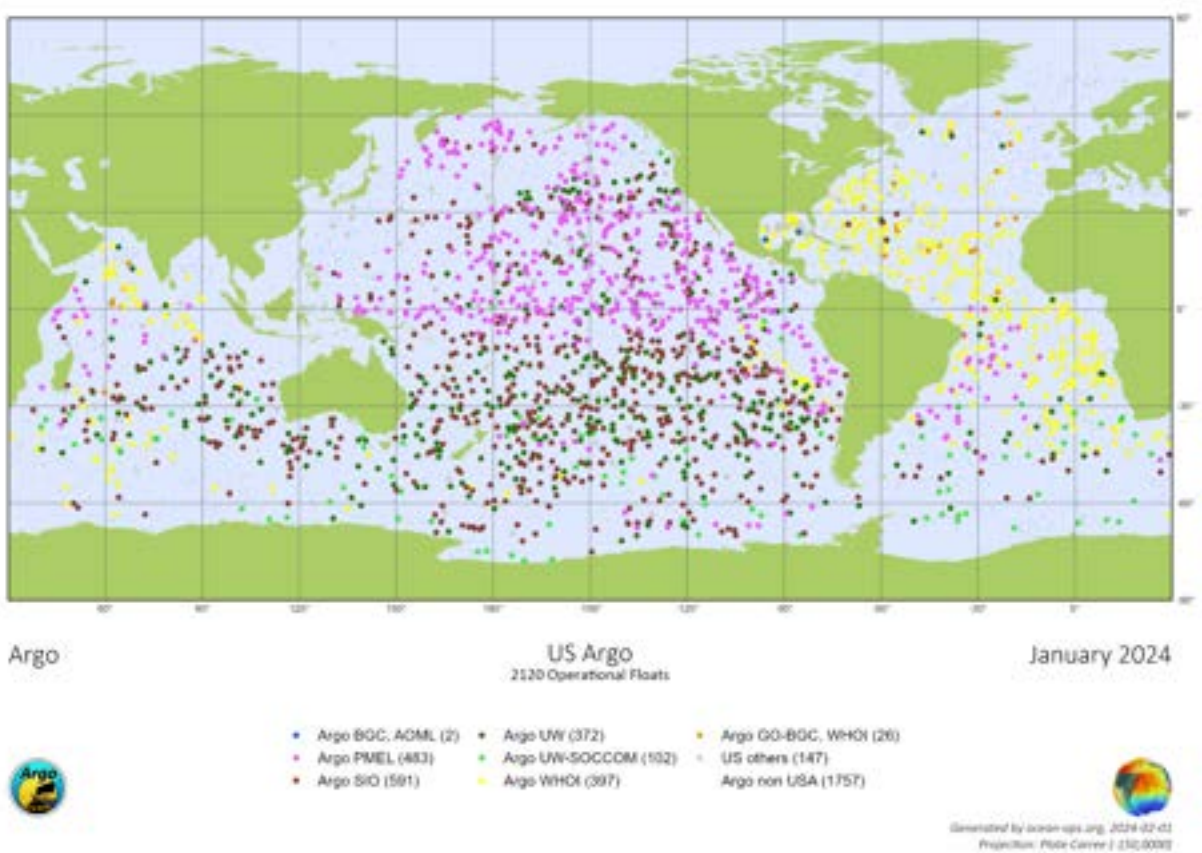


Fig. 1*: Location of operational U.S. Argo Program, SOCCOM, GO-BGC, and other U.S. Argo equivalent floats as of January 2024 (Source: OceanOPS).*

As of January 2024, there were 2120 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 U.S. Core Argo floats have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have nearly been offset by increases in float lifetimes, with over 73% of floats deployed in 2017 still operational as of February 2024, and higher percentages for more recent deployments (Table 1). Hence the number of operational U.S. Argo floats, which peaked at around 2200 in 2016 and 2017, has decreased gradually to the January 2024 count of 2120.

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.

Year deployed	Number deployed	Number operational (3/2024)	% operational (3/2024)
2014	366	6	2%
2015	335	77	23%
2016	315	157	50%
2017	331	242	73%
2018	255	206	80%
2019	259	200	77%
2020	256	208	81%
2021	259	207	80%
2022	234	211	90%
2023	177	168	95%

Table 1: *Number of U.S. Core Argo floats deployed in each year from 2014 through 2023 and the number still operational as of March 2024 (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, sea freight delays, and inflation. Nonetheless, the relatively long life of Argo floats mitigated the Covid-19 reduction in activities, as evidenced by the small decline in numbers of operational US Argo floats over the past several years.

While there were only 177 US Argo Program Core Argo floats deployed during 2023 (Table 1), well below the totals of the previous few years, US Argo deployed a substantial number of Deep and BGC floats through NOAA and NSF funding. Including all missions there were 304 US Argo floats deployed in 2024 that were operational as of February 2024 (Fig. 2).

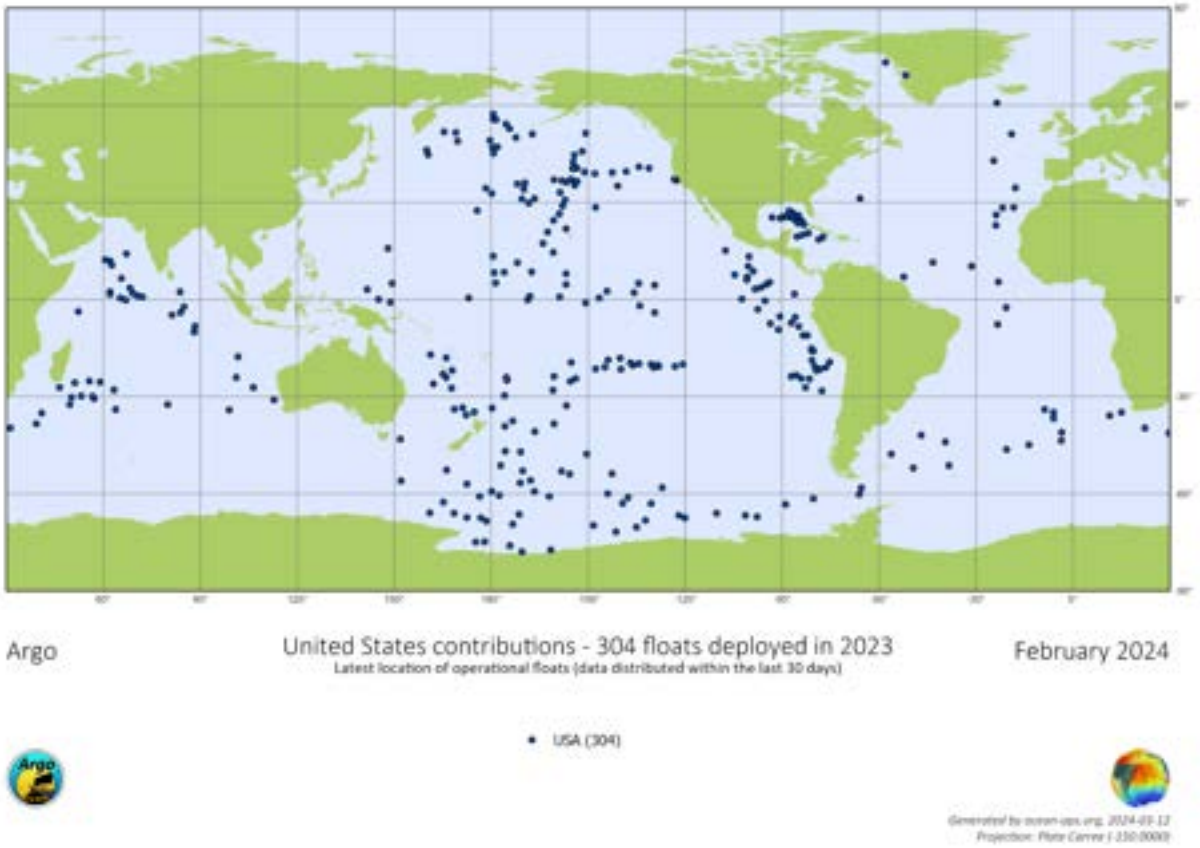


Fig. 2: *Locations of US Argo floats deployed during 2023 and still operational as of February 2024 (Source: OceanOPS).*

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:

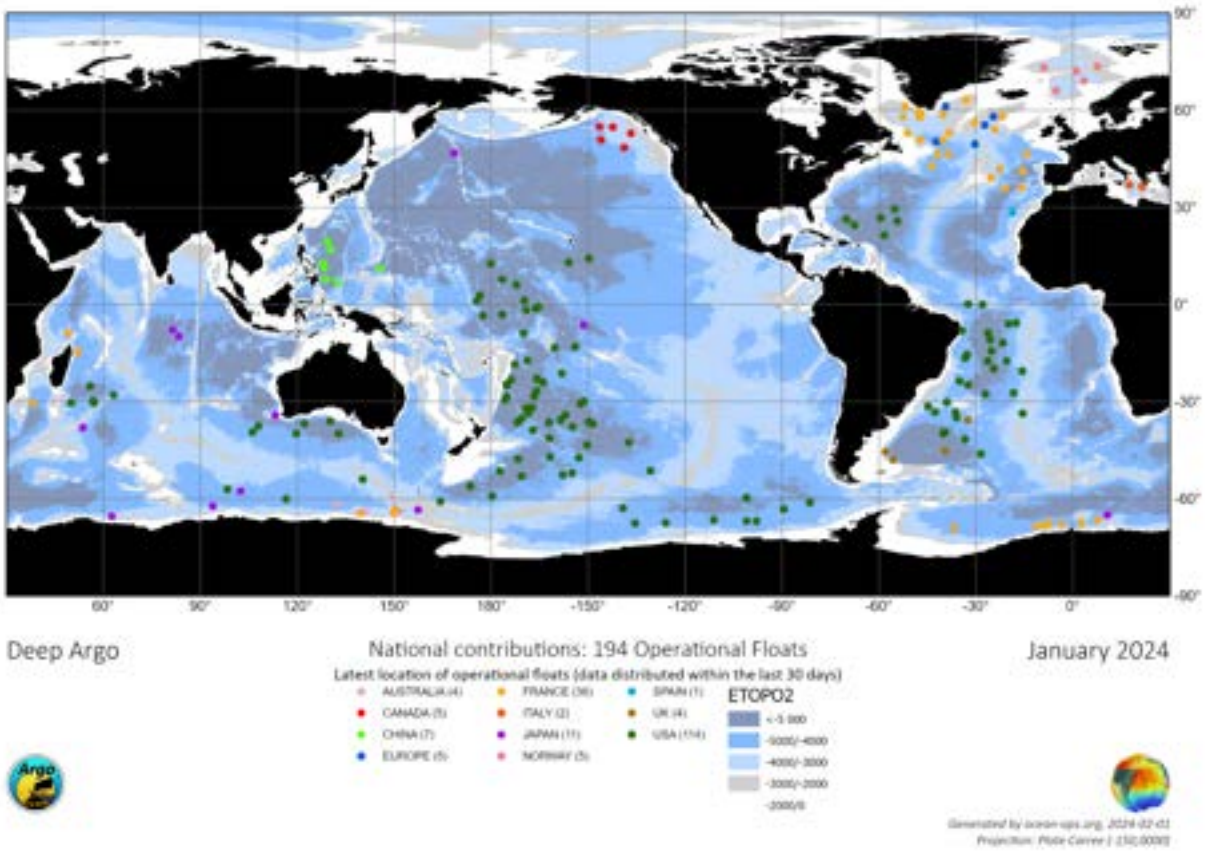


Fig. 3*: Location of all 194 operational Deep Argo floats, as of January 2024, by National Program, with the 114 operational U.S. Deep Argo floats indicated by dark green filled circles (Source: OceanOPS).*

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 2016, in the western North Atlantic in 2017, in the Australian Antarctic Basin in 2018, in the western South Atlantic in 2019, in the SE Pacific Sector of the Southern Ocean and western Indian Ocean in 2023, with operational US Deep Argo floats in all of those regions (Fig. 3).

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 ± 3 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 took place in April 2023 for testing/validation of new SBE-61 conductivity and pressure sensors.

BGC Argo:

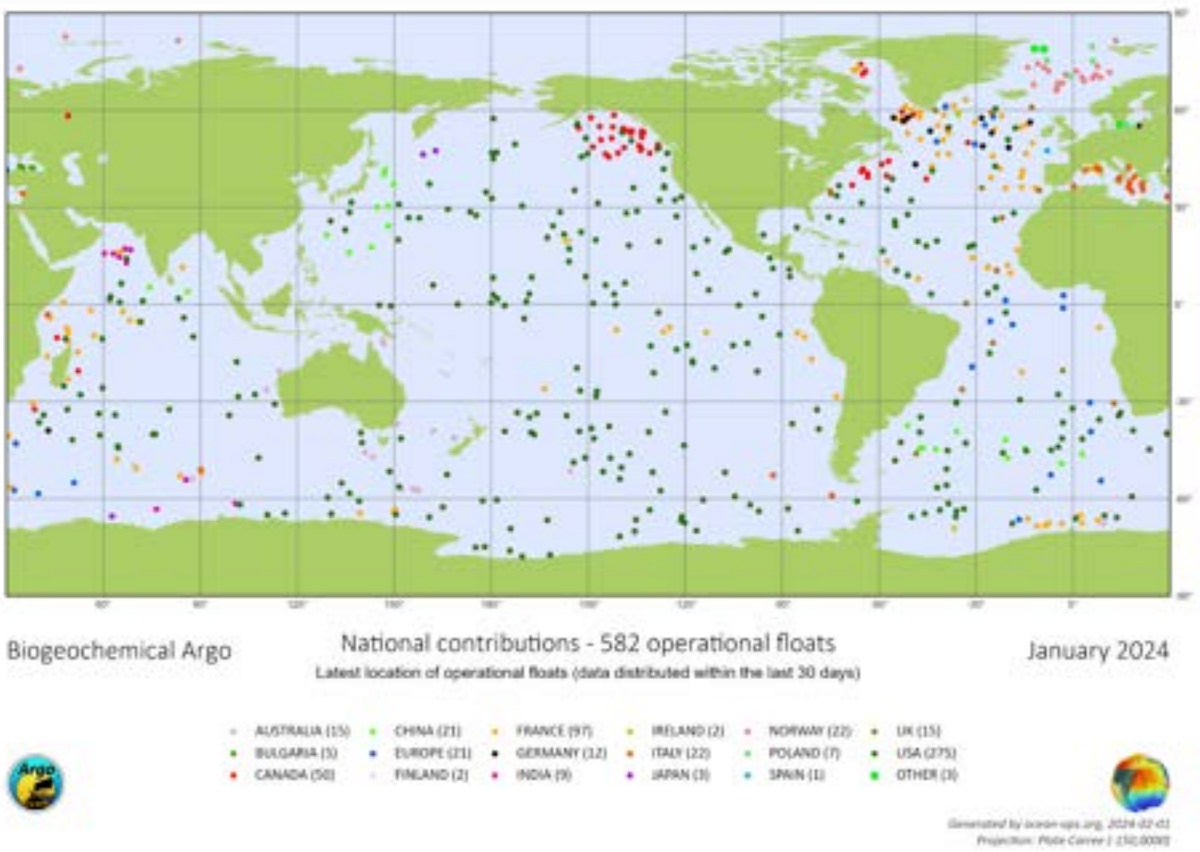


Fig. 4: *Locations of 582 operational BGC-Argo floats as of January 2024, including 274 US Argo floats, mostly from SOCCOM and GO-BGC. US BGC floats are indicated as dark green filled circles (Source: OceanOPS).*

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 January 2024, US BGC floats, mostly from SOCCOM and GO-BGC, with several US Argo Consortium contributions, number 275 of the total 582 operational BGC Argo floats (Fig. 4), with 237 of the US BGC floats measuring 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 2024. 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 FY2024 are not yet finalized but are expected to roughly match FY2023 levels.

Deployments are planned along the new RV Kaharoa delivery voyage from Spain to New Zealand(Fig. 5) departing March 2024. The ship will deploy 175 Argo floats (mostly US floats with some float contributions from Australia) along the transit, including 7 Deep and 15 BGC floats. Since 2004, 25 voyages on RV Kaharoa have deployed at least 2172 Argo floats (Source: OceanOPS).

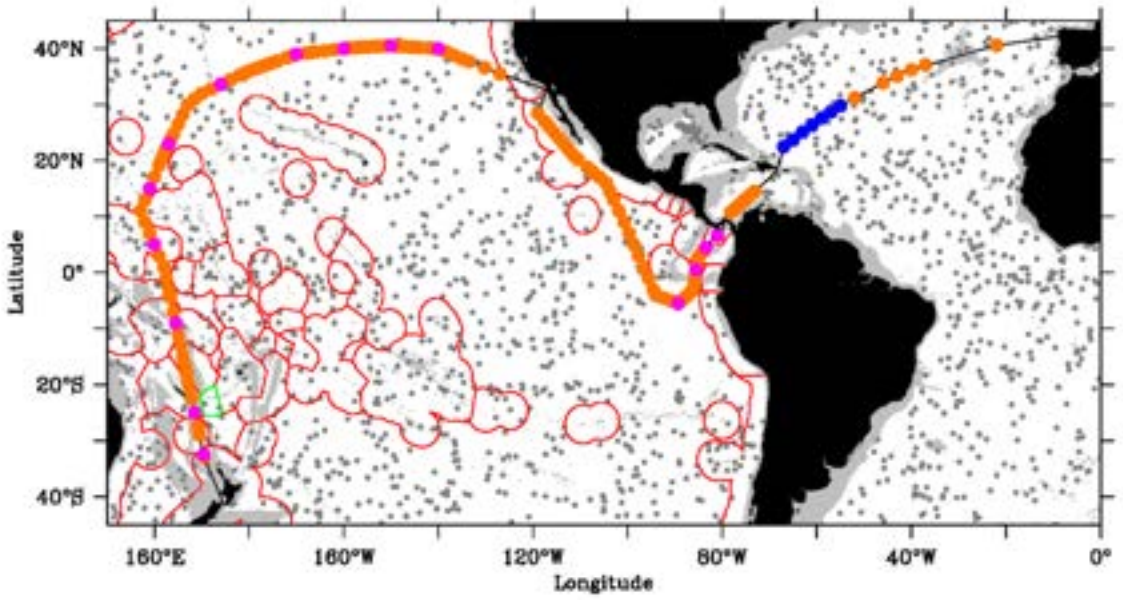


Fig. 5: *Cruise track and deployment plan for the New Kaharoa delivery voyage with planned core (orange, BGC (magenta) and Deep (Blue) locations indicated. Existing float locations are shown as gray dots.*

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.