

23rd meeting of the International Argo Steering Team



Hosts: International Hydrographic Organization
Secretariat & Monaco Ocean Week
Monaco
23 – 25 March, 2022

[Link](#) to google doc with AST-23 meeting notes

[Link](#) to google drive for AST-23 with presentations and reports

Contents

Welcome and introduction	5
9h00 Welcome from IHO Director (Mathias Jonas)	5
9h10 Welcome from Explorations of Monaco (EdM) director (G. Bessero).....	5
Challenges of implementing OneArgo design.....	5
Status of action items from AST-22 (M. Scanderbeg).....	6
Update commitments table including global Argo, extensions and equivalent floats (V. Turpin)	6
WMO update (M. Belbeoch).....	9
OneArgo Status update	10
Overall Argo status by OceanOPS.....	10
BGC Argo Mission status and challenges (K. Johnson and H. Claustre).....	11
Deep Argo Mission status and challenges (N. Zilberman and B. King).....	12
Polar Argo - status and challenges.....	12
OneArgo Array design status discussion (led by S. Wijffels)	13
Implementation issues.....	15
Deployment coordination across missions (Tammy Morris).....	15
Report from Float sampling and surfacing working group led by S. Riser.....	16
Discussion items from National Reports and a quick oral round table of highlights or key issues	18
Data Management and related issues	18
Feedback from ADMT-22 (S. Pouliquen, M. Scanderbeg).....	18
QC'ing and Distributing RBR 2K Pilot Data (A. Wong)	19
Argo NVS reference tables (V. Paba).....	20
Metadata, tech data from manufacturers into data system (B. King, V. Paba)	21
CTD Reference data during COVID (S. Diggs, S. Purkey)	22
Float performance & evaluation of the health of the array.....	22
Technical updates on floats, including float production and supply chain issues.....	22
Under-ice floats.....	22
Core floats	23
Deep Argo floats	25
BGC Argo floats (Ken Johnson, H. Claustre)	26
Sensor progress	26

SBE61 (N. Zilberman)	26
Tracking and monitoring abrupt salinity drift in SBE CTDs (B. Klein) create plots of where these compromised sensors are	27
RBR (Clark Richards).....	28
RBR Argo6000 (V. Thierry/B. King/B. Owens)	29
BGC Sensors (H. Claustre, K. Johnson)	29
Implementation issues continued.....	29
AIC Funding (M. Belbéoch).....	29
EEZ guidelines and strategies (M. Belbéoch).....	30
Argo Pilot to support Hurricane Prediction (E. Smith /S Jayne)	30
Using Argo floats to determine bathymetry (Mathias Jonas).....	30
EuroArgo Status including EuroArgo Rise Project (C. Gourcuff)	31
Argo in Denmark (Fletcher Thompson)	32
Argo in Indonesia (Nelly Florida)	32
Core Argo Best Practices paper (Tammy Morris)	32
Report from Argo Tech Community of Practice working group	33
Demonstrating Argo's value.....	34
Argo bibliography (M. Scanderbeg).....	34
Argo Steering Team Website & Program Office Updates (M. Scanderbeg)	34
Data visualizations (D. Giglio, M. Scanderbeg)	35
Océans Connectés (C. Saout)	36
Culture Océan : outreach activities (Carolyn Scheurle : IMEV-LOV)	37
2 nd Ocean Observers Workshop Report (E. Rusciano).....	37
Ocean Observing System Report Card Update.....	39
Upcoming science conferences and technical workshops –	40
Argo Science Workshop in Brussels 11 – 13 October 2022 (C. Gourcuff)	40
Boundary Current workshop (Tammy Morris).....	40
Saving Ukranian Data (Steve Diggs).....	40
ADMT-23: AOML	40
AST-24 (B. Greenan)	41
AST Membership.....	41
Other business	41

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Welcome and introduction

9h00 Welcome from IHO Director (Mathias Jonas)

We measure and chart the oceans just like Argo. Seabed topography is instrumental. This comes together in our joint activity that I will report on on Friday. Other things which are similar. Know that there is a legal aspect for floats entering into waters of jurisdiction. We have the same for bathymetric measurements in these waters. WE recently invented a geographic filter that sorts out these measurements prior to entry into our database. Based on EEZs and territorial waters and could be of interest to you as well. Collaboration would be welcome and we can overcome this artificial barrier between oceanography and bathymetry. Notion of a digital twin of the ocean is a vision for all of us. Interoperability is easy to speak to, but way more complicated to make it a reality. Our data framework is called S100 and addresses exactly that. Creates data formats based on ISO standards and really are interoperable with one another. Must come to a situation where we can combine data from different areas like LEGO bricks. Wish you a productive meeting.

Action item 1: Ask AST co-chairs to write to IHO with a letter of thanks.

9h10 Welcome from Explorations of Monaco (EdM) director (G. Bessero)

Monaco Explorations is a government owned platform that works to protect and learn about the oceans. It brings together Prince Albert's foundation, the oceanographic institute, and the Yacht Club of Monaco. Monaco Explorations also brings international help to organize educational output and coordination. Dr. Bessero noted that understanding and knowing about the ocean has long been an interest of Monaco and Prince Albert. Prince Albert I led 28 cruises and pushed the development of instruments including surface floats and the precursor to the niskin bottle. Monaco Explorations has supported GEBCO and the mapping of the ocean floor. Dr. Bessero invited everyone to visit the Oceanographic Museum to learn more about Prince Albert's heritage.

Prince Albert II continues this commitment to oceanographic support. He is the only head of state to have visited both the North and South poles. Monaco Ocean Week is an example of his commitment to the ocean and we hope you all can take part in some of the events this week. In 2017, the P Albert foundation started to help fund BGC Argo through Herve Claustre. Two years later, we are now supporting a person in OceanOPS to help coordinate BGC Argo. As we commemorate the centennial of Prince Albert I's passing, supporting commitments to the ocean is fitting. Dr. Bessero ended by wishing everyone a warm welcome.

Challenges of implementing OneArgo design

Susan Wijffels thanked our host and all the participants for attending the meeting. She noted that Argo is facing some challenges for the second time around, as well as new challenges, and stated that we need to work together to meet these challenges. She expressed happiness at the ability to meet in person again, but acknowledged that hybrid meetings are here to stay. She asked that everyone remain mindful of the large group of remote participants.

She pointed out that this is one of the first face to face meetings that Dean Roemmich has not been present for. He only missed one previous meeting due to illness. Susan thanked Dean and let him know that he is missed.

Finally, she mentioned that Sylvie Pouliquen is retiring soon and thanked her for her work as founding co-chair of the ADMT and shepherding Argo data through so many improvements. She stated that Argo's Data Management is a huge success largely because of her.

Status of action items from AST-22 (M. Scanderbeg)

Megan Scanderbeg stepped through each action and explained what's been done since we last met.

Mathieu explained the meaning of Article 247 - relating to Action 10 - noting that he will elaborate on Friday.

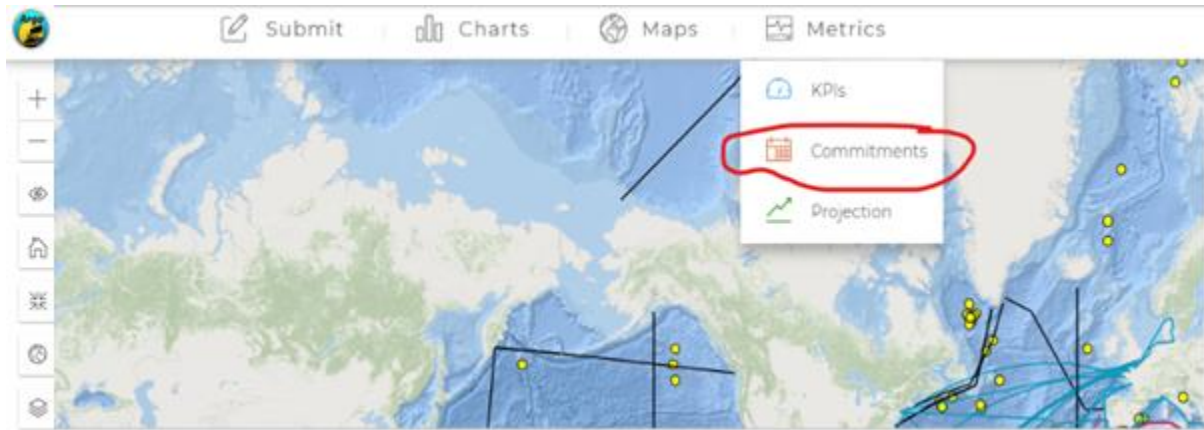
After consideration, Peter Oke did not end up preparing a community talk aimed at the modeling and operational community. It was agreed that Argo needs to continue improving connections with the operational community and to that end Susan Wijffels suggested that the group think about how to do this in a more organized manner. This improved communication could result in Argo making or endorsing an 'easy' Argo product with only good data that we send to our operational center.

Most of the other unfinished Action items from AST-22 will be addressed in different sections of this AST-23 meeting report. Concerning EarthScope and the Mermaid 300 UN Ocean Decade activity, Argo is beginning to engage with OSEAN the Mermaid float manufacturer to add a SBE CTD to their float and to consider how to adjust the float in order to reach 6000m and not just 4000m. The previously formed Argo working group has agreed to continue working with EarthScope to find ways to collaborate.

Action item 2: Establish a regular virtual Argo-ForeSea/OceanPredict Forum: The purpose of this new forum is to initially address the problem that the operational and modeling centers (including reanalysis centers) may mis-use Argo data due to a lack of direct and regular information exchange with the Argo community. These centers should be considered as key users of Argo and specific interfaces/information channels should be set up with them. One output could be first 'What's new with Argo' communication on status of Argo data with understanding it will be updated regularly (every 4-6 months). Peter Oke, Pierre-Yves LeTraon, Emily Smith, Susan Wijffels, Yosuki, Annie Wong, Catherine Schmectig, Megan Scanderbeg, Claire Gourcuff, and both ADMT and AST people

Update commitments table including global Argo, extensions and equivalent floats (V. Turpin)

Commitments are essential to have a clear vision for deployment planning and on the stock of floats available. We highly encourage Argo National Programs to fill in the commitments table on OceanOPS (the access has been simplified and feedback is welcome).



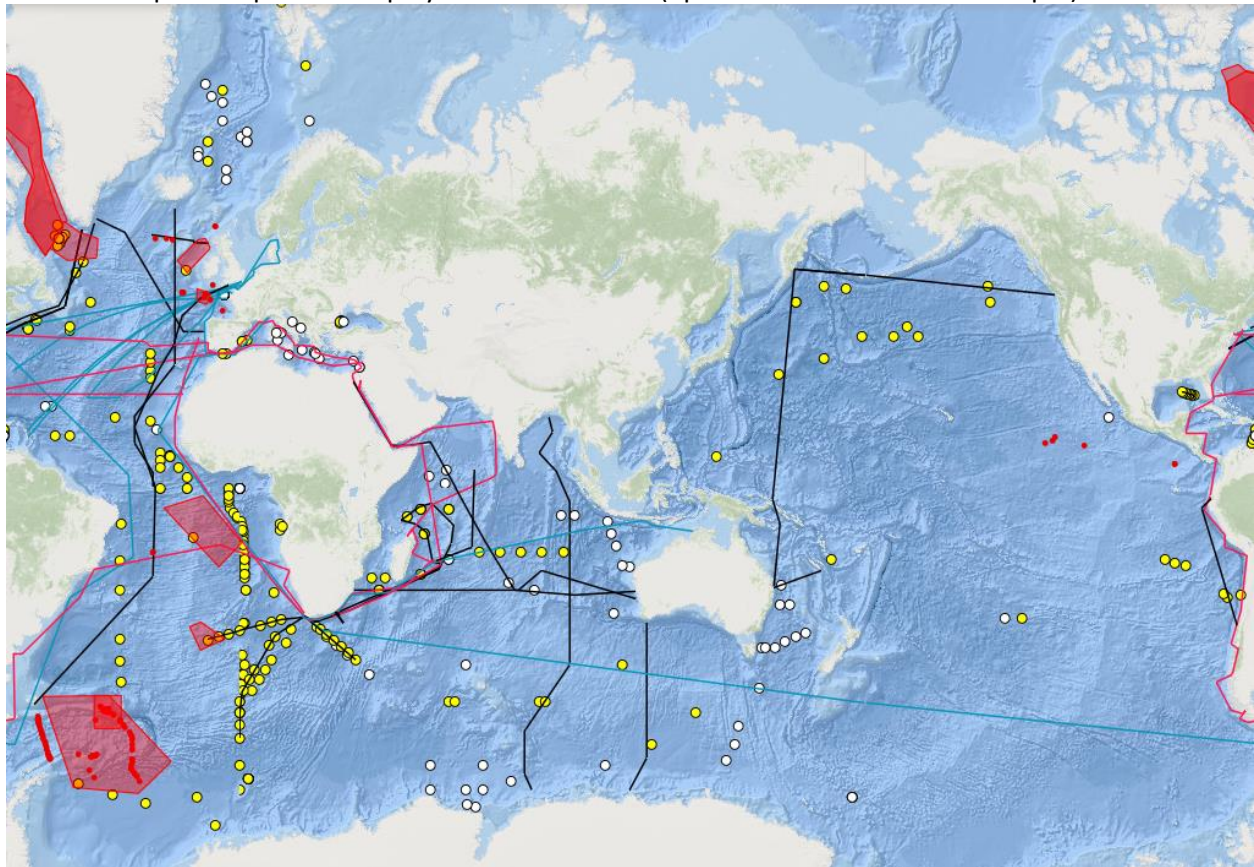
However, based on the commitment table we have identified a backlog of 400 floats that have been purchased, but not yet deployed. This number is growing, it was 250 last year and up to 400 this year. We understand that it is tricky to register the exact number of floats to actually be deployed but would prefer it to be conservative to actually capture reliable numbers.

The following numbers are up to the date of 20th April 2022:

- 607 core of the 970 target
- 214 bgc of the 250 target
- 49 deep of the 260 target

Review cruise plan for 2022

Here is a map of the planned deployments and cruises (up to the data of the 20th of April).



Cruise Lines ...

CRUISE_TYPE

- Academic
- Charter
- Civil Society
- Commercial: Freight
- Commercial: Liner
- Tourism
- Unknown
- Others

Cruise Polygons



Argo latest locations

Cruise Points



Platform status

PROBABLE

CONFIRMED

A coordination group should be formed in the next month to work on the Indian Ocean deployment plans. The Indian Ocean has been under stress for a couple of years now.

Globally speaking, we need probably more than 800 floats per year deployed to develop OneArgo without impacting the core mission. We've been three years in a row now with less than 800 floats. With covid it has been hard, but we are not deploying enough floats to maintain the array.

WMO update (M. Belbeoch)

WMO has a new approach to include ocean data and is now supporting OceanOPS. Mathieu Belbeoch is fully employed and funded by WMO.

There was significant political work done to obtain agreement on the updated WMO unified data policy which includes core data and recommended data. In addition, there is a Global Basic Observing Network (GBON) and a systematic observations financing facility (SOFF). These three entities interact and feedback to each other.

There is a request to the Commission for Observation, Infrastructure and Information Systems to continue work under GBON and to expand to include more measured variables. Argo is part of the 'core' data and BGC Argo is under the 'recommended' data.

Under GOOS, we have proposed to expand the measured variables under GBON. When this is accepted, there will be a monitoring system at GBON to identify places where more observations are needed and this could be a way to get more funding. A call would be put out for more observations and any institution could make a proposal to deploy instruments. This will be tested with other instruments first, possibly drifters, but Argo floats are in the cue.

In the discussion, Susan Wijffels thanked Mathieu for his fantastic work on this and for bringing the ocean into WMO's sphere. She then asked if ocean measurements are part of GBON, does that mean Argo can operate under WMO convention or do we still need to follow UN law of the seas convention? Mathieu said it was still a bit unclear, but he hopes that it will help with data sharing in EEZs in the long run. For now, he reiterated that we must follow UNCLOS.

Steve Riser asked about how Deep Argo fits into the 'core' and 'recommended' data for the WMO and Mathieu said that GBON is just beginning and that as both Deep Argo and GBON mature, we can bring a proposition about Deep Argo data to the OCG to raise with GBON.

Pierre-Yves LeTraon asked for clarification about what will happen when gaps are identified and how the possible additional floats will be connected to Argo. Mathieu reiterated that any entity can answer the call and deploy floats in gap areas. He thinks the call will be on a 5 year cycle and any group could apply to those calls. Given that, it would be great for Argo to have a Best Practices document which these new entities could refer to in order to successfully fill the identified gaps.

Action item 3: Ask Mathieu to watch GBON (Global Basic Observing Network) and let Argo know when it needs to prepare Argo service specifications and best practices.

Action item 4: Ask Mathieu for help to organize a side event with WMO to help champion OneArgo.

OneArgo Status update

Overall Argo status by OceanOPS

Mathieu Belbeoch reported on the overall status of Argo and its progress towards implementing the OneArgo array. He noted that while there are around 4000 operational floats operated by 24 countries, 10 countries sustain 95% of the array. He welcomed new contributors including Denmark, Indonesia, and Portugal.

He echoed what others have noted that Argo has had difficulty in maintaining coverage in the Indian Ocean over the past few years, some of which is likely due to Covid. He noted that there has been good international collaboration efforts in the Atlantic and the TPOS region and asked if this could be applied to the Indian Ocean as well.

Mathieu stated that charters are essential to sustaining the global array and it was nice to see the cooperation between the USA, Canada and EuroArgo on the recent charter across the Atlantic Ocean to deploy 95 floats. He gave a big thanks to Emily Smith for her help.

He then moved on to reporting on activity that has been stable for the past 7 years. Most of the basins are adequately operated, however the Marginal Seas have been decreasing over several years and the Southern Ocean is stable at around 50% activity. The biggest concern is that the Indian Ocean is starting to decrease. He also pointed out that there are 200 excess floats in the Atlantic Ocean and asked if Argo can we redirect some of those floats to the Southern Ocean, the marginal seas, and the Indian Ocean.

He moved onto spatial coverage and noted that gaps will be appearing in the Indian, Pacific, and Southern Ocean soon. In terms of intensity, he noted that the Atlantic had twice as many deployments as needed. In addition, the Indian Ocean has older floats, many of which are older than 5 years and one third of floats in the SE Pacific older than 5 years.

In terms of the increased density in Western Boundary Currents and Equatorial regions, there are overall implemented at 60%, but not consistently. For example, the TPOS region is 80% implemented, but other equatorial regions are not as well implemented.

He noted that the Deep Mission is slowly improving with the regional pilots, but more deployments are needed to reach full implementation. The BGC Mission has pretty good coverage, but almost half of the floats are oxygen only and OceanOPS needs to refine this metric according to the desires of the BGC Mission.

He concluded by saying that Argo needs to improve deployment planning coordination and to consider diversification to be resilient.

Sylvie Poulouen commented on a forthcoming study from the EuroArgo Rise project to study how to use tools to help configure floats to stay in boundary currents. Susan welcomed this study and also suggested that implementation in these regions could be difficult and Argo may want to consider changing to more frequent sampling in those areas rather than doubling the float density. Gliders may also help in boundary regions and perhaps a working group on boundary currents involving various instrument experts would be useful to plan how best to obtain enough measurements.

Action item 5: ASK EA Rise to report back to AST on Boundary Current study. Ingrid

Action item 6: Ask Tammy Morris to keep AST informed on Western Boundary Current OCG working group. Ask for virtual participation at upcoming (East & West) workshop in early May.

Interested in synergies with glider community, piloting in boundary currents. Nathalie Zilberman, Ingrid, Miguel, V. Turpin

BGC Argo Mission status and challenges (K. Johnson and H. Claustre)

The BGC-Argo community continues to utilize the profiling float dataset for a broad variety of innovative studies. Over 70 papers were published in 2021, which is a record number. Many appear in high profile publications such as Nature and Nature Geoscience. The number of operating BGC floats is at a record high of ~450, but most are equipped with only one or two sensors. About 200 floats have 5 or more sensors, so the BGC-Argo array can be considered ~20% complete, relative to the desired array of 1000 five or six sensor floats. Over the next five years, there are strong (funded) commitments for about 800 floats with five or six sensors.

The BGC-Argo Data Management Team continues work to improve the quality of the real-time and delayed-mode data sets. Updated documentation for a variety of variables was added in 2021. A BGC DMQC workshop is being planned, tentatively for fall, 2022. The DOXY and BBP audits are enabling significant increases in the fraction of delayed-mode data that is available. An audit of quality flag assignments showed some variation between DACs in the criteria used to assign flags. There was also significant discussion of producing a data package that contained only good data (Flag = 1).

The need for deployment planning was emphasized as the BGC array starts to reach the desired density in several areas, such as the North Atlantic, while other areas such as the Indian Ocean have very low densities.

Several working groups reported making significant progress. This includes a group focused on radiometry, led by Emanuele Organelli. They are approaching a recommendation that all BGC, 4-channel radiometers standardize on wavelengths of 380, 443, 490, and 555 nm. They are also recommending 1-m sampling resolution where possible. A working group on mission planning has been led by Steve Riser. They are recommending that all floats operate on a schedule where all hours of the day are sampled at a nearly equal probability, rather than fixed times of day. Some accommodation was recommended for floats with radiometers to ensure that profiles within a few hours of noon were made each month.

Two recent workshops for BGC-Argo were reported on. A G7 workshop was held in March and April. A US-OCB workshop was held in June.

Action item 7: Explore how to create a product that contains only good data on standard depth levels with error bars. Explore how the standard depth level products that Argo points to are created and how Argo might be able to create such a product. Sarah Purkey, Peter Oke, Susan Wijffels, Annie Wong, Claire Gourcuff, Nicolas Kolodziejck

Action item 8: Ask OceanOPS to explore making density coverage plots based on good quality parameters.

Deep Argo Mission status and challenges (N. Zilberman and B. King)

The Deep Argo array is composed of 190 floats of which ~70% (132) are 6000-m floats (Deep SOLO and Deep APEX models) and ~30% (58) are 4000-m capable (Deep Arvor and Deep NINJA). Four additional Deep Argo float models will be operational in 2-3 years. The 4000-m and 6000-m Deep Argo floats from China, and the 4000-m Mermaid from France are under testing. A 6000-m float model from France is under development with first deployments planned in 2025. Most Deep Argo floats are equipped with SeaBird CTDs (6000-m capable SBE-61 and 4000-m SBE-41). A CTD from RBR is under testing on the 4000-m float model from China, and the 2-headed and 3-headed Deep Arvors. Out of the 190 active Deep Argo floats, 41% (78) are equipped with oxygen sensors (55 Deep Arvor and 23 Deep APEX). MRV (Deep SOLO float manufacturer) has started engineering work to implement DO sensors on Deep SOLO floats.

Three Deep Argo pilot arrays will be implemented in the Pacific, Atlantic, and Indian oceans in 2022. The deployment rate (53 floats) for 2022 is just enough to maintain the regional Deep Argo arrays, and represents only 17% of the yearly value needed to implement the global 1200 Deep Argo float array. Only nine national programs contribute to the implementation of Deep Argo; some Argo partners are involved in data quality control, deployment, and technical support. Significant increase in float contribution from the national programs and capability of the float and sensor manufacturers is needed.

The third Deep Argo workshop was held remotely in September 2021 by EuroArgo to assess the status and progress of the Deep Argo mission, define plans to increase oxygen sampling from Deep Argo floats, and strengthen interactions and collaborations with the BGC Argo mission and other observing systems. A paper describing the strategy for the global implementation of the Deep Argo array will be submitted in August 2022. This publication is especially addressed to funding agencies, stakeholders, and new Deep Argo partners.

Polar Argo - status and challenges

The Euro-Argo RISE project produced a report as part of the activities to contribute to the Argo extension towards high latitudes entitled: *Report on the current state of ice avoidance methods and recommendations for deploying Argo floats in the Arctic Ocean*, and available [here](#).

The report compiled case studies, which show that the best method to avoid ice is using regional ISA configurations in the Arctic, but if they are not available, timeout methods do a good job. It is crucial to share information about methods that have been tested (hardware and software), especially about those that failed or are not being developed anymore.

It includes deployment recommendations, configuration parameters that have worked properly in several Arctic regions and links to toolboxes in the EuroArgodev GitHub also available [here](#). The main aspects are provided in a 'cheat sheet' to help operators know what to pay attention to when planning deployments in seasonally ice covered regions.

It is hard to find floats with ice detection in OceanOPS and one can only see European floats. We would like to know if this is true or if metadata is appropriate.

Action item 9: Ask that float deployers please inform OceanOPS upon deployment if ice-detection software is included in the float

Wondering if we can add a flag to profile files rather than keep it in tech files to indicate it has ice-detection.

Action item 10: Consider adding information to profile files to indicate if a float has detected ice. Ask ADMT to discuss. Polar Mission Team, ADMT

The [presentation](#) included relevant information (active floats, planned deployments, problems) provided by the following countries:

- Canada, Norway, Poland, Finland, France and Germany in Arctic
- UK, Italy, Australia, NZ, USA, France, Germany in Southern Ocean

It was noted that delays in deployments meant that floats were “lost under the ice” without knowing if they were working properly, because there was less time to adjust missions.

There is a desire to improve under-ice positions and European countries are using the terrain-following interpolation method developed by Yamazaki.

The virtual fleet planning tool produced many comments in the Slack channel.

Matt Donnelly has made some connections via the Southern Ocean ARC, but it has been a bit stalled.

Brian King noted that Mission teams are formed to work on technical and data problems, refine the scientific design and interact with others in their area. If those reasons all apply, then we should think about forming a Polar Mission team. Especially as the SOARC has largely been data focused.

Action item 11: The AST suggests the formation of a Polar Mission team, in a similar manner to the Deep and BGC Argo Mission teams, with terms of reference, and a webpage on AST website. Consider looking for leadership from current SOARC groups and Arctic groups. Nicolas Kolodziejczyk, Alison Gray, Ingrid Angel, Mathieu from takuvik in Canada, Esmee van Wijk, Steve Jayne

OneArgo Array design status discussion (led by S. Wijffels)

Implementation challenges including how core, BGC, and Deep floats will contribute to the array

A very quick presentation was given on the current status of floats deployed in the ocean basins. Gaps were re-iterated for the Southern Ocean, the Indian Ocean and parts of the Pacific Ocean. The North Atlantic is saturated with too many floats now and consideration should be taken by teams to move excess floats ready for deployment to other regions if possible.

After some roundtable discussion on possibilities for cruises to deploy floats and having key people in regions of regions, two task teams will be set up to engage communities further around deployments - the Indian Ocean and South Atlantic Oceans.

Technical challenges

Susan made some remarks on the OneArgo Array status prior to discussion. She noted that Argo continues to have both high impact and high demand which can be seen by the large number of

research output and the uptake by operational centers. In fact, work by the ADMT to deliver much of the data within 3 hours is great for coupled data assimilation systems for forecasting and helps with both weather and storm forecasting. She noted that the OneArgo design is highly anticipated, but that has not materialized into additional resources. Argo continues to add new countries and she welcomed Indonesia, Portugal and Denmark.

Next, she moved on to noting some of the challenges facing OneArgo including sensor and platform quality, supply and timeliness (particularly for BGC and Deep, but also for core). Covid, which has affected the supply chain and the workforce, coupled with inflation have translated into major price increases for floats and sensors.

In terms of deployment planning, she said that Deep and BGC float deployment needs to be more precise and we need to work together carefully to address this. Some Research Vessels are fielding multiple Argo team requests and she suggested that we may need to assign one Argo person to each RV or program since we cannot afford to discourage these groups from allowing deployments.

Argo is facing increasing technical complexity due to more sensors, the need for calibration casts, and more metadata. All of this results in a huge stress on the DACs and we need to help DACs prioritize their work. Unfortunately, reliability seems to be going down and she urged everyone to stay vigilant on floats and sensors and hopes that Argo can work together closely with the manufacturers on these issues.

As of now, we have not been able to secure increased funding for OneArgo. Already, there is evidence that Deep and BGC floats are replacing core ones which results in many fewer core floats being deployed. The difficulty is that Deep and BGC floats do not last as long as a core float, so we cannot do a one to one swap right now.

She concluded by saying that these are big challenges and asked for ideas on how to communicate that this additional funding is crucial and required and that we cannot fulfill the OneArgo array with just increased efficiency. It is crucial to raise Argo's profile and any ideas on how to do that are welcome. The UN Ocean Decade could help, but it is not yet clear how OneArgo fits in with all the other activities. Please feel free to use your voice to advocate for Argo and let others know that Argo is degrading without financial help.

Her final message was that Argo has done the work to prepare for OneArgo, but we need the additional funding. This lack of funding will likely mean making tough decisions on how to move forward as core Argo is our top priority.

In the discussion that followed, Virginie Thierry noted that we could increase BGC and Deep float lifetimes by using additional batteries and while this is true, it could take awhile for this to have an impact. There was general agreement that Deep and BGC float lifetimes need to improve. Sylvie Pouliquen noted that EuroArgo is studying power consumption and float lifetimes and suggested that just looking at float age is not enough. In addition, we should be looking at how float configurations can impact lifetime and use that to guide our deployments, configurations and management.

Greg Johnson (RBR) suggested thinking in terms of cost per profile and noted low sensor energy consumption would also help improve lifetimes.

Emily Smith said that at NOAA, and likely other funding agencies, she cannot just replace core floats with Deep and BGC ones right now and she is trying to figure out how to proceed. She also said that we need strong supporters outside of Argo itself.

Breck Owens suggested asking the WMO or the G7 to help make the case for funding OneArgo.

Ken Johnson noted the G7 resource strategy group meeting is next Monday and suggested we bring this message to them.

Nathalie Zilberman said that there is a project in the works to start using Argo floats to determine bathymetry and there could potentially be funding there.

Dean Roemmich reiterated that Argo has been clear that the core array is the top priority, but as things have developed, Argo no longer has as much influence over the distribution of resources. He also said that we had not appreciated enough that manufacturers might lose interest in floats and sensors depending on demand.

Sylvie Pouliquen said we may need to find additional ways to communicate the positive message that Argo has done the groundwork and is ready to implement the array with additional funding. Perhaps we need to work with the communication people at our institutions and we should try to find ways to translate research funding to operational funding.

There was general agreement that different countries have different ways of supporting Argo and that we need to take advantage of every opportunity we can such as the UN Ocean Decade, GOOS, POGO, OceanPredict and the G7.

In terms of the UN Ocean Decade, we need to be ready to help interact with decade activities when asked. We may also need to hold more AST executive meetings to help guide us through the UN Ocean Decade.

Action item 12: Revisit list of UN Decade Activities that AST members can collaborate with. M. Scanderbeg, AST members

Susan asked for further studies on how many floats should carry an oxygen sensor because while it would be beneficial, it is more expensive and more to quality control. She said that we need to be very careful and deliberate about adding new sensors because regional arrays are not enough. The real scientific utility comes from a global, uniform data set.

Action item 13: AST encourages studies of enhanced oxygen sampling in core and/or deep with clear articulation of the cost benefit over current OneArgo design. Virginie Thierry, Ken Johnson, Roo Nicolson?, Claire Gourcuff

Implementation issues

Deployment coordination across missions (Tammy Morris)

Tammy presented several slides echoing what was presented earlier by Mathieu Belbeoch which is that the North Atlantic is over sampled while we are losing coverage in the Western Indian Ocean, Southern Ocean, North Pacific and South Pacific off the west coast of South America.

She suggested a couple of steps to start tackling this:

1. Load cruise plans into OceanOPS and the sooner the better. She asked how we can start engaging other vessels such as vessels of opportunity, sailing yachts, Navys, and possibly others. She noted that we could engage with countries that aren't involved in Argo, but do other ocean work.

2. Set up working groups to focus on ocean regions of concern and seek guidance from OceanOPS on basin-wide coordination.
3. Think out of the box for other solutions. For example, OCG is always asking us what we need and maybe we can ask them for help on basin wide deployment coordination.

Susan Wijffels then shared that a group of scientists at WHOI is talking to shipping companies about doing deployments from these ships. The WHOI Argo group has worked with one of these ships and it is very attractive because they can do transport shipments. In other words, whenever these ships go to port, they can pick up floats and transit them to where we want them to be picked up and deployed.

Sylvie Pouliquen noted that at the European scale, there is a partnership with OrangeMarine to deploy floats and that tourist cruises are also used to deploy floats. She suggested that through the OceanOPS ODYSSEA initiative we could build opportunities with commercial users. She agreed with Tammy's suggestion to talk to countries outside of Argo about deploying floats. Countries in Europe have tried this in the Marginal Seas for both float deployment and recovery.

Dean Roemmich shared that the Kaharoa will have a replacement vessel in place in 2024. The difference with that one is that it can go to a higher latitude - 60S, it will be a bit larger and will have a greater range. This means it will have easier access to the Indian Ocean by going further south of Australia. He acknowledged we would have to pay for deployments on it, but it is a small fraction of the total cost of the Argo program.

Birgit Klein noted it is great if deployers have a storage area for floats onsite. For example, South Africa has a great storage facility and this ensures that we can make sure floats get on the cruises.

Mathieu Belbeoch reminded the AST that OceanOPS ran a set of meetings on deployment planning for the Atlantic and found it beneficial to have several experts in one meeting to discuss logistics and opportunities. He agreed that the Indian Ocean is the biggest priority right now and that the first step is to share cruise plans. He suggested that Argo could also invite other networks to these deployment planning meetings. He noted that Marine Facility Planning may be helpful as countries start to use it.

Sylvie Pouliquen pointed out that it is important to include the technical people who organize deployments at a national level at the basin wide deployment meetings

Action item 14: Form basin deployment planning teams that meet regularly and report back at each AST and ADMT meeting. These teams need to include people who actually plan float deployments. Highest priority is on the western Indian Ocean. Indian: Tammy Morris, Pattabhi Rama Pacific: Sarah Purkey, Shigeki Hosoda, Atlantic: Fiona Carse, OceanOPS

Report from Float sampling and surfacing working group led by S. Riser

Steve Riser reported on the work done by the Argo Sampling Committee over the past year whose job was to investigate:

1. The effects of nonstandard timing of Argo profiles
2. The effects of high-frequency sampling for BGC purposes on the lifetime of the Argo array
3. The vertical resolution of profile sampling associated with BGC variables, especially in the context of radiometers
4. The possibility of park-depth sampling of variables beyond temperature and pressure

He stated that many floats deployed in the past two years have not carried out random sampling at all times of the day. Instead, there is a preference for standard profiling times, sometimes around noon, but at other times as well (*TOD sampling*). He showed an example of a UW float that has been programmed to sample every 10 days plus 1.92 hours which means it takes 13 months to the floats to cycle through one day of surface arrival times. He noted that it is possible to systematically examine phenomena that occur on time scales faster than the nominal Argo period of 10 days when using space-time averaging, but this only works if the timing of the profiles are uniformly distributed throughout all times of the day. This was demonstrated by Johnson and Bif (2021), but they could only use about 30% of the profiles due to non-randomness of profile times. This non-uniform sampling throughout the day could also lead to bias in estimating ocean temperatures.

The group's recommendations:

- 1) All Argo floats should be set to sample at approximately 10 days (ie 10.08 days, but not a divisor of 24 hours), drift at 1000m and profile to 2000m, whenever possible. The goal should be to obtain an even distribution of surfacing time. In general, floats should not use TOD sampling.
- 2) This approximate 10 day sampling should be implemented on all floats in the future. For some float types, this may mean a change in the manufacturer's default settings prior to deployment.
- 3) Present floats using some other protocol yielding non-uniform sampling should be changed to the approximate 10-day protocol as soon as it is feasible, using two-way communication (if possible).
- 4) Float users and manufacturers should work together to ensure that these changes are implemented in the proper manner.

BGC variables were then examined for preferred sampling time and some (NO₃, pH) had no preference, while O₂ and FLBB somewhat prefer the dark and the radiometer has a strong desire for noon sampling. This was the strongest preference and the group came up with the following recommendations to accommodate this preference:

- 5) Add one full 0-2000m noon profile per month. This would be additional profile and all surrounding profiles would stay with regular sampling strategy.
- 6) Flag these profiles in the database so that they can be easily removed if not wanted for certain studies.
- 7) Set the radiometer to sample at the maximum practical rate near the surface during ascent.

The final topic considered was park-level sampling and here are the group's recommendations:

- 1) All BGC-Argo floats should sample temperature, pressure and FLBB (or equivalent) hourly during the park-phase.
- 2) Salinity and nitrate would be useful, but they consume too much energy for this to be practical.
- 3) The radiometer could also provide useful sampling during park depth, but more discussion is needed.

During the ensuing discussion, there were questions about how or if some float types can technically be adjusted to add an additional noon profile per month. The AST asked for more exploration into this topic. It also recommended that the working group continue to study how often the radiometer needs to sample during drift. Overall, the AST agreed to endorse the recommendations about cycling frequency and the noon profile every 1 -2 months.

Action item 15: Ask for more clarification on drift sampling and whether radiometer is suggested every hour or once per drift. Explore which float types can sample just the

recommended T & P and whether this recommendation can be followed. Float Sampling Working group led by S. Riser

Action item 16: Investigate further the recommendation from Sampling Working group for floats with radiometers to do a noon profile every 1-2 months. Explore how this might technically work with floats. Float Sampling Working group to reach out to float type experts

Action item 17: Follow the recommendations from the Float Sampling Working group to cycle to 10+ a small amount of time to randomize the time of day floats arrive at the surface.

Discussion items from National Reports and a quick oral round table of highlights or key issues

Peter Oke: Australia had quite a few float failures which we are described in detail in our National Report.

Virginie Thierry: The price of floats is increasing and so the number of floats purchased will go down. She noted that Argo may not be able to double deployments in some areas as requested and that we may need to think about sampling twice as often instead. In addition, there is a large percentage of the fleet affected by Abrupt Salty Drift in SeaBird CTDs and she urges Argo to continue monitoring this, while also expanding to other sensors.

Toshio Suga: He apologized for the loss of the data stream at JAMSTEC last March and said that the system update needed to address the issue will be completed soon. He also said that the Japanese government requires EEZ clearance and this means that there needs to be registered national focal points to make the clearance request. If there are more focal points, it would make float deployments easier for Japan.

Action item 18: Ask Matheiu Belbeoch to ask IOC to send a new circular letter asking for new national focal points

Malika Kheiredd from Saudi Arabia: We plan to deploy 2 BGC floats in the Red Sea for the next 5 years. The first one is in two days and the second is in April. It is still unclear how the floats will work in the Red Sea, but they want to explore this more. They also plan to deploy in the Arabian Sea.

Data Management and related issues

Feedback from ADMT-22 (S. Pouliquen, M. Scanderbeg)

S Pouliquen presented a summary of the Argo Data Management Team in 2021. The details can be found in the [ADMT22 meeting report](#). In her [presentation](#) she made the following highlights:

- Data management system is evolving to manage all the components of the OneArgo missions both in NRT and DM
- DACs remain stressed and are having trouble implementing action items in a timely manner. However they are delivering the data with very good timeliness both on GTS and on GDAC for 24H and 12H targets that are the agreed target by DAC.
- Delayed Mode of T & S has progressed well but the Abrupt Salinity Drift issue in SBE CTD has increased the workload on DMQC operators. The degradation of the quality of the data is visible

on the quality KPI available at OceanOPS and this impact is still not completely known as some of the suspicious floats are not yet DMQCed.

- Monitoring of data quality needs to be implemented operationally for ALL variables taking into account the specifics of BGC variables and need to be specified with the ADMT before being visible of official Ocean KPI dashboard.
- GDACs are performing well and have been stable over the past year. File Checker activity is important and needs to be sustained after Mark retires. A small working group is working on this organization. Linking file checker to the Argo vocab is very important and need to be organized.
- Activities in the ARC are on hold in some regions due to a lack of resources or it is a lower priority compared to other real time and dmode activities.
- Using Cloud technology for Archiving or serving the Argo data is being studied and could enhance services to users in the coming years.
- With the development of OneArgo, new communities are contributing to the OneArgo data management activities and using the Data. We need to figure out how to support them in their activities.

As a conclusion she provided the following take-home messages to the AST :

- Argo Data System is great but managed by human beings with their limits. We collectively have to define priorities to streamline the activities.
- Argo Data System has been able to evolve to handle new missions but not all elements are yet fully defined, nor implemented on sustained fundings. New man power and expertise need to be devoted to the OneArgo data system both on method development and on implementation.
- No platform/sensor is perfect and monitoring data quality is essential to anticipate actions when a failure is detected. It is essential to extend to ALL variables tools similar to what exist for T & S and run operationally ideally on a monthly timescale.
- Argo data are managed and used by new communities and we should, like we used to do 20 years ago, organize training and outreach workshops/materials to facilitate new actors engagement and new user Argo uptake

Finally Sylvie mentioned that she was retiring in 2022 and therefore, with Megan, she has been looking for a new co-chair to take over. Claire Gourcuff, from the Euro-Argo ERIC office, accepted to take over and everybody welcomed her as new co-chair of the ADMT .

It was noted that both the quality of psal and temperature data is going down and it was not immediately clear why temperature quality was going down. Sylvie and Megan agreed to work with OceanOPS to look into this.

Action item 19: Ask ADMT, Deep, BGC co-chairs to work with V. Turpin to study and improve KPIs on OceanOPS.

Action item 20: AST suggests another DAC workshop. Suggest Thierry Carval, Tanya Maurer, Claudia Schmid to lead.

QC'ing and Distributing RBR 2K Pilot Data (A. Wong)

Annie Wong gave a summary of how RBR 2K CTD data were going to be quality controlled and distributed in the Argo data system. The QC and adjustment procedures were the result of work done by the RBR Argo data task team since May 2020. This work has resulted in a manuscript by Dever et al, submitted to JTech in December 2021. Based on comparisons with shipboard data, T and P

measurements were found to be accurate within manufacturer accuracy, but salinity was found to require compressibility correction and thermal inertia correction. Compressibility correction is not required for RBR CTDs calibrated after April 2021, because after that date RBR switched to a unit-based procedure that provided optimized individual coefficients. RBR new compressibility coefficients for pre-April 2021 cells and all adjustment procedures are now available in the Argo QC manual and on github.com/ArgoDMQC. To facilitate integrating RBR metadata into the Argo data files, metadata listed in Argo variable names are available by using the serial number search in RBR's OEM lookup system, <https://oem-lookup.rbr-global.com>.

Annie then recounted the recent agreement reached at the ADMT meeting in December 2021 to flag post-April 2021 RBR salinity with `PSAL_QC='1'` in real-time, if all real-time QC tests were passed. This means the Argo community recognizes that the RBR CTDs have improved to a point where their raw salinity data can be treated equally in real-time as the other CTD data in Argo. It was noted that as of March 2022, no floats with post-April 2021 RBR CTDs have yet been deployed.

Annie concluded with an optimistic note that the data task team now felt more confident in the data quality from RBR CTDs.

Susan Wijffels took the opportunity to thank everyone involved on this RBR data task team and said that Argo really wants to encourage national programs to purchase RBR floats.

Argo NVS reference tables (V. Paba)

In 2018, the EU Horizon 2020 ENVRI-FAIR funding allowed BODC and Euro-Argo to start working on making the Argo data and metadata system more 'FAIR', i.e. Findable, Accessible, Interoperable and Reusable.

Part of this work required moving the Argo reference tables from .pdf documents and spreadsheets to the NERC Vocabulary Server (NVS), thus turning them into controlled vocabularies with unique URLs, accessible by humans as well as machines.

Current work is focused on the remaining tables still stored in Excel spreadsheets, which include the more complex technical and configuration parameter names tables. These are being reviewed in collaboration with float manufacturers, particularly Teledyne. Moreover, new vocabularies are being created by the wider Argo data management community to constrain currently free-text or loosely regulated Argo netCDF metadata variables (e.g. Float ending cause, `PI_NAME`, sensor stage, ICES adoption etc.)

Introducing machine-readability to the metadata complementing the Argo netCDF files is fulfilling our goal of making the Argo data system FAIR. This is adding major benefits to the whole program, including:

- DACs have less chance of error, higher efficiency in adding and implementing NVS additions
- GDACs: enhanced automation in netCDF file checker
- User: Argo netCDF files are fully descriptive
- Enhanced discoverability through EOVS mappings and Argo ontology

Information on the Argo NVS collections, teams and workflow can be found on the Argo data management website: <http://www.argodatamgt.org/Documentation/Argo-vocabulary-server>. Information on the Argo ontology and our connection to Linked Data can be found here: <http://www.argodatamgt.org/Documentation/Argo-vocabulary-server/Argo-linked-data-and-SPARQL-endpoint>. The Argo NVS work has been led by the Argo Vocabulary Task Team, mostly using a dedicated GitHub space as the main platform for new ideas, requests and discussion: <https://github.com/orgs/nvs-vocabs/teams/avtt>

Metadata, tech data from manufacturers into data system (B. King, V. Paba)

Between Nov 2021 and Jan 2022, as part of EA RISE, there was a series of six meetings on Zoom with vendors who have links to Euro Argo users: RBR, TWR, MRV, SBE, NKE, and OSEAN.

The format was a 1 hour meeting with an optional extension of an extra 30 minutes, with one vendor per session. This provided a chance for vendors or users to talk about anything that either side wanted to raise.

A common recurring theme was the effort required by DACs to compile float metadata in a format that could be entered into NetCDF files. Some float and sensor vendors make this easy, some do not. For example, extracting sensor calibration data by re-typing, or cutting and pasting out of pdf files, is time consuming and prone to error. Users also emphasized that when a float engineer changes the format or content of data telemetered ashore, this can have consequences for the RT DACs that the float engineer may not appreciate.

The vendors all expressed a willingness to engage on this topic with a view to providing:

- > machine-readable metadata (minimum requirement)
- > machine-to-machine metadata (preferable)
- > decoders that provide a DAC with tech and profile data with vocabulary close to what the DAC must upload to the GDACs, and which don't change with minor float firmware revisions.

All vendors acknowledged the pain that DACs feel over these issues and expressed a willingness to work to maintain or improve systems that would

- > speed the process at DACs
- > reduce errors
- > assist DACs to develop vocabularies that appropriately describe hardware and firmware evolution

Some vendors are already in quite good shape over these issues, others acknowledged that they have quite a lot of work to do.

Main action so far:

Follow-up interaction with Teledyne to map out a variety of things that would make tasks much simpler for users of APEXs. A direct interaction between DAC staff and TWR engineers. TWR have gone away to see what they can come up with. We really appreciate their engagement and look forward to the next round of interactions. In other presentations, NKE illustrated steps they have taken to ensure that CTS-5

controllers output data with near-to-Argo vocabularies. RBR provide machine-to-machine access to sensor metadata from their web site with a user key.

These are not issues that will be fixed overnight, but one or two years from now we don't want to be stuck having the same discussions. We look forward to working with all the vendors to ensure maximum ease of use of their products.

CTD Reference data during COVID (S. Diggs, S. Purkey)

Steve Diggs reported that 847 reference profiles collected by CCHDO have been added to the CTD reference database since AST-22. NCEI also contributed over 7000 casts. However, ship time was down significantly in 2020 and 2021 largely due to the COVID pandemic, so there will be less reference CTD data for that time period. Steve also introduced a webpage where you can enter a CCHDO cruise number and it shows nearby Argo profiles. You can also reverse that query and enter an Argo float number and locate nearby CCHDO profiles.

17h00 Public lecture by S. Wijffels and H. Claustre

End of day one

Day two: CLOSED SESSION

Float performance & evaluation of the health of the array

Report & discussion on current float lifetimes, including by core, Deep, BGC Mission (Led by V. Turpin, M. Belbéoch with input from community)

Technical updates on floats, including float production and supply chain issues

Under-ice floats

Estimated positions for under-ice floats (P. Oke, EuroArgo)

Peter Oke presented a simple method for estimating Argo float trajectories under ice. The method uses multiple, static constraints, including potential vorticity, mean sea-level and density at 1000m depth; and identifies continuous trajectories that approximately preserves these properties between measured positions. Up to three different trajectories can be produced for each "position gap". Peter suggested that the system could possibly be run a couple of times a year, with estimated trajectories manually assessed by experts to determine whether they should be adopted instead of linear trajectories. The estimated trajectories using the proposed method appear to be feasible, and have fewer

inconsistencies than simple linear paths between known positions. The method has been submitted for peer review.

Under-ice floats (S. Riser)

Steve Riser updated the AST on the status of under-ice profiles which are part of SOCCOM. 66 floats have obtained 2617 under-ice profiles which corresponds to 11.5% of SOCCOM profiles. 18 floats have at least 50% of their profiles under-ice. He also reported on a climatology being developed from SOCCOM floats and showed differences in the winter as compared to the summer for temperature, salinity, oxygen and nitrogen.

SOLO Arctic float (C. Lee, D. Rudnick)

Craig Lee reported on his experience with acoustic geopositioning on gliders and floats in the Arctic and the plan to develop a SOLO-II float for the Arctic. There will be hardware changes to improve the antenna, integrate a new modem and hydrophone port. There will also be software changes to accommodate increased data backlogs, to interface with the acoustic controller and payload. The plan is to deploy 30 SOLO-II floats at a rate of 10 per year starting in 2022 and all data will be processed by Scripps and AOML to make it available as part of the Argo data stream.

Core floats

APEX (S. Riser)

Steve Riser reported on three problems associated with APEX floats in recent years. The first, the air bladder problem, occurs when the air bladder sticks together and does not inflate. When this happens, the float can have trouble getting high enough in the water while on the sea surface to transmit data to a satellite. Oftentimes, the data is stored and can be retrieved later, but the float may use excess battery power trying to communicate. This needs to be fixed by the manufacturer and they are investigating this. University of Washington has been adding a few milliliters of mineral oil to the air bladder during assembly in order to stop the sticking.

The second is early battery depletion which was discovered by CSIRO and has floats failing around profile 88. These floats were traced to one order of 24 floats from TWR and the manufacturer is investigating the problem. The third problem is failed BGC floats which were unfortunately ballasted incorrectly and did not resurface.

ALTO (S. Wijffels/S. Jayne)

Susan Wijffels reported on behalf of Steve Jayne on the latest improvements to the ALTO firmware after testing revealed a bug in the communications with the GPS receiver. The new firmware is being tested at WHOI with no issues being discovered thus far. Shorter surface intervals have been implemented and drift measurements have been improved. Further work is being done on the ice algorithm. Finally, they noted that the ALTO has good control over the rise rate which makes it useful for testing the RBR CTD and one ALTO has been run at varying ascent speeds to test the thermal response and lag of the RBR conductivity cell.

SOLO-II (N. Zilberman)

Currently active core SOLO floats (663 SOLO IIs from Scripps and 400 S2As from MRV) represent 27% of the global Argo array. The SOLO-II model shows great performances in the field with a survival rate of 86% 4 years after deployment and 72% after 8 years. Some cases of failure from float deployments of 2021 have been linked to faulty antenna and flooding and are under investigation by the Scripps Argo lab. Challenges have arisen in float production linked to supply chain shortages (i.e. CPU chips), price increase of parts and sensors (11% increase of SBE-41 CTD) and last-minute deliveries of float parts. Uncertain and sporadic sea freight has led to resorting to air freight at ~10 times the cost for float shipment, with added risk of bad handling and no temperature monitoring available. COVID restrictions have limited access to ships for float loading and start up. Short-range and fluctuating UNOLS ship schedules have reduced deployment opportunities.

NAVIS (S. Wijffels, G. Johnson)

PMEL and WHOI reported difficulties with recent NAVIS floats which have exhibited signs of reduced manufacturing QA and have resulted in many floats being returned to the manufacturer. SeaBird has been slow to respond.

HM2000 (Zenghong Liu)

Zenghong Liu from CSIO reported the progress on HM2000 float that HSOE developed. Over the past five years, nearly 90 HM2000 floats had been deployed and half of them are floats with BDS communication system. Evaluated from those inactive floats, the lifetime of HM2000 is about two years. To increase it, HSOE will try to install and test Tadiran batteries onto 10 floats requested by CSIO. Several HM2000_DO floats have been built and deployed last year, and quite good oxygen profiles have been obtained. However, technical issues are still found in the last year's deployment which leads to early failure of 4 floats.

Arvor (Xavier André)

Xavier presented the results of the 2021 deployments: with 163 Arvor deployed, it is the most deployed profiling float within Argo. Also noteworthy is the constant increase in deployments in marginal seas, with almost only Arvor deployed there. In terms of performance at sea, Xavier recalled the importance of sample selection. Euro-Argo has conducted an interesting study on the life span of Core floats (https://www.euro-argo.eu/content/download/157738/file/V1.4_D2.6.pdf). If we take into account only profiling floats that cycle at 10 days in open ocean, the Arvor currently has a "survival rate 1" of 93% at 5 years. Concerning the Arvor-I RBR, 13 units have been deployed for nearly 800 cycles. To note, three early failures on CTDs. The implementation of the 1Hz/1cbar acquisition is planned for the end of 2022. Finally, the good functioning of the ISA on the Arvor was recalled, and a video of deployment of an Arvor under the ice pack in the Eurasian Sea was shown.

Deep Argo floats

Deep SOLO (N. Zilberman)

Currently active Deep SOLO floats (65 Scripps and 43 MRV floats) represent 57% of the Deep Argo array. The Deep SOLO model shows great performances in the field with a survival rate (84% 5 years after deployment) similar to the Core SOLO float. Estimated life expectancy is 6.5 years at 10-day sampling. Near real-time vertical sampling of 2-dbar binned between 0-500 dbar and 10-dbar between 500-1000 dbar on ascent (in addition to full-depth profiling on descent) is feasible and compatible with the recommended (> 4-5 years) float lifetime and requirements received from operational centers.

Action item 21: AST asks all Deep SOLOs that can be, to be reprogrammed to profile on ascent to accommodate the operational community.

Deep APEX (S. Hosoda)

The main users of the Deep APEX manufactured by Teledyne Webb Research (USA) are JAMSTEC and NOC. So far, JAMSTEC has deployed 25 Deep APEX floats in total, mainly in the North Pacific and Southern Ocean, and their data have been delivered to the GDAC. Some of the Deep APEXs are equipped with Oxygen sensor (Aanderaa Optode 4831 and RINKO AROD-FT), however, the observations are not going well, especially S/N 53 deployed in 2021, which is equipped with the RINKO, missed its telecommunication in the short term. The other Deep APEXs with SBE61 CTDs tend to obtain good profiles, although problems with buoyancy failure, emergency surfacing, and miscommunication between float and CTD occurred in over half of the deployed floats. With regards to NOC's Deep APEXs, three of the five floats, which were deployed in Dec. 2020 - Mar. 2021, are working normally and reaching the seabed at depths of 4800, 5000, 5800 dbar. Two other floats, in depths approaching 6000 meters, are struggling. They have reached depths between 5500 and 5750 meters, but seem unable to suck in sufficient oil to reach the full ocean depth. Basically, the Deep APEX is gradually starting to work well and become more stable after lots of collaboration with the manufacturer and scientists/technicians. However, the production and deliveries are still unstable and difficult because of a lack of parts and issues in the factory. Teledyne owes two more replacements for JAMSTEC and one for NOC (change from a SBE61 to an RBR 6000 dbar CTD) due to previous failures, but the deliveries are delayed and their delivery date has not been fixed yet.

Deep NINJA (T. Suga, T. Kobayashii)

Capable of profiling up to 4000 dbar, the Deep NINJA has the ability to avoid sea ice and the seafloor. The sensors installed so far are the SBE41CP CTD and JFE Advantech's RINKO DO sensor AROD-FT. There are also enough payload to equip with additional sensors. The communication method is bidirectional with Iridium SBD. The lifetime is currently over 70 profiles, but TSK plans to develop a new buoyancy engine to extend the lifetime to over 100 profiles. Additional sensor installations are underway, and a model with a turbulence sensor, high-speed thermistor, and shear probe provided by Rockland, Canada, is under development. Currently, turbulence data is stored on the float and retrieved after the float is recovered. Models with additional sensors are also in the planning stages.

Deep Arvor (Xavier André)

Xavier reminded us of the main features of the Deep-Arvor: profile is done according to Argo specifications (i.e. profile on ascent), regulation of descent and ascent speed, up to 4000 samples, ISA, and grounding management. Several technical problems have affected the performance of the Deep-Arvor, but are now resolved: hydraulic problem, bluetooth issue resulting in an overconsumption, and bug in the management of the grounding. Of particular note: several water intakes by the optode (mechanical adjustment problem of some parts of the optode). 102 Deep-Arvor were deployed, 58 are active (8 to 155 cycles completed). In 2021, 29 Deep-Arvor have been deployed. Xavier also recalled the strong carryout capabilities of the Deep-Arvor, especially for the cross-comparison of Seabird and RBR CTDs: the 3-headed Deep-Arvor deployed in December 2020 highlighted a pressure effect on the first RBR 6000m CTDs, which design was reviewed by RBR. In March 2022, one 3-headed Deep-Arvor and two 2-headed Deep-Arvor were deployed to validate the evolutions of the RBR 6000m CTD. Finally, Xavier presented the work in progress to integrate the Aanderaa 4330 and JFE Advantech AROD-FT optodes on a Deep-Arvor, to cross-comparison the sensors at sea.

HM4000, HM6000 (Zenghong Liu)

Zenghong Liu introduced the updates on HM4000 & 6000 floats. Last year QNLM (Qingdao Pilot National Laboratory for Marine Science and Technology) deployed 9 HM4000 floats in the NW Pacific, of them 8 are floats with RBR 6k CTD and one with SBE61 CTD. He reported pressure-dependent salinity bias occurred in some floats with RBR CTD and systematic salinity offset in the float with SBE61. In addition, CTD early failure problem is also found in 3 floats with RBR CTD, resulting in the failure of float's diving. This year, QNLM is going to start pilot deployment of HM6000 floats in the NW Pacific.

BGC Argo floats (Ken Johnson, H. Claustre)

Two new float platforms were described. The SOLO-II has been adapted to carry all six recommended BGC sensors. The first units have been successfully deployed. The Jumbo-Provor was also described. It carries additional batteries and has sufficient buoyancy to carry additional sensors. The cost of six sensor floats was noted as a significant problem for many operators.

Sensor progress

SBE61 (N. Zilberman)

Six NOPP Deep SOLO floats were deployed in the Southwest Pacific Basin in March 2021 to define the accuracy and stability of the Kistler pressure sensor (currently used on SBE-61 CTD), and Mensor and Keller pressure sensor candidates based on comparisons with standalone high-quality Quartzdyne pressure sensor. Pressure sensor accuracies on the Deep SOLO floats are ± 4.5 dbar from the Kistler model, and ± 1.5 dbar from the Mensor and Keller, consistent with shipboard measurements. One SBE-61 with Keller showed significant drift. The float was recovered and results showed that the drift was

generated from a CTD leak and unrelated to the pressure sensor. The other SBE-61 with the Keller showed remarkable stability (within ± 0.5 dbar during park). In-lab results from SeaBird and Keller suggested that the Keller pressure stability could be further improved. One SBE-61 with a Mensor showed stability within ± 1 dbar during park, while the other started drifting 6 months after deployment. The source of pressure drift from the CTD with the Mensor sensor is under investigation. Out of 6 NOPP Deep SOLO floats deployed, 3 Deep SOLOs show salinity within targeted ± 0.002 PSS-78 accuracy, and the remaining 3 show salinity accuracy of ± 0.003 - 0.004 PSS-78 using the CPcor value of $-12.5E-8$ recommended by the ADMT. SeaBird has started the development of a method to assess individual CPcor values for SBE-61 CTDs. Future plans include to deploy 6 Deep SOLO floats in the Southwest Pacific Basin in May 2023 to assess the stability of the improved Keller pressure sensor model based on comparisons with Quartzdyne measurements, and to test SeaBird's ability to estimate individual CPcor on SBE-61 CTDs based on comparisons with nearby reference data.

Tracking and monitoring abrupt salinity drift in SBE CTDs (B. Klein) create plots of where these compromised sensors are

On behalf of the working group, Birgit Klein gave an update on the floats affected by abrupt salty drift (ASD). The presentation showed updates from the comparison of raw float data against climatology (CARS/MIMOC). This comparison shows the already known SN cohorts 6000-7000, 8000-9000 and 10482-11252 with high differences between climatology and floats. Beyond these ranges, the occurrences of salty drift are few and random, with the caution that younger floats with SN >11252 have not accumulated long time series yet. Figures can be viewed at http://argo.who.edu/argo/sbedrift_wmo/ and http://argo.who.edu/argo/sbedrift_wmo/SN_cohorts/.

Similar findings were obtained from a spreadsheet on abrupt salty drift operated jointly by all dmqc-operators which contains around 660 entries at the moment with some dmqc still pending. (<https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/edit#gid=0>). In the SN range 10482-11252, in which SBE had identified a manufacturing problem in 2018, 88 floats were entered into the table by the dmqc operators. Only 11 floats were identified beyond the SN range 11252 yet and plots for all of these are included into the presentation. Results from the spreadsheet show that the number of floats deployed with abrupt salty drift is decreasing for now. The number of cycles lost (QC=4) is not going down yet, due to the fact that most of the floats are still alive. About 11% of all PSAL cycles are affected at the moment. Preliminary horizontal maps show a uniform distribution of the cycles over all ocean basins and no specific spatial patterns. Instructions from last ADMT to DMQC operators were reiterated: *'Float salinity data from the ASD phase should be considered as bad and unadjustable'*.

Action item 22: AST thanks the ASD working group for their work and asks that they continue to monitor salty drifters. AST also asks the group to consider making comparisons with CARS more automatic and to reach out to SBE with Argo's analysis of ASDs. B. Klein

Action item 23: AST suggests that the ASD working group meets with Kim Martini and SeaBird in the near future to discuss warranty relief for these floats.

RBR (Clark Richards)

The presentation provided an overview of the current state of the RBR pilot (primary focus on the 2k CTD), and included a summary of all relevant data quality issues addressed or examined to date. The main topics included: a summary of the recent ADMT recommendation to flag real-time PSAL as “good”, an overview of the continued high stability of the RBR CTD compared against climatologies and with the OWC analysis, a summary of the recently submitted manuscript outlining flow-dependent coefficients for the various dynamic error corrections, and a brief overview of new heat modeling work being lead by Breck Owens and Clark Richards to fully understand and quantify the nature of the thermal inertia errors for an RBR cell. The last point of the summary was to show that work on the 6k CTD (made from titanium instead of plastic) will need to progress ASAP to similarly look at dynamic response, as it will need to meet the same criteria as the 2k CTD, but is significantly different in terms of materials and is expected to have very different dynamic response.

In December 2021 the ADMT recommended that any RBRArgo CTD manufactured after April 2021 be flagged with PSAL_QC=1. This recommendation followed work by RBR to implement CTD-specific conductivity compressibility coefficients in their calibration procedure, which was recently validated in the field with a batch of 10 Argo CTDs mounted to a rosette by Mat Dever. The next step will be to see the effect of the new calibration on floats, but to date none have been deployed. Regardless, progress on the compressibility issue is encouraging. On dynamic response, a recent series of experiments with an RBRArgo CTD has been performed in a recirculating flume tank, for the first time providing estimates of the 3 key dynamic correction coefficients (ctcoeff, alpha, tau) as a function of flow speed. The results have been included in a submitted manuscript to JTECH. Evaluation of the speed-dependent corrections on an MRV float configured to run at various speeds with 1Hz sampling through a seasonal mixed layer shows promise, but not all profiles are corrected completely. Regardless, the corrections at least reduce the dynamic error, in particular the “long term” error (which has a time scale of ~150s), which will be important for ensuring that RBR data collected in high gradient regions is not biased. More work to quantify the impact of this correction/undercorrection should be undertaken by the RBR data task team. A potential recommendation for RBR-equipped floats could be to profile them at higher speeds, e.g. 20 cm/s, as the magnitudes of both the long-term and short-term dynamic errors are much reduced at those speeds. Finally, a brief update on the recent work lead by Breck and Clark on thermal modeling of the heat transfer in an RBR cell was presented, including a very preliminary analysis of the RBR6k cell which has not been evaluated for dynamic performance to date.

Action item 24: Noting that RBR CTDs post April-2021 can distribute data in real time with good QC flags, the AST strongly encourages National Programs to ramp up the RBR array and gain experience in distributing, correcting and qc'ing the data.

Action item 25: Ask RBR TT & others who are interested to gather together information on suggested float set up, information needed from float for purchasing. RBR TT, Annie Wong, Susan Wijffels

RBR Argo6000 (V. Thierry/B. King/B. Owens)

V. Thierry presented a few slides prepared by Mat Dever from RBR on the analysis of recent deployments of two 2-head Deep Arvor floats and one 3-head Deep-Arvor float. The 2-head Deep Arvor floats are equipped with a RBRargo3|deep and a SBE61 sensor. The 3-head Deep Arvor floats are equipped with a sSBE41cp, a SBE61 and a RBRargo3|deep sensor.

The 3 floats were deployed from the BO Angeles Alvarino during the RAPROCAN cruise in the Canary Islands in March 2022.

This preliminary analysis focused on the pressure response of the RBRargo3|deep conductivity sensor. Each sensor was individually calibrated as a function of pressure before deployment. The comparison with pre-calibrated SBE9 data reveals that no obvious pressure response was observed as for the earlier version of the sensor for which “a knee” was clearly present at 2500 dbar. Further analysis will be conducted to refine the comparison to the other sensor and to calibrated SBE9 data.

BGC Sensors (H. Claustre, K. Johnson)

Updates on pH, oxygen, nitrate, and chlorophyll sensors were described. Two new versions of the DuraFET pH sensor are in production to improve mechanical reliability. It was also noted that increased rates of failures in Sea-Bird pH sensors and Aanderaa oxygen sensors have been noted on recent deployments. pH sensors with FET serial numbers in the range 10000 to 11118 were noted as prone to early failure. A new version of the SBS oxygen sensor (SBS 83) that is pumped and capable of air calibration was described. Work to incorporate the Trios Opus nitrate sensor on profiling floats was also described. The first units have been deployed in the Baltic Sea. Finally, a version of the Sea-Bird FLBB chlorophyll sensor that operates with an emission wavelength of 435 nm, in addition to the current 470 nm excitation was described.

END OF CLOSED SESSION

Vendors 15h05 - 17h30

End of Day two

Implementation issues continued

AIC Funding (M. Belbéoch)

Mathieu Belbeoch reminded the AST that the Argo Information Centre has been dissolved and OceanOPS has taken its place and is well aligned with other observation networks under the Global Ocean Observing System (GOOS) and WMO. The OceanOPS team consists of 8 - 9 people and they support several observing systems including DBCP, SOT, OceanSITES, GO-SHIP, OceanGliders. Argo constitutes about 20% of OceanOPS and we hope that Victor Turpin will take over as Argo lead since

Mathieu has taken the role of OceanOPS lead. The budget is in good shape and he noted that in the future there will continue to be less travel by OceanOPS, but this has allowed the saved money to be used to hire more people. If you are having trouble contributing to OceanOPS for technical reasons, please inform Mathieu.

EEZ guidelines and strategies (M. Belbéoch)

Recommendations will come out in a Best Practices document as part of the EuroArgo Rise project, but deploying a non-Argo floats is much more work as you need to get clearance to deploy floats in EEZs. Mathieu said that he has learned this week that the IHO has a list of 30 countries that have agreed to share bathymetry measured in their EEZs and he will try to see if Argo and the IHO can work together with countries to make it easier to gather information within their EEZs. He noted that it does depend on the country deploying the instrument and where it is being deployed.

Mathieu reminded the AST that the notification system set up at OceanOPS works once a float is registered and deployed. There are a dozen countries who have asked for notifications when floats drifts into their EEZ. The system runs every Friday and notifies float owners via email. When you receive an email, depending on your country's policy, you may need to make notifications.

He reiterated that if you have sensors in addition to a CTD or the agreed 6 BGC parameters, the deployment and notification process becomes more complex. It is important that OceanOPS be notified of these additional sensors to ensure that proper protocol is being followed under IOC resolutions.

He reported that Argo could try to implement UNCLOS 247 which involves an international organization requesting consent for deployment permission. For example, OceanOPS could create a plan for float deployments in the Gulf of Mexico and then ask the IOC for consent for all the floats rather than each nation asking for consent. Argo could ask GOOS to do a pilot project this year to test UNCLOS 247 and if it goes well, we could do this one year in advance.

Susan Wijffels reinforced Mahtieu's point that it is a privilege to deploy and measure in other country's waters, so please remember this, be respectful, and follow the rules. If you have extra sensors, please apply for UNCLOS permission if you're deploying in EEZs.

Argo Pilot to support Hurricane Prediction (E. Smith /S Jayne)

The US Argo Program conducted a pilot program during the 2021 hurricane season by fast cycling (2.5 days) core Argo floats in the eastern Atlantic and the Gulf of Mexico. These initial conditions provide valuable data for hurricane intensity forecasting. Hurricane Ida passed directly over one float and had some ALAMOs deployed in front of it. Hurricane Ida's intensity increased in a matter of days and the Argo profiles show before the storm of a very warm (>30C) surface ocean to 29C and deepening of the mixed layer. The 2022 Hurricane Season will have similar levels of support to continue this important data set.

Using Argo floats to determine bathymetry (Mathias Jonas)

Mathias Jonas reported on the status of a collaboration between Argo and GEBCO to improve ocean bathymetry through Argo float groundings. This work is being carried out by E. van Wijk, L. Wallace, B.

Halley, and N. Zilberman as well as other members of the Argo Bathymetry Task team and is supported by various Australian agencies, the International Hydrographic Organization, and GEBCO.

Initial work has identified ~216,000 potential groundings of Core Argo floats and ~20,000 potential groundings of Deep Argo floats. As a reminder, Core Argo floats ground occasionally while Deep Argo floats regularly reach the sea floor and ground.

Several regional examples were shown of Argo float depths as compared with current GEBCO bathymetry and there are many potential groundings, but grounding validation work still needs to be carried out. For float depths within +/- 50m of GEBCO depth, the mean depth difference was between 7 and 9 meters for each region. When the float depth was greater than GEBCO by 50m, the mean difference was more than 100 m for each region.

To reiterate, there is still work to be done to validate the groundings and this depends on float type and behavior. Further updates will be shared at future meetings.

EuroArgo Status including EuroArgo Rise Project (C. Gourcuff)

Claire presented the status of Euro-Argo activities, focussing on Euro-Argo RISE EU results. The project is in line with the objectives of the Euro-Argo Research Infrastructure. It has been funded for 4 years, with 19 partners sharing 4M€. It is in its final year. 30 reports are already available on the project webpage at the moment. Progress has been made in 4 main areas:

- Technology: partners worked on assessing new sensors for the core mission (RBR CTDs, with Arvor floats from NKE now available with RBR CTDs), the Deep mission (RBR & SBE61, tested on 1 3-head float and 2 2-head floats, as presented by Virginie on Thursday), and the BGC mission (OPUS for nitrates, with measurements of the first test showing potential, which will be further studied in a German project starting this year – see Henry's presentation of Thursday, and RAMSES sensor for Irradiance which show very promising results). An extensive study of floats behavior at sea has been performed with recommendations for float lifetime increase reported in D2.6 as well as in a condensed version. Argo floats were deployed in coastal shallow areas of the 3 European marginal Seas (Baltic, Black and Mediterranean Seas): analysis of the tests is in progress and recommendations will be provided at the end of this year. Recommendations for deploying floats in the Arctic are available in D5.1 (see Ingrid's presentation). A virtual fleet software was developed and used for optimization of mission parameters in order to improve the sampling of Boundary Currents with Argo.
- Data management: Activities have also been performed for the core mission (new DMQC method, improvement of the Reference data base, vocabulary, etc), the Deep mission (implementation of new data corrections, work on deep reference data for DMQC, organization of the 3rd international Deep Argo workshop) and the BGC mission (development of new QC procedures for Oxygen, Chl_a, NO₃, BBP and Irradiance, organization of BGC data management within Europe)
- Services to users: the Argo Online School has been finalized, the new data selection portal associated with the Coriolis GDAC has been released, and Euro-Argo has also started to work on Argo used cases to highlight the usefulness of Argo in various applications. A new web application was developed to help operators in float recoveries, and work on the *Argopy* python

library was continued. A Memorandum of Understanding was signed with the Copernicus Marine Service to foster collaboration.

- Community enhancement: various events were organized targeting various stakeholders: Political Argo event, regional Argo workshops, science meeting in Athens, Ocean Observers educational workshop, series of informal meetings with manufacturers and a Marine RIs side event to the 9th EuroGOOS Conference. Following the regional workshops, several countries expressed their interest in joining the Euro-Argo community, and Denmark became a new Candidate Member in December 2020.

In the current year, Euro-Argo will deliver 3 important reports: its strategic, sustainability & implementation plans. As part of Euro-Argo RISE & EuroSea EU projects, we will organize the 7th Argo Science Workshop together with the international committee formed late 2020. Euro-Argo is also participating in several new EU projects & proposals, and is continuing its lobby activities to try to get substantial EU fundings to complement national efforts towards the OneArgo implementation in the next decade.

Argo in Denmark (Fletcher Thompson)

Denmark is a candidate member of EuroArgo and they have purchased 2 Provor CTS5 Jumbo floats, with one deployed in the Fram Strait. Argo floats would contribute to Denmark's efforts to better sample and understand the Arctic Ocean which is a challenging environment to sample. They hope to learn more about Argo and to establish national support for a sustained contribution to EuroArgo. They also noted that they are happy to help with deployments and retrievals in the North Atlantic and Arctic region, including through a collaboration with the Royal Danish Navy.

Argo in Indonesia (Nelly Florida)

Indonesia is an archipelago located between two continents and two large oceans along the equator and they experience many weather events such as El Nino, IOD, Monsoon and MJO. As we know, the weather and climate really depend on the behavior of the ocean and the density of ocean observations in Indonesia's inner sea is not sufficient to support the Indonesian Government's (BMKG) operations. Therefore, our government wants to fill the ocean observation gaps by deploying surface drifters and floats, especially in our inner seas and in our EEZ. There are plans to deploy 15 drifters and 10 Argo floats in 2022. The first deployment was two weeks ago on March 12, 2022 and Indonesia plans to continue to deploy floats over time.

Core Argo Best Practices paper (Tammy Morris)

Tammy Morris provided an update on the status of the Core Argo Best Practices work that has been occurring since AST-22, including a layout for the proposed paper. The main sections will include:

- An introduction
- Getting started in the Argo Program
- Physical handling of floats
- Metadata
- Data

- Additional considerations

She noted that in addition to the paper, there will be links to multi-media showing how to use the OceanOPS system, float deployments and, where possible, float testing. This will be included as supplementary material on the Ocean Best Practices System (OBPS). Hopefully these media will rely as little as possible on language so that they can be widely distributed and used.

The goal is to finish a draft of the document by the end of June 2022 after which it will be shared with the Argo community for feedback. After feedback has been received and incorporated, the document will be sent to co-chairs of both the AST and ADMT for endorsement and then sent onto the OCG co-chair for Best Practices (Juliet Hermes). After that, it will hopefully be endorsed by the GOOS team, and then will be published with OBPS as a community and GOOS endorsed paper with a DOI reference.

A summarized version will be published within Frontiers with links to the full version and supplementary material. The Best Practices work will then be presented at various Argo and OBPS workshops over the next year.

Report from Argo Tech Community of Practice working group

(Pat McMahon, <http://www.cmar.csiro.au/argo/dmqc/html/ArgoCop.html>)

Pat McMahon provided an overview of a new Argo Technicians Community of Practice which he founded in September 2021 with the support of the AST co-chairs.

The CoP targets technicians and people directly involved in preparing floats for deployment.

His main motivation for forming the group was to create a space for shared ideas and collaboration in the technical sphere.

By forming the working group, Pat hopes we will be more agile as a community when it comes to identifying emerging failure modes and outcomes will be mutually beneficial for the Argo community and vendors alike.

The Argo Technicians CoP meets quarterly over Zoom with the chair and responsibility for setting the agenda rotated amongst the group.

Groups and Individuals are encouraged to lead discussions and share resources (automated scripts and procedures) on the groups Slack account.

The group is currently closed to vendors, however Pat hopes to host virtual field days where a manufacturer is invited to speak to the group outside the quarterly meeting.

For further information, or to get involved contact pat.mcmahon@csiro.au

Demonstrating Argo's value

Argo bibliography (M. Scanderbeg)

M. Scanderbeg reported that 500+ Argo papers per year were found in the past three years with a slight decrease in 2021. Overall, most of the statistics that are regularly tracked continued on their current trajectories:

- Data source in the papers continues to move away from GDACs and towards secondary products and databases of curated profiles
- BGC and Deep Argo missions continue to add more papers each year
- Argo DOI and Acknowledgements continue to be more frequent
- New countries continue publishing papers with Thailand being added in 2021
- Argo PI as an author continues to trend down to about 15% of all papers including an Argo PI

She also presented a brief analysis of the statistics on the Argo DOI download provided by SENOE. She noted that Argo DOI data was downloaded from 100 countries and even all seven continents. The number of countries was increased as compared to 2020 and the number of downloads was up 130%.

She plans to continue monitoring the Argo bibliography and hopes to update it quarterly in 2022. She will also report to the steering team on the bibliographic analysis from IFREMER when she receives it in April.

Argo Steering Team Website & Program Office Updates (M. Scanderbeg)

M. Scanderbeg reported on updates to the AST website in the past year. She noted that the 'Next Phase' tab was updated with the OneArgo design, a new page was added on OceanOPs, the Data FAQs were updated with additional ways to access BGC data and links were added for GitHub repositories that include both QC software and tools.

She reported on a survey sent out to Argo data product producers which overall indicated that they apply QC flags, do their own additional QC, mostly use adjusted data, but need to refresh their Argo profiles more frequently. It was agreed that this information was interesting to learn, but would not be posted on the AST website.

She presented information on the top visited webpages and many of them were related to data, visualizations, products as well as the status and about pages. This is a change from previous years when the bibliography and FAQ pages were often included in the most visited pages.

In the coming year, she hopes to improve the different mission webpages and asked for help on how best to monitor OneArgo coverage so it can be displayed clearly on the AST website.

Finally, she reported on the topic of emails sent to argo@ucsd.edu and support@argo.net. She was happy to report that there were no questions on how to cite Argo data and only one question on the environmental impact of Argo floats, both of which used to produce several emails a year. This implies that the AST website is doing a better job of communicating on these topics. There were many requests

related to data and how to access it, the usual questions about image permissions, the float technology, best practices, website difficulties and offers of cruises by individuals interested in deploying Argo floats.

Action item 26: Ask for a volunteer from each Mission Team, Megan and OceanOPS to develop OneArgo coverage tracking or density

Data visualizations (D. Giglio, M. Scanderbeg)

Donata Giglio reported on educational activities using the Argovis web app and database, as well as upcoming features of the new Argovis API that will be arriving later in 2022. She reminded the audience the goal of the Argovis web app and database is to make it easier for anyone (both scientists and non-scientists) to visualize and access co-located datasets using a browser or via API.

She explained that Argovis works by building a URL based on selection parameters that may include start and end date, selection area, variable of interest and more. This URL can be used in the browser or in your own programming environment to access data in Argovis using the Argovis API.

There are currently Jupyter Notebooks that have been created to access Argo data via Argovis and plot it; these are available on the Argovis education module webpage: [Argovis Education Module API \(colorado.edu\)](https://argovis.colorado.edu). Dr. Giglio noted that these notebooks will have to be updated when the new version of the Argovis API is released later in 2022. An early demo notebook for the new Argovis API will be posted on GitHub in summer 2022. On the Argovis website, there is also a section with educational activities using the [web interface](#) which will be updated as well later in 2022.

The new release of the Argovis API will include the following datasets:

- Argo profiles
- GO-SHIP and other public CCDHO profiles
- Roemmich and Gilson climatology
- Tropical cyclone track data
- Float trajectory forecasts by Chamberlin et al

New features in the upcoming release will include the ability to search for Argo data by variable (e.g. temperature, oxygen, etc), source of data (e.g. Argo, BGC-Argo, GO-SHIP, etc), and data mode (e.g. real time, adjusted or delayed mode). One will also be able to search by WOCE line and to co-locate GO-SHIP profiles and Argo profiles.

Please reach out with suggestions or comments on the Argovis web app. We plan to have demo notebooks of the new Argovis API available in the summer of 2022 on the educational web pages listed above.

Here are some useful links:

- argovis.colorado.edu
- Educational activities are available at https://argovis.colorado.edu/docs/Argovis_EdModule.html

- A user guide is available on the website at https://argovis.colorado.edu/docs/Argovis_User_Guide.html
- Please reach out if you have any questions/feedback! https://argovis.colorado.edu/docs/Argovis_About.html#contact
- User guide and educational activities will be updated as Argovis API and frontend are upgraded

Océans Connectés (C. Saout)

Océans Connectés - Connected Oceans - is a new online media totally dedicated to marine sciences. <https://oceansconnectes.org/en/home/>

It aims at informing on “oceanography on progress” showing news on at-sea campaigns or activities, as well as developments and innovations in laboratories or companies. It’s also opening a new space to share events or open jobs in marine sciences.

By showing and informing ocean sciences, the main objective of this media is :

- to link the scientific community with society (stakeholders, industries, associations, citizens etc..),
- to inspire oceanographic careers or innovations,
- to impact by pushing people to act for ocean protection.

By increasing the visibility of marine science and sharing our knowledge with as many people as possible, we will participate in the construction of a common and shared culture of the oceans. We think this step is a prerequisite for collective and sustainable actions for the oceans.

This project of “connected oceans” is innovative -there is no such global hub for oceanography, and aims to be both collective and virtuous for marine sciences itself.

Many partners are sustaining océans connectés. But we are focused on reaching many more, because we want to bring together worldwide institutes and laboratories who are working in oceanography, around this place of “oceans connectes”.

In 2022, we aim to expand our team and develop new products and services.

Action item 27: Contact oceans connectes if you want to share news on your activities, if you want to announce an event or an open job in your lab or company, or if you want to share resources you have (images, videos, podcasts, other media articles, educational resources etc...). Contact oceans connectes also if you want your institute or your lab to be part of the “connected oceans” community !

Culture Océan : outreach activities (Carolyn Scheurle : IMEV-LOV)

Ocean literacy is becoming more important and is part of the UN Decade. Defined as: understanding of the ocean's influence on you and your influence on the ocean.

Activities are based on four axes:

- Scientific projects with a scientific mediation and communication component
- Projects and programs dedicated to science outreach
- Specific events and actions on local, national and international level
- Involvement in international ocean literacy committees and networks

'The Ocean' collection is part of the online journal Frontiers for Young Minds. Mainly focused on ocean sciences. The collection launched in OceanObs19 and we are working to make the collections more accessible via translations and multimedia resources. Please contribute if you're interested. Each article has a DOI. You can also become a mentor.

Adopt a float:

Classrooms get to name their float and visit the lab, if at all possible. Now we have around 900 students! Interactive map, handbook. Each class has a science

We're always looking for float deployment or scientific field work videos

Action item 28: Please consider sending float deployment or other scientific field work videos to Culture Ocean. [Culture océan | EN - Outreach & Promotion of scientific culture \(culture-ocean.com\)](https://culture-ocean.com)

2nd Ocean Observers Workshop Report (E. Rusciano)

E. Rusciano from OceanOPS provided a brief report about the Ocean Observers initiative and the 2nd workshop organized in November/December 2021 in collaboration with C. Gourcuff and M. Bollard from Euro-Argo.

In the last part of her presentation she also briefly introduced and gave an update about the Ocean Observing System Report Card.

The Ocean Observers initiative is an international education network made up of different actors, such as scientists, educators, marine communicators, who are willing to share experiences on educational activities related to in situ ocean observations.

Even if the Ocean Observers initiative aims at enhancing the integrated value of all observing activities for educational purposes, the Argo component is the most represented in this initiative showing that the Argo community is actively involved in outreach and educational activities.

The Ocean Observers initiative was born in 2017 with the organization of the 1st workshop and the establishment of an international and multidisciplinary Working Group in charge of coordinating the initiative. The Ocean observers goals are to:

1. Share expertise and materials related to ocean observations;

2. Establish international collaborative activities;
3. Assemble multi-languages educational materials in a unique, free repository, to build a global ocean observation learning platform www.oceanobservers.org

The 2nd workshop was organized on 29-30 November and 1 December 2021 as a virtual event, with two sessions per day of 2 hours each, one in the morning and the other in the afternoon, in order to allow people from different time zones to attend the workshop.

The workshop was simultaneously translated in English, Spanish and French. The workshop was organized by the Ocean Observers Working Group in the framework of the European Union H2020 Euro-Argo RISE project, and it was endorsed by the UN Ocean Decade as a Decade action. The objectives of the workshop were to:

- Review existing initiatives;
- Support discussions & bring up collaboration between participants;
- Engage new people in ocean observing educational activities;
- Give educators marine science information they could apply to their environment;
- Give scientists tools to share their results with the public at large.

The workshop was attended by several dozen participants. We received 160 registrations and up to 70 participants for the first session from 22 countries, mainly from France, Spain, Ireland, and the US but also there were some representatives from South Africa, the Netherlands, South Korea, Kuwait, New Zealand, etc, with a wide representation of people from diverse sectors. Most of the participants were communicators, scientific outreach officers and scientists, and almost all attendees were already well involved in educational activities. Globally, the workshop was very well received, and the preliminary feedback was very positive, with very interesting discussions. During the workshop, people also seemed to be very interested in developing new international collaborations and despite a large variety of activities presented, many connections were made between people engaged in educational activities developed in different countries. After the workshop we set up a questionnaire and we received a lot of good feedback about the content and the organization of the event. As organizers of the event, we think that the great success of this workshop was mainly due to the commitment of the Working Group who helped us a lot with the organization of the workshop, as well as the enthusiasm and involvement of all attendees, the sessions' chairs, and moderators.

Some of the main concepts that were highlighted during these three days, and that we should keep in mind when we carry out educational activities are that:

1. Ocean science can be addressed in different disciplines, not only science (e.g. art, geography, language classes, etc.)
2. Covid-19, despite its disadvantages, allowed the development of new ways to communicate and educate;
3. Educational activities should be complemented by restitution days and diplomas to promote students' work ;
4. It is important to ask for participants feedback after each educational activity;
5. There is a need to develop interactions between scientists/engineers and teachers, especially to adapt the existing scientific data visualization tools to educational purposes for young minds;
6. It is important to "humanize" ocean science.

What we proposed at the end of the workshop as future perspectives is to:

1. Assemble educational materials presented during the workshop and gather new multilanguage resources to populate the website;

2. Keep the community and the initiative alive, through promoting new collaborations, publishing news about the initiative and brainstorming about the 3rd workshop.
3. Make known the Ocean Observers initiative worldwide, presenting the initiative during conferences and workshops and using the #OceanObservers on Twitter
4. Engage with new schools & educators
5. Look for new human and financial resources to continue developing the community.

Currently, we are making a short (3-4 minute) video to summarize and promote the initiative and the workshop. The preliminary work on the video was done by an intern recruited in February, and it will be finalized and published soon and disseminated through OceanOPS and Euro-Argo social media channels. We have also recruited a 6-months intern (during April- September) to collate new educational materials and populate the website and to develop a brochure to communicate about the initiative.

Ocean Observing System Report Card Update

The report card is an annual report on the global ocean observing system from the GOOS OCG – 6th edition in 2022. The objectives of this publication are to:

1. communicate on the status and value of the GOOS (starting from societal applications of OO through to human stories)
2. assess observing networks progress
3. focus on challenges needed to keep improving the observing system
4. encourage international collaboration and new partners to join the ocean observing community.

The audience includes the ocean observing community, funders and implementers of the observing system, high-level stakeholders and decision makers and WMO-IOC Member States and countries. The Editorial Board at the heart of the report is renewed each year and it is currently open. The report is published and disseminated in three formats: printed, electronic and pdf versions. A survey questionnaire and statistics carried out during past years has showed that the report is considered very useful and informative and about 10,000 users have accessed the web version, while the PDF version was downloaded almost 30,000 times last year. During the past editions of the Report, Argo was at the heart of the report highlighting, through human stories, the value of Argo observations to address many societal applications. Some of the stories include the high value of Argo real-time observations for tropical cyclone forecasting and sea level rise monitoring. Argo was also highlighted as a main contributor to educational and outreach activities and as a unique example of international scientific collaboration. In 2019 the report card also focused on the 2 million profiles milestone. During the last 2 years one main focus of the report was the monitoring of ocean oxygen and acidification through the BGC Argo Mission expansion. This year, the Report Card will evolve towards a more broader GOOS Report with a focus on BioEco and BGC observations and stories. The Report will focus on:

1. the in situ and satellite ocean observation status
2. Networks expansion and extending capabilities
3. International collaborations and capacity development stories
4. Cross-network stories around the 3 GOOS delivery areas with and EOVs/ECVs view

It will be released at the end of June, the first call with the Editorial Board was set up at the end of March. Emanuela also asked the Argo community to not hesitate to contact her to join the Editorial Board or to share some cross-network stories for the report. Breck Owens volunteered to join the editorial board.

Upcoming science conferences and technical workshops –

Argo Science Workshop in Brussels 11 – 13 October 2022 (C. Gourcuff)

The dates for the 7th Argo Science Workshop are 11-13 October 2022, in Brussels (room booked at the Royal Belgium Museum). An organizing committee has been set up, but additional volunteers are still welcome, especially experts from BGC Argo and people from Asia. During the first committee meeting, there was an agreement for the event to be a hybrid meeting. The call for abstracts has been drafted and should be ready to publish after a second meeting is organized early April. As this event can not cover all, it was agreed at AST23 meeting to focus our efforts on attracting the satellite and modeling/assimilation communities.

Boundary Current workshop (Tammy Morris)

As part of OCG-12 (2021), workshops were held prior to the meeting to enhance cross-network collaborations. One of these was for Boundary Currents, which looked at the various ways ocean observing platforms are used to monitor eastern and western boundary currents. An article was produced for *Frontiers in Ocean Observing for Oceanography* (<https://tos.org/oceanography/issue/volume-34-issue-04-supplement>). A second workshop is planned prior to OCG-13 on 24 May to continue this discussion, particularly around how changes to standard missions could be actioned to increase observations. The work will also be presented as an exemplar project for the GOOS Co-Design Workshop (7-9 June 2022), which will hopefully generate funding for a pilot boundary current ocean observing system.

There is also some work being presented at the Eastern Boundary Upwelling System (EBUS) conference in Lima, Peru, to look at instrumenting and monitoring eastern boundary systems (<https://www.ebus-lima2022.com/>).

Saving Ukrainian Data (Steve Diggs)

Steve Diggs reported that he has learned that physical data repositories might be at risk in Ukraine and asks that you contact him if you know of someone with data repositories in Ukraine or if you would like to be involved in any of these efforts.

ADMT-23: AOML

AOML plans to host the ADMT meeting later this year with the understanding that it will be a hybrid event. The ADMT co-chairs will work with an organizing committee to try and implement some of the current best practices around hybrid meetings and EDI.

AST-24 (B. Greenan)

Blair is offering to host AST-24 in Halifax next year in March and is investigating venues for a hybrid meeting.

AST Membership

Susan Wijffels took the opportunity to remind the AST that AST members are responsible for communicating with the other members of their team and to ask for any new AST members to make themselves known. As Dean Roemmich noted, AST membership has never been exclusive and it is possible to have more than one representative per country if needed. Each Nation should feel free to nominate whoever they would prefer.

Mathieu and Susan both noted that at times, it is still important to have a single person to notify in terms of deployment and EEZ issues. So, if a country has more than one representative, please choose one who will be the primary contact in those situations.

Action item 29: Please let Megan Scanderbeg and Mathieu Belbeoch/OceanOPS know of new AST members. (Denmark, Portugal, Saudi Arabia, others?)

Action item 30: AST members are asked to disseminate information to all other Argo PIs and support people in their Nation/Group

Other business

- 1.1. IEEE Award to the Argo Program: “For innovation in large-scale autonomous observations in oceanography with global impacts in marine and climate science and technology.”

Susan Wijffels thanked Dean for nominating Argo for this award and said she would be on hand to receive the award and give a short speech. Megan Scanderbeg suggested that Argo create a virtual award gallery on the AST website to celebrate this and other awards that Argo has received.

Extra time for discussions that arise

Meeting adjourns Friday 25 March

Action	Responsible	Status	Notes
1 Ask AST co-chairs to write to IHO with a letter of thanks			
2 Establish a regular virtual Argo-ForeSea/OceanPredict Forum: The purpose of this new forum is to initially address the problem that the operational and modeling centers (including reanalysis centers) may mis-use Argo data due to a lack of direct and regular information exchange with the Argo community. These centers should be considered as key users of Argo and specific interfaces/information channels should be set up with them. One output could be first 'What's new with Argo' communication on status of Argo data with understanding it will be updated regularly (every 4-6 months)	Peter Oke, Pierre-Yves LeTraon, Emily Smith, Susan Wijffels, Yosuki, Annie Wong, Catherine Schmectig, Megan Scanderbeg, Claire Gourcuff ADMT and AST people		
3 Ask Mathieu to watch GBON (Global Basic Observing Network) and let us know when Argo needs to prepare Argo service specifications and best practices	Mathieu Belbeoch		
4 Ask Mathieu for help to organize a side event with WMO to help champion OneArgo.			
5 Ask EA Rise to report back to AST on Boundary Current study	Ingrid		
6 Ask Tammy Morris to keep AST informed on Western Boundary Current OCG working group. Ask for virtual participation at upcoming (East & West) workshop in early May. Interested in synergies with glider community, piloting in boundary currents.	Nathalie Zilberman, Ingrid, Miguel, V. Turpin		
7 Explore how to create a product that contains only good data on standard depth levels with error bars. Explore how the standard depth level products that Argo points to are created and how Argo might be able to create such a product.	Sarah Purkey, Peter Oke, Susan Wijffels, Annie Wong, Claire Gourcuff, Nicolas Kolodziejck		
8 Ask OceanOPS to explore making density coverage plots based on good quality parameters.			
9 Ask that float deployers please inform OceanOPS upon deployment if ice-detection software is included in the float			
10 Consider adding information to profile files to indicate if a float has detected ice. Ask ADMT to discuss	Polar Mission Team, ADMT		
11 The AST suggests the formation of a Polar Mission team, in a similar manner to the Deep and BGC Argo Mission teams, with terms of reference, and a webpage on AST website. Consider looking for leadership from current SOARC groups and Arctic groups.	Nicolas Kolodziejcyk, Alison Gray, Ingrid Angel, Mathieu from takuvik in Canada, Esmee van Wijk, Steve Jayne		
12 Revisit list of UN Decade Activities that AST members can collaborate with. M. Scanderbeg, AST members			
13 AST encourages studies of enhanced oxygen sampling in core and/or deep with clear articulation of the cost benefit over current OneArgo design. Being considered in Deep Argo implementation paper.	Virginie Thierry, Ken Johnson, Roo Nicolson?, Claire Gourcuff		
14 Form basin deployment planning teams that meet regularly and report back at each AST and ADMT meeting. These teams need to include people who actually plan deployments. Highest priority is on the western Indian Ocean. Also need to identify one person who will interact with an individual cruise. OceanOPS would like to support this effort and will continue to receive deployment plans	Basin leads: Indian: Tammy Morris, Patabhi Rama Pacific: Sarah Purkey, Shigeki Hosoda Atlantic: Fiona Carse, OceanOPS		IHO regularly sends ships to Antarctica
15 Ask for more clarification on drift sampling and whether radiometer is suggested every hour or once per drift. Explore which float types can sample just the recommended T & P and whether this recommendation can be followed.	Float Sampling Working group led by S. Riser		
16 Investigate further the recommendation from Sampling Working group for floats with radiometers to do an a noon profile every 1-2 months. Explore how this might technically work with floats.	Float Sampling Working group to reach out to float type experts		
17 Follow the recommendations from the Float Sampling Working group to cycle 10+ small amount to randomize the time of day floats arrive at the surface			
18 Ask Mathieu Belbeoch to ask IOC to send a new circular letter asking for new national focal points			
19 Ask ADMT, Deep, BGC co-chairs to work with V. Turpin to study and improve KPIs on OceanOPS.	ADMT co-chairs, Deep co-chairs, BGC co-chairs		
20 AST suggests another DAC workshop. Suggest Thierry Carval, Tanya Maurer, Claudia Schmid to lead.			
21 AST asks all Deep SOLOs that can be, to be reprogrammed to profile on ascent to accommodate the operational community. Include details from Nathalie about suggested sampling scheme to follow.			
22 AST thanks the ASD working group for their work and asks that they continue to monitor salty drifters. AST also asks the group to consider making comparisons with CARS more automatic and to reach out to SBE with Argo's analysis of ASDs.	B. Klein		
23 AST suggests that the ASD working group meets with Kim Martini and SeaBird in the near future to discuss warranty relief for these floats.	ASD, SBE		
24 Noting that RBR CTDs post April-2021 can distribute data in real time with good QC flags, the AST strongly encourages National Programs to ramp up the RBR array and gain experience in distributing, correcting and qc'ing the data.			
25 Ask RBR TT & others who are interested to gather together information on suggested float set up, information needed from float for purchasing.	RBR TT, Annie Wong, Susan Wijffels		
26 Ask for a volunteer from each Mission Team, Megan and OceanOPS to develop OneArgo coverage tracking or density			
27 Contact oceans connectes if you want to share news on your activities, if you want to announce an event or an open job in your lab or company, or if you want to share resources you have (images, videos, podcasts, other media articles, educational resources etc...). Contact oceans connectes also if you want your institute or your lab to be part of the "connected oceans" community ! https://oceansconnectes.org/en/home/			
28 Please consider sending float deployment or other scientific field work videos to Culture Ocean: https://culture-ocean.com/index-en.html			
29 Please let Megan and OceanOPS know of new AST members. (Denmark, Portugal, Saudi Arabia?)			
30 AST members are asked to disseminate information to all other Argo PIs and support people in their Nation/Group			

Argo Australia National Report 2022 – AST-23

Peter Oke¹, Pat McMahon¹, Christina Schallenberg^{1,3}, Jenny Lovell¹, Gabriela Pilo^{1,3}, Esmee Van Wijk¹, Peter Strutton³, Tom Trull¹, Tatiana Rykova¹, Annie Foppert³, Craig Hanstein¹, Catriona Johnson¹, Lisa Krummel², Beatriz Pena-Molino¹, Steve Rintoul¹, Roger Scott¹, Dirk Slawinski¹,
¹CSIRO Oceans and Atmosphere; ²Bureau of Meteorology; ³University of Tasmania

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. Floats deployed and their performance

During 2021, Argo Australia deployed 76 floats, including 67 Core floats, 7 BGC floats, and 2 Deep floats. The locations of the floats deployed in 2021 are shown in in Figure 1. We deployed floats from 9 different vessels¹.

We had more early failures than usual during 2021. We had 7 core floats fail with early battery depletion, and we had 15 (out of 35) core APF11s, all ordered in 2019, that have developed a bladder air entrapment problem.

We deployed 7 BGC floats in 2021, including a mix of APEX and PROVOR, all with 6 BGC sensors. Three floats (all APEX) went under the ice (and haven't resurfaced). The other four, all deployed in the tropics and subtropics, are operating well. However, the pH sensor on two of those floats (one APEX and one PROVOR) failed on deployment.

One of the 2 MRV Deep SOLO floats deployed this year (7900923) failed early after 40 cycles. Fortunately, the float had not drifted too far in the month after deployment and was able to be retrieved by L'Astrolabe on their second search attempt. The float has been returned to MRV so that we can determine what happened. We also had some issues with our first cohort of Deep floats not reliably picking up new missions (some did and some didn't, and we are unsure of the exact cause).

b. Technical problems encountered and solved

Argo Australia activities that have encountered technical problems or identified technical solutions include:

- Establishing an Argo Technical Community of Practice;
- Development of a remote-controlled Argo Release;
- BGC decoding;

¹ Aurora Australis, Everest, RV Investigator, Falkor, Antarctic Discovery, Tangaroa, Antarctic Aurora, RV Kaharoa, Outer Limit

- Identification of APF11s with early battery depletion;
- Identification of pneumatic air loss issues seen on a subset of APF11's ordered in 2019;
- Identification of cohort of BGC APF11 floats that failed to surface after going under ice;
- Floats with RBR CTDs; and
- Estimation of Argo trajectories under ice.

These activities and issues are described below.

Argo Technical Community of Practice

A new Argo Technical Community of Practice (CoP) was established in 2021. The Argo Technical CoP is a forum for collaboration, knowledge sharing, and coordinated action between Argo Technicians. The CoP aims to establish, review, and refine best practice procedures for pre-deployment testing of floats to eliminate premature deaths and performance-debilitating failures for core and BGC Argo. A summary of recent and upcoming Argo Technical CoP activities follows:

- September 2021 – Argo Technical CoP endorsed by AST Co-Chairs
- October 2021 – Established Terms of Reference with founding group
- January 2022 – Discussion of NAVIS floats
- April 2022 – Discussion of APEX floats

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

<http://www.cmar.csiro.au/argo/dmqc/html/ArgoCop.html>

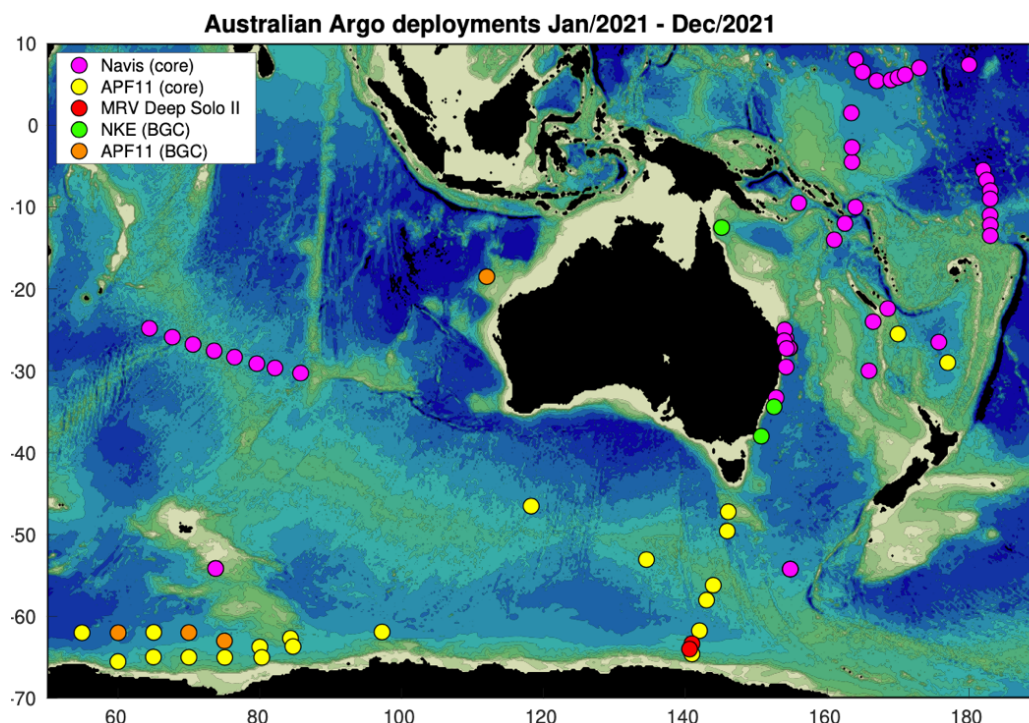


Figure 1: Map showing the deployment locations for floats deployed by Argo Australia in 2021. The colours of the dots denote the float types.

Remote-Controlled Argo Release

Early morning on 23 February 2022, the L’Astrolabe deployed an Argo float at 60S using a Remote-Controlled Argo release. The deployment was uneventful and the float started operating on deployment as expected. The Argo release is the first of its kind, invented by Pat McMahon. Use of the Argo Release significantly reduces the safety risks associated with Argo deployments, which is particularly important at high latitudes and in rough seas, and reduces the risk of failed deployments (which risks damage to floats). Some photos of the release are presented in Figure 2.



Figure 2: Photos of the Argo Release gear (left), the unit ready for deployment (middle), and a test on CSIRO’s wharf in Hobart (right).

APF11s with early battery depletion

CSIRO noticed that a batch of APEX floats have shown an early battery depletion – often at around profile 88 (with all floats on a standard 10-day mission). We traced this to a batch of floats ordered from TWR in 2018. That order included 24 APEX floats. Of those 24 floats, 7 are dead, apparently with early battery depletion; 3 others are showing signs of early battery depletion. It’s possible that the problem is unique to CSIRO’s floats. Floats operated by other DACs that failed around 80 to 110 profiles might be worth assessing for this problem. Perhaps the Argo Technician CoP will look at this together.

Pneumatic air loss issues seen on a subset of APF11’s ordered in 2019

A number of APF11’s, ordered in 2019, have developed a bladder air entrapment problem. It causes air to be forced out of the bladder and results in a high internal vacuum, which the air pumps can’t overcome to fully inflate the bladder at the surface. The problem causes floats to intermittently miss GPS fixes and results in poor telecommunication (resulting in higher-than-normal telecommunication costs). Once the internal vacuum reaches 5 dbar, the air pumps will run for 10 minutes before timing out, when they can’t overcome the increased internal vacuum

to inflate the bladders. We're working with TWR to estimate the number of years per float until the vacuums reach 5 dbar.

We are also working with TWR to diagnose whether a firmware problem in 2.15.0 and earlier could also be causing the bladders to not fully inflate. We identified four undeployed floats in the same Hull range as the floats which developed the bladder air entrapment problem. These have been returned to TWR for a bladder replacement.

Suspected Failed BGC floats

During Austral summer 2021, we deployed 12 APF11 floats, including 3 APF11 BGC floats. All floats used firmware version 2.15.0 or an earlier revision with the exception of one float which used UW Swiftware. All three BGC floats failed to resurface after going under ice. Seven other floats, deployed on the same voyage, but farther south, have all reported after going under ice and the two floats deployed further north have reported as expected in February 2022. Only the BGC floats in this cohort failed to surface.

After deployment, we learnt that all of these floats were incorrectly ballasted. They all have a carbon hull, but were ballasted as if they have aluminium hulls. Probably as a result of the ballasting, two of the three floats descended deeper than 2000m on deployment (they all had a park depth of 2000m). After the floats performed 16 profiles, we changed the park depth to 1500m for winter.

Also, after deployment, TWR requested that undeployed floats running firmware version 2.15.0 be upgraded to 2.15.4 or 2.15.5. They noted that using version 2.15.0, a float may perform a fake inflate – causing the air bladder to inflate too early. This behaviour was fixed in 2.15.1. We note that two of the three BGC floats which failed to surface after going under ice attempted to inflate the air bladders early during the first 16 profiles.

We deployed a fourth APF11 BGC float (with hull number 9279 – WMO 7900935) the sub-tropics. Unlike the floats deployed at high latitude, this BGC float had its firmware updated to 2.15.4 before leaving TWR and was corrected ballasted as a carbon hull. It's performing well.

Floats with RBR CTDs

Nine ALTO floats with RBR sensors are operating. The presentation by M.Dever at ADMT22 listed all nine as having reference data identified. We have not yet received updated calibration coefficients for these floats. In addition, one float with an early pilot RBR sensor has recently died. Processing of the data from this float will require collaboration with RBR to determine calibration procedures.

In addition, we have 8 floats in the lab that have RBR sensors. We intend to deploy each of these with a 'buddy' float that has a Seabird CTD and to sample daily for an initial period in order to collect a good reference dataset.

Estimating Argo trajectories under ice

It's well known that Over 26,000 Argo profiles have sampled under ice at high-southern latitudes, and are disseminated without measured positions. We know of three papers that describe methods for estimating these trajectories: one applied to grounded floats, using bathymetry and depth of bottom measurements; and two that assume trajectories approximately follow depth, or potential vorticity contours. We developed a system that assumes trajectories approximately follow contours of potential vorticity. We found that it failed in some regions. We generalised the method to assume that other fields might be approximately conserved along trajectories. We used mean sea-level and density at 1000 m depth. All of these constraints failed for some cases. But when used together, we found that we could produce trajectories for over 99% of cases. In some cases, our method produces three estimates for unknown trajectories. We could easily add additional fields to produce more. We wonder whether this estimation could be part of the DMQC process. Perhaps multiple estimates of trajectories could be produced – and then an expert operator could look at the estimated trajectories, and considering the oceanography, past trajectories in the region, etc, they could select the trajectory that they think is most realistic. An example is presented in Figure 3. We've submitted a paper describing our method for peer review:

Oke, P. R., T. Rykova, G. S. Pilo, J. L. Lovell, 2022: Estimating Argo float trajectories under ice, submitted to *JGR Earth and Space Science*.

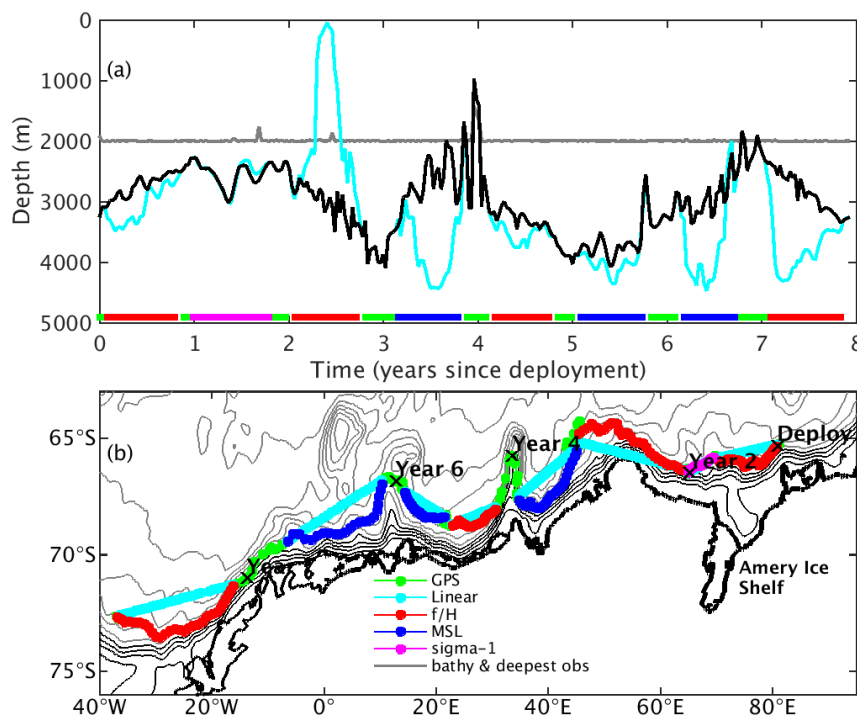


Figure 3: Example of the estimated trajectory for float 7900310. Showing (a) time-series of the depth of the deepest measurement (grey), and bottom depth beneath the trajectory for the linear (cyan) and multiple-constraint (black) method; and (b) the trajectory (overlying bathymetry) from by GPS (green), and from the linear (cyan) multiple-constraint method - showing when we use f/H (red), MSL (blue), and sigma-1 (magenta). The coloured lines along the bottom of panel (a) show which method is used at different times. Time references along the trajectory are shown in panel (b) along the float's path.

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)

High salinity drift floats

We have 42 floats listed on the Abrupt Salty Drift spreadsheet (float that showed significant PSAL drift before cycle 80). Only 8 of these floats are still returning correctable data, the others have either died or are returning uncorrectable PSAL data.

Decoding difficulties

We're struggling to find the best way to decode BGC profiles. PROVOR and APEX floats report pressure for the BGC sensors very differently. APEX only provide a time stamp, which then requires interpolation to get to pressure. At the moment, the file structure coming out of the two float types differs for our DAC (6 BGC pressure profiles for PROVOR, 1 BGC pressure profile for APEX, resulting in sparse profiles for each BGC variable). The GDAC seems happy with what we do, but our own DOXY DMQC software is struggling. We've identified a work-around for this problem, but we're thinking about how to solve this problem eloquently.

Deep floats

Our deep float data has thus far been QC'd independently by Annie Foppert (outside of our existing DMQC software suit for core and DOXY). It is our intention to update the DMQC software to be able to handle and QC Deep Floats in the future.

BGC floats

Christina took a leading role to update the document outlining RTQC for CHLA and CHLA_FLUORESCENCE; the international BGC team has finally agreed on the tests and procedures for these variables, which took a lot of testing, meetings and compromises, but we got there; Christina has also been part of two international BGC working groups: one about BBP RTQC tests, with a publication in prep (Dall'Olmo is lead author), and she has also been part of a radiometry working group, with the goal to optimize the 4 wavelengths measured by radiometers mounted on BGC Argo floats.

With respect to our RTQC efforts: pH is finally up and running (nitrate and oxygen have been good for a while), so now CHLA is the last outstanding variable for RTQC that we need to tackle (until the BBP documentation is available; then we need to do BBP as well).

d. Status of delayed mode quality control process

Our Matlab-based DMQC system is actively maintained to ensure that all of our data can be processed efficiently. Our system now uses OWC-v3. We are using the ARGO_for_DMQC_2020V03 and CTD_for_DOMQ_2021V01 reference databases. We currently have three DMQC Operators regularly performing DMQC on our data, and one software engineer supporting the code.

To date, we have processed about 93% of eligible T/S/P data. We have updated our list of floats on the Abrupt Salty Drift spreadsheet and responded to alerts in the Coriolis reports. We have not started DMQC of our floats with RBR sensors. RT processing is being modified to include the updated calibration factors and then the further calibration will be included in the DMQC code. The calibration factors for our float are not yet available on the git repository. In addition, we have one older RBR float that needs individual attention to determine calibration.

Our over-all capacity in DMQC was reduced for 2022, as staff effort has shifted between projects. We are hoping to recruit a new DMQC Operator soon.

DMQC of BGC variables is starting to take shape, but with slow process. The Matlab code for DOXY DMQC has been updated and is in the testing phase. Hopefully it will be ready for action in the next few weeks. DMQC for CHLA and BBP (the most abundant sensors in our BGC array, when including dead floats) is being coded in Matlab and has been tested on a few floats. It is ready to go from the QC perspective for these floats, but we're still understanding how to update history fields etc in the netcdf files (hoping to not corrupt other aspects of the files).

Tatiana Rykova initiated a virtual discussion with the DMQC community on challenging/interesting floats in January 2022. The first meeting included a presentation on Abrupt Salty Drifters (by Annie Wong) and a presentation of two challenging floats (led by Tatiana Rykova). A second meeting is planned for April 2022, and will focus on DMQC of Deep floats. If there's interest, this series of meetings may continue.

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)

Argo Australia has secured funding for salary and operating costs to support our Argo operations until June 2023 from the Australian Integrated Marine Observing System (IMOS). We expect this funding to continue until at least 2028 at an equivalent level. This includes support for salary and operating costs for the Australian Argo Program.

In 2022, we expect to acquire 59 Core floats, 12 Deep floats, and 4-6 BGC floats. Core and BGC floats are funded from a strong partnership between IMOS (contracted until June 2023, and likely extended until June 2028), CSIRO (reviewed annually), the Australian Department of Defence (reviewed annually), BoM (reviewed annually), and AAPP (contracted until 2029). BGC floats are funded by IMOS, CSIRO, UTAS, and AAPP. Deep floats are funded by AAPP and CSIRO.

Argo Australia has (some fraction of) two technical officers; one person running real-time operations and maintaining our Matlab-based RT system; one person developing a new Python-based system and doing most of the decoding; six people contributing to the delayed-mode operations (including one dedicated to BGC and one dedicated to software development and

maintenance). Our operational team supports activities of Core, BGC, and Deep Argo. Argo Australia also supports a number of people not directly contributing to the technical, RT, or DM elements of the program. This includes two people in Core Argo, two in BGC Argo, and three in Deep Argo – although the lines distinguishing between these efforts is becoming blurred – something that our program is embracing. In total, Australian Argo draws on ~6 FTE, with ~4.5 FTE for operations; ~0.5 FTE for Core Argo leadership and applications, ~0.5 for BGC Argo leadership and applications, and ~0.5 FTE for Deep Argo leadership and applications.

Argo Australia intends to continue providing AUD\$100K funding to support operations of the RV Kaharoa (and its successor), and AUD\$30K funding to support OceanOps. We received greater scrutiny over this budget item than previously. We've secured this funding until June 2022, and we will work hard to keep it as an ongoing budget item.

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

We currently have 59 Core floats, 6 six-sensor BGC floats, and 12 Deep floats either in our laboratory or on order. Our deployment plans for 2022 and 2023 are represented in Figure 4. We plan to focus deployments around Australia in the coming season – mostly so that we can use deployment opportunities that we think are reliable. Regular replanning because of COVID-related restrictions has taken a lot of time. We hope to avoid that if we can. We haven't planned all of our deployments – particularly for BGC floats. We hope to identify appropriate cruises that have capacity to perform CTD profiles on deployment. Our experience over the past two years has led us to take every opportunity to deploy. In the past, we planned more carefully. But with travel restrictions, and lost opportunities, we're taking a more pragmatic approach for the near-term.

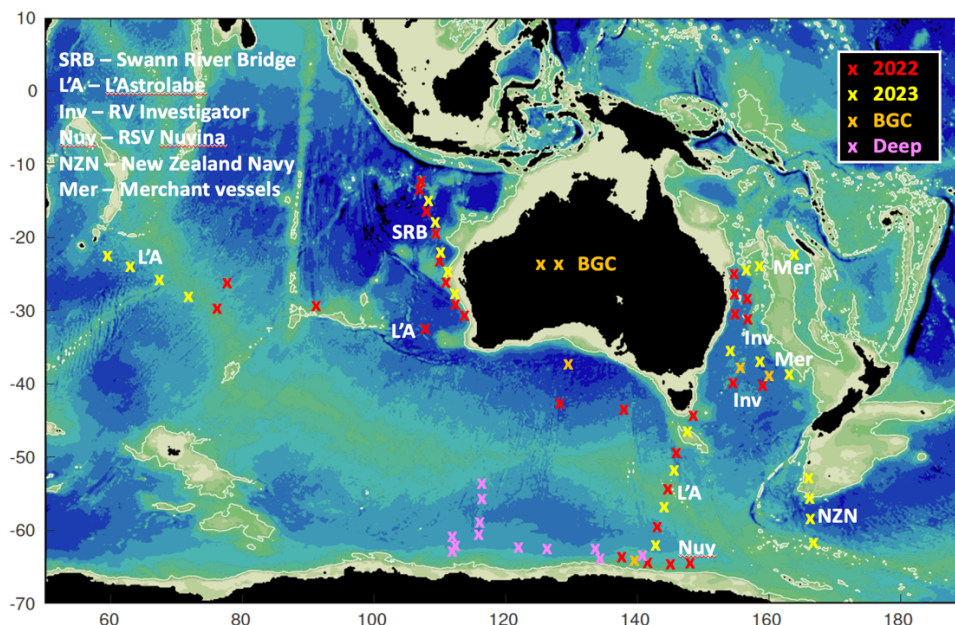


Figure 4: Approximate locations of planned core deployments for 2022 (red) and 2023 (yellow); and BGC (orange) and Deep floats (blue) floats planned for 2022/23. Locations for 2 BGC floats are yet planned (but we won't deploy these in central Australia).

We have a preliminary plan for the deployment of the 12 Deep Floats. The voyage that these floats were originally planned for has now been delayed by one more year, so these floats will not now be deployed until Austral summer 2024. There is a possibility to deploy these earlier on a voyage in Sep 2023 but as this is a marginal ice zone voyage, there may be too much ice around for safe deployment.

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.

A new modelling activity to examine the impact of data from Abrupt Salty Drifters (ASDs) in assimilating models/systems has been initiated under the OceanPredict Observing System Evaluation Task Team. This study involves a series of Observing System Experiments, where a sub-set of data are systematically with-held from assimilating systems. For the planned experiments, data from the floats with potential ASDs are with-held from some calculations to quantify their impacts. Systems included in the study use different models and different data assimilation methods. There will be at least three different systems included. Using this approach, we hope to identify the robust impacts, rather than the system-specific impacts. The lead for this study is Yosuke Fujii, from JMA. Others involved include Peter Oke (CSIRO) and Hao Zhu (ECMWF).

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.

Argo data is one of the key data sets that underpin Australian ocean reanalysis efforts. A paper describing the 2020 version of our reanalysis – called the Bluelink ReANalysis, BRAN 2020 – has been published. Data span 1993-2021 and are publicly available. BRAN2020 assimilates Argo data, altimetry, and satellite SST data, plus other in situ data sources. The main improvement in BRAN2020, compared to previous versions, is the reduction (almost elimination) of deep biases. This improvement is attributed to a new multi-scale data assimilation approach that constrains broad-scales separately from mesoscales, in a two-step assimilation process. A link to the BRAN2020 data follows:

https://geonetwork.nci.org.au/geonetwork/srv/eng/catalog.search#/metadata/f9372_7752_2015_3718

Argo data is one of the key data sets that underpin our new analysis system – called Blue Maps. A paper describing Blue Maps has been published. Work on the evaluation and development of Blue Maps is ongoing. Data currently available from Blue Maps spans 2006 to present. Blue Maps grids data from Argo, satellite altimetry, and satellite SST. A link to Blue Maps data follows:

https://dapds00.nci.org.au/thredds/catalog/gb6/BRAN/Blue_Maps/MAPS-v1p0/catalog.html

National Argo program web pages include:

- imos.org.au/facilities/argofloats; and
- imos.org.au/facilities/argofloats/bgcargo.

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

We know that the Deep Argo community are looking at options for sampling with Deep floats on ascent, as well as on descent. We would support sampling on ascent, so that this data can be used for operational purposes, as well as research purposes.

COVID has resulted in many cancelled voyages. As we try to recover from this, we'd welcome extra international coordination for deployments. We understand that Go-BGC is working hard on this.

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.

If a float is deployed on a research voyage with a co-located CTD then, shipboard CTD data is correctly populated in the CSIRO float meta files if the PI sends the CTD information in the deployment email (this is not always done). We will remind our PI's that if CTD's are planned then that information must be provided to us – so that we can improve this in future. There is some work to do to correct this information in the files retrospectively.

CTD Profiles coincident with Argo float deployments are summarised in the Table below.

WMO ID	Deployment date	PI (CSIRO)	Ship & Cruise	CTD Cast
5906635 (BGC)	09/5/2021	Dr. Chris Chapman	RV Investigator IN2021_V03 EAC Mooring	#3
5906636 (BGC)	11/5/2021	Dr. Chris Chapman	RV Investigator IN2021_V03 EAC Mooring	#4
5906638 (core)	13/5/2021	Dr. Chris Chapman	RV Investigator IN2021_V03 EAC Mooring	#6
5906639 (core)	14/5/2021	Dr. Chris Chapman	RV Investigator IN2021_V03 EAC Mooring	#9

5906642 (core)	24/5/2021	Dr. Chris Chapman	RV Investigator IN2021_V03 EAC Mooring	#25
5906645 (BGC)	16/6/2021	Rod Palmer or Claire Grubb	RV Investigator IN2021_T01	#8

7. Bibliography

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

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.

COVID-19 has impacted all areas of our operation, but we have actively adapted to restrictions to maintain the overall performance. Impacts on each area of our work are summarized below:

- Float Procurement
 - Manufacturers of Argo floats have done really well to maintain production of floats despite the pandemic. We're grateful for their efforts. Despite this, we've encountered some delays, which have had flow-on effects to our finance – resulting in additional challenges to maintain funding from some sources.
- Automated pre-deployment testing:
 - COVID-19 travel bans encouraged us to continue developing pre-deployment scripts and applications to simplify final shipside tests so any person can perform a thorough test and identify outliers. We see it as an opportunity to further adapt our operations to reduce our dependency on travel.
 - We developed a Python based program to perform automated tests on NAVIS Argo floats and reduce our reliance on travel during the pandemic.
 - The program provides an increased number of checks over a built-in self-test.
 - We used the program to identify a serious bladder problem in a NAVIS float where the float still passed the built-in self-test.
 - We tested 21 floats at a destination port with the assistance of suitably trained technicians who gained exposure to scientific instrumentation.
- Deployments
 - Some deployment opportunities were lost, when cruises were cancelled or postponed. In those instances, we changed our deployment plans and shifted floats to other opportunities. This resulted in deployments in locations that were not our first choice. But we tried to make sensible choices that would positively contribute to the global array.
 - In some cases, a delay in a voyage has meant that some ice floats were deployed very late in the season, and some of these have disappeared early under winter ice before it could be verified that they were working correctly, or the float missions updated.

- Our usual practice has been to ship floats to their final port, and then one of our Argo Technicians travels to that port to perform final pre-deployment checks. This wasn't possible. Instead, we recruited suitably-skilled technicians near each final port, and worked with them to perform the final tests for us. This turned out to be a significant cost saving, and is something we may consider continuing in the future, regardless of travel restrictions.
- Data processing
 - Our work-force was not directly impacted by COVID-19. However, staff all worked from home for most of 2021, especially after the dirty Mainlanders were allowed to bring disease to our pristine southern state. This has made everything harder – collaboration, coordination, motivation.
- Budgets
 - Our travel budgets were all frozen. We adapted to this, as noted above, but it's possible that post-pandemic travel budgets may be lean.

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

Despite the challenges we've faced during our initial deployment of ALTOs with RBR sensors, it is our intention to include some portion of floats with RBR sensors each year. We still have 11 floats with RBR sensors in our labs that are awaiting deployment, so we may not order floats with RBR sensors this year. But once we have ironed out the issues with manufacturers, we will purchase floats with RBR sensors each year – perhaps 4-8 floats per year (representing ~10-20% of our annual investment).



ARGO National Report 2021: Bulgaria

1. The status of implementation

BulArgo programme is a component of the MASRI – Infrastructure for Sustainable Development of Marine Research and Participation in the European Infrastructure Euro-Argo. MASRI (<http://masri.io-bas.bg/>) is a project of the National roadmap for scientific Infrastructure (2020-2027) of Republic of Bulgaria. The BulArgo 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.

Three floats model Arvor I - DO were purchased by the Institute of oceanology-BAS via Euro Argo- ERIC tender procedure in the fall 2020. Two of them were deployed by the Bulgarian Argo team in the western Black Sea from the board of R/V Akademik. The floats integrate Iridium satellite telemetry system which provides a dual telecommunication capability, allowing modification of the configuration in real-time. The BulArgo floats (WMO 3902004 and 3902005) were deployed on 21st of October 2021 in Bulgarian EEZ at depths 1300 m and 1150m, respectively. The floats were programmed to cycle between the surface and 1500 dbar every 5 days and to drift at the parking depth of 750 dbar. Both floats are still active. The status information for the Bulgarian floats deployed in the Black Sea during 2021 is presented on Table 1. Surface positions of the BulArgo active floats are shown on Figure 1.

a) BulArgo floats deployed in 2021 and their status

Table 1. Status information for the Bulgarian floats deployed in the Black Sea during 2021

Model	WMO	Deployment date	Deployment time	Latitude	Longitude	№ of Cycles	Status
Arvor-I-DO	3902004	21/10/2021	18:19	42.9863	28.8105	29	Active
Arvor-I-DO	3902005	21/10/2021	23:00	43.1467	29.0843	29	Active



Figure 1. Trajectories of active BulArgo floats deployed in the Black Sea during 2021 (WMO 3902004-grey line and WMO-3902005 –red line)



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

Carried out by Coriolis for the Institute of oceanology-BAS

c) Status of delayed mode quality control process

Carried out by OGC, Italy for the Institute of oceanology-BAS.

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

Bulgaria continues to be a committed member of the Euro-Argo ERIC and will comply with the minimum requirement of deploying 3 floats per annum. The national funding is provided by the National roadmap for scientific infrastructure (2020-2027) and covers membership subscription, float procurements, deployment and communication costs and part-time personnel support.

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)

IO-BAS plans to deploy 3 BulArgo floats in 2022. Additionally two BGC floats are planned to be deployed in the Black Sea in 2022 in the frame of H2020 project DOORS (Developing Optimal and Open Research Support for the Black Sea) as well one Italian Argo core floats. The deployment plans of these floats could be affected by political situation in the Black Sea region and its financial repercussions.

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.

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

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

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

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.

Nothing.

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.

The CTD casts were performed just before the floats deployment. No data uploaded to the Argo reference database.

Argo Canada – Report of Activities for 2021

(submitted by Blair Greenan, Fisheries and Oceans Canada)



23rd meeting of the Argo Steering Team (AST-23)

Location: Monaco & Virtual

21-25 March 2022

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)
 - a. floats deployed and their performance

From January 2021 to December 2021, Argo Canada deployed a total of 25 floats in the following regions:

- Northeast Pacific: 13 NKE Arvor floats
- Northwest Atlantic: 3 NKE Arvor floats
- Caribbean Sea: 2 NKE Arvor (RBR CTD) floats (A20/A22 GO-SHIP mission)
- Baffin Bay: 3 NKE Arvor (SBE CTD) floats (CCGS Amundsen)
- North Atlantic: 4 NKE Arvor (SBE CTD) floats (Blue Observer Mission)
- Of these 25 floats, 1 Arvor (RBR CTD) float failed after 18 cycles over the period 26 April 2021 to 28 May 2021. The 24 remaining floats are still operational and functioning properly.
- As of 31 January 2022, Canada has 124 operational floats in the Argo Canada program.
- In addition, the Takuvik lab deployed the following floats in Baffin Bay in October and November 2021 (DarkEdge mission on CCGS Amundsen):
 - 4 BGC floats (model CTS5-Usea by NKE)
 - 3 of them were refurbished floats (after recovery) with new high sensitive PAR (MPE by Biospherical/collaboration Takuvik)
 - 1 with UVP6 / Hydrooptics particle size abundance

- b. technical problems encountered and solved

A failure in an O-ring seal on the RBR CTD resulted in an ingress of seawater and thereby a failure of the Arvor float. This float beached in the Turks and Caicos Islands and was recovered through joint coordination between RBR and Fisheries and Oceans Canada. RBR has updated the assembly procedure for the CTD units to reduce the risk of this type of failure in the future.

All of the NKE Arvor and PROVOR floats delivered to DFO in 2021 were recalled for a warranty repair. These floats have now been returned to our facilities, but this resulted in some missed opportunities for deployments.

- 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 125 Argo floats of which 6 floats has had trouble reporting in the last 6 months. Data are issued to the GTS and GDACs hourly in BUFR TM315003 and NetCDF formats. Data are available for delayed mode QC as soon as they are sent to the GDACs. The data of all Canadian floats together with some graphics are posted on a website and updated daily: <http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/index-eng.html>

From January 2021 to January 2022, on average, 327 messages per month were issued to the GTS in BUFR format, of which 83 % of the data were within 12 hours of the float reporting.

Since AST-22, the following tasks have been completed:

- Developing the modules to decode data from BGC floats in anticipation of new BGC floats deployments in 2022.
- Correct DOXY data using the quarterly reports provided by Monterey Bay Aquarium Research Institute.
- Modifying BUFR encoder to include DOXY data and sharing it with NOAA'S Atlantic Oceanographic and Meteorological Laboratory (AOML).
- Implementing multi-profiles and MTIME in the NETCDF profile file.
- Testing the Python core real-time QC package before implementing it in the processing chain
- 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: <http://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/argo/canadian-products/index-eng.html>.

- d. status of delayed mode quality control process

As of November 17, 2021, there is a total of 611 Argo Canada floats with their profiles on GDAC sites. Of these 611 floats, 31 (i.e., 5%) have no profile files. 76% of all active floats, had their profiles DMQCed following the latest delayed-mode procedures at least once, greater than the last year's percentage of 67%. About 10,008 profiles from 96 active core

Argo floats have been DMQced within the last year; 8,678 of these profiles have been fully QCed and 1330 have partially QCed profiles.

Of all BGC floats, 12% have had their profiles either visually QCed or fully DMQced at least once. It should be noted that DMQC only applies to DOXY for Argo B-profiles.

The DMQC tool for core Argo floats has been updated to the latest OWC method as well as the most recent climatology and reference database. There is also a plan to develop the DMQC procedures for time and position according to the latest DMQC manual version 3.5. The DMQC procedure for deep-Argo floats was revisited last year in preparation of upcoming deployments. The DMQC tool for BGC Argo floats focusing on DOXY is coded by python and under development with notable improvements. All source codes have been shared on Github (<https://github.com/ArgoCanada/bgcArgoDMQC>).

The monthly anomaly reports issued by Ifremer (French GDAC) were carefully reviewed and the anomalies were flagged and updated to GDAC NETCDF files.

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)

Financial resources

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

Ongoing capital for float purchases has not been identified and, therefore, it remains necessary to request capital resources on an annual basis to obtain the funding required to purchase new floats. The Government of Canada (DFO and Department of National Defence – DND) committed \$1.03M for purchases of core NKE Arvor-I, NKE Arvor-RBR, and Provor CTS4 floats in the Fiscal Year 1 April 2021 to 31 March 2022. The funding will result in acquisition of 14 core Argo floats, 10 BGC-Argo floats (3 or 4- BGC sensors) and 3 NKE Arvor floats with RBR CTDs.

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

In addition, funding for "A BGC Argo Program for the NW North Atlantic Ocean" led by Dalhousie University and the Memorial University of Newfoundland, is conditionally approved by CFI for a total cost of \$8.8M. Final approval is still pending, but expected shortly as all

conditions imposed by the funder have been met. The plan is to acquire about 40 BGC-Argo floats for deployment in the NW North Atlantic.

In addition, CFI funding held jointly by the Universities of Victoria and British Columbia (C-PROOF, see details in Section 4) that has been providing additionally oxygen sensors for floats deployed in the Northeast Pacific will be ending in 2022. In addition to the add-on oxygen sensors, they plan to purchase 8 BGC Argo floats in 2022.

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, RBRArgo data task team member, ArgoFloats R package development
- Jaimie Harbin (DFO, BIO, Halifax) – ArgoFloats R package developer developer and Commonwealth Blue Charter training coordinator
- Igor Yashayev (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

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

National Coordination

With increasing participation in the Argo program within Canada, both in core Argo and BGC-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.

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.

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

Here is a [link](#) to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

Argo Canada (with financial contributions from Fisheries and Oceans Canada and the Department of National Defence) will procure the following 27 floats by March 2022 (end of fiscal year):

- 9 NKE Arvor-I with SBE41 CTD
- 5 NKE Arvor-I with SBE41 CTD + DO
- 3 NKE Arvor with RBR CTD
- 6 NKE Provor CTS4 with SBE41 CTD + DO + chl_a + backscatter
- 4 NKE Provor CTS4 with SBE41 CTD + DO + pH + chl_a + backscatter

In 2022, Argo Canada plans to deploy about 38 of the floats in the Northeast Pacific and North/South Atlantic (firm commitment):

- 22 Argo Core (18 SBE CTD, 4 RBR CTD)
- 16 Argo BioGeoChemical (14 O₂ only, 2 O₂ + bio-optical triplet)

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. GLOPS 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. GLOPS analyses are also used to initialize the operational forecasts from the Canadian Seasonal-Interannual Prediction System (CanSIPS). RIOPS analyses are produced in a model that includes tides and provides daily three-dimensional state of the ocean estimates for Canada's three coastlines on a domain covering the North Pacific, Arctic, and North Atlantic Oceans. An observing system experiment is underway to assess the impact and potential benefits of assimilating seasonal Argo floats from the Arctic Ocean into RIOPS. Coastal forecasts are produced for the east and west coast of Canada at 2km resolution using a spectrally nudging to RIOPS analyses.

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

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

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

Argo data are used in the preparation of Fisheries and Oceans Canada's State of the Ocean reporting (e.g. <https://www.dfo-mpo.gc.ca/oceans/publications/soto-rceo/2019/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. C-PROOF has ordered 5 dissolved oxygen sensors to add to some of the DFO Arvor floats ordered for delivery in March 2022; however, supply issues with pH sensors precluded UVic from being able to add some of these sensors to the DFO Provor floats.

The Argo Canada web site is maintained by Fisheries and Oceans Canada at <http://www.isdm.gc.ca/isdm-gdsi/argo/index-eng.html>

The Canadian BGC Argo website is maintained by Katja Fennel at <http://bgc-argo.ocean.dal.ca/>

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.

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.

Nothing to report this year.

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

Kelley, D. E., J. Harbin, and C. Richards (2021), argoFloats: An R Package for Analyzing Argo Data, *Frontiers in Marine Science*, 8(409), doi: <https://www.frontiersin.org/article/10.3389/fmars.2021.635922>

Koelling, J., D. Atamanchuk, J. Karstensen, P. Handmann, and D. W. R. Wallace (2022), Oxygen export to the deep ocean following Labrador Sea Water formation, *Biogeosciences*, 19, 437–454, <https://doi.org/10.5194/bg-19-437-2022>.

Pennelly, C., and P. G. Myers (2021), Impact of Different Atmospheric Forcing Sets on Modeling Labrador Sea Water Production, *Journal of Geophysical Research: Oceans*, 126(2), e2020JC016452, doi: <https://doi.org/10.1029/2020JC016452>

Rühs, S., E. C. J. Oliver, A. Biastoch, C. W. Böning, M. Dowd, K. Getzlaff, T. Martin, and P. G. Myers (2021), Changing Spatial Patterns of Deep Convection in the Subpolar North Atlantic, *Journal of Geophysical Research: Oceans*, 126(7), e2021JC017245, doi: <https://doi.org/10.1029/2021JC017245>

Smith, G.C., Y. Liu, M. Benkiran, K. Chikhar, D. Surcel Colan, A. A. Gauthier, C. E. Testut, F. Dupont, J. Lei, F. Roy and J. F. Lemieux (2021), The Regional Ice Ocean Prediction System v2: a pan-Canadian ocean analysis system using an online tidal harmonic analysis. *Geoscientific Model Development*, 14(3), pp.1445-1467, <https://doi.org/10.5194/gmd-14-1445-2021>

Wang, B., K. Fennel and L. Yu (2021), Can assimilation of satellite observations improve subsurface biological properties in a numerical model? A case study for the Gulf of Mexico, *Ocean Science*, 17, 1141–1156, <https://doi.org/10.5194/os-17-1141-2021>

Ph.D./M.Sc. Thesis

Cervania, A. (2021), Isopycnal Shoaling Causes Interannual Variability in Oxygen on Isopycnals in the Subarctic Northeast Pacific, M.Sc. thesis, 64 pp., University of Victoria, <http://hdl.handle.net/1828/13441>

Izett, R. W. (2021), Improved estimates of net community production in the Subarctic Pacific and Canadian Arctic Ocean using ship-based autonomous measurements and computational approaches. Ph.D. Thesis, 229 pp., University of British Columbia, Vancouver, British Columbia, <https://dx.doi.org/10.14288/1.0398454>

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 2021 were impacted by a combination of COVID-19 and vessel availability issues. The primary platform for oceanographic research on the east coast of Canada has been the CCGS Hudson which is almost 60 years old. In 2021, the Hudson availability for operations

was very limited due to repair issues and resulted in a loss of opportunity to deploy Argo floats in the region east of Newfoundland and Labrador. It was announced recently that the Hudson was being decommissioned and it will be approximately 5 years before the replacement vessel goes into service. DFO has committed to find solutions for the gap before the replacement vessel arrives, but at this time the future remains uncertain.

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

Argo Canada is committed to deploying additional floats equipped with RBR CTDs. In 2022, our program will be deploying 4 floats and are purchasing an additional 3 floats. The procurement plan for 2023 is not known at this time. We have 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.

Argo China National Report 2021

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1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. floats deployed and their performance

In 2021, China deployed 36 floats in the western Pacific, Bay of Bengal and the south Atlantic Ocean, which includes 33 PROVOR (including 14 BGC floats and 19 Core floats) and 3 HM2000 floats (including 2 Core floats and 1 BGC float). Of these floats, 11 are contributed by Ocean University of China (11 PROVOR DO floats deployed in the south Atlantic), 1 is contributed by the Pilot National Laboratory for Marine Science and Technology (Qingdao) (QNLN) and the remaining 21 floats were deployed by a joint cruise in the tropical western Pacific, which was organized by the Second Institute of Oceanography and the Third Institute of Oceanography, Ministry of Natural Resources. It is worth noting that QNLN added their 38 HM2000 floats deployed in the period 2018-2021 to China Argo in October 2021, which led to a total 546 float deployments in China Argo by the end of 2021, and ~ 80 operational floats.

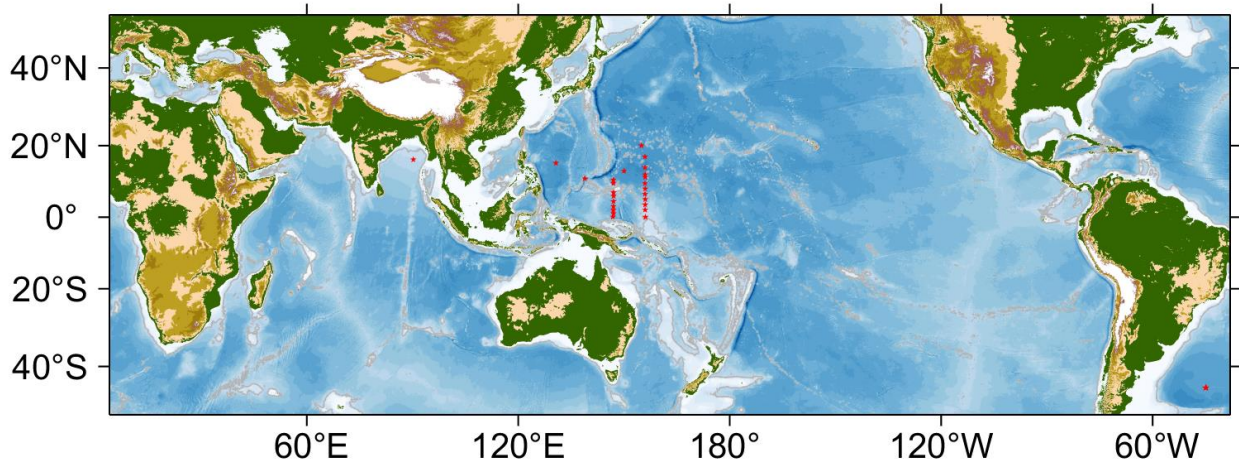


Fig.1 Launch positions of the Chinese floats in 2021

In May and June 2021, QNLM deployed 9 HM4000 floats around the region of the Kuroshio-Oyashio Extension in the North Pacific, with 8 of them equipped with RBRargo deep CTD and one with an SEB61 CTD sensor. This was the pilot deployment of HM4000 float, so data from these floats were not submitted into GDACs. By the end of 2021, seven floats were still reporting data and over a hundred 4000-m temperature and salinity profiles had been acquired (Fig. 3). The comparisons between observations from the floats, shipboard CTD, salinometer, and climatology indicate that half of the floats have obtained fairly good temperature and salinity profiles at least at the time they were deployed, whereas the remainders are observed systematic or pressure-dependent salinity biases.

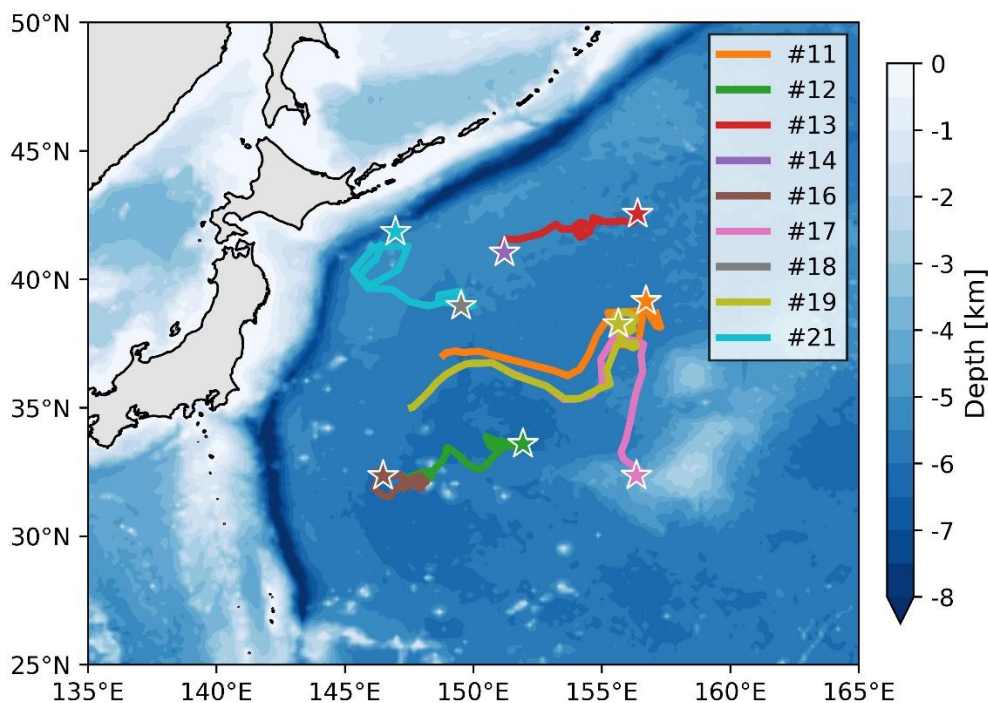


Fig. 3 Trajectories of nine HM4000 floats deployed in the North Pacific Ocean by the end of 2021.

b. technical problems encountered and solved

One BGC PROVOR float (WMO: 2902747) was unable to dive since its 122th cycle, the problem can't be solved by a configuration change through Iridium satellite. Now we are seeking ships to recover it.

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 2021 CSIO received 5,104 core profiles plus 709 DOXY, 643 CHLA, 608 CDOM, 1,113 IRRADIANCE and 492 NITRATE profiles from 135 active floats (Fig.4). All the profiles have been submitted into GDACs and core & DOXY profiles have been inserted into GTS via CMA after being converted into BUFR bulletin.

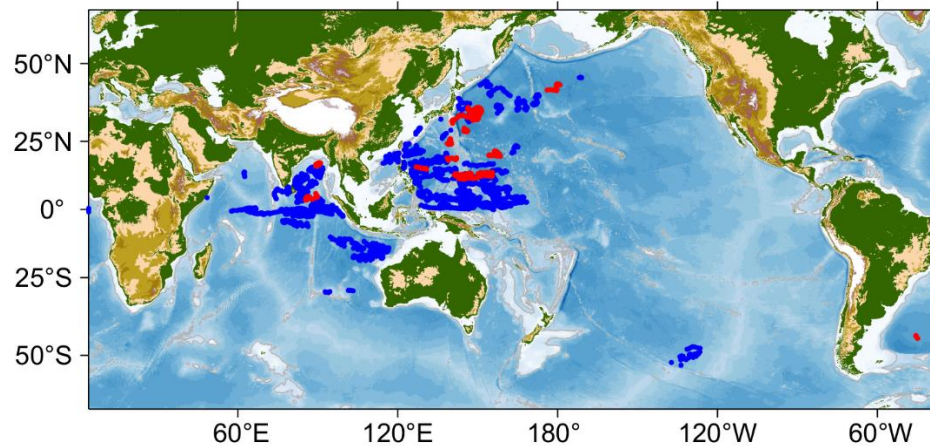


Fig.4 Positions of core (blue) and BGC (red) profiles.

A list of fast salinity drift floats had been updated prior to AST-22. The DMQC for these FSD floats almost stopped because our DMQC operator had a maternity leave. We plan to restore this work after this April.

Some PROVOR CTS5 APMT floats have been and are planned to be deployed this year. CSIO is developing the corresponding decoding software under the help of Jean-Philippe Rannou from Altran, France.

d. status of delayed mode quality control process

Last year we had sent about 15,226 D-files to GDACs. In total about 75% R-files has been DMQC'd and submitted. CSIO's DMQC operator, Ms Xiaofen Wu was pregnant and had a 5-month maternity leave. She will come back this March and continue this task.

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)

A project that implements the development and pilot deployment of HM6000 float will be granted this year, from which over 60 HM6000 floats are going to be developed and manufactured. As proposed, they will be deployed in the North Pacific in the next three years and data will be submitted to GDACs.

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.

CSIO will deploy 4 Navis-BGC floats with SeaTrec rechargeable batteries and 1 HM2000-O2 float in the northwestern Pacific this year. Besides, 3 Provor-BGC floats with 6 core BGC variables have been purchased by the Ocean University of China, and will be deployed in the Kuroshio Extension area as soon as possible.

Other float deployments will come from the contributions from several universities and institutions, but we are unable to estimate the amount. CSIO will still try to encourage those PIs to incorporate their floats into China Argo and share data with Argo community.

As for Deep profiling floats deployment, one 6000-m float will be deployed in the Philippine basin during June and July, and over ten 6000-m floats will be assembled and tested in the second half of year. By the end of 2022, there will be over 10 floats in the North Pacific.

Other float deployments will come from the contributions from several universities and institutions, but we are unable to estimate the amount. CSIO will still try to persuade those PIs to incorporate their floats into China Argo and share data with Argo community.

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.

CSIO provides a mirror access to the global Argo data set (synchronize with the GDAC server four times per day), and also provides a data transfer service (post-QC'd global Argo data set) for several operational departments. The values of Argo data have been fully recognized, nowadays Argo data and data product have been widely used in scientific research and operational forecasts.

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

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

None.

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

In 2021 CSIO submitted 10 CTD casts obtained in the northwestern Pacific 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

Zhang, C., W. Si, and C. Xie (2021), Analysis of T/S characteristics of Sulawesi Sea based on Argo and XBT, *Marine Science Bulletin*, 23(1), 27-36, 10.11840/j.issn.1001-6392.2021.01.004.

Zhou, Y., R. H. Lang, E. P. Dinnat, and D. M. Le Vine (2021), Seawater Debye Model Function at L-Band and Its Impact on Salinity Retrieval From Aquarius Satellite Data, *IEEE Transactions on Geoscience and Remote Sensing*, 59(10), 8103-8116, doi: 10.1109/TGRS.2020.3045771.

Chen, H., S. Li, H. He, et al. (2021), Observational study of super typhoon Meranti (2016) using satellite, surface drifter, Argo float and reanalysis data, *Acta Oceanol. Sin.* 40(1), 70–84.
<https://doi.org/10.1007/s13131-021-1702-9>

Gao, Z., Z. Chen, X. Huang, H. Yang, Z. Zhao, C. Ren, and L. Wu (2021), Internal Wave Imprints on Deep Ocean Temperature Change as Revealed by Rapid-Sampling Profiling Floats, *Journal of Geophysical Research: Oceans*, 126, e2021JC017878. <https://doi.org/10.1029/2021JC017878>.

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.

Except CTD delivery from SBE to HSOE (HM2000 manufacturer), the COVID-19 has little impact on China Argo project. In 2021, the SBE CTD delivery was delayed several months which impacted the timeliness of HM2000 float's supply.

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

In 2021, QNLM deployed 8 HM4000 floats mounted RBR 6k CTD sensor. The observations and comparisons have shown half of them reported systematic or pressure-dependent salinity biases. So HSOE may switch to use SBE61 CTD in their further developed HM6000 floats unless RBR can provide convincing products.

ARGO National Report 2022 – 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:

- 101 floats have been purchased since 2004
- 25 are working
- 6 will be deployed soon

Twelve floats will be bought in 2022 (order already placed).

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

In their observation strategy adopted in 2006 KNMI has expressed the intention to deploy about 7 floats per year. However, the actual number of floats purchased varied a lot during the past years. For 2022, extra money became available for floats to be deployed in the Caribbean Sea.

Presently, the Netherlands only contributes to the core mission.

One person (Andreas Sterl) is working on ARGO. He does so besides his other duties.

3) Summary of deployment plans.

Six floats are already on board a ship for deployment in the southern the Atlantic Ocean.

Four floats are prepared for deployment in the Caribbean Sea.

Eight 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), especially in the Caribbean Sea.

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

- van der Boog, C. G., Koetsier, J. O., Dijkstra, H. A., Pietrzak, J. D., & Katsman, C. A. (2021): Global dataset of thermohaline staircases obtained from Argo floats and Ice-Tethered Profilers. *Earth System Science Data*,13(1), 43–61, <https://essd.copernicus.org/articles/13/43/5152021/doi:10.5194/essd-13-43-2021>.

- C.G. van der Boog, H.A. Dijkstra, J.D. Pietrzak, C.A. Katsman (2022): Spatial variations of Antarctic Intermediate Water in the Caribbean Sea due to vertical mixing along its path. *Geophys. Res. Lett.*, <https://doi.org/10.1029/2021GL095977>.

8) COVID-19 impact

Delay/canceling of deployments in 2020. Backlog has been cleared in 2021, making use of the Atlantic charter organized jointly by WHOI, Argo Canada and Euro Argo.

9) RBR sensors

Four floats with RBR CTDs will be deployed in the Caribbean Sea in April/May of this year.



Euro-Argo Report – AST23

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

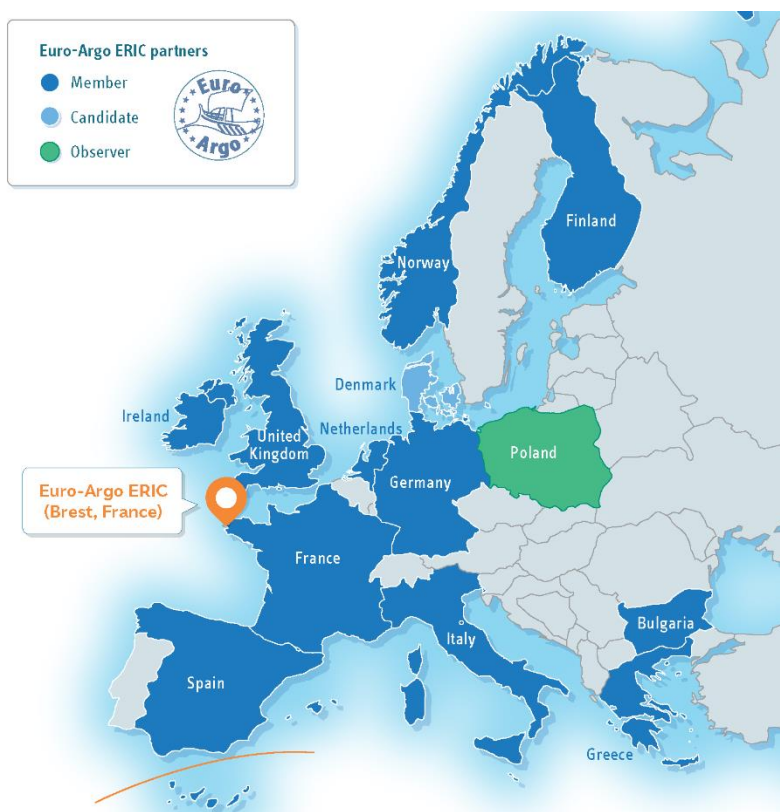


Figure 1. Euro-Argo ERIC membership in 2021

In December 2021, the Euro-Argo ERIC involved 13 countries: **11 Members, 1 Observer** and 1 Candidate (Denmark, newly involved).

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

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2020)

a. floats deployed and their performance

In 2021, 17 EU-funded floats were deployed. Among these 17 floats, 10 were funded under the EU H2020 EuroSea project: 5 BGC with 5 variables (no Nitrate) deployed in the tropical Atlantic and 5 DEEP floats with optodes deployed in the North Atlantic. The 7 other floats were bought under Euro-Argo ERIC budget (2 core floats and 5 floats with oxygen sensors). These 17 floats come in addition to the 240 floats deployed by the National members. The table below shows the floats deployed, both as number of measurements per variable and per type of float.

Table 1. European floats deployed in 2021, per parameter measured (blue, 7 first columns) and per type of float (green, 5 last columns). "BGC" stands for floats measuring the 6 BGC variables and "Bio" stands for other floats equipped with 1 to 5 BGC sensors, except the Deep-O2 floats only counted in the "DEEP" column.

	T&S	O2	Chla	BBP	NO3	Irradiance	pH	core	BGC	Bio	Deep	Total (floats)
EU funded	17	14	5	5	0	5	5	3	0	9	5	17
Member states	240	83	33	33	8	22	12	153	2	57	28	240
total	257	97	38	38	8	27	17	156	2	66	33	257

A total of 257 floats have been deployed in 2021, with 86% of them being NKE floats. 6 out of the 257 floats have been recovered, most of them in the marginal seas.

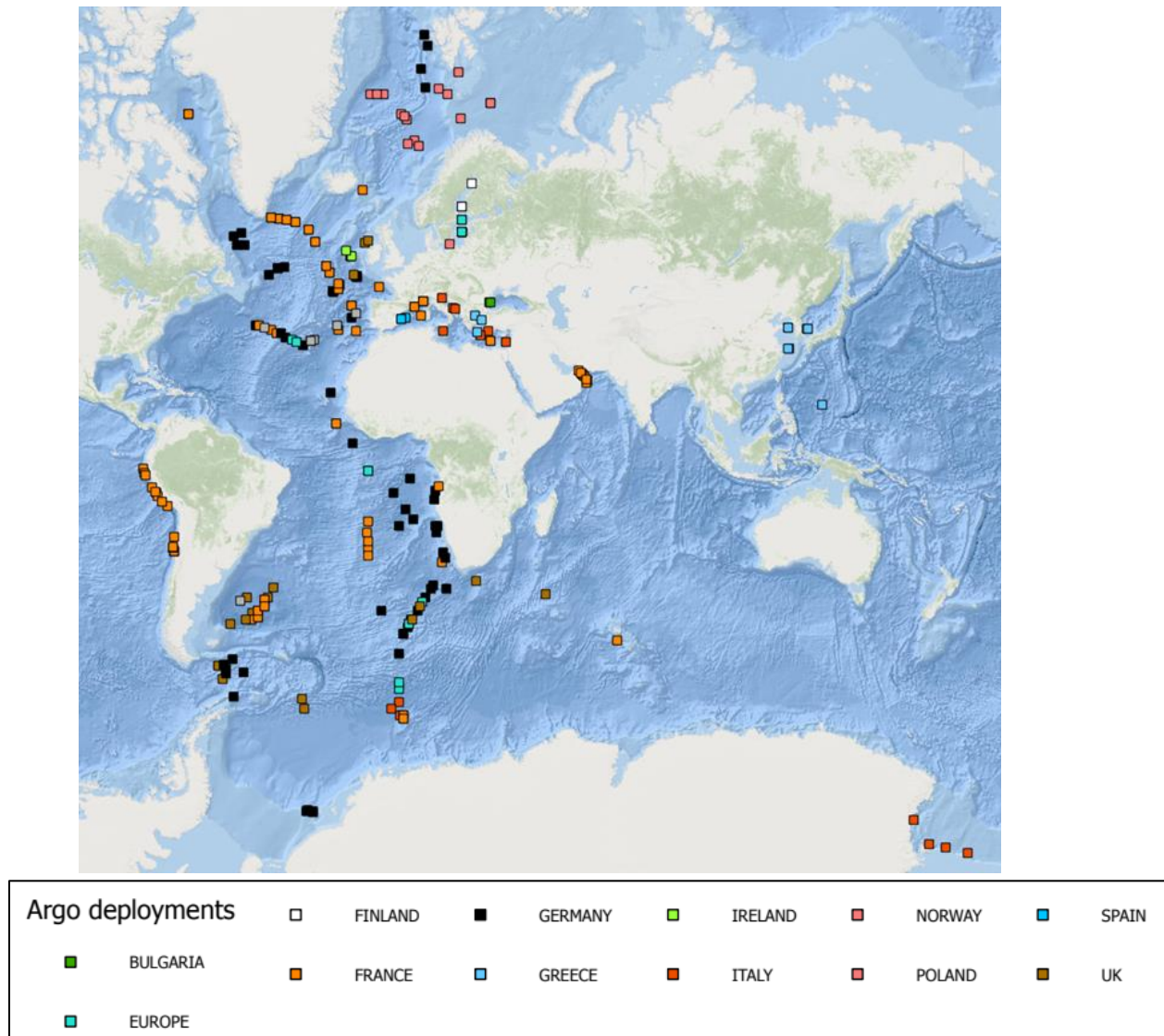


Figure 2. Deployment positions of the European floats deployed in 2021 (Credit OceanOPS)

The launch location of all Argo floats deployed in 2021 are shown in Figure 2.

Figure 3 presents the evolution of Euro-Argo deployments since 2008. In 2021 Euro-Argo deployed 257 floats, representing 32% of the global effort, one of the highest percentages since 2008. The year 2021 remained influenced by the COVID pandemic, but Euro-Argo ERIC members managed to catch up with most of the deployment backlog due to Research Vessels cruises postponed or cancelled in 2020. Those efforts resulted in the deployment of ~100 more floats than in 2020.

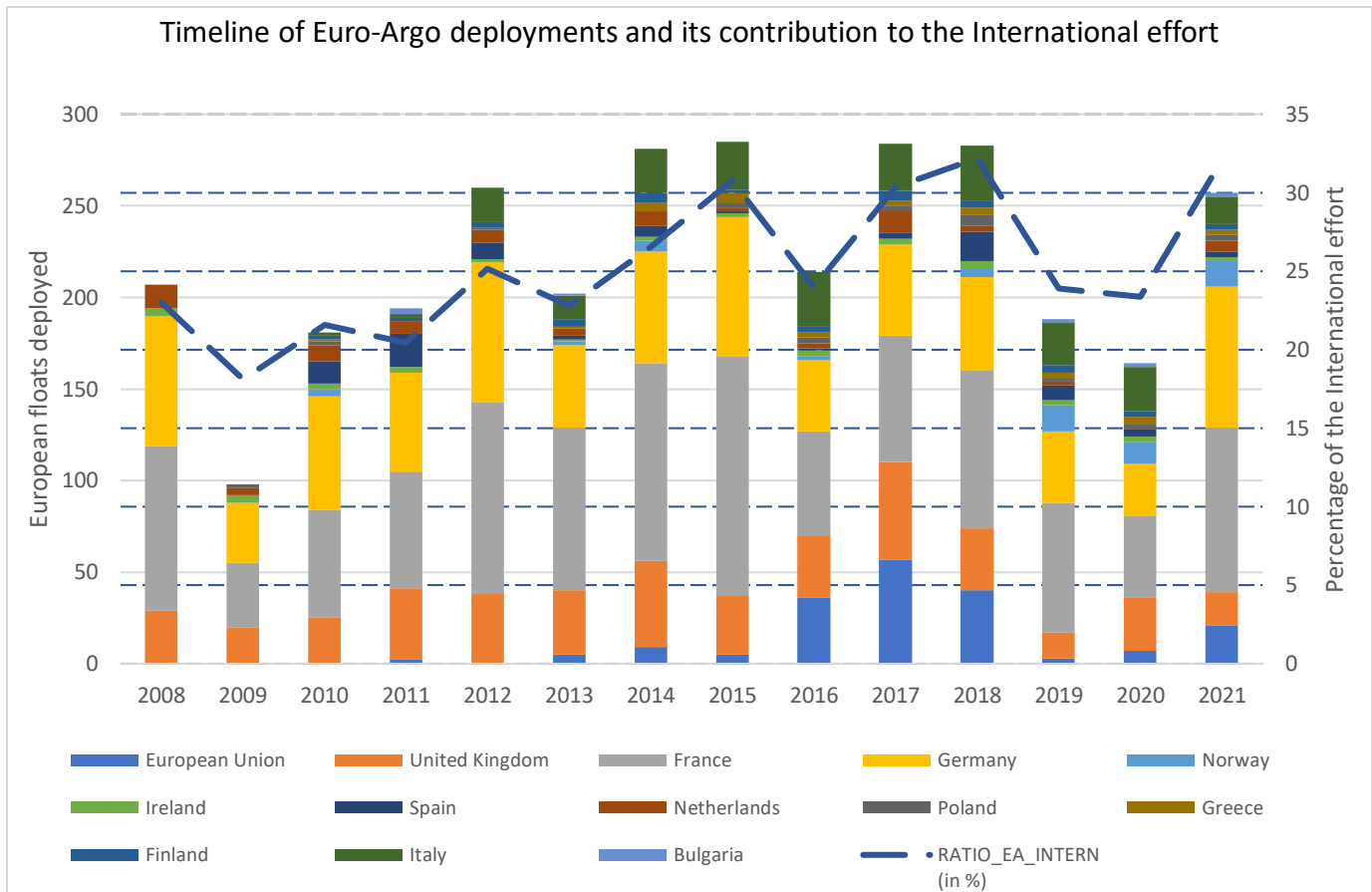


Figure 3. Timeline of Euro-Argo deployments (in number of floats, colored bars, left axis) and its contribution to the international effort (in %, blue dashed line, right axis).

b. technical problems encountered and solved

No specific technical problem has been encountered last year.

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)

All European floats are processed by Coriolis and BODC DACs (respectively 87% and 13% of European profiles in 2021), and DMQC of T and S parameters is currently shared between several institutes (4 leading: BSH, OGS, Ifremer & BODC, and several new partners entering the game). European partners have proposed several new procedures for the QC of BGC parameters that were endorsed at the last ADMT meeting. The organisation of BGC DMQC is also presently being discussed at European level, with various scenarios investigated, and a consolidated proposition of organisation between various institutes involved should be ready at the end of 2022.

The European fleet is impacted by the abrupt salinity drift on SBE sensors and Euro-Argo had started to investigate this issue from a DMQC point of view in 2019 (see Euro-Argo github public Forum: <https://github.com/euroargodev/publicQCforum/issues/11>). Euro-Argo maintains an international [Google spreadsheet](#) on the subject, and is actively participating in the international WG on the subject. The spreadsheet records have been extended to gather all observed drifts, including early “moderate” drifts.

The tab on statistics of the issue for European floats in the spreadsheet (Figure 4) shows that (as of mid-March 2022) the issue was most significantly present in profiles made by floats deployed in 2015-2016-2017, but is still affecting data made by floats deployed in the more recent years: 4.3% of data made by floats deployed in 2019 are impacted by a drift, with 1.4% of the data being lost (uncorrectable drift).

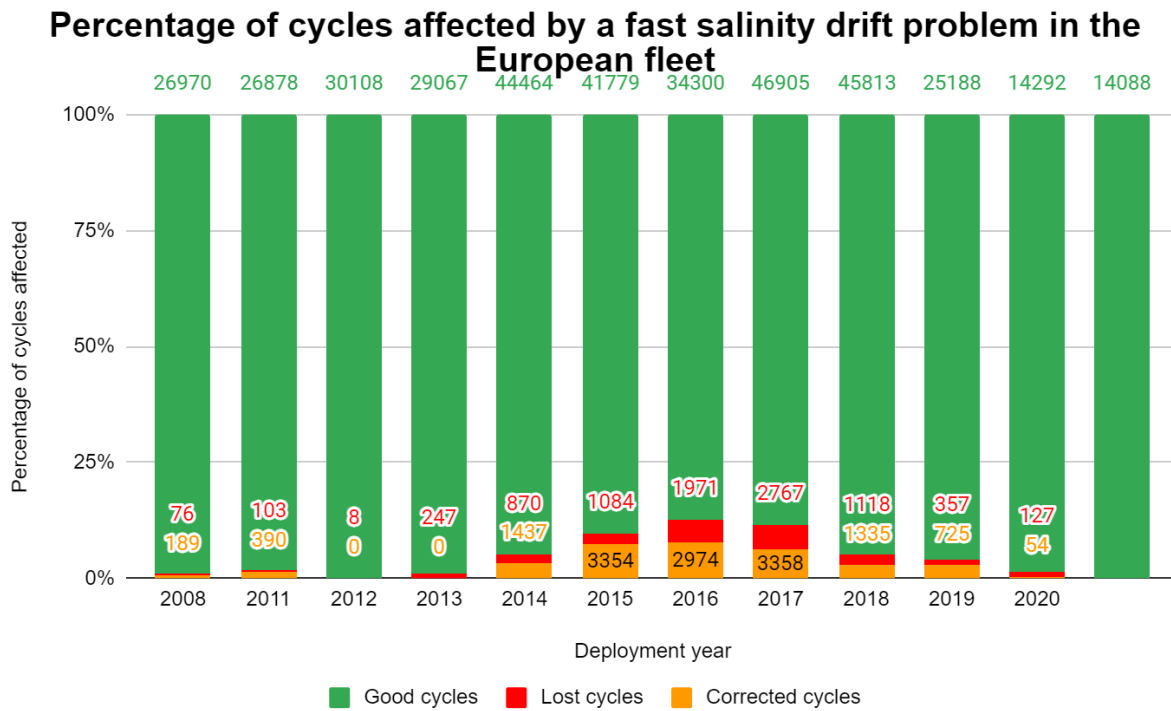


Figure 4. Percentage of cycles affected by fast salinity drift problem in the European fleet – as of mid-March 2022.

d. status of delayed mode quality control process

At the end of 2021, the percentage of the whole European fleet (EU-funded + National) processed in Delayed Mode amongst eligible floats was almost 80%.

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

In 2021, the Euro-Argo ERIC coordination office was a team of 5,3 FTE (3.3 permanent and 2 project-funded). This team supports European countries to sustain and optimise the European contribution to the Argo International programme, and comes in addition to the national members' personnel.

The European contribution to Argo is still benefiting from the Euro-Argo RISE EU project (Euro-Argo Research Infrastructure Sustainability and Enhancement), that involves all the Euro-Argo ERIC members except Netherlands for a 4 years duration (until December 2022). The project has been granted 4M€, including funds for float purchase (**12 floats in total including Deep and BGC floats**) and a total of more than **100 men months per year** dedicated to Argo activities in all aspects (technological development, science, data management, outreach, legislation, etc.). Euro-Argo RISE is coordinated by the Euro-Argo ERIC.

Euro-Argo is also involved in the **EuroSea EU project** that funded **5 Deep floats and 5 BGC floats** deployed in 2021 as well as the organisation of workshops on Deep and BGC Argo in Autumn 2021, and in the **ENVRI-FAIR EU project** in which Euro-Argo is funded to work on improving **FAIRness** (FAIR: Findable, Accessible, Interoperable, Reusable) of **Argo data**, through the involvement of the two European Argo DACs (BODC & Ifremer).

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

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

Float deployments planned for 2022 are presented in Table 2 per region and type of float. In total, Europe plans to deploy 235 floats, significantly more than the number of floats effectively deployed in 2021, but these numbers are to be taken with care because of uncertainties in fundings availability for several partners. Only one of these floats will be funded by the Euro-Argo ERIC.

Table 2. European deployment plans for 2022: total [national + EU-funded] & (EU-funded in brackets). “T/S/O2” stands for core floats equipped with an additional oxygen sensor (DEEP floats equipped with an oxygen sensors are counted in the DEEP column), and “Bio/BGC” stands for all other floats able to measure other BGC variables.

	Core	T/S/O2	Bio/BGC	DEEP	Total
Nordic	5	2	13	4	24
Med Sea	12	4	3	1	20
Black Sea	1	3	2 (1)	0	6 (1)
Baltic	4	0	2	0	6
Southern	36	0	6	8	50
Arctic	7	0	0	0	7
Global	175	3	34	10	222
Total	183	12	60	23	335 (1)

In addition to data processing, European institutes are continuing **their R&D work for improving data quality**, through the development of new DMQC methods, both for T/S and for BGC parameters. Collaboration at European level is being enhanced and this will continue in the coming years, thanks to work carried out in **Euro-Argo RISE & ENVRI-FAIR projects**. BGC data management is also being organised at European level and this work will continue in 2022. A new EU project will start in 2022 (**FAIR-EASE**) in which Euro-Argo will be funded (150 K€) to develop a BGC data QC workbench that should ease the use of QC tools and methods, in particular for Oxygen, by a wide community.

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

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

Argo data and/or products derived from Argo data are used by European operational services such as Copernicus Services and ECMWF, for satellite calibration and validation and for research carried on by the Euro-Argo ERIC partners (see national reports for details). Regarding operational services, a **MoU** was signed in 2021 between **Euro-Argo ERIC and Mercator Ocean** in charge of the implementation of

the Copernicus Marine Service to better define areas of collaboration between the two entities, and discussions have started **to better define future collaborations with the Copernicus Climate Change Service and ECMWF** as well.

Within the Euro-Argo RISE EU project, European contribution to Argo ARCs is being reinforced, in particular in the Southern Ocean ARC (see UK national report).

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.

Here is a list of several items that Euro-Argo would like to be addressed at AST level:

- Large costs increase on sensors and other float components (expected 5-10%) may have a strong impact on the network implementation, for 2022 and the years to come.
- Increased coordination is needed at basin scale level to take into account the development of all missions and the contribution of DEEP and BGC to the CORE mission. In the context of price increase, this coordination is even more important for an efficient implementation of OneArgo.
- Around 5% of recent European floats are impacted by salty drifts. It is essential to continue to evaluate and monitor the impact in terms of data loss and to extend the monitoring to other sensors.
- The current political situation is impacting the development of Argo in several regions of European interest: Arctic Ocean, Black Sea and Baltic Sea, including delays or cancellation of cruises for deployments.

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

See national reports.

7. Keeping the Argo bibliography ([Bibliography | Argo \(ucsd.edu\)](#)) up to date and accurate is an important part of the Argo website. This document helps demonstrate the value of Argo and can possibly help countries when applying for continued Argo funding. To help me with this effort,

please include a list of all papers published by scientists within your country in the past year using Argo data, including non-English publications.

There is also the thesis citation list ([Thesis Citations | Argo \(ucsd.edu\)](#)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

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

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.

The COVID-19 impacted Euro-Argo in terms of float and sensor procurement, with delays on manufacturers’ side. In terms of deployments, Euro-Argo caught-up its back logs with about 100 more floats deployed in 2021 compared to 2020. Euro-Argo also contributed with USA and Canada to an Atlantic charter that aimed at filling gaps in the Atlantic Ocean, with a total of 17 European floats deployed this way in 2021.

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

Europe has been involved in RBR CTD pilot studies, with 3 head-float prototypes (for intercomparison with SBE CTDs) and Arvor-I RBR developed within the Euro-Argo RISE project and successfully deployed in 2020, and 2 more floats equipped with RBR CTDs deployed in 2021. Two ‘2-Headed’ and one ‘3-Headed’ Deep Argo floats (range 4000 m depth) have also been deployed in March 2022 in the Canary basin under the framework of the EA-RISE project, through collaborative work between Ifremer & IEO. Two of the 3 floats are equipped with an RBR argo3 sensor.

Europe will continue to investigate the potential of these new CTD in the coming years, with most of the European partners planning to have part of their fleet equipped with RBR sensors (e.g. UK, Germany, France).

Argo National Report 2021 – Finland

1. Status of implementation

The Finnish Argo program is run by the Finnish Meteorological Institute (FMI). Since 2010 FMI has deployed altogether 12 floats in the Nordic Seas, including two on Barents sea 2018 and 2020. In addition of oceanic operations, 26 floats (starting 2012) have also been deployed into the shallow and low salinity Baltic Sea. Six of the Baltic float deployments have bio-optical sensor suite.

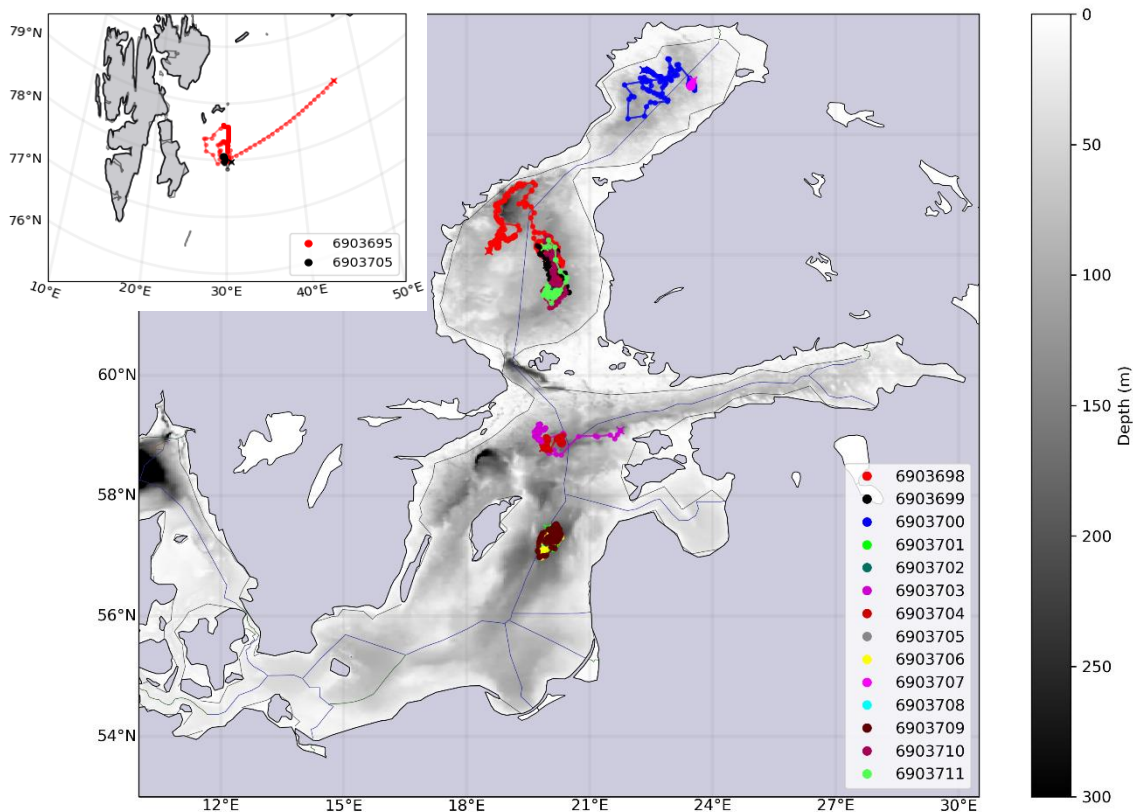


Figure 1, Routes of FMI Argo floats which operated in the Baltic Sea in 2021. Upper left inset shows the trajectories of the Barents Sea floats. The dot indicates the deployment location. Cross indicates the recovery point or latest measurement for each Argo float.

In 2021 FMI deployed total of 3 floats. One Apex float was deployed on Gotland Deep (WMO 6903708), on on Bothnian Sea (WMO 6903711) and one on Bothnian Bay (WMO 6903707).

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

FMI has committed to purchase and deploy three floats in a year, at minimum, and spends roughly 3 person months in Argo operations each year. Euro-Argo Rise project has made it possible to increase the total person months used in Argo activities closer to 12. Our main geographical operation area is the Baltic Sea. Currently we are further developing the operation of Argo floats in

shallow, and ice-covered seas. First experiments with ice-avoidance on the Baltic Sea has been performed during winter 2015-2016. In 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 one winter and is currently under ice.

3. Summary of deployment plans

FMI plans to deploy total of 3 floats in 2022. One float will be deployed on Bay of Bothnia, and two in Barents Sea.

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 Siirä 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. The Euro-Argo could coordinate developments and deployments of ice-tethered Argos.

6. CTD data uploaded to CCHDO

No data uploaded.

7. Bibliography

Haavisto N, Tuomi L, Roiha P, Siirä 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, Siirä 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>

Siirä 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. Effects of COVID-19

COVID-19 situation forced some cruises to be rescheduled which had caused challenges for deployment planning. The challenges have been manageable.

9. RBR CTD piloting and deployment plans

Two deployments of Argo floats with RBR sensors were done within the Euro Argo Rise project in 2021. The results of these floats will be used to determine further plans for Finnish Argo operations.



French National Report on Argo - 2021 AST 23

By the Argo-France Management Board :

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Sauzède, C. Schmechtig, P.Y. Le Traon, N. Poffa, S.
Pouliquen and V. Thierry*

[Background, organization and funding of the French Argo activities](#)

[Organization](#)

[Funding](#)

[Long term evolution of Argo](#)

[Float development](#)

[The status of implementation](#)

[Floats deployed and their performance](#)

[Technical problems encountered and solved](#)

[Status of contributions to Argo data management](#)

[Status of delayed mode quality control process](#)

[Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible](#)

[Operational ocean forecasting](#)

[Support to the Mercator and Coriolis scientific activities](#)

[European Argo-data project involving French Argo community](#)

[National Research](#)

[Key project activities](#)

[ISAS T/S gridded fields](#)

[ANDRO Trajectory dataset](#)

[ICES North Atlantic Ocean State Report \(IROC\)](#)

[H2020 EARISE \(Euro-Argo Research Infrastructure Sustainability and Enhancement, 2019-2022\)](#)

[ERC REFINE \(Robots Explore plankton-driven Fluxes in the marine twilight zone, 2019-2022\)](#)

[PIE Ifremer PIANO \(Argo Novel Observations Investment Plan ; 2021-2025\)](#)

[Equipex+ Argo-2030 \(3rd Investment Plan of French Research Ministry: 2021-2028\)](#)

Bibliography

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

Argo France program

Purchases and tests

Deployments at sea

DAC/GDAC and data management

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

Background, organization and funding of the French Argo activities

Organization

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

All Argo-France activities are led and coordinated by:

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

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

Funding

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

Since 2000, around 1450 French floats have been deployed in different geographic areas. Deployments focused on meeting specific French requirements while also contributing to the global array.

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

As follow up of this project:

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

-the [Argo2030 project](#) (2021-2028) has been recently accepted and funded by the Ministry of research to consolidate and improve the French contribution to BGC-Argo (funding of 15 BGC floats), and to test the next generation of french deep-Argo-6000 floats (funding of 22 floats), and of BGC-ECO floats (funding of 14 BGC-ECO float).

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

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

Total (2000-2020)			1424		1423
2022	1400k€	15	80		

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

Long term evolution of Argo

At the national level, Argo-France will contribute to the new phase of Argo with about 69 floats/year with the following repartition:

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

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

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

Float development

As part of the [EA-RISE 2019-2022 H2020 project](#):

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

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

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

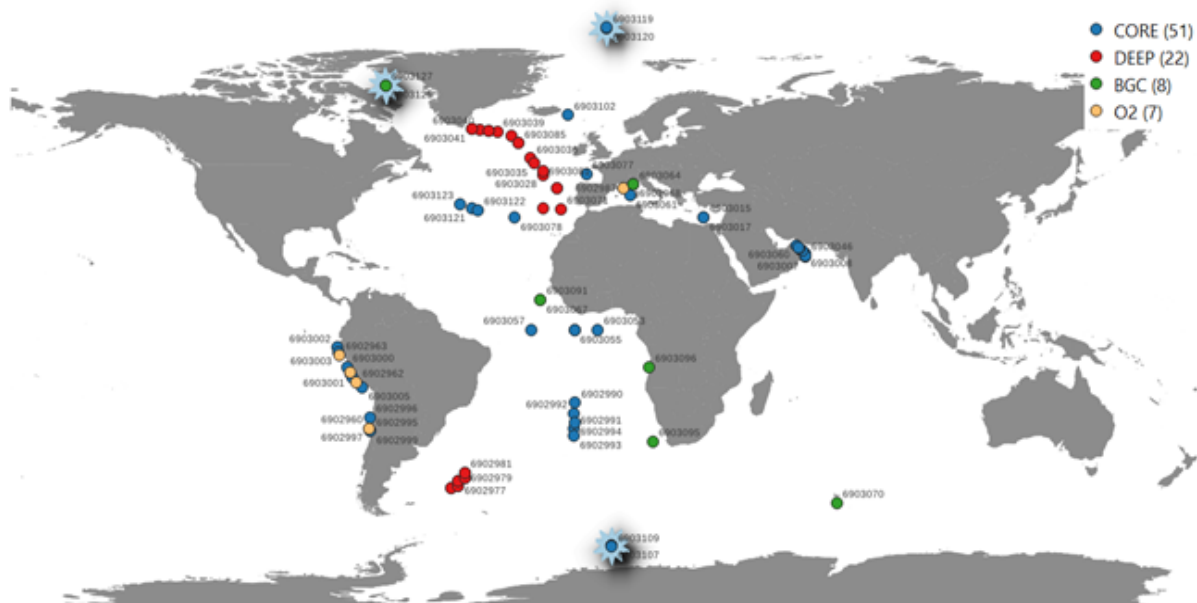
As part of the new [lfremer PIANO project](#) the expected technological developments are :

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

The status of implementation

Floats deployed and their performance

90 floats have been deployed by France in 2021 (51 T/S Core, 7 T/S/O₂, 10 BGC, 22 DEEP). We deployed those floats from French RVs Atalante, Thalassa, Marion Dufresne and Beautemps Beupre, international RVs Sonne, Amundsen and Sarmiento de Gamba but also from ships of opportunity (commercial ship, fishing vessels and sailing yachts Tara and Iris). The deployment areas are chosen to meet French requirements in terms of research and operational activities and also to contribute in establishing the global array (especially in the Southern Ocean) using OceanOPS tools. Note that due to COVID19 pandemic, ship opportunities from the French Scientific fleet previously scheduled in 2020 have been deployed in 2021.



Deployment locations of Argo-France floats in 2021 by float types.

Technical problems encountered and solved

Technical problems.

- 2 DEEP disappeared prematurely: Unidentified problems
- 1 CTS4 End of life mode after deployment (deployed off Peruvian shelf)
- 1 CTS3-DO disappeared after grounding on the Gulf of Lion shelf

Seabird batch of drifting CTDs is being assessed and monitored.

Since 2014, a larger than expected percentage of SBE conductivity sensors have drifted prematurely, eventually to an uncorrectable state (Abrupt Salty Drift - ASD). To monitor this issue, floats affected are listed in a spreadsheet that is concatenated at the international level and updated regularly:

<https://docs.google.com/spreadsheets/d/1TA7SAnTiUvCK7AyGtSTUq3gu9QFbVdONj9M9zAq8CJU/e/dit#gid=0>

- So far, 38 French Floats are listed as having a moderate or severe drift, this represents about 6% of the french float affected by this failure.

Status of contributions to Argo data management

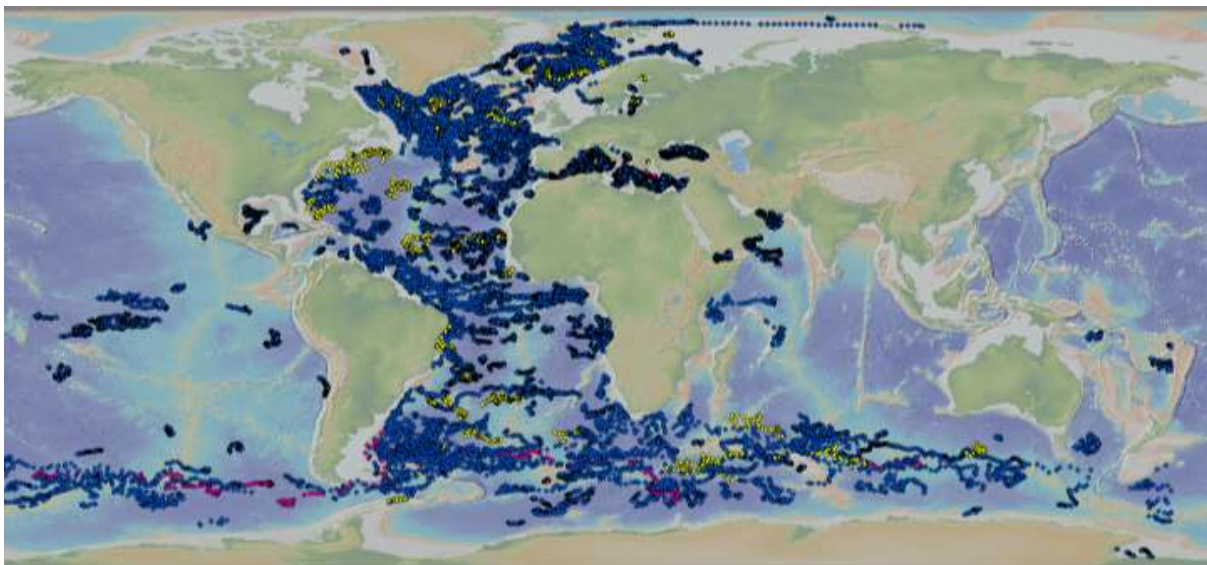
Within Argo-France, data management is undertaken by Coriolis, which plays three roles: Data Assembly Centre, Global Data Centre, and leader of the North Atlantic Argo Regional Centre. Coriolis is located within Ifremer-Brest and is operated by Ifremer with support of SHOM. Since 2016, the BGC floats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

All Argo data management details are in the Coriolis DAC and GDAC 2021 annual report (english) : <https://archimer.ifremer.fr/doc/00737/84949/>

Data Assembly Center

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

In the last 12 months, 58 535 profiles from 828 active floats were collected, controlled and distributed. Compared to 2020, the number of profiles has increased (+12%), the number of floats increased by 5%. These figures show a fair stability in Coriolis DAC activity. The 828 floats managed during that period had 52 versions of data formats.



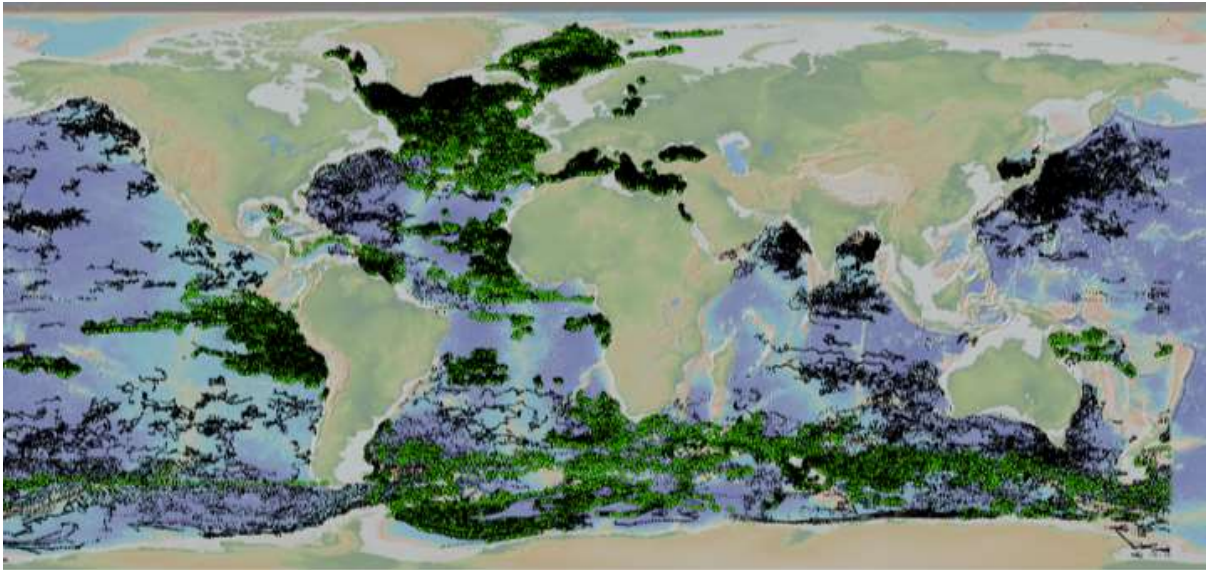
Map showing the 58 535 profiles from 828 active float decoded by Coriolis DAC in 2021

Apex Nova Provor Nemo

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

Coriolis DAC manages 622 BGC-Argo floats from 5 families and 57 instrument versions. They performed 79 192 cycles. The data processing chain is freely available:

- Coriolis Argo floats data processing chain, <http://doi.org/10.17882/45589>



Map of 622 flotteurs BGC-Argo managed by Coriolis DAC (gray: BGC floats from other DACs). Measurements are dissolved oxygen, chlorophyll, turbidity, CDOM, backscattering, UV, nitrates, le bisulfite, pH, irradiance, PAR.

Global Argo Data Centre

Coriolis hosts one of the two global data assembly centres (GDAC) for Argo that contains the whole official Argo dataset. The Argo GDAC ftp server is actively monitored by a Nagios agent (see <http://en.wikipedia.org/wiki/Nagios>). Every 5 minutes, a download test is performed. The success/failure of the test and the response time are recorded. There is a monthly average of 633 unique visitors, performing 5218 sessions and downloading 4.53 terabytes of data files.

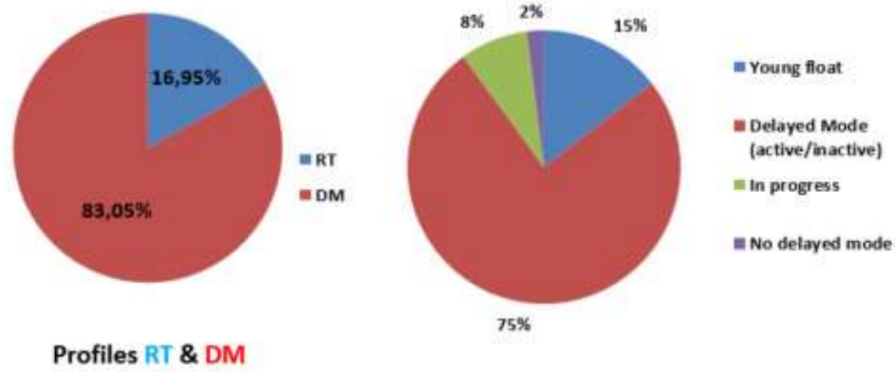
Within the EMODnet and CMEMS-INSTAC projects, in continuity of the prototype developed in the [EU AtlantOS project](#), Ifremer is setting up a dashboard (Semaphore) to monitor data distribution and give credit to data providers such as Argo floats partner institutes. FTP downloads log files are ingested in an Elasticsearch index. A link between downloaded files, download originators, floats included in the downloaded files and institution owners of the floats is performed. These links are displayed in a Kibana dashboard. This dashboard will offer the possibility to give credit to Floats owner institutions such as how many data from one particular institution was downloaded, by whose data users

North Atlantic Argo Regional Centre

See section 5.4

Status of delayed mode quality control process

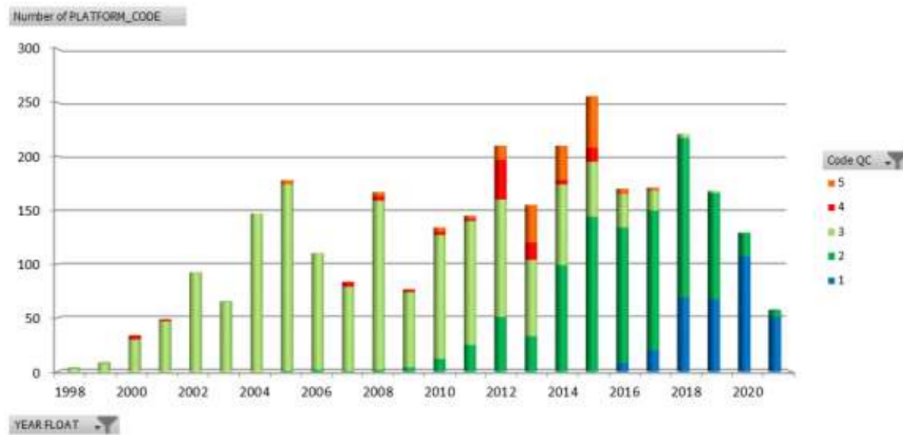
Last year (November 2020-November 2021), 49 671 new delayed mode profiles were produced, validated by PIs and sent to GDACs. A total of 323 450 delayed mode profiles have been produced and validated since 2005. In November 2021, 83.05% (75%) of the profiles (floats) processed by the Coriolis DAC were in delayed mode (see Figure below).



Status of the floats processed by Coriolis DAC.

Left: in terms of profile percent and right: in terms of float percent (DM : delayed mode – RT : real time).

The status of the quality control done on the Coriolis floats is presented in the following plot. For the two last years (2020- 2021), most of the floats are still too young (code 1) to be performed in delayed mode. For the period 2012-2015, we are still working on the DMQC of some floats. The codes 2 and 3 show the delayed mode profiles for respectively active and dead floats.



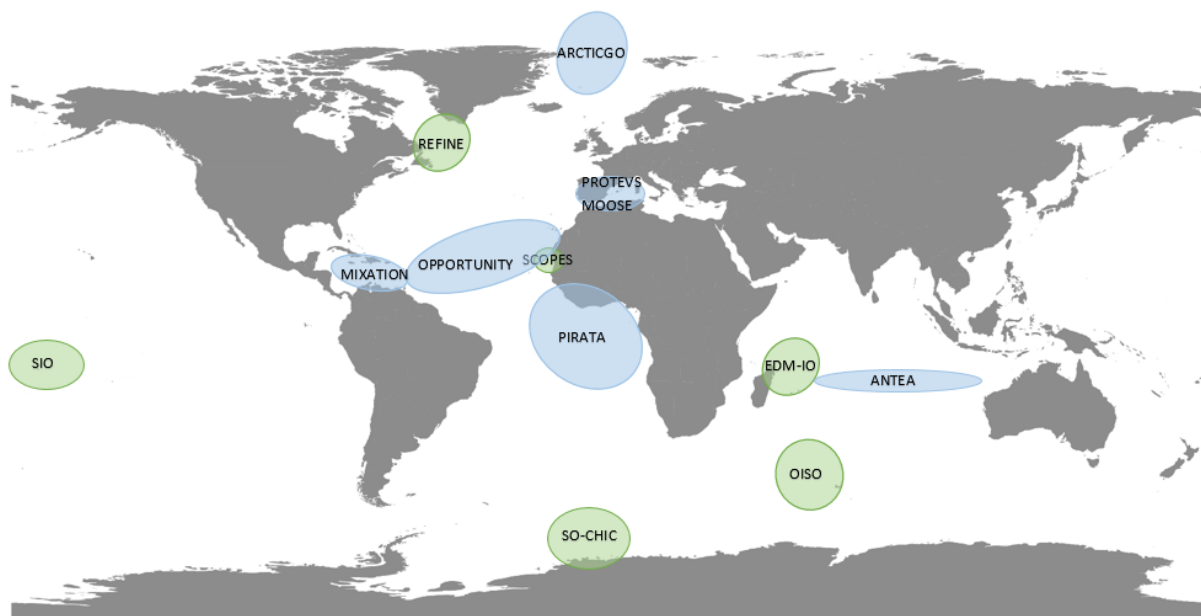
Status of the quality control done on profiles sorted by launch's year, code 1: young float, code 2: active float, DM done, code 3 : dead float, DM done; code 4 : DM in progress, code 5 : waiting for DM , code 6 : problems with float.

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

According to the current deployment plan, 80 floats are scheduled to be deployed in 2022 (57 confirmed : 16 T/S, 29 BGC, 12 DEEP), see map below.

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

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



Deployment locations of Argo-France floats planned in 2022 by ship cruises : blue are core Argo deployments and greens will include BGC floats.

COVID19: In 2021, Argo-France has managed all deployment postponed from 2020. The COVID19 impact has been reported at the OceanOPS and Euro-Argo level for possible coordinations to sustain the array

(<https://docs.google.com/spreadsheets/d/1ofo5jipeBLFRpNVKpcbTZuiKjpCmWwVU2TPI3-bBO0BM/edit#gid=0>).

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

Operational ocean forecasting

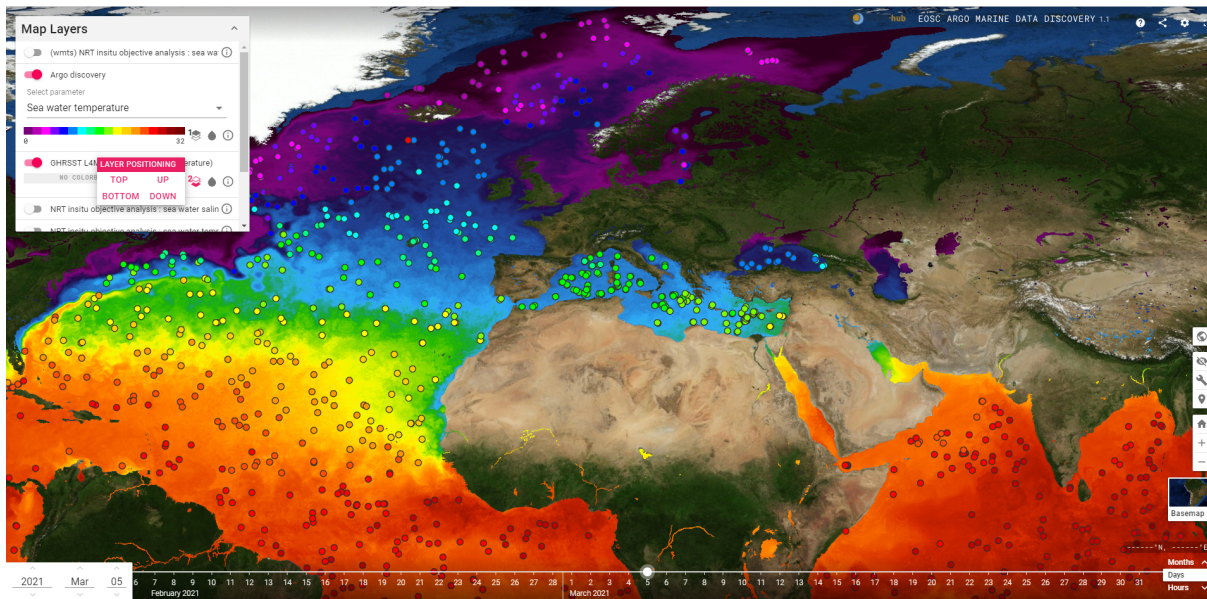
All Argo data (alongside with other in-situ and remotely sensed ocean data) are routinely assimilated into the MERCATOR operational ocean forecasting system run by the MERCATOR-Ocean structure. MERCATOR also operates the Global component of the European Copernicus Marine Environment Monitoring Service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

Support to the Mercator and Coriolis scientific activities

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

European Argo-data project involving French Argo community

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



Map of Argo-Float surface temperature overloaded with satellite SST

National Research

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

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

Key project activities

ISAS T/S gridded fields

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

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

ANDRO Trajectory dataset

Argo-France contributes to the DMQC on Argo float trajectories and provides updates to the ANDRO product (Atlas of Argo trajectories). An update for the period 2010-2021 including the floats of the AOML and Coriolis DACs was published in 2021. The delayed-time QCs of the Argo float trajectory data have been updated, as well as the Andro Atlas of float travel velocities at DOI:

Ollitrault Michel, Rannou Philippe, Brion Emilie, Cabanes Cecile, Reverdin Gilles, Kolodziejczyk Nicolas (2021). ANDRO: An Argo-based deep displacement dataset. SEANOE. doi:<https://doi.org/10.17882/47077>

ICES North Atlantic Ocean State Report (IROC)

As every year, in 2021, Argo-France contributed and assembled the French contribution to the ICES report on the state of the North Atlantic Ocean in 2020. The ISAS temperature and salinity fields are

used in its "Ocean State Report" (www.ices.dk): Kolodziejczyk Nicolas, Desbruyeres Damien (2021). Contribution to the ICES Report on Ocean Climate : North Atlantic Ocean in 2021. National report: France, May 2021. LOPS-WGOH-2021-05:

https://www.umr-lops.fr/content/download/157761/file/LOPS_21_05_IROC_WGOH_France_v2.pdf

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

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

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

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

After obtaining a first ERC in 2011 (remOcean), Hervé Claustre obtained in 2019 a second ERC (Advanced Grant) for the REFINE project . The scientific objective of REFINE is to understand and quantify the physical, biological and biogeochemical processes that control the biological carbon pump, a key element in CO₂ sequestration. It is in the mesopelagic zone (or twilight zone), between 200 m and 1000 m, that most of the key processes occur. Yet this zone represents one of the least well known ecosystems on our planet. The REFINE project will therefore focus on exploring the meso-pelagic zone and will be implemented through four major coordinated actions:

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

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

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

- procurement of BGC-Argo floats (12 floats over 5 years)

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

Equipex+ Argo-2030 (3rd Investment Plan of French Research Ministry; 2021-2028)

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

- The new generation of French BGC-Argo floats (referred to as "BGC-ECO" Argo) will add unique imagery and active acoustics capabilities. These floats will allow the exploration of the mesopelagic zone (100-1000 m) including its biological/fishing dimension (it is believed that the protein resources of this zone are underestimated by at least an order of magnitude) assuming that it is the main site of the remineralization of CO₂, and therefore it is decisive for CO₂ sequestration.
- The new generation of French Deep-Argo floats (the Deep-Arvor "6000") will target 6000 m depth (the floats developed and successfully tested in the NAOS Equipex are designed to target 4000 m depth). It will offer a high capacity for carrying additional sensors (oxygen in particular), allowing the Deep-Arvor "6000" to be positioned as the first Deep + BGC mixed float. These floats will help estimate the role of the deep ocean on the planet's energy balance, sea level rise, deoxygenation, and acidification in key regions (Atlantic, Southern Ocean). Their deployment will be combined with Deep-Argo 4000 floats to best resolve geographic structures and seasonal to interannual variations in heat and freshwater content, steric height and circulation at the basin scale within deep (> 2000 dbar) and abyssal (> 4000 dbar) oceanic layers.

Argo-Regional Center: Atlantic

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

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

<http://www.umar-ops.fr/en/SNO-Argo/Activities/NAARC/Consistency-checks-of-DM-salinity-correction>

[S](#)

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

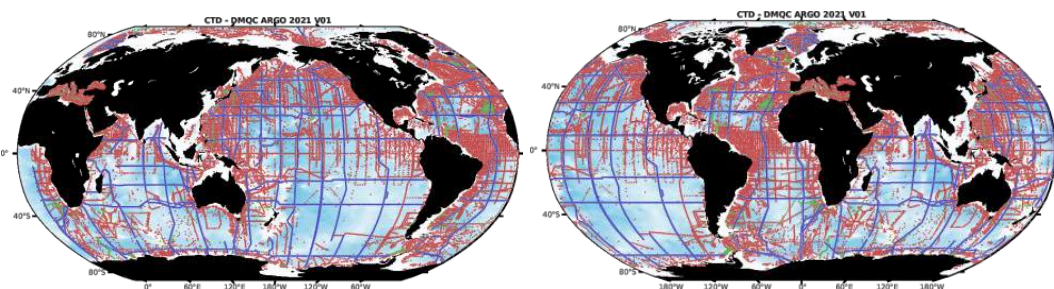
performance of the Argo data system. If you have specific comments, please include them in your national report.

- Large cost increases in 2022 on Seabird Sensor and other float components (expected increase of float cost by 5-10%) with no additional budget at national level to cover the cost increase. We thus expect to buy 5-10% less float than originally planned in the coming years. We expect the same issue in other countries and that cost will continue to increase regarding the current international situation. This will certainly impact the Argo program.
- In this context and to be as efficient as possible, Argo France stresses the need for international coordination among the One Argo network for the implementation of the BGC and Deep components as a contribution to the Core component.
- 6% of our fleet was impacted by salinity sensor drift. Such monitoring needs to be done on the long-term and extended to other sensors.

CTD cruise data in the reference database

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

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



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

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

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

Bibliography

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

In 2021, at least 65 articles with a scientist affiliated in France as a coauthor have been published in peer reviewed journals. Note that the list of all publications in which a scientist from a French laboratory is involved is available on the Argo France website and on the Argo Bibliography web page. To date, more than 400 articles have been listed:

<https://www.argo-france.fr/en/Bibliography/Publications>

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

Argo France program

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

Purchases and tests

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

Deployments at sea

Due to COVID19 pandemic ship opportunities from the French Scientific fleet previously scheduled in 2020 have been deployed in 2021.

DAC/GDAC and data management

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

Meeting/outreach

AST 22 in visio conference March 2021

Deep and BGC workshop in visio conference in September/October 2021

ADMT 22 in visio conference December 2021

Most of meeting and outreach events have taken place in mixed presental/remote in 2021

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

In the framework of the H2020 Euro-Argo-RISE project, Ifremer has developed the Arvor-I/RBR, which is a standard Arvor-I float equipped with the RBR CTD. 2 floats of this type were deployed during the Spanish RAPROCAN2020 campaign off the Canary Islands in December 2020. 2 other Arvor RBRs purchased by Argo-France (Ifremer budget) were also deployed in the North Atlantic in 2021. The data will be analyzed by LOPS in the framework of Euro-Argo RISE. 6 Arvor RBRs were purchased by Argo-France in 2021 for deployment in 2022. Argo-France also provided 4 Arvor with SBE41CP to be deployed by Argo Netherlands in the Caribbean in April 2022 with simultaneous deployments of 4 Arvor RBR owned by KNMI.



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

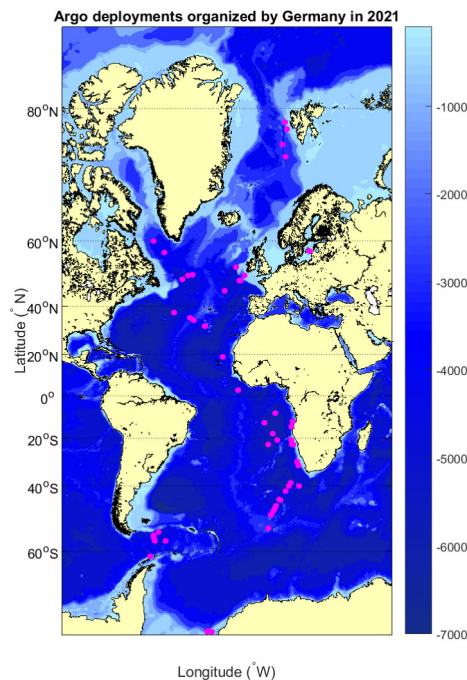
Argo-France: <https://www.argo-france.fr/>
French bibliography: <https://www.argo-france.fr/en/Bibliography/Publications>
Argo PhD list: <https://www.argo-france.fr/en/Bibliography/Theses>
NA-ARC data mining website: <https://www.umr-lops.fr/SNO-Argo/Activities/A-ARC>
Coriolis FTP:
<http://www.coriolis.eu.org/Data-Services-Products/View-Download/Download-via-FTP>
Coriolis DAC:
<http://www.coriolis.eu.org/Observing-the-ocean/Observing-system-networks/Argo>
IUEM OSU: <http://www-iuem.univ-brest.fr/observatoire>
Argo2030 project : <https://www.argo-france.fr/en/Projects/Argo-2030>
PIANO project : <https://www.argo-france.fr/en/Projects/PIE-PIANO>
NAOS project: <http://www.naos-equipex.fr>
Euro-Argo: <http://www.euro-argo.eu>
Coriolis: <http://www.coriolis.eu.org>
Laboratoire d'Océanographie Physique et Spatiale: <http://www.umr-lops.fr/>
Laboratoire d'Océanographie de Villefranche: <http://www.obs-vlfr.fr/LOV>
Mercator: <http://www.mercator-ocean.fr>

German National Report 2021 for the Argo Steering Team Meeting AST23

Submitted by Birgit Klein on behalf of Argo Germany

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021) a. floats deployed and their performance

Most floats deployed by Germany in 2021 were operated by BSH. 86 floats were acquired in 2021 and altogether 77 floats were deployed including one Float from GEOMAR, 6 Floats from AWI and 20 floats from the national project DArgo2025. Nine floats were loaded on ships in 2021 and have now been deployed in early 2022. Due to cancellation of cruises in 2020 because of the COVID pandemic more floats were deployed in 2021 than in other years. The South African Weather Service (Tamaryn Morris) had kindly accepted to store German floats on their premises to be picked up by German Ships calling into Cape Town and to be deployed on the regular South African cruises (SANA, SAMBA, Good Hope). Most deployments were carried out on research vessels, which comprised German, Polish, South African and UK ships. A contribution of five floats was made to the deployment by the sailing ship Iris that was chartered in 2021 specifically for deployments in the Atlantic Ocean. Another four floats were delivered to the Bark Europa a sailship operating tourist cruises around Antarctica and the Southern Ocean. The deployment locations for 2021 are shown in Fig. 1. The majority of the deployed floats except were Argo floats with TS sensor only, 15 floats deployed in the DArgo2025 project were floats with BGC sensors and the remaining five floats from the project carried RBR sensors.



Stand 07.03.2022

Fig. 1: Deployment positions for floats operated nationally in 2021 in the Atlantic Ocean.

b. technical problems encountered and solved

None of our floats deployed in 2021 has experienced serious technical problems.

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

Germany has continued its work in the European Research Infrastructure Consortium EURO-ARGO-ERIC, which was established in July 2014. In 2020, the EuroArgo ERIC has started a joint census of floats affected by fast salinity drift at European level to estimate the effects on the data stream. Initially, the list was established on GitHub and shared as a google-docx document. The working group on fast salinity drift reported at ADMT-21 and ADMT-22 on the issue. It was decided to collect the information in a joint spreadsheet with information on all premature salty drifter regardless if the develop abrupt salty drift or drift more or less continuously. The link to the spreadsheet is given below and entries can be entered either from all DMQC operators directly or be send as lists to Birgit.klein@bsh.de for inclusion in the table.

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

The national contributions to the spreadsheet will be updated for AST-23.

status of delayed mode quality control process

BSH had adopted floats from all German universities and agreed last year to perform similar services for the AWI floats. The status of delayed mode quality process for German floats is good. The overall percentage of D-files from all German programs is remaining at a high level (>90%). DMQC has now also been performed for the subset of re-processed AWI floats (now in V3.1) and is awaiting approval from AWI PIs. Now only 42% of the AWI files are available as D-files. The census of the delayed mode quality control was given in detail in the data management report from November 2021.

BSH has also adopted floats from Finland (37 floats), the Netherlands (92 floats), Norway (58 floats) and Poland (26 floats) for DMQC and is responsible in the framework of the MOCCA project (coordinated by the ERIC) for the delayed-mode quality control of 65 MOCCA floats in the Nordic Seas, the subpolar gyre and the Southern Ocean. The progress in these programs providing D-files is generally good. Since Argo-Norway has received funding from the national research council to increase the number of Norwegian floats deployed per year, the program will get more involved in the DMQC activities after we had organized a DMQC training workshop for Norway and Poland in 2019. Floats deployed from 2020 onward will be covered by Norwegian and Polish DMQC operators.

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)

At the moment all our national funding from the BMVI is still for core Argo only. The aim is to switch our contribution to a mix of 36 core floats, 14 deep floats and 12 BGC floats annually. The budget proposal for 2022-2026 was principally supported at BMVI level. The negotiations for the national budget are presently delayed because of the elections and both budgets for 2022 and 2023 have asked for a full implementation of the One Argo strategy and a rise in annual budget to 2.5 Mio €. A decision is now expected until April/May 2022, but due to the recent political event the situation may be changed.

The Federal Ministry of Science (BMBF) had provided considerable funding in 2020 to start the transition into the new multidisciplinary strategy. The project DArgo2025 (08/2020-12/2021) had received funding in 2020 for 20 floats, 15 of which are BGC floats and 5 core floats, but equipped with RBR CTDs. The proposal was headed by BSH with partners from the newly created BGC group (GEOMAR, ICBM and IOW). Deployments of all DArgo2025 floats have taken place in 2021 and addressed open technological questions with the data return from the floats. Some of the BGC floats carry novel sensors such as a nitrate sensors and hyperspectral sensors from the German TRIOS company. In the project C-Scope (01/2021-12/2023) additional funding has been received to promote pH measurements on floats. In 2022-2023 six floats will be upgraded with pH and O₂ sensors and a new sensor of pCO₂ will be tested.

In the context of the European Project EuroArgo-Rise the BSH has worked on a contribution for the Arctic and has developed a decision tool for selecting parameters for Ice Avoidance algorithms (ISA). Two floats from national funding were deployed in 2020 north of Svalbard, one of which was the first float to reach the Laptev Sea. Sea after nine month under the ice. Cooperation have been established with the AWI and its Arctic working group to participate in upcoming Polarstern expeditions to the High Arctic. Two more floats will be deployed in 2022 from Polarstern north of Svalbard.

For the Southern Ocean AWI has restarted its activities in float deployments including RAFOS technology. AWI will deploy 23 floats in the southern Weddell Gyre in 2022, but no long-term funding scheme is established.

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. The BSH logistics related to technical aspects, float deployments and satellite data transmission are handled by Anja Schneehorst and Simon Tewes. Ingrid Angel Benavides and Corinna Jensen are involved in Argo in project related matters. The national BGC group established in 2020 involves three research institutes: GEOMAR, ICBM and IOW. A complete list of people involved is given below.

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

Name and institution	Area of expertise
Ingrid Angel-Benavides (BSH)	Research scientist (EuroArgo Rise) and related DMQC obligations
Henry Bittig (IOW)	Research scientist (DArgo2025, C-Scope), BGC group, DMQC operator (BGC sensors)
Hendrik Bünger (ICBM)	Research engineer, BGC group, DMQC operator (BGC sensors)
Corinna Jensen (BSH)	Research scientist (DArgo2025) and related DMQC obligations
Birgit Klein (BSH)	National program lead, research scientist (DArgo2025, C-Scope, EuroArgo Rise), DMQC operator (core Argo)
Arne Körtziner (GEOMAR)	Research scientist, BGC Argo, DMQC operator (BGC sensors)
Anja Schneehorst (BSH)	Technician, float procurement, contracting, deployment logistics and performance monitoring
Tobias Steinhoff (GEOMAR)	Research scientist, BGC group, DMQC operator (BGC sensors)
Simon Tewes (BSH)	Technician, technical support, and performance monitoring
Malin Waern (IOW)	Research scientist, BGC group
Oliver Zielinski (ICBM)	Research scientist, BGC group
Olaf Boebel (AWI)	Research scientist, RAFOS technology

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.

Due to a larger contribution of floats with RAFOS capability for the Southern Ocean from the AWI (23) about 72 deployments are expected in 2022 (see figure 2). 8 Floats will be BIO floats (4 from ICBM, 3 from BSH and 1 from IOW). Deployment opportunities come mostly from regular research cruises The commitment table at OceanOPS ([link](#)) has been edited based on the present plans and will be modified again when the national budget for 2022 is finally released and we can proceed with our procurements. The present number of 72 floats is based on the assumption that the raise in budget is postponed and we will remain to buy only TS floats with our regular national budget.

Argo potential deployments organized by Germany in 2022 (72 floats)

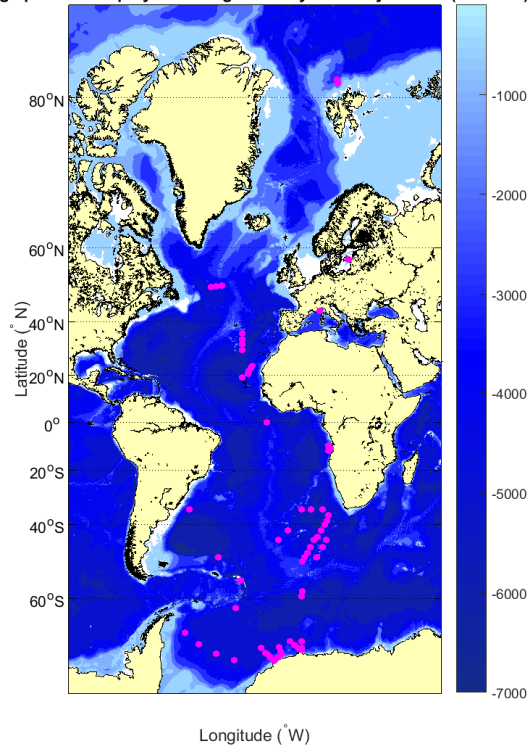


Fig. 2: Deployment positions for floats operated nationally in 2022 in the Atlantic Ocean.

GER	2021						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas	4	4					
Mediterranean Sea							
Black Sea							
Baltic Sea/North Sea	6				6		
Southern Ocean	6	6					
Arctic Ocean							
Global Ocean	61	51		1	9		
Total	77	61		1	15		

Table 2: German deployments (BSH, AWI, ICBM, GEOMAR) deployments in 2021 according to area and subprogram.

The numbers in for 2022 depend on the national budget negotiations for 2022, at minimum there will be 50 core TS floats from the operational BSH budget, 23 floats from AWI in the Southern Ocean and 3 Bio-floats from the C-Scope project and 4 Bio-floats from ICBM deployments. Deployment positions are not yet determined, the 23 AWI Floats will all be deployed in the Southern Ocean and the remaining floats will go mostly to the Global Ocean.

GER	2022						
	Total	T/S Core	T/S/O2	BGC	Bio	Deep	
Nordic Seas							
Mediterranean Sea	1				1		
Black Sea							
Baltic Sea/North Sea	2				2		
Southern Ocean	23	23					
Arctic Ocean	2	2					
Global Ocean	44	40			4		
Total	72	65			7		

Table 3: German (BSH, AWI, ICBM) deployments in 2022 according to area and subprogram.

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

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

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

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

The annual user workshop for 2021 was held as a virtual event on 18.02.2021. The meeting was well attended and provided a good forum for users to share their scientific work and methods.



A key aspect of the use of Argo data at BSH is to develop a data base for climate analysis to provide operational products for interpretation of local changes and data for research applications for BSH related projects (e.g. Expertennetzwerk BMVI). Argo data are being used by many researchers in Germany to improve the understanding of ocean variability (e.g. circulation, heat storage and budget, and convection), climate monitoring and application in ocean models.

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 the AIC, the coordination of activities at an international level and the performance of the Argo data system. If you have specific comments, please include them in your national report.**

We will be in contact with our colleagues at AWI about future prospects for deployments in the high Arctic after 2022. But due to the present political situation we expect delays or cancellation of Polarstern cruises and therefore also the need to the revise plans to further test technology and software in the Nansen Basin.

The strong price increase in sensors and floats might also pose a challenge to maintain the expected number of float procurements.

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.

BSH regularly ask PIs from our deployment cruises to provide us with any CTD profiles recorded after float deployments for calibration and comparison. These data are shared with Coriolis. In addition, we have collected new reference data for the Arctic and will perform quality checks on the soon to be released in the next update of the global CTD reference data base.

- 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.**

Roemmich, D., L. Talley, N. Zilberman, E. Osborne, K. S. Johnson, L. Barbero, **H. C. Bittig**, N. Briggs, A. J. Fassbender, G. C. Johnson, B. A. King, E. McDonagh, S. Purkey, S. Riser, T. Suga, Y. Takeshita, V. Thierry and S. Wijffels (2021). The technological, scientific, and sociological revolution of global subsurface ocean observing. *Oceanography* 34: 2-8, doi: 10.5670/oceanog.2021.supplement.02

A. Jemai, H. Bünger, R. Henkel, D. Voß, J. Wollschläger and O. Zielinski, "Hyperspectral underwater light field sensing onboard BGC-Argo Floats", *OCEANS 2021: San Diego – Porto*, 2021, pp. 1-8, doi: 10.23919/OCEANS44145.2021.9705770. (<https://doi.org/10.23919/OCEANS44145.2021.9705770>)

Jemai A, Wollschläger J, Voß D and Zielinski O (2021) Radiometry on Argo Floats: From the Multispectral State-of-the-Art on the Step to Hyperspectral Technology. *Front. Mar. Sci.* 8:676537. doi: 10.3389/fmars.2021.676537 (<https://doi.org/10.3389/fmars.2021.676537>)

- 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 in 2021 were still affected by COVID but not as strongly in as in 2020. Fortunately, budgets were not affected since the procurements could be finished in time in 2021 and floats were stored in our warehouse or at partner's premises.

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

BSH has deployed a small ensemble of 5 RBR CTDs together with 5 SBE CTDs in January 2021 in the North Atlantic (Fig. 3 and 4) in the framework of the DArgo2025 project. The 10 floats were deployed in an eddy to minimize dispersion and had been reporting at a two-day cycle for the early cycles. The analysis of the data has been carried out during 2021 and made use of the reference data collected during the cruise to calibrate the pressure dependence of the RBR conductivity cell. The coherence of the swarm appears very good (Fig.5) and until February 2022 most of the floats from the swarm still remain in its vicinity and show a fresh bias compared to climatology. It is planned to perform a similar experiment in fall of 2022 and buy at least 5 RBR CTDs.

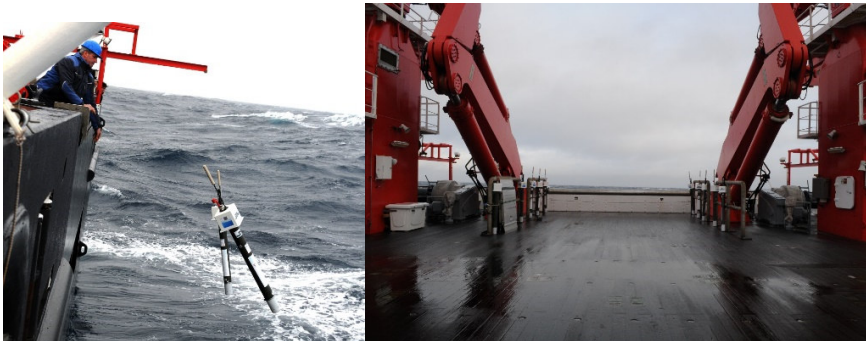


Fig.3: Deployment of Arvor floats equipped with RBR and SBE CTDs in January 2021 on RV Sonne cruise SO280.

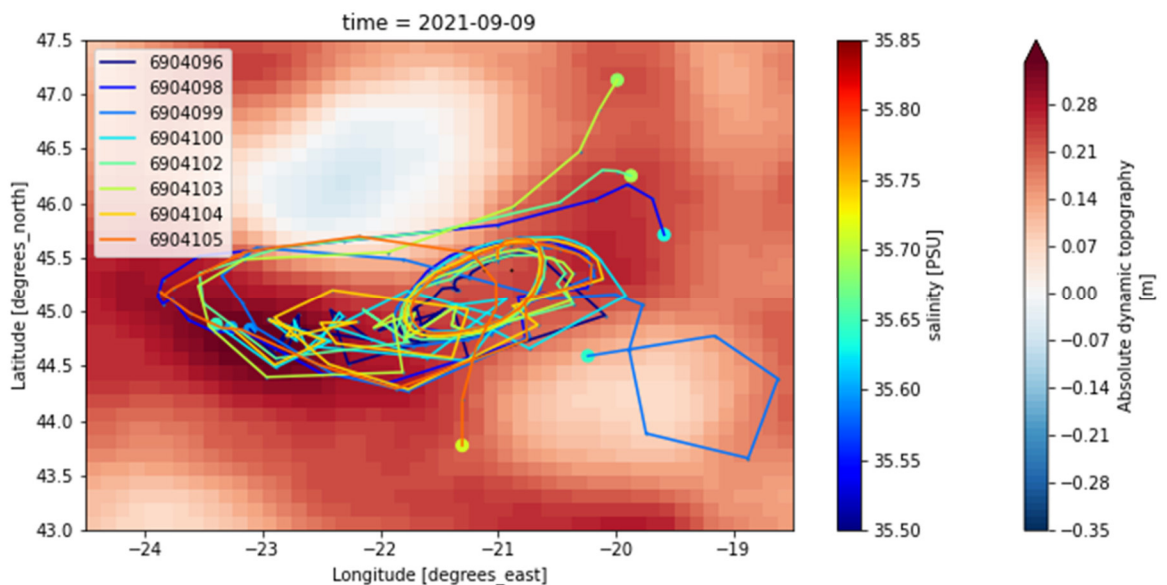


Fig. 4: Deployment positions for RBR pilot and trajectories of the swarm for the first nine month after deployment.

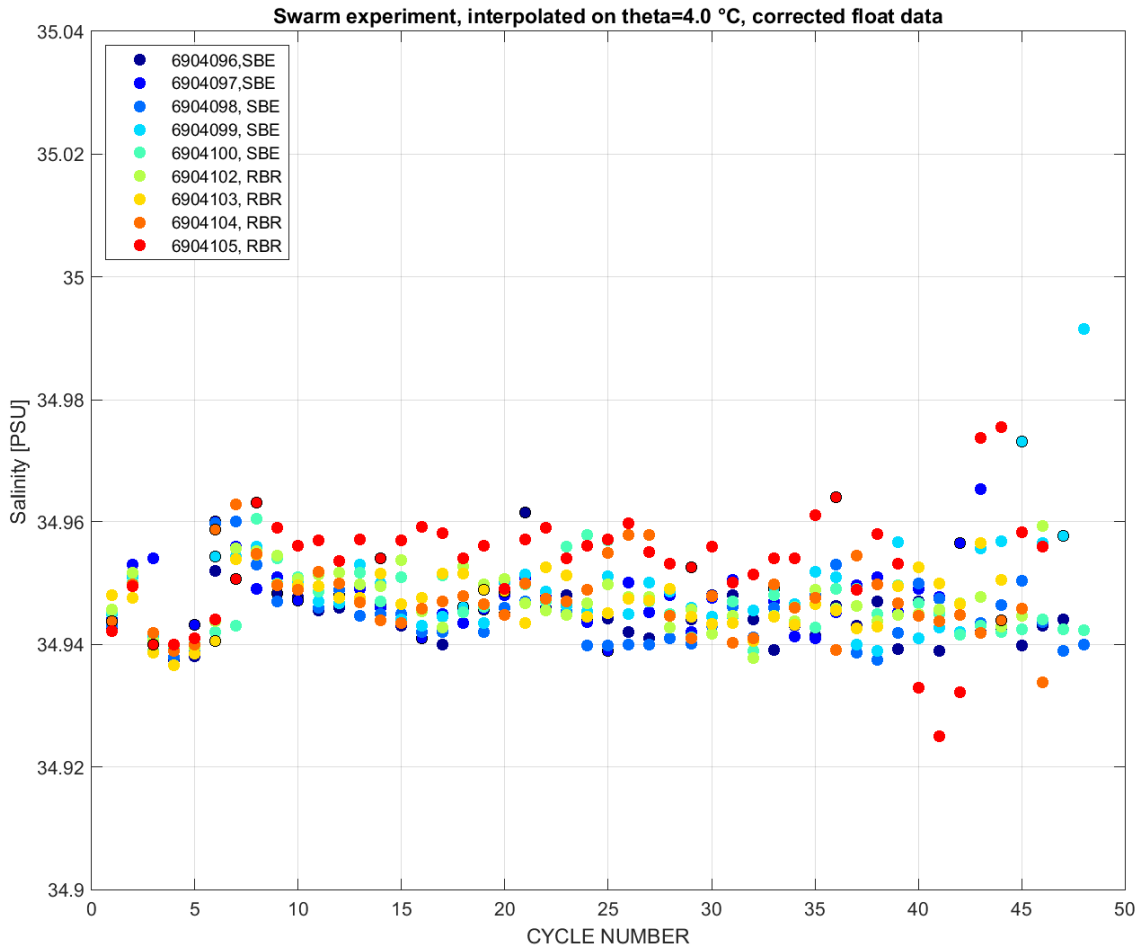


Fig. 5: Salinities at around 1600-1800 m depth on the 4.0 isotherm. The legend indicates whether the float carries an SBE or an RBR CTD.

GREEK ARGO PROGRAMME
PRESENT STATUS AND FUTURE PLANS

G. Korres and D. Kassis
HCMR
March, 2022

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 2021, five (5) Argo floats were deployed in the Greek Seas under the framework of the Greek-Argo RI activities, and the Euro-Argo ERIC cooperation activities. Three (3) of the floats were Arvor-I type purchased by the Greek Argo RI whilst, two Italian floats, one (1) Arvor-DO and one (1) Arvor – Deep, were deployed by Greek Argo team on behalf of the Argo-Italy. The floats were deployed in the Aegean and Levantine 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 Arvor floats has been satisfactory until now (see Table 1). Regarding Greek floats, 2 were deployed in the Aegean during POSEIDON network maintenance (these cruises were funded by HIMIOFOTS national project), and 1 in the North Aegean with the help of Aegean University (funded by Euro-Argo RISE project). Two of the Greek floats (6903297-8) were deployed at deep-coastal plateaus of the North Aegean continuing the Euro-Argo RISE project task 6.1 activities within the context of the potential of Argo to contribute on the monitoring of coastal areas. The two deployments related to Italian floats (6903803-4) were undertaken by the Greek MSFD winter cruise. All missions were successful, 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 2021

A/A	Float type	WMO	SERIAL NUMBER	Deployment Date	Deployment time	Deployment Latitude	Deployment Longitude	Available profiles	Status
1	ARVOR DO	6903803	AI2632-20EU010	20/09/2021	04:20	34.81	26.16	36	Active
2	ARVOR DEEP	6903804	AD2700-20EU002	20/09/2021	23:55	36.02	28.63	35	Active
3	ARVOR	6903296	AI2600-21GR001	13/09/2021	16:15	35.72	25.12	37	Active
4	ARVOR	6903297	AI2600-21GR006	17/10/2021	05:45	39.83	24.42	30	Active
5	ARVOR	6903298	AI2600-21GR004	13/11/2021	12:20	38.87	26.42	25	Active

All floats have been integrated in the MedArgo project. The 6903298 float was configured to cycle every 5 days, drift at 450 m and acquire profiles from 600 m under its special test mission whilst, for the 6903296 and 6903297 float we followed the standard MedArgo specifications. The mission parameters of the floats were set as follows: The parking depth of the floats was set to 350 m, its profiling depth to 1000 m and the cycle period to 5 days. 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

In June 2021, the Greek Argo team undertook a difficult Argo recovery mission in Kissamos Bay of North-western Cretan coast (Photo 1). The float had been seen laying on the seabed by a scuba diving centre in March 2021 (Figure 2). The Greek Argo team organized a recovery mission on the 11th of June 2021 and using scuba diving equipment recovered an APEX float with the help from a local professional scuba diver. The float was stuck on the seabed at 38 m depth and had major damages both on the upper part (antenna and CTD sensor, and at the bladder. The S/N on the float (9112) hasn't been identified yet.



Photo 1. The recovery mission of the APEX float found at the west Cretan coastline stranded at 38 m depth

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.

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 will cover the deployment needs for this year.

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.

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 2022 will be performed according to the plans of the Greek-Argo research infrastructure. The main goal within 2022 is to continue the development of the Greek-Argo infrastructure array in accordance with the Euro-Argo infrastructure. 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 2021 generally includes:

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

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.

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° resolution, Aegean Sea 1/130° resolution and Ionian – Adriatic Sea at 1/50° resolution) of the POSEIDON operational system.

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

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

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

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

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

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

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

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

Korres, G., K. Nittis, L. Perivoliotis, K. Tsiaras, A. Papadopoulos, I. Hoteit and G.

Triantafyllou, 2010. Forecasting the Aegean Sea hydrodynamics within the POSEIDON-II operational system. *Journal of Operational Oceanography*, Vol. 3, nu. 1, 37-49.

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

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

5.2 Ocean science and environmental studies

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

Publications in scientific journals and conferences proceedings:

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

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

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

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

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

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:

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 Mediane 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 (2022)
(Submitted by E. Pattabhi Rama Rao)

1. The status of implementation

1.1a Floats deployment

During the year 2021-22, India has deployed one core Argo float in the Indian Ocean, thus taking the total contribution to 494 floats. All the active floats data are processed and sent to GDAC.

1.1b Performance Analysis of Floats deployed

Of the 494 floats deployed so far, 83 are presently active and transmitting data

1.2 Technical problems encountered and solved

None

1.3 Status of contributions to Argo data management

- **Data acquired from floats**

India had deployed 494 floats so far (till Jan 31, 2022). Out of these 83 floats are active. All the active floats data are processed and sent to GDAC.

- **Data issued to GTS**

BUFR format messages from these floats are being sent to GTS via RTH New Delhi.

- **Data issued to GDACs after real-time QC**

All the active floats (83) data are subject to real time quality control and are being sent to GDAC.

- **Web pages**

INCOIS is maintaining Web-GIS based site for Indian Argo Program. It contains entire Indian Ocean floats data along with trajectories. Further details can be obtained by following the link: <https://incois.gov.in/argo/argo.jsp>

- **Statistics of Argo data usage**

There is a wide array of users in India for the Argo data, both profile data as well as value added products. These userbase include students and researchers from Academia, research centres, operational centres etc. Indian Meteorological Department (IMD), the nodal agency for monsoon forecast in India, is using Argo data for their operational purpose. Scientists, Students and Researchers from INCOIS, NIO, SAC, C-MMACS, NRSA, IITM, NCMRWF, IISc etc are using Argo data in various analysis and published several peer reviewed scientific papers utilizing this data. Increased availability of biogeochemical variables from the Argo floats are used for the validation of Biogeochemical model outputs like ROMS with Fennel module, and for the basic research on biogeochemical aspects.

INCOIS Argo web page statistics during the year 2021-22 are as shown below:

Page	Number
Argo Web Page Views	24654
Argo Data Download	1810
Argo Products	3520

Products generated from Argo data

- Value added product generation from the Argo profile data were continued during the reporting period. The Argo T/S data are first objectively analysed, and the gridded output is used in deriving value added products. Value added products developed and provided for scientific use include Depth of 20° isotherm, depth of 25° isotherm, dynamic height, geostrophic currents, heat content, isothermal layer depth, mixed layer depth and geostrophic currents. All these data are available for free download through INCOIS LAS. For further details visit <http://las.incois.gov.in>.

1.4 Status of Delayed Mode Quality Control process

- INCOIS started generating and uploading D files to GDAC from July 2006, and as of today, profiles belonging to all eligible floats have been subjected to DMQC.
- Enhanced Delayed Mode Quality Control software OWC is being used successfully for QC purpose. Using this software all the eligible floats are reprocessed to tackle pressure sensor offset problems, salinity hooks, thermal lag corrections, salinity drifts etc
- About 55% of the eligible profiles are subjected to DMQC and the delayed mode profiles are uploaded on to GDAC. Majority of the old dead float which are passed through DMQC are converted to Ver 3.1 and uploaded to GDAC

1.5 Trajectory files status:

INCOIS Ver 3.1 trajectory files for all APEX Argo and Iridium floats are still found to be having issues and are being rejected. The problem is still being worked out.

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

Indian Argo Project is fully funded by Ministry of Earth Sciences, (MoES), Govt. of India. Funding is requested for the procurement of 30/40 Argo floats per year including (3:2 Normal and Bio), Data management activities, Data analysis, etc. for the period 2021-2026. India plans to deploy these floats in the Bay of Bengal, Arabian Sea, Equatorial Indian Ocean and Southern Ocean sector of Indian Ocean

Three Permanent and one temporary scientific/technical personnel are working under Indian Argo project, which include personal for deployment of Argo floats, Data system, Analysis of Data, etc.

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.

India is committed to deploy floats in the Indian Ocean wherever gap exists. India will be deploying 30-40 floats per year during 2021-2026 period. Generally, a 3:1 ratio will be maintained between core Argo floats (CTD only) and BGC floats. After ascertaining the gap region, cruise plan of MoES research vessels and availability of funds, these floats will be procured and deployed.

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

Operational: All Argo data are being routinely assimilated in Ocean Model for providing Global ocean analysis. This analysis is being used by Indian MET department for initialization of coupled ocean-atmosphere forecast of the Monsoon. From the year 2011, India is providing seasonal forecast of monsoon using dynamical model wherein Ocean analysis (with assimilation of Argo) is an important contribution. The analysis products are being made available through INCOIS live access server (las.incois.gov.in).

Research: Argo data are being widely used for many applications to understand the Indian Ocean dynamics, cyclone and monsoon system in relation to heat content, thermocline component of sea level and validation of OGCM by various Indian institutions and university students.

Argo Regional Centre (ARC) - Indian Ocean

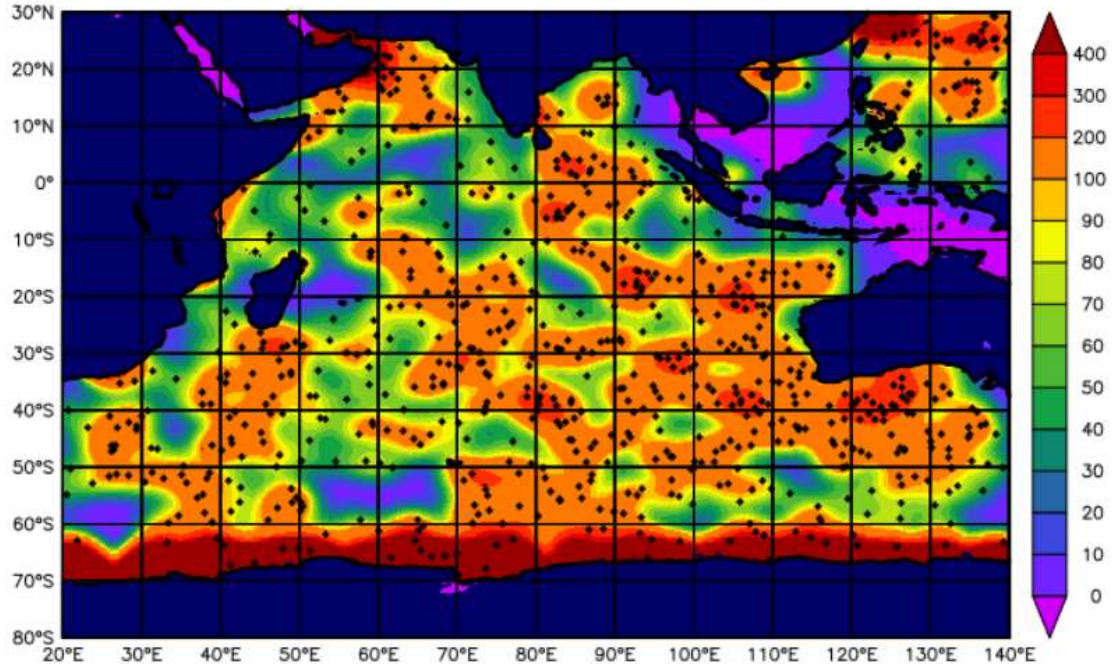
(<http://www.incois.gov.in/argo/ARDCenter.jsp>)

- Acquisition of Argo data from GDAC corresponding to floats other than deployed by India and made them available on INCOIS web site.
- All these data sets are made available to the user through a s/w developed with all GUI facilities. This s/w is made available through FTP at INCOIS and UCSC web sites.
- Delayed Mode Quality Control (Refer 2.0 above)
- Data from the Indian Ocean regions are gridded into 1x1 box for monthly and 10 days and monthly intervals. These gridded data sets are made available through INCOIS Live Access Server (ILAS). Users can view and download data/images in their desired format.
- ERDDAP site was set up for the data and data products derived from Argo floats (<http://erddap.incois.gov.in/erddap/index.html>)
- Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.
- Value added products: Two types of products are currently being made available to various user from INCOIS web site. They are:
 - (i) Time series plots corresponding to each float (only for Indian floats).
 - (ii) Spatial plots using the objectively analysed from all the Argo floats data deployed in the Indian Ocean.

These valued added products can be obtained from the following link <https://incois.gov.in/argo/ANDCProducts.jsp>

float density in Indian Ocean as of February, 2022 is shown below.

Active Float Density as on 06-Feb-2022



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

None

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

Data Sets (CTD, XBT, Subsurface Moorings) are being acquired from many principle investigators. These data are being utilized for quality control of Argo profiles.

7. Argo bibliography

INCOIS is actively involved in utilization of Argo data in various studies pertaining to Indian Ocean. Also INCOIS is encouraging utilization of Argo data by various universities by funding them. Some of the publications resulted from Argo data which includes scientists from INCOIS are given below:

- 1) Banik, T., V. Thandlam, B. K. De, S. S. Kundu, R. B. Gogoi, P. L. N. Raju, and A. Guha (2021), Understanding dynamics of tropical cyclones in the Bay of Bengal using lightning data, *Meteorology and Atmospheric Physics*, 133(5), 1505-1522, doi: <https://doi.org/10.1007/s00703-021-00824-y>
- 2) Chandra, A., and S. Kumar (2021), Sea surface temperature and ocean heat content during tropical cyclones Pam (2015) and Winston (2016) in the Southwest Pacific region, *Mon. Weather Rev.*, 149(4), 1173-1187, doi: <https://doi.org/10.1175/MWR-D-20-0025.1>
- 3) Chowdhury, K. M. A., W. Jiang, G. Liu, M. K. Ahmed, and S. Akhter (2021), Dominant physical-biogeochemical drivers for the seasonal variations in the surface chlorophyll-a and subsurface chlorophyll-a maximum in the Bay of Bengal, *Regional Studies in Marine Science*, 48, 102022, doi: <https://doi.org/10.1016/j.rsma.2021.102022>
- 4) Dandapat, S., A. Chakraborty, J. Kuttippurath, C. Bhagawati, and R. Sen (2021), A numerical study on the role of atmospheric forcing on mixed layer depth variability in the Bay of Bengal using a regional ocean model, *Ocean Dyn.*, 71(10), 963-979, doi: <https://doi.org/10.1007/s10236-021-01475-8>
- 5) Gadi, R., P. N. Vinayachandran, and D. N. Subramani (2021), Data-driven feature-oriented modeling of Southwest Monsoon Current, *Ocean Model.*, 168, 101912, doi: <https://doi.org/10.1016/j.ocemod.2021.101912>
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8. How has COVID-19 impacted your National Program's ability to implement Argo in the past year? This can include impacts on deployments, procurements, data processing, budgets, etc.

COVID-19 has severe impact on the Argo Programme on budget, procurement and deployments. India deployed one float during the year 2021. However, data processing is not affected by COVID.

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

India plans to procure and deploy 15 floats each in 2022 and 2023. We do not have provision for procurement of specific brand. The procurement process is through the open / global tender with general technical specifications.



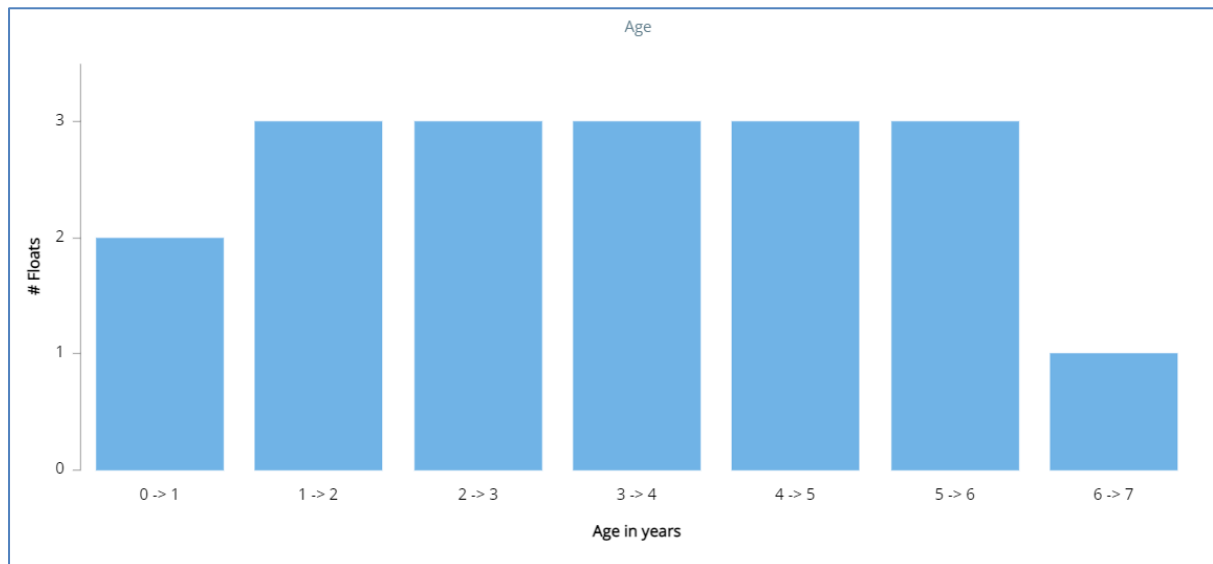
Argo National Report 2021: Ireland

1) The status of implementation (major achievements and any issues in 2021):

a) Irish Argo float Overview

In 2021, Ireland deployed two Argo floats. The floats consisted of a core T&S Arvor float and a Core +O2 float.

The Marine Institute deployed float 6901938 on the 7/3/2021 at 52 59.950 N, 15 31.189 W. Float 6901939 was deployed on the 8/3/2021 at 54 09.012 N, 17 14.334W. These floats were deployed by the Marine Institute research vessel RV Celtic Explorer during the annual Ocean Climate Cruise. A third float was due to be deployed on this cruise also, however, due to issues beyond the control of the scientific team the float was not deployed. A further 3 Arvor floats were deployed by the Celtic Explorer during the AIMSIR cruise in June of 2021 on behalf of our colleagues in BSH (Argo Germany).



Above: Age distribution of Irelands Argo Fleet.

2021 saw the Irish fleet increase to 18 floats which is an all-time high number of profiling floats within the Irish Argo fleet. The planned deployment of further floats in 2022 will add considerably to the amount of data being recorded as well as to the research capabilities within the Irish Argo fleet. It is envisaged that in 2022 a core Arvor float will be deployed as well as a Teledyne APEX BGC float.

Marine Institute Argo Float Overview (2021)					
Operational Floats (2021)					
Float	WMO #	Float Identifier	Make/ Model	Deployed	Status
1	6901919	7244	TWR/APEX	22/04/2015	OPERATIONAL
2	6901921	7243	TWR/APEX	23/03/2016	OPERATIONAL
3	6901922	7242	TWR/APEX	14/04/2016	OPERATIONAL
4	6901923	7241	TWR/APEX	09/04/2016	OPERATIONAL
5	6901924	7240	TWR/APEX	10/02/2017	OPERATIONAL
6	6901925	7841	TWR/APEX	11/02/2017	OPERATIONAL
7	6901926	7842	TWR/APEX	20/05/2017	OPERATIONAL
8	6901928	7844	TWR/APEX	12/02/2018	OPERATIONAL
9	6901929	AI2600-17EU001	NKE/ARVOR	12/02/2018	OPERATIONAL
10	6901930	AI2600-17EU002	NKE/ARVOR	27/03/2018	OPERATIONAL
11	6901931	AI2600-17EU003	NKE/ARVOR	06/12/2019	OPERATIONAL
12	6901932	AI2600-17EU004	NKE/ARVOR	29/05/2019	OPERATIONAL
13	6901933	AI2632-18EU038	NKE/ARVOR + (O2)	28/05/2019	OPERATIONAL*
14	6901934	AI2600-18EU030	NKE/ARVOR	31/08/2020	OPERATIONAL
15	6901935	AI2600-18EU032	NKE/ARVOR	10/09/2020	OPERATIONAL
16	6901937	AI2600-18EU031	NKE/ARVOR	05/09/2020	OPERATIONAL
17	6901938	AI2600-18EU029	NKE/ARVOR	07/03/2021	OPERATIONAL
18	6901939	AI2600-18EU039	NKE/ARVOR + (O2)	08/03/2021	OPERATIONAL

b) Irish floats deployed in 2021 and their status.

17	6901938	AI2600-18EU029	NKE/ARVOR	07/03/2021	OPERATIONAL
18	6901939	AI2600-18EU039	NKE/ARVOR + (O2)	08/03/2021	OPERATIONAL

c) Technical problems encountered and solved

An issue with processing the data being returned from Arvor Core&O2 floats was resolved in 2021. The Marine Institute would like to thank its partners in BODC and indeed in the Euro-Argo ERIC for their assistance in solving this issue.

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

Carried out by BODC for the Marine Institute (Ireland).

e) Status of delayed mode quality control process

Carried out by BODC for the Marine Institute (Ireland).

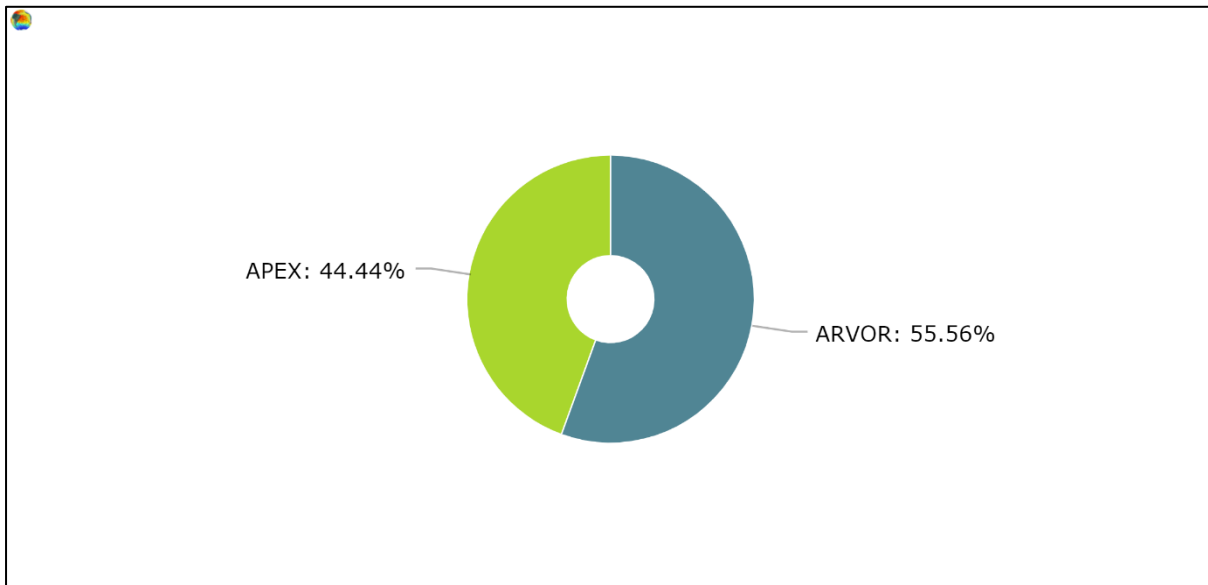
2) Present level of, and future prospects for; national funding for Argo including a summary of the level of human resources devoted to Argo.

Ireland continues to be a committed member of the Euro-Argo ERIC. Deployment plans for 2022 consist of an NKE Arvor Core Float and a Teledyne APEX BGC float. Ireland, via the Marine Institute will deploy additional floats where funding allows and will also assist the ERIC in deploying project specific floats where appropriate. Efforts continue towards securing multi-annual funding for Ireland's Argo programme on the national level.

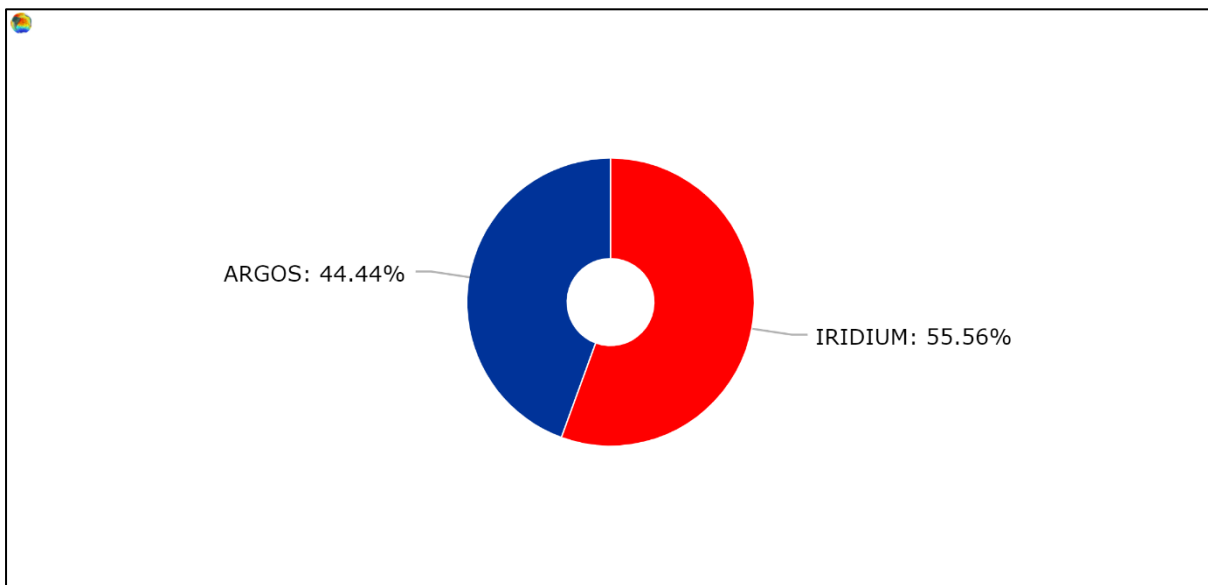


3) Summary of deployment plans (level of commitment, areas of float Deployment, low or high resolution profiles, extra sensors, Deep Argo) and other commitments to Argo (data management) for the upcoming year and beyond where possible.

The Marine Institute had planned to deploy three floats in 2021 as per its annual commitment. However, impacts on operational and technical ability due to the Covid-19 pandemic limited deployment opportunities for floats. It is envisaged that a core float and a BGC float will be deployed during 2022. Efforts continue towards securing multi-annual funding for Ireland's Argo programme on the national level.



Above: Illustrating the breakdown of Irish floats (NKE (ARVOR) and Teledyne Webb (APEX)). With NKE being the Euro-Argo ERIC tender winning bid, Ireland is seeing the number of ARVOR deployed floats increase.



Above: Graph showing the number of Irish floats using ARGOS or Iridium communications. With floats procured via Euro-Argo ERIC having Iridium communication systems the number of Irish floats with iridium communications will continue to increase over the coming years.



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

Argo data is primarily used to validate ROMS models in the Oceanographic Services section of the Marine Institute. Argo data will also be utilised by a number of PhD students within the Marine Institute and 3rd level institutes across Ireland. Irish deployed Argo float data may also be used by researchers on an international level as all data is open and freely available.

Irish Argo National Webpage (hosted by the Marine Institute):

<https://www.marine.ie/Home/site-area/infrastructure-facilities/marine-research-infrastructures/argo-network>

Irish Argo Float Data*:

<https://www.digitalocean.ie/>

*May not visualise correctly via Internet Explorer web browser

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

N/A. Any issues are dealt with via the Euro-Argo ERIC office.

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

No CTD data are uploaded to the CCHDO website.

However, all CTD data are emailed to Else Juul Green (else@ices.dk) who checks the data before it is uploaded to the ICES Oceanographic data portal annually:

<http://ocean.ices.dk/HydChem/HydChem.aspx?plot=yes>

- 7) **Keeping the Argo bibliography (<http://www.argo.ucsd.edu/Bibliography.html>) 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. We reached more than 2000 papers published using Argo data! 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.**

N/A.

Report on the Italian Argo Program for 2021

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. floats deployed and their performance

In total, 16 Italian floats were deployed in 2021 (see Tables 1 and 2 for details). These floats were Arvor-I and Arvor-Ice, Provor CTS4, Deep-Arvor designs manufactured by NKE (France). All floats transmit data via Iridium telemetry.

Mediterranean deployments

Seven units were released in the Mediterranean (Table 1). Most floats have a parking depth at 350 dbar and maximal profiling depths alternating at 700 and 2000 dbar. They all have cycles of 5 days except for one Arvor-I float (WMO 6903801) which had short cycles of 3 h during most of their initial operating life to measure high-frequency processes in the Sicily Channel. One Italian float was deployed in the shallow northern Adriatic (WMO 6903800) as a complement of the Euro-Argo RISE (EU H2020 project) fleet. The platform was used in a targeted shallow mission close to the coast. The cycle length was set to 5 days and the parking depth equal to the maximal bathymetry (about 70 m).

Most floats were deployed from research vessels of opportunity (i.e., R/V Dallaporta, R/V Bat-Galim, R/V Aegaeo, Malta Guard Coast for the Mediterranean and R/V Agulhas II and Laura Bassi for South Atlantic, South Pacific and Southern Ocean) with the help of colleagues from Greece, Malta, Italy and Israel.

South Atlantic, South Pacific and Southern Ocean

Four Italian floats were deployed in the Ross Sea polynya with the help of Italian colleagues onboard the R/V Laura Bassi. Two of them (6903794 and 6903795) were recovered after the previous mission and redeployed (Table 2). All floats are ice detection type. The Arvor-Ice uses an Ice Sensing Algorithm (ISA) based on temperature readings to abort surfacing when sea ice is present at the sea surface. The adopted configuration for the polynya area was a drifting and profiling depth of 1000 dbar and a cycling period of 7 days. Two floats were recovered in early 2022 (6903793 was redeployed and 6903795 sent to maintenance) and two died in 2021.

Five Italian floats were deployed in the South Atlantic Ocean in 2021 (Table 2) with the help of Italian colleagues onboard the R/V Agulhas II. Three out of 5 floats are Arvor-Ice model. All the floats were programmed to cycle between the surface and 2000 dbar every 10 days and to drift at the parking depth of 1000 dbar. They were all still active in early 2022.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor - T/S Diss. Oxy	6903799	25-Apr-2021 13:30	41.65	17.22	79	14-Feb-2022 00:50	41.85	17.06	A	5
Arvor - T/S Core	6903800	04-May-2021 10:58	44.05	13.62	33	12-Ott-2021 06:18	43.96	13.63	D	5
Arvor - T/S Core	6903801	10-Jun-2021 09:56	35.96	14.09	263	13-Feb-2022 05:48	35.23	19.23	A	5
Arvor - T/S Diss. Oxy	6903802	10-Aug-2021 23:02	33.15	34.16	38	12/-Feb-2022 05:48	33.82	33.98	A	5
Arvor - T/S Diss. Oxy	6903803	20-Sep-2021 04:18	34.81	26.16	30	13-Feb-2022 05:52	35.32	22.66	A	5
Arvor-I DEEP	6903804	20-Sep-2021 23:55	36.02	28.63	29	09-Feb-2022 06:05	35.76	28.58	A	5
Provor CTS4	6903805	11-Nov-2021 09:43	41.53	18.06	33	28-Jan-2022 11:34	41.14	17.59	A	5

*Status in early February 2021: A = active, D = dead

**Cycle: Length of cycle in days

Table 1. Status information for the 7 Italian floats deployed in the Mediterranean Sea during 2021.

Model	WMO	Depl. Date	Lat	Lon	Cycles	Last Date	Lat	Lon	Status*	Cyc.**
Arvor-T/S Core	6903806	10-Dec-2021 08:43	-60.04	-0.05	7	09-Feb-2022 05:57	-59.27	3.34	A	10
Arvor-T/S Core	6903807	11-Dec-2021 11:12	-63.99	1.48	-	11-Dec-2021 11:12	-63.99	1.48	-	10
Arvor-T/S ICE	6903792	18-Jan-2021 05:48	-77.16	168.93	8	02-Mar-2021 06:12	-77.28	168.68	D	7
Arvor-T/S ICE	6903793	19-Jan-2021 03:08	-77.42	174.34	61	26-Jan-2022 06:08	-76.27	173.94	recovered	7
Arvor-T/S ICE	6903794	21-Jan-2021 20:36	-77.73	-178.52	49	25-Dec-2021 05:57	-77.69	-179.92	D	7
Arvor-T/S ICE	6903795	30-Jan-2021 03:56	-75.28	164.01	57	23-Jan-2022 05:54	-74.97	164.63	recovered	7
Arvor-T/S ICE	6903798	24-Feb-2021 00:15	-64.00	0.43	36	10-Feb-2022 05:55	-61.55	-8.73	A	10
Arvor-T/S ICE	6903796	24-Feb-2021 14:25	-63.00	-2.44	36	10-Feb-2022 05:53	-62.75	-9.75	A	10
Arvor-T/S ICE	6903797	24-Feb-2021 20:30	-62.07	0.13	36	10-Feb-2022 05:51	-61.47	-9.00	A	10

*Status in early February 2021: A = active, D = dead

**Cycle: Length of cycle in days

Table 2. Status information for the 9 Italian floats deployed in the Southern Ocean, South Atlantic and South Pacific during 2021. Four Arvor-I in the Ross Sea polynya (bold).

Overall status at the end of 2021

In summary, at the end of 2021, the ARGO-ITALY program had a total of 77 active floats, including 29 instruments in the Mediterranean Sea, 1 in the Atlantic Ocean (it escaped from the Mediterranean through the Strait of Gibraltar), 3 in the Black Sea (Figure 1) and 44 in the South Pacific, South Atlantic and Southern Oceans (southern of 60 °S, see Figure 2).

ARGO-ITALY FLOAT TOT MISSION DAYS ON 31-Dec-2021 -- TOTAL FLOATS: 33

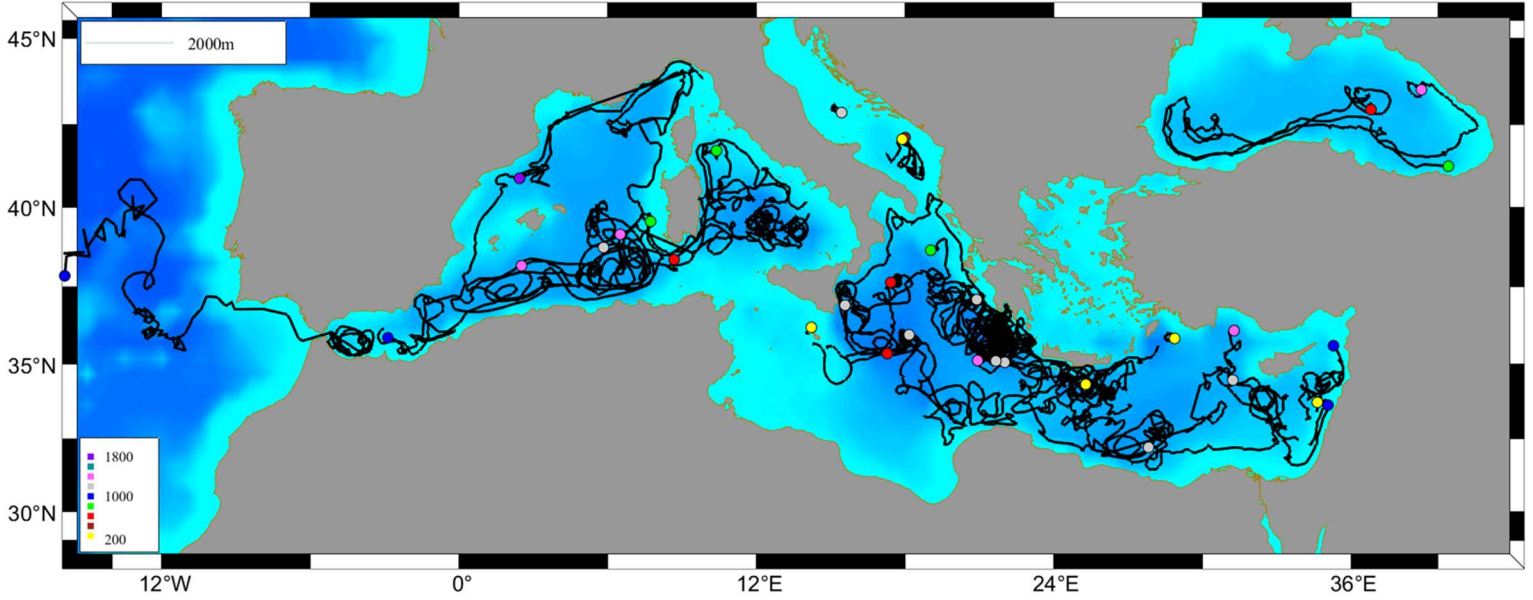


Figure 1. Trajectories and positions (circle symbols) on 31 December 2021 of the 33 ARGO-ITALY floats active in the Mediterranean and Black Sea. The circle symbols are color-coded as a function of float age in days.

ARGO-ITALY FLOAT TOT MISSION DAYS ON 31-Dec-2021 -- TOTAL FLOATS: 44

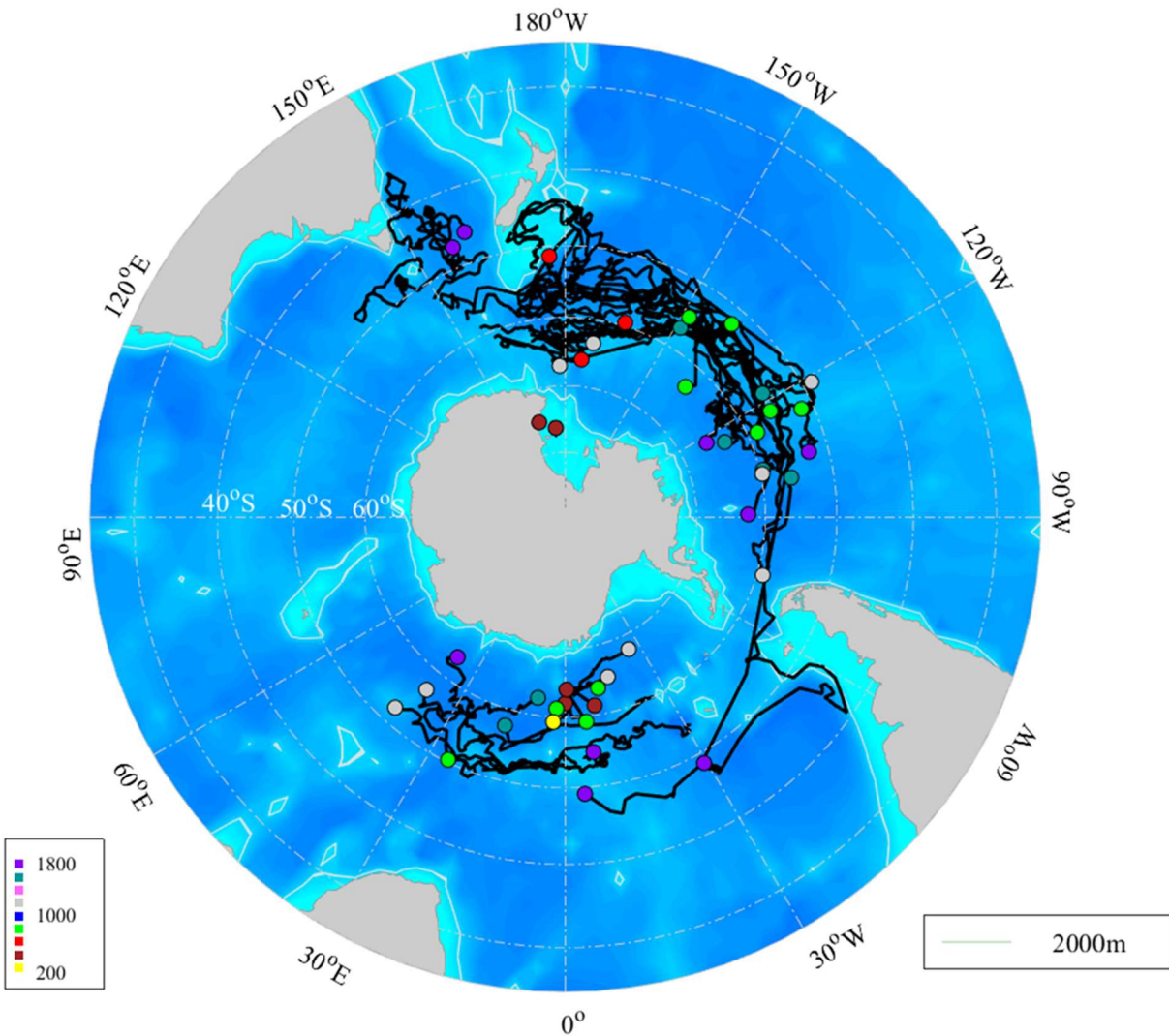


Figure 2. Trajectories and positions (circle symbols) on 31 December 2021 of the 44 ARGO-ITALY floats in the South Pacific, South Atlantic and Southern Oceans. The circle symbols are color-coded as a function of float age in days.

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 2012-2021. The float population in 2012-2021 is quite stable at about 77 active instruments in 2021. In 2021, the number of dead floats exceeded the number of deployments.

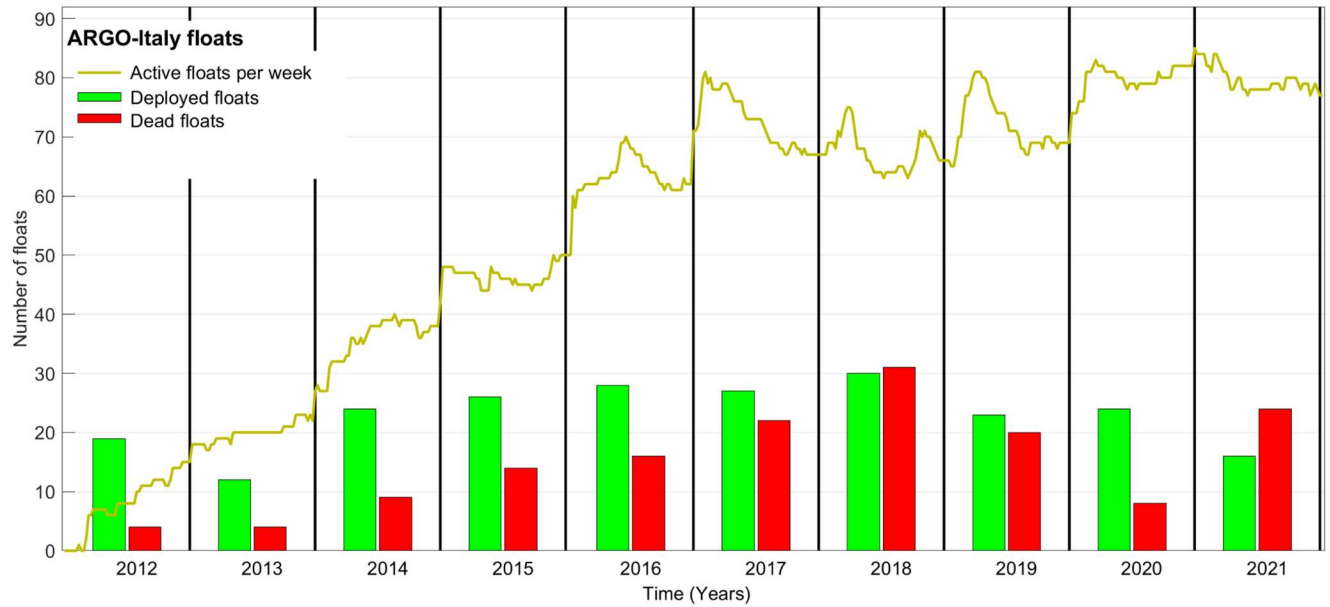


Figure 3. Temporal evolution of the number of ARGO-ITALY active floats with weekly resolution and histogram of the annual float deployments and losses.

Since 18 February 2012, a total of **229 ARGO-ITALY floats** have been deployed, 133 in the Mediterranean and Black seas, and 96 in the oceans of the Southern Hemisphere. In less than 10 years, they have provided about **33060 CTD profiles**. The histogram of the number of CTD profiles per float is shown in Figure 4. Ninety-three floats, about the 40 % of the total deployments, have done more than 180 profiles. In total (during 2012-2021), ~6 % of the floats have failed just after deployment.

Argo-ITALY status table (31/12/2021, 229 floats deployed)

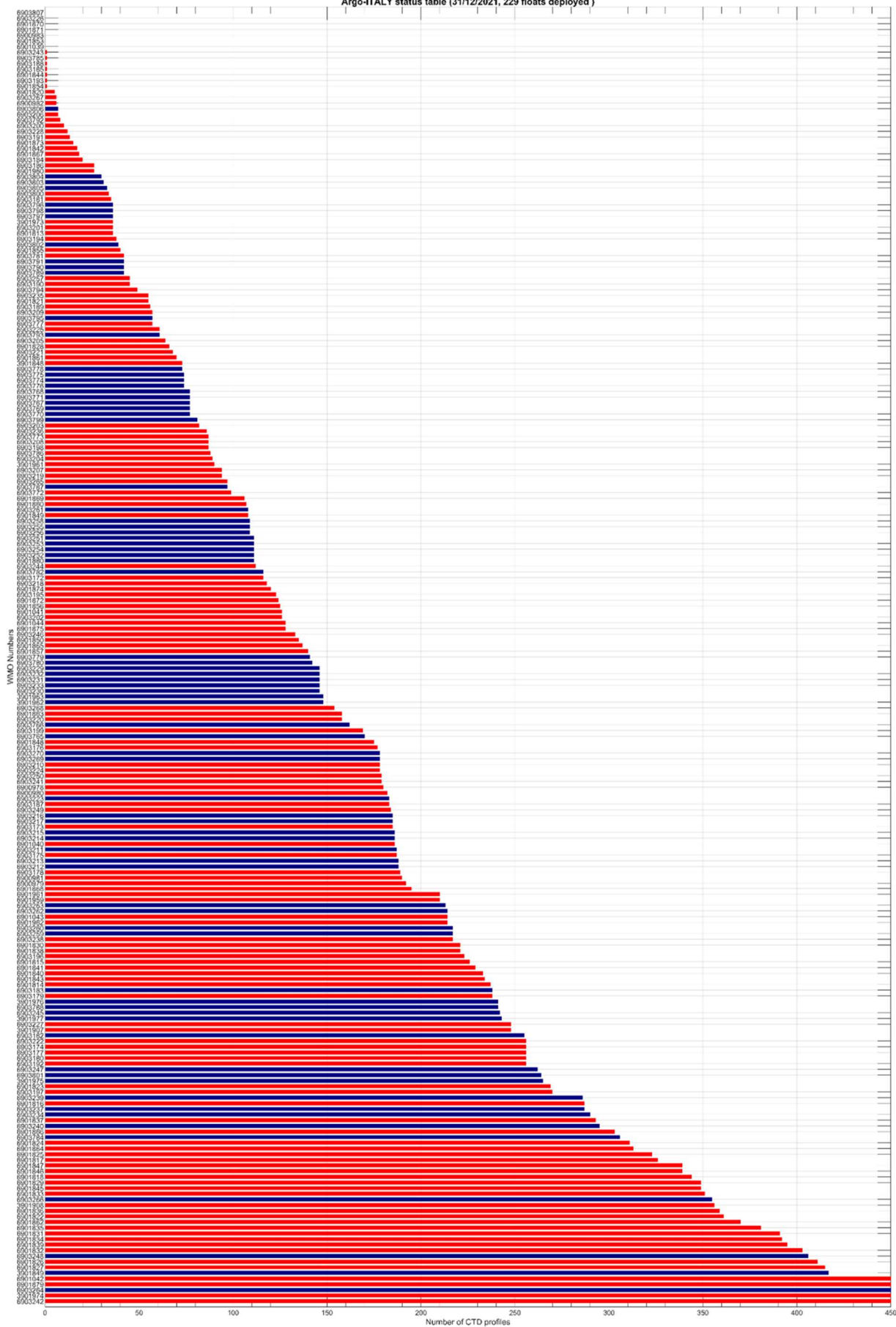


Figure 4. Histogram of the number of CTD profiles per float (red: dead float, blue: alive at the end of 2021).

b. technical problems encountered and solved

Mediterranean Sea

N/A

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://app.activecollab.com/186315/projects/45?modal=Task-4086-45>

OGS started the DMQC of the Deep-Argo physical data and updated the “deep” reference dataset in the Mediterranean Sea used for the quality control procedure.

One OGS expert was included in the BGC working group for the DMQC strategy in Europe.

d. status of delayed mode quality control process

The delayed mode quality control (DMQC) of the physical data (pressure, temperature and salinity) provided by the Italian floats in the Mediterranean and Black seas was done for about 95 out of about 134 eligible floats (all information and statistics to create the D-files sent to Coriolis). The temperature and salinity data of those floats were quality controlled following the standard Argo procedure, covering the period 2010-2020. The OWC procedure is used to check and adjust salinity data. It is a statistical method and it is based on reference datasets. The accuracies of the float data are assessed by comparison of Argo salinity profiles with calibrated reference measurements. An accurate reference dataset plays an important role in the quality control analysis and these data have to be quite close in time and space to the float measurements. The latter is necessary, in order to reduce the effects both of the inter-annual and the seasonal variability of the Mediterranean Sea, mostly in the upper and intermediate layers of the water column. For these reasons, OGS collected CTD data in complement of the official reference dataset using two approaches: personal contacts and regional data services. The standard statistical method adopted by the Argo community for the salinity correction is strictly affected by the natural changes in the water column of the Mediterranean Sea and hence a careful interpretation of the method results is necessary. For this reason, we adopted other qualitative checks (i.e., the comparison between nearby floats and analysis of the deepest portion of the temperature-salinity diagram) in order to increase reliability of the analysis. The DMQC of the Italian floats deployed in the Southern Ocean (and

South Pacific and Atlantic oceans) started in 2019 and was applied to 70 out of about 85 eligible floats.

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

The Italian Ministry of Research has provided funding to buy 19 floats in 2021, including 4 instruments with dissolved oxygen sensors, 5 standard T/S floats, 7 standard T/S floats with Ice Detection Algorithm implemented and 3 floats with biogeochemical sensors. 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 2021. It is expected that the same level will be maintained in 2022, including the procurement of 19 additional standard floats, 1 Bio floats and 2 Deep floats. The Italian Ministry of Research is committed to provide funding in order to sustain the Italian contribution to Argo beyond 2022 as a founding member of the Euro-Argo Research Infrastructure Consortium. In addition to the Italian national funding, OGS has funding from EC projects (e.g. Euro-Argo RISE) for several activities related to Argo.

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.

The Italian deployment plans for 2022 and 2023 are detailed in Table 3. The main areas of interest are the Mediterranean and Black seas and the oceans of the South Hemisphere.

Year	T/S floats (some of them with DO)		BGC/BIO floats		Deep floats		Total
	Quantity	Area	Quantity	Area	Quantity	Area	
2022	10	Mediterranean	2	Mediterranean	1	Mediterranean	23
	1	Black Sea	1	Black Sea			
	8	South Hemisphere					
2023	10	Mediterranean	2	Mediterranean	1	Mediterranean	22
	1	Black Sea	0	Black Sea			
	8	South Hemisphere					

Table 3. Italian float deployment plans for 2022-2023.

On the longer time frame, Italy is interested to maintain contributions to the Argo Core mission and the BGC and Deep Argo extensions with numbers similar to those listed in Table 3. OGS is committed to carry out the DMQC for all the Argo floats of the Mediterranean and Black seas and for some floats in the World Ocean as part of the ARGO-ITALY and Euro-Argo RISE projects over the next years.

The websites for the Italian contribution to Argo (Argo-Italy) are <http://argoitaly.ogs.trieste.it/> and argo.ogs.it. The link to the Mediterranean & Black Sea Argo Center (MedArgo) is argo.ogs.it/medargo.

- 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.

All Argo temperature and salinity data in the Mediterranean (along with other in-situ and remotely sensed data) are routinely assimilated into the operational Mediterranean Forecasting System (MFS) run by the Centro Euro-Mediterraneo sui Cambiamenti Climatici (CMCC which is a component of the Copernicus Marine Environment Monitoring Service (CMEMS). Assessments have clearly demonstrated the positive impact of Argo data on ocean analyses and predictions. In particular, studies on the optimization of float sampling and cycling characteristics for the Mediterranean have been performed, as well as the development of methodology for the assimilation of Argo float subsurface velocities into numerical models. Moreover, BGC Argo data are also assimilated in the 3D BGC models of the Mediterranean Sea and OGS runs the biogeochemical component of the Mediterranean Copernicus model system. Short-term forecasts of the Mediterranean Sea (Med-Biogeochemistry) are produced by the OGS ECHO research group by means of the MedBFM model system.

Ocean science.

Argo data are being used by several researchers in Italy (see some examples in the bibliography 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. 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.**

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.**
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.

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. hal-03330612v2. In: 9th EuroGOOS International conference, Shom; Ifremer; EuroGOOS AISBL, May 2021. Brest, France.

MENNA M., GERIN R., NOTARSTEFANO G., MAURI E., BUSSANI A., PACCIARONI M. AND POULAIN P.-M. (2021). On the circulation and thermohaline properties of the Eastern Mediterranean Sea. *Frontiers in Marine Science*.

MIHANOVIC H., VILIBIC I., ŠEPIC J., MATIC F., LJUBEŠIĆ Z., MAURI E., GERIN R., NOTARSTEFANO G. AND POULAIN P.-M. (2021). Observation, Preconditioning and Recurrence of Exceptionally High Salinities in the Adriatic Sea. *Frontiers in Marine Science*.

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 RIES project). hal-03336612v2. In: 9th EuroGOOS International conference, Shom; Ifremer; EuroGOOS AISBL, May 2021. Brest, France.

POULAIN P.-M., CENTURIONI L., ÖZGÖKMEN T., TARRY D., PASCUAL A., RUIZ S., MAURI E., MENNA M. AND NOTARSTEFANO G. (2021). On the Structure and Kinematics of an Algerian Eddy in the Southwestern Mediterranean Sea. *Remote Sens.* 2021, 13, 3039.

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

We experienced some delays related to float procurements and deployments but the impact was not too strong

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

Not planned yet

Japan National Report

(Submitted by Toshio Suga)

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. Floats deployed and their performance

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) deployed 40 Core Argo, Deep Argo, Biogeochemical (BGC) Argo and Argo equivalent floats from January to December 2021: 21 floats for Core Argo (APEX), 2 floats for Deep Argo (Deep APEX), 17 floats for BGC Argo (BGC-NAVIS and BGC-APEX). Since 1999, JAMSTEC had deployed 1436 Core Argo, Deep Argo, BGC Argo and Argo equivalent floats mainly in the Pacific, Indian and Southern Oceans. Because COVID-19 influenced cruise plans, the number of our float deployment was largely decreased. The current positions of all the active Japanese Argo floats are shown in Fig.1. Under the limited cruise conditions, collaboration with Japanese voluntary agencies, institutes, universities, and high schools was still ongoing, enabling deployment in 14 cruises. One float was deployed by a voluntary cargo ship owned by a Japanese merchant ship company, NYK. The arrangement of the semi-regular float deployment by cargo ships was made under the cooperative relationship between JAMSTEC and NYK, which was established in 2011 to increase float deployment opportunities. In December 2021, 2 Deep NINJA floats were operated. One Deep NINJA float is planned to be deployed in the Southern Ocean in 2022/23 summer in corporation with CSIRO, Australia. Twelve of the BGC Argo floats are equipped with RINKO ARO-FT oxygen sensor and partly SeaFet pH sensor, which is supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, Grant-in-Aid for Scientific Research on Innovative Areas (19H05700).

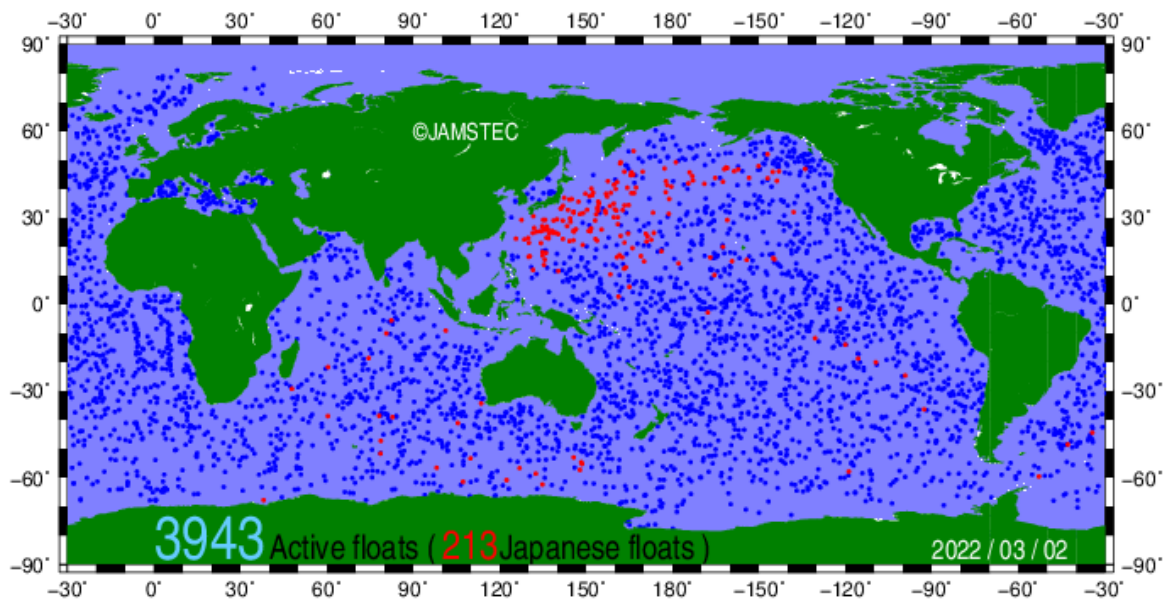


Figure 1: The distribution of active Argo floats. The red dots represent active Japanese floats.

The Japan Meteorological Agency (JMA) deployed 23 Argo equivalent floats (23 ARVOR floats) in the seas around Japan from January to December 2021. All the floats get 2,000 dbar T/S profiles every 5 days for operational ocean analysis and forecast.

Among 365 floats (14 PROVOR, 194 APEX and 157 ARVOR floats) which JMA has deployed from 2005 to 2021, 47 floats (47 ARVOR floats) are active as of the end of December 2021, while 27 floats (11 APEX and 16 ARVOR floats) terminated the transmission in 2021. JMA deployed 3 ARVOR floats from January to February 2022.

b. Technical problems encountered and solved

1) Float hardware troubles and updates

One BGC NAVIS float (F0950) was deployed in March 2021, however, it could not send any data, although the activation data was delivered at the deployment. The cause of the trouble is still under investigation in collaboration with SBE.

Some BGC APEX floats with RINKO ARO-FT oxygen sensors were deployed in February 2021. However, one of the floats (S/N 9015) entered the emergency mode and started to drift at the sea surface. Through checking and maintenance remotely by manufacturer TWR, this float started to send healthy data and is now in normal operation. The cause of this drifting is also still unknown. Another float (S/N 9012) sent only science files after the deployment, not the other technical files, thus the data could not be submitted to GDAC due to insufficient data. Based on the manufacturer's analysis, the float needed to modify the buoyancy parameter and to clean all accumulated data. Although TWR and JAMSTEC tried to a large effort, the data could not deliver smoothly and finally the float stopped sending all data.

Data from pH (SeaFet) sensor mounted on BGC Navis floats had a negative bias. The negative bias frequently appears in the other pH sensors mounted on floats in the world, so we will monitor the change of situation and long-term drift of this bias to investigate its cause and resolve.

Two of Deep APEX floats with APF11 controller (S/N: 50 and 53) occurred buoyancy control failure and were necessary to change buoyancy parameters. RINKO AROD-FT oxygen sensor mounted on some Deep APEX floats failed to measure oxygen value, which is in contrast to the Aanderaa Optode sensor which is successfully delivered the data for a long time. The cause of this failure is still unknown, however, it is a possibility that the communication between APF11 and RINKO sensor is not working well.

2) Sensor screening for SBE41 conductivity and pressure sensors

JAMSTEC developed a new CT sensor screening system, J-Calibration, for use with the SBE41 on the Argo float and is now in operation (Hosoda et al., 2018). Although the J-Calibration system requires careful temperature control of the artificial seawater as it is critical to maintain a uniform water temperature, it is suitable for use in laboratory screening prior to deployment. In this year, the J-Calibration has been conducted for 16 C sensors. Based on the screening, we did not find any doubt C sensors. We also conduct P sensor screening using DWT. In this year, 13 pressure sensors were checked. All sensors were healthy and passed satisfying the Argo criteria.

3) Recovery BGC float suffering ASD in collaboration with Japan Defence Force and its analyses for temporal drift

One active BGC Navis float (equipped with oxygen, nitrate, and chlorophyll sensors) was successfully retrieved with the cooperation of the Maritime Self-Defense Force (JMSDF), whose salinity sensor was causing ASD, and salinity data were already unavailable. We thank the JMSDF

for their prompt recovery despite the bad weather condition in twilight time. The retrieved BGC Navis float was sent to SBE for verification and repair. SBE reported that the recovered sensors were in very good condition, and each sensor verification work proceeded. As a result, the manufacturer reported that ASD was certainly detected for the C sensor through the SBE calibration process, while long-term drift for the other sensors was quite small within accuracy criteria. The results were reported in ADMT-22 from Dr. Martini in SBE. The BGC Navis is ready for re-launch, by replacing the C sensor, recalibrating all other sensors, and renewing the batteries.

4) Influence of suffering network security incident in JAMSTEC

In March 2021, JAMSTEC suffered unauthorized access to its core network system and leakage of personal information and has completely shut down the network (https://www.jamstec.go.jp/j/about/press_release/20210318_2/). Accordingly, the Argo JAMSTEC data management system and related websites were also shut down, and data submission to GDAC was suspended. As a result, the number of float operations in Japan temporarily dropped below 100 but is now almost back to normal due to the temporary process. However, the impact has been severe, and the delivery of products such as websites, including PARC, and data sets are not working yet because of the re-construction of the data system to be more secure. Currently, Argo-related servers and network security is being addressed, and processing raw data and delayed mode QC will soon be restored to normal.

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

The Japan DAC, JMA has operationally processed data from all the Japanese Argo and Argo-equivalent floats including 216 active floats as of March 1, 2022. 11 Japanese PIs agree to provide data for the international Argo. All the profiles from those floats are transmitted to GDACs in the netCDF format and are also issued to GTS using the BUFR codes after real-time QC on an operational basis. Argo BUFR messages have been put on GTS since May 2007.

JMA and JAMSTEC have converted the almost all of Japanese meta-files, except a few Iridium floats, from v2 to v3.1 and submitted them to GDACs. JMA has converted almost all of Japanese tech-files and submitted them to GDACs. JMA has converted the Rprof-files of Japanese ARGOS floats, except floats with NST sampling scheme and Iridium floats. JAMSTEC has converted all v2 Dprof-files of Japanese floats to v3.1 and submitted them to GDACs. JMA has converted about 30% of Japanese traj-files from v2 to v3.1 and submitted them to GDACs.

JMA has made meta-, tech-, traj-, and Rprof-files v3.1 of the floats newly deployed since March 2016 and JAMSTEC has made meta-files in v3.1 of JAMSTEC's floats newly deployed since October 2015. JAMSTEC has made Dprof-files in v3.1 since January 2016.

Abrupt salty drift floats

Japan has 483 floats with SBE41/SBE41cp whose serial number is larger than 6000, which had been deployed since 2013. 90 floats of them had clearly high salinity drift, and 65 floats of them had differences larger than 0.05 between salinity observed by float and climatology near 2000dbar. The salinity of most of these floats started drifting from about 40-100 cycles. Four floats with SBE41CP whose SN are larger than 11252 have salty drift, and one of them has salty drift that is not able to be corrected. Japanese floats with high salinity drift were mainly launched into the North Pacific, and most of them were deployed in 2017 and 2019. Moreover, 4 Deep APEX floats with SBE61 have clearly high salinity drift. While about 170 active floats with SBE41/SBE41cp whose serial number is larger than 6000 and 22 active Deep APEX floats have not suffered from this issue,

we continue to monitor salinity data of Japanese floats for detecting floats with high salinity drift and understanding features of high salinity drift found in floats. We have shared this information and joined the discussion about this issue through ADMT and the working group of this issue so that we contribute to improving salinity data quality.

As reported last year in our national report, most of the salinity profiles flagged as probably bad or bad in all layers have been "Abrupt Salty Drift" in the past few years, and the number of salinity profiles flagged as probably bad or bad in all layers has been increasing every year. The percentage of global salinity profiles with all layers flagged as probably bad or bad in 2021 was 16%, higher than that in 2020. This is consistent with the results predicted last year. JAMSTEC will continue to monitor the results.

New challenge to quality control for Core Argo profiles

JAMSTEC is now challenging to implement quality control methods using machine learning, developed by Sugiura and Hosoda (2019), for Core-Argo profiles. We performed supervised learning for existing Argo data with quality control flags by using the signature method. We aim to achieve efficient quality control by introducing this.

d. Status of delayed mode quality control process

JAMSTEC has submitted the delayed-mode QCed Core data (P, T, and S) of 175,661 profiles to GDACs as of December 2021. JAMSTEC had submitted D-Core files of 1,476 profiles in 2021. Due to the network security incident that occurred at JAMSTEC in March 2021, our data quality control processing system had to be updated, so the number of DQCed Core profile file submissions was low last year. The system update will be completed soon, so we will be able to increase the number of submissions this year.

JAMSTEC has adjusted salinity data of Deep floats by using optimal CPcor for each Deep float. When our Deep float is launched, shipboard-CTD observation is often performed. Therefore, the optimal CPcor for each Deep float is estimated by comparing its first profile with shipboard-CTD data at its deployment.

JAMSTEC has started performing delayed mode QC for our BGC floats. We are now preparing to process programs for DOXY-DMQC. We are also testing whether Nitrate and pH observed by our BGC floats in the North Pacific are corrected well by SAGE. We aim to start to submit D-mode DOXY_Adjusted of our BGC floats to GDAC this year.

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

Japan Argo had been conducted in a 5-year program from FY1999 to FY2004, as a part of Millennium Project implemented under cooperation among the Ministry of Education, Culture, Sports, Science and Technology (operation: by JAMSTEC), the Ministry of Land, Infrastructure and Transport, JMA and Japan Coast Guard. After the Millennium Project terminated in March 2005, JAMSTEC has continued the operation until FY2013 nearly on the same scale (about 80 floats to be deployed every year and associated delayed-mode data management) under its two consecutive mid-term programs for FY2004-2008 and FY2009-2013. JAMSTEC continues the float deployment and delayed mode data management but in the scale somewhat lower than before under its recent mid-term program FY2014-2018. Because of budget cuts in FY2014-2015, the number of technical staff devoted to delayed mode QC and PARC activities has been decreased from 5 to 4 since FY 2015 and the number of purchased floats had been reduced to about 12-15. In FY2016,

owing to ocean monitoring enhancement recommended by G7 Ise-Shima Summit, especially its Science and Technology Ministers' Meeting in Tsukuba, the additional fund for Core Argo and Argo extensions (Deep and BGC Argo) was allocated for aiming to sustain Core Argo array and to enhance Deep and BGC Argo. Furthermore, following its communique and our original research plans, JAMSTEC had got extra research funds to purchase 50 Core, 25 Deep and 10 BGC Argo floats in FY2017, and are being deployed in the Pacific, Indian and Southern Ocean in FY2018-19.

From FY2019, JAMSTEC has started new mid-term programs for 7 years. In FY2021, 25 Argo floats were deployed, including 19 Core, 4 Deep and 2 BGC floats, following JAMSTEC's research purposes. In FY2021, the level of human resources for Argo deployment and QC is the same as in FY2021 (3 persons) including temporal staff. However, because of dmQC complexity including core, deep, BGC Argo, the number of technicians is insufficient. The deployment plan for Core, Deep and BGC Argo floats in FY2022 is not yet fixed but will be decided soon.

JAMSTEC is also planning to examine "next generation Argo" toward constructing a higher valuable observing system, including ArgoMIX. The construction of the observing system is already addressed a load map of ocean science in Japan as "Global deployment of deep-sea Argo floats for more accurate prediction of climate and ecosystem change" and consensus among the Japanese ocean science community. To achieve the load map, JAMSTEC examine a validation of Argo float equipped with turbulence sensor (RBR fast-response CTD) in nearshore field test, in collaboration with Rockland and MRV. Also, JAMSTEC will purchase Mermaid-Argo floats from OSEAN in France, which is equipped with SBE61 and hydrophone sensors in 2022. The float will be examined to apply Argo data flow as well as planning toward a next generation observing system.

JMA allocates operational budget for 27 floats in FY2022.

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

To maintain the Argo array and to achieve the research purposes, JAMSTEC will deploy 19 floats mainly in the North Pacific for 11 Core, 1 Deep, 3 BGC, and 4 Argo equivalent floats. The 11 Core Argo includes 2 RBR Argo floats. For the Argo equivalent floats, 3 RBR CTD Argo floats will be deployed in the western equatorial Pacific for the purpose of the air-sea interaction study, and "hotspot2" research team of special research fund "Grant- in Aid for Scientific Research in Innovative Area", being supported by JSPS KAKENHI, will deploy one BGC Argo equivalent float with RINKO oxygen sensor around the subtropical region south of the Kuroshio Extension in 2022.

JMA plans to deploy 27 Argo equivalent floats (12 floats are deployed in the western boundary region) around Japan in FY2022 and in the coming years. All the JMA floats are identical with the core Argo floats except that they are operated in a 5-day cycle, synchronized with JMA's real-time ocean data assimilation and forecast system.

JMA continues serving as the Japan DAC. JAMSTEC continues running the Pacific Argo Regional Center for the upcoming year.

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

Many groups in JAMSTEC, JMA, FRA, and Japanese universities are using Argo data for oceanographic research on water mass formation and transport in the Pacific Ocean, the mid-depth circulation, the mixed layer variation, the barrier layer variation, and tropical atmosphere-ocean interaction in the Pacific and the Indian Ocean and so on. Japanese fisheries research community is

conducting their biogeochemical studies using Argo floats equipped with chlorophyll and/or oxygen sensors.

JMA issues operationally ocean analysis and forecast by using satellite data and in-situ data including the global Argo BUFR messages. Daily, 10 day mean and monthly products of subsurface temperatures and currents for the seas around Japan and North Pacific, based on the output of the real-time ocean data assimilation system (MOVE/MRI.COM-JPN), are distributed through the JMA web site (in Japanese). Numerical outputs of the system are available from the NEAR-GOOS Regional Real Time Data Base (<https://www.data.jma.go.jp/goos/data/database.html>) operated by JMA. Monthly diagnosis and outlook of El Niño-Southern Oscillation based on the outputs of the Ocean Data Assimilation System and the El Niño Prediction System (an ocean-atmosphere coupled model) are also operationally distributed through the JMA web site (in Japanese) and the Tokyo Climate Center (TCC) web site (<https://ds.data.jma.go.jp/tcc/tcc/products/elnino/>). These systems were upgraded in Feb. 2022 (for descriptions of the new systems, please refer to https://ds.data.jma.go.jp/tcc/tcc/products/elnino/move_mricom-g3_doc.html, and https://ds.data.jma.go.jp/tcc/tcc/products/model/outline/cps3_description.html). The ocean-atmosphere coupled model is also used for seasonal forecast of climate in Japan. The model products for seasonal forecast are available from the TCC web site (<https://ds.data.jma.go.jp/tcc/tcc/products/model/>).

JAMSTEC is providing a variety of products including objectively mapped temperature and salinity field data (Grid Point Value of the Monthly Objective Analysis using Argo float data: MOAA-GPV), objectively mapped velocity field data based on YoMaHa'07 (version September 2010), and gridded mixed layer depth with its related parameters (Mixed Layer data set of Argo, Grid Point Value: MILA-GPV). JAMSTEC has released Argo temperature and salinity profile data put through more advanced automatic checks than real-time quality controls (Advanced automatic QC Argo Data version 1.2a) since October 2014. JAMSTEC has also provided scientifically quality controlled data of Deep NINJA floats for convenient use on scientific or educational purposes. The QC is based on comparisons with highly accurate shipboard CTD observations conducted nearby float observations.

The Pacific Argo Regional Center (PARC) is operated by JAMSTEC, providing information about consistency check of float data related to delayed-mode QC through the web site. Since 2006, PARC and its website had been operated by JAMSTEC and IPRC in collaboration with several coastal states of the Pacific region. JAMSTEC mainly operates PARC, and will construct a new PARC website soon as the mentor of the Pacific Ocean. Float PIs and DMQC operators can exchange various information about the deployment and technical information, data quality of floats, DMQC, scientific products, etc. to improve the status of the Pacific Argo array.

ESTOC (Estimated state of ocean for climate research) is a JAMSTEC product; an integrated dataset of ocean observations including Argo data by using a four dimensional variational (4D - VAR) data assimilation approach. ESTOC is the open data that consists of not only physical but also biogeochemical parameters. It is upgraded to version 04a in April 2020 to cover 58 - year period during 1957 - 2014 (See the web site in JAMSTEC, <http://www.godac.jamstec.go.jp/estoc/e/top/>). Version 04a added two observational elements of ocean mixing and geothermal heating. Deep and BGC float data can be assimilated into the system after 2016. We plan to release a 60 - year state estimation (version 4b). Some scientific papers related to the ESTOC were published (e.g., Osafune et al, 2020, Masuda and Osafune 2021).

JCOPE2M (Japan Coastal Ocean Predictability Experiment 2 Modified) is the model for prediction of the oceanic variation around Japan which is operated by Application Laboratory of JAMSTEC. JCOPE2M is the updated version of JCOPE2, developed with enhanced model and data assimilation schemes. The Argo data are used by way of GTSP. The reanalysis data 29 years back (from 1993 to

present) and the forecast data 2 months ahead are disclosed on the following web site:

<http://www.jamstec.go.jp/frcgc/jcope/>. More information is shown in http://www.jamstec.go.jp/frcgc/jcope/htdocs/jcope_system_description.html.

JCOPE-T DA, a downscaled version of JCOPE2M, has been recently developed by the collaboration of JAMSTEC and JAXA. It is designed for real-time (daily-basis) assimilation of satellite and in-situ data including the Argo data and 10-day lead forecast updated every day. The latest available forecast information is available from: https://www.eorc.jaxa.jp/ptree/ocean_model/index.html.

FRA-ROMS is the nowcast and forecast system for the Western North Pacific Ocean developed by Japan Fisheries Research and Education Agency (FRA) based on the Regional Ocean Modeling System (ROMS). Instead of FRA-JCOPE, which was the previous system of providing the hydrographic forecast information around Japan, FRA started the FRA-ROMS operation in May 2012. Argo has been one of important sources of in-situ data for the FRA-ROMS data assimilation system. The forecast oceanographic fields are provided every week on the website <http://fm.dc.affrc.go.jp/fra-roms/index.html/>.

Tohoku University has released gridded dataset of subsurface chlorophyll maximum depth, using Chl-a measurement data in the World Ocean Database 2018 (Boyer et al. 2018) and the Global Ocean Data Analysis Project version 2.2019 Release (Olsen et al., 2019). The Chl-a measurement data includes Argo profile data as well as bottle samples, CTD fluorescence, gliders and so on. This gridded dataset can be downloaded on the websites (<http://caos.sakura.ne.jp/sao/scm/>).

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

As reported in 2011, EEZ clearance procedure for Argo float deployed had been simplified following IOC Resolution XLI-4. This change reduced our time and effort for the process of EEZ clearance. However, the traditional EEZ clearance is still needed for some key countries because Argo national focal points (NFPs) of those countries are not registered on the list at AIC. Japan Argo hopes for more NFPs, especially of nations in and around the Pacific Ocean to be registered to facilitate more timely and optimal deployment of Argo floats, especially about the southern islands in the Pacific Ocean. This could be also helpful for smooth implementation of any future extension of Argo and less trouble with the countries.

6. CTD cruise data being added to the reference database

After the last upload of CTD data to the CCHDO website in January 2020, which was included in the national report the year before last, we have uploaded 485 CTD cast data as "Private for Argo" in the western North Pacific.

7. Outreach activity

Online event "One Ocean Science": In advance of the 26th United Nations Conference of the Parties on Climate Change (COP26, Nov. 1-12, Glasgow, UK), the online event "One Ocean Science" was held by IFREMER of France in recognition that "ocean science is the key to predicting and addressing climate change. Digital World Tour of Science". JAMSTEC contributed to provide a video message. The objective of this event is to raise awareness of the importance of the oceans by communicating from scientists to the general public, industry, non-profit

organizations, etc., how the science they are doing is important for our future. Short videos were created by major ocean science institutions in Japan, France, and other related countries, and made available online via Twitter and YouTube. JAMSTEC provided an explanation of the importance of the BGC Argo.

Certificate of appreciation for volunteer deployments: JAMSTEC's Argo deployment requires the cooperation of lots of volunteers from related organizations. As contributions to the SDGs, are becoming more common, certificates of appreciation were presented to 7 organizations for their cooperation to express gratitude for the FY 2019 VOS input. JAMSTEC will continue providing such certificates of appreciation for the voluntary groups to be more recognizing Argo and ocean environment problems.

8. Argo bibliography

(1) Articles

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(2) Doctorate thesis
None,

9. 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, some of the cruise plans were canceled or modified, mainly going to the far area from Japan. That must modify JAMSTEC's deployment plan, and we suffer difficulty to fill in the gap of the global Argo array.

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

In 2021, JAMSTEC did not have any plan to deploy RBR Argo float. However, we will purchase totally 5 RBR APEX floats, 2 for Core Argo and 3 for Argo equivalent in 2022. The 2 RBR core Argo floats will be deployed in the western North Pacific, and the 3 RBR Argo equivalent floats will be deployed in the western equatorial Pacific region, observing the air-sea interaction regarding MJO and ENSO. The shipboard CTD cast will be carried out at all deployment points.

Argo-KOREA Annual Report 2021

by National Inst. of Meteorological Sciences/KMA

23th Argo Steering Team Meeting (AST-23)
Virtual, 21-25 March 2022

1. Status of Implementation

The National Institute of Meteorological Sciences of Korea Meteorological Administration (NIMS/KMA) has deployed **259** Argo floats around the Korea Peninsula and the Northwestern Pacific Ocean since 2001, including 16 active floats as of March 2022. In 2021, the NIMS/KMA deployed 6 Argo floats in the East Sea, Yellow Sea and off the coast of Jeju Island of Korea (Figure 1). Two floats were deployed in the East Sea on October 16, 2021 with 800m of parking depth and seven-day profiling scheme, and four floats were in the Yellow Sea and South Sea of Korea on November 14~15, 2021, for the shallow sea observation with two-day profiling scheme and 60m of parking depth. Especially all floats deployed at the Yellow Sea by using the GISANG1, the KMA's research vessel, could obtain the two-day cycle profile since the starting day.

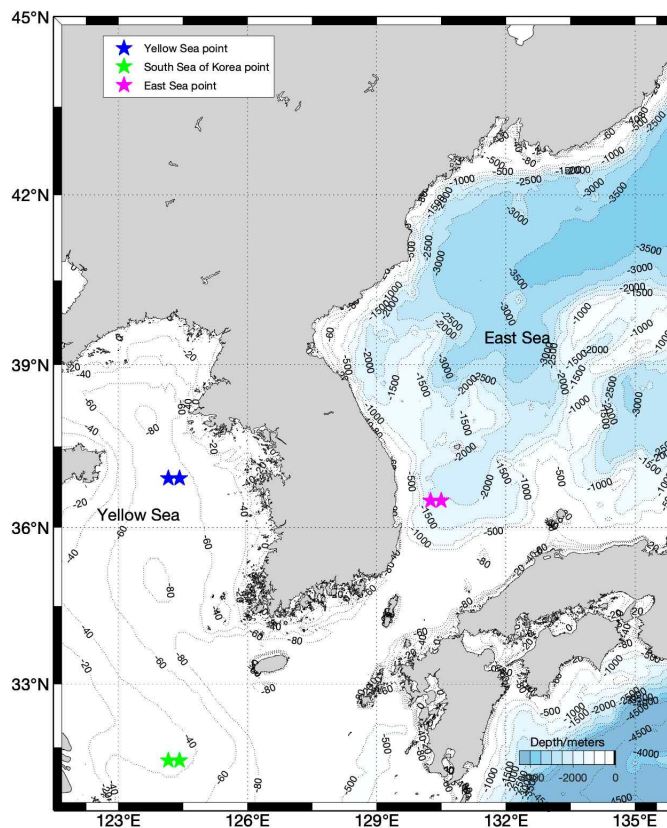


Fig. 1. Initial position of Argo floats deployed by the NIMS/KMA in 2021

- Status of contributions to Argo data management

- Development of quality control program for the shallow sea data (Yellow Sea)
 - We developed QC program for the Yellow Sea data about 1,128 profiles obtained from September 2017 to December 2021.
 - We used the OW software version 3.0.0 which was same version used for the East Sea and the Northwestern Pacific, and new reference data-base and new parameters. Since the shallow sea is prone to change its distinctive salinity characteristic every season, only shipboard CTD data collected at the similar time and location were used for OW.
 - We completed DMQC test and sent D-files of shallow sea to the GDAC.
- The RTQC procedure has been updated for MEDD test for the Pacific and Yellow Sea .(East Sea: Gradient test)
- Implementing the Argo data format check program.
- The RTQC procedure has been updated for grey-list.
- The data quality-control system was improved. (e.g. removal of the duplicated data)

- Delayed Mode QC

• We had DMQCed on most KMA Argo floats, except for the floats deployed in late 2021. Last year, we completed DMQC operation on 1,866 profiles (701 profiles from the East Sea, 37 profiles from the Northwestern Pacific, 1,128 from the Yellow Sea), which had been observed until September 2021. The profiles had been sent to the Ifremer GDAC on November 3 2021 in NetCDF format.

• We are planning to implement the DMQC operation on profiles from the East Sea and the Yellow Sea, which have been observed until early April 2022. The profiles will be DMQCed based on the KMA DMQC process and OWC 3.0.0. The D-files will be sent to the Ifremer GDAC in late April 2022 in NetCDF format(Ver.3.1).

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

We purchased 6 floats in 2021 and successfully deployed all around the Korea Peninsular. In 2022, we will buy 7 Argo floats and keep same deployment strategy. Following persons contribute to the Argo-Korea program.

- KiRyong KANG, Hyeong-Jun JO (KMA)
- Sung-Dae KIM, Hyuk-Min PARK (KIOST)
- Jong-Jin PARK, Gyu-ri Lee (Kyungpook National University)

3. Summary of deployment plans

The NIMS/KMA has a deployment plan for 7 floats in 2022: three floats will be deployed at the East Sea to keep the observation network and two floats at the Yellow Sea to continue the shallow sea observation scheme in the regional ocean. Continuing the observation in the Yellow Sea, observation program using the Argo float will be preformed to investigate the ocean environment variation in west sea of Korea. In addition, two floats will be deployed at off the coast of JeJu island for law-salinity water monitoring (Figure 2).

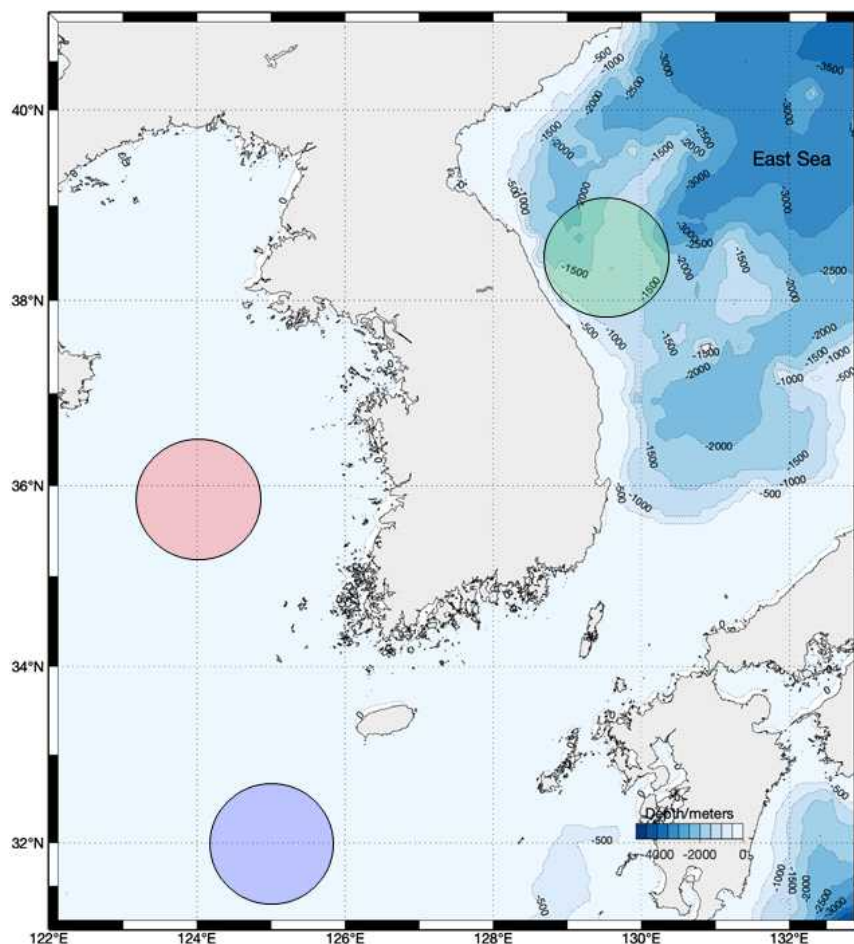


Fig. 2 Location of Argo float deployment in 2022.

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

In 2021, it was successfully observed through Argo deployed in the shallow sea, for example four floats deployment at the Yellow Sea and off the coast of Jeju Island. In particular, Argo float 2901799 has been operated for more than 360 days from November 11, 2020 to December 5, 2021. It is good observation performance with two-day cycle in the shallow sea area. The NIMS/KMA will try to keep this kind of shallow Argo observation network in around Korean peninsular area.

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 are uploaded to the CCHDO website.

7. Bibliography

- KiRyong Kang and Il-Ju Moon, 2022; Sea Surface Height Changes due to the Tropical Cyclone-Induced Water Mixing in the Yellow Sea, Korea, Front. Earth Sci. 10:826582. doi: 10.3389/feart.2022.826582
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8. Effects of COVID-19

- We experienced some delays related to float procurements and deployments but the impact was not too strong.

9. RBR CTD piloting and deployment plans

- Not planned yet

<The End>

Argo New Zealand National Report, March 2022.

Phil Sutton. National Institute of Water and Atmospheric Research (NIWA), Wellington, New Zealand

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

a. floats deployed and their performance:

2 Solo2 floats were purchased and deployed (WMO #s 5906702 and 5906703).

2 Apex floats with ice-avoiding software were purchased and deployed in the Ross Sea in January 2022 by F/V San Aotea II (WMOs 7900924 and 7900926). This work is being led by Craig Stewart (NIWA) with assistance from Esmee van Wijk (CSIRO).

New Zealand also deployed floats for other organisations on four voyages:

i) R/V Kaharoa Voyage (Western Pacific):

R/V Kaharoa deployments September-December 2021.

- 9 Scripps Institution of Oceanography Deep Solo
- 16 University of Washington Apex
- 23 CSIRO
- 48 Scripps Institution of Oceanography Solo2
- 2 PMEL Deep Solo

ii) R/V Tangaroa Voyage (Southern Ocean):

R/V Tangaroa deployments January-February 2021

- 12 Scripps Institution of Oceanography Solo2
- 3 Scripps Institution of Oceanography Deep Solo

iii) R/V Tangaroa Voyage (Deep Argo Development Voyage: Western Pacific):

R/V Tangaroa deployments April 2021

- 6 Scripps Institution of Oceanography Deep Solo

iv) R/V Tangaroa Voyage (Western Pacific):

R/V Tangaroa deployments July 2021

- 12 Scripps Institution of Oceanography Solo2

b. technical problems encountered and solved:

The NZ floats are functioning well. Other partners will report on their floats.

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

none

d. status of delayed mode quality control process:

DMQC on NZ floats is performed by Scripps Institution of Oceanography (John Gilson).

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

New Zealand Argo float funding continues on a year-to-year basis at the level of two floats per year.

Funding for personnel is via a research programme, also funded year-to-year and a contract with Scripps Institution of Oceanography associated with the R/V Kaharoa charter. This supports of the order of 2 months of personnel time.

A further voyage undertaking Deep Argo Development is planned for 2023. This voyage was intended for 2022, but deferred because of COVID-19. The timing and funding are to be confirmed.

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

New Zealand floats: planned purchase and deployment of 2 Solo2 floats in the South Pacific

Deployments for other countries:

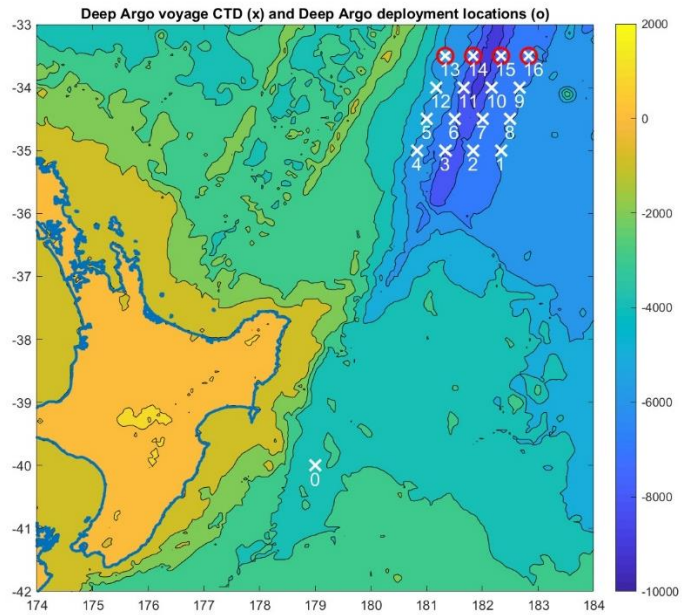
- a) Planned 2022 Kaharoa Voyage (~ September 2022)
110 Core floats split between Scripps Institution of Oceanography, University of Washington, CSIRO and New Zealand.
- b) R/V Tangaroa Antarctic Voyage: January-February 2023.
To be confirmed.
- c) R/V Tangaroa Tsunami servicing voyages (southwest Pacific):
To be confirmed.
- d) R/V Tangaroa DWBC and Deep Argo Development Voyage: April 2023.
Voyage and floats to be confirmed.

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

A R/V Tangaroa Deep Argo Development Voyage in collaboration with Scripps Institution of Oceanography (Nathalie Zilberman) and Sea Bird Scientific was performed between 27 March and 11 April 2020. The key aim of the voyage was to perform 6000m CTD casts with a number of experimental SBE sensors mounted on the CTD rosette to collect intercomparison data. COVID-19 border issues meant that intended US participants could not take part. Scripps Institution of Oceanography and SBE each funded one extra New Zealand participant, meaning that the voyage could proceed. Data were sent off the ship after each cast to Dave Murphy and Nathalie Zilberman so they could monitor progress.



Study site bathymetry and station locations.

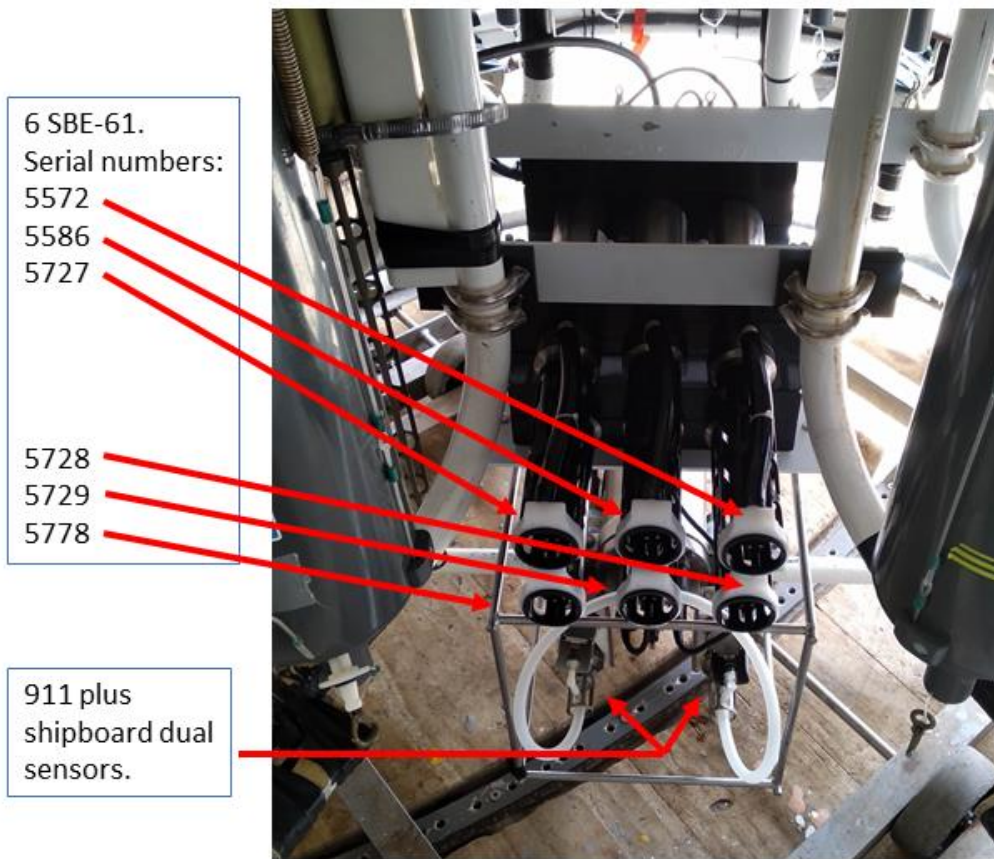


Photo: Matt Walkington, NIWA.

The experimental SBE 61s mounted on the CTD rosette.

27 6000m CTD casts were completed. The data appear to be of high quality. In addition, 6 Deep Solo floats with experimental sensor packages were deployed

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.

No issues beyond those faced universally, i.e. funding and Covid-19 disruptions.

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

CTD data from the Deep Argo Development Voyage will be provided for the reference database.

7. Argo bibliography ([Bibliography | Argo \(ucsd.edu\)](#))

Morrongiello, J.R., Horn, P.L., Ó Maolágain, C, Sutton, P.J.H. 2021. Synergistic effects of harvest and climate drive synchronous somatic growth within key New Zealand fisheries. *Global Change Biology*. DOI:10.1111/gcb.15490.

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

There have been impacts on voyage mobilization:

- Border restrictions meant that the Deep Argo Development Voyage had to use local personnel without some of the desired expertise.
- Border restrictions making it impossible to get foreign technicians into New Zealand to start and load the floats.
- Shipping delays.

- A further Deep Argo Development voyage planned for 2022 has been postponed.
- There could be budget impacts in the future resulting from COVID-19.

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

New Zealand currently has no intention to purchase RBR CTD floats. We will deploy other nations' RBR-equipped floats (e.g. SIO, CSIRO).

National report of Norway (2021)

Submitted by Kjell Arne Mork, Institute of Marine Research (IMR), on behalf of Argo Norway (24.02.2022)



1. The status of implementation

Argo Norway (NorArgo, <https://norargo.hi.no>) is the Norwegian contribution to the Euro-Argo European research infrastructure (ERIC) and to the global Argo programme. The main focus area for Argo Norway is the Nordic Seas (Greenland, Iceland and Norwegian Sea) and Arctic.

a. Floats deployed and their performance

In 2021, Norway deployed in total **14 Argo floats**:

- 4 floats in the Greenland Sea
 - 1 BGC-Provor CTS4 floats (all six BGC-variables) ●
 - 1 BGC-Provor CTS4 floats with 4 BGC-variables (DO, fluor., bbp, irradi.) ●
 - 1 Deep Arvor floats (with DO) ●
 - 1 core Arvor float ●
- 7 floats in the Norwegian Sea
 - 2 BGC-Provor CTS4 floats with 4 BGC-variables (DO, fluor., bbp, irradi.) ●
 - 1 core/BGC Arvor float with oxygen ○
 - 4 core Arvor floats ●
- 3 floats in the Barents Sea
 - 3 core/BGC Arvor floats with oxygen ○

The deployment locations are shown in Fig. 1. All 14 floats have so far performed well and are today active.

At present, Argo Norway has 36 operative Argo floats.

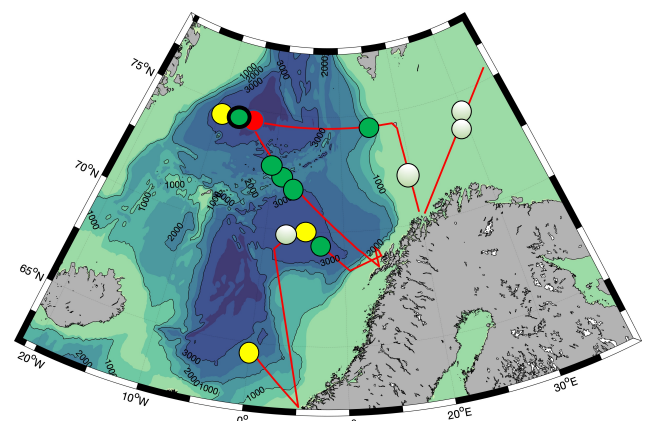


Figure 1. Locations of deployed Argo floats in 2021.

b. Technical problems encountered and solved

- One BGC (PROVOR-CTS4) float failed during self-test at sea and was not deployed. During self-test there was no response from the REM-A sensor. The float has been sent back to NKE Instrumentation for service.

c. Status of contributions to Argo data management and delayed mode quality control process

We do DMQC of our floats that were deployed in 2018 and later (see below, point d). Three of our floats have Fast Salinity Drift (6903556, 6903557, 6903562) that also are in the grey list.

d. status of delayed mode quality control process

We have recently started to do the DMQC of our floats that were deployed in 2018 and later (Argo Germany has done DMQC for our “older” floats). We do DMQC of core, bgc and deep floats. We have done DMQC of temperature/salinity for 20 core/bgc floats and 7 deep floats. For the Bio and BGC-floats we have done DMQC for oxygen (16 floats), nitrate (4 floats) and pH (1 float). DMQC-work of the other variables is ongoing and will be done within 2022. 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

Financial resources

The funding has been a combination of self-financed (i.e., funded by Institute of Marine Research) and funding from the Norwegian Research Council (NRC, Ministry of Education and Research) during 2012-2015.

For 2018-2023 we receive funding from the NRC for the extension of the national Argo infrastructure project (NorArgo2), approximately 600 k€ per year. Within this project we purchase and deploy approximately 13 floats per year in the Nordic Seas and the Arctic that include core, BGC and deep floats. To keep the target of having minimum 30 operative Argo floats beyond 2023, submission of a new project proposal to the NRC is planned.

Human resources

NorArgo2 has approximately 36 person months per year and more than 10 people contribute from six Norwegian institutes (IMR, Norce, NERSC, MET.no, Akvplan-niva, UoB).

National coordination

The Norwegian Argo Infrastructure (NorArgo, <https://norargo.hi.no>) is coordinated by Kjell Arne Mork, Institute of Marine Research, who also is the leader of the NorArgo2 project.

3. Summary of deployment plans

In May/June 2022 we plan to deploy **16 floats** in the Nordic Seas and Barents Sea. The floats include:

- 2 BGC-floats: PROVOR CTS4 with all 6 BGC-variables + CROVER + UVP6
- 4 BGC-floats: PROVOR CTS4 with all 6 BGC-variables
- 2 BGC-floats: PROVOR CTS4 with 4 BGC-variables (DO, Chl, bbp, irradiance)
- 3 Deep-floats (Arvor + DO)
- 2 core/bgc floats (Arvor) + DO
- 3 core floats (Arvor)

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

Argo Norway focuses on both research topics and marine climate monitoring of the Nordic Seas. There is an increasing interest in using Argo data in Norway, and two climate centres are now using the data operationally in climate models (NERSC and MET.no). For instance, the operational TOPAZ4 modeling system assimilates Argo data into the ocean model to provide forecast product for the Nordic Seas and Arctic Ocean under the EUs Copernicus Marine Environment Monitoring Services (CMEMS, <http://marine.copernicus.eu/>).

The present scientific topics are mainly within the Nordic Seas (Norwegian, Iceland and Greenland Seas) and Arctic, including:

- Heat and fresh water contents in the Nordic Seas are regular updated
- Water mass changes in relation with biological activities. This topic is also one of the reasons that we have included bgc sensors on the Argo floats.
- Studies that involve the mixed layer, primary production and carbon cycle.

Link to Argo Norway (NorArgo): <https://norargo.hi.no>

5. Issues we wish to be considered and resolved

6. Improving the quality and quantity of CTD cruise 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. The Argo bibliography

No new articles to add that are not included in the Argo bibliography.

8. The COVID-19 impact

Two BGC-floats and one deep float were delivered too late for the cruise with Argo deployments in 2021. Instead, these floats will be deployed one year later, in 2022. In addition, a cruise was shortened due to COVID-issues, and as a result some planned Argo deployments needed to be modified.

9. RBR CTD

We have no deployment plans for RBR floats.



Argo-Poland National Report 2021

Waldemar Walczowski, Małgorzata Merchel

IO PAN, Sopot, Poland, 31.01.2022 r.

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array

a. floats deployed and their performance

In 2021, during the AREX 2021 summer cruise, seven floats were launched from the board of Institute of Oceanology Polish Academy of Sciences (IO PAN) vessel *r/v Oceania*. Four floats belong to Germany, three to Argo-Poland. One float was launched on the way in the Baltic Sea, five floats were deployed in the Norwegian and Greenland Sea and one in the Barents Sea (Fig. 1).

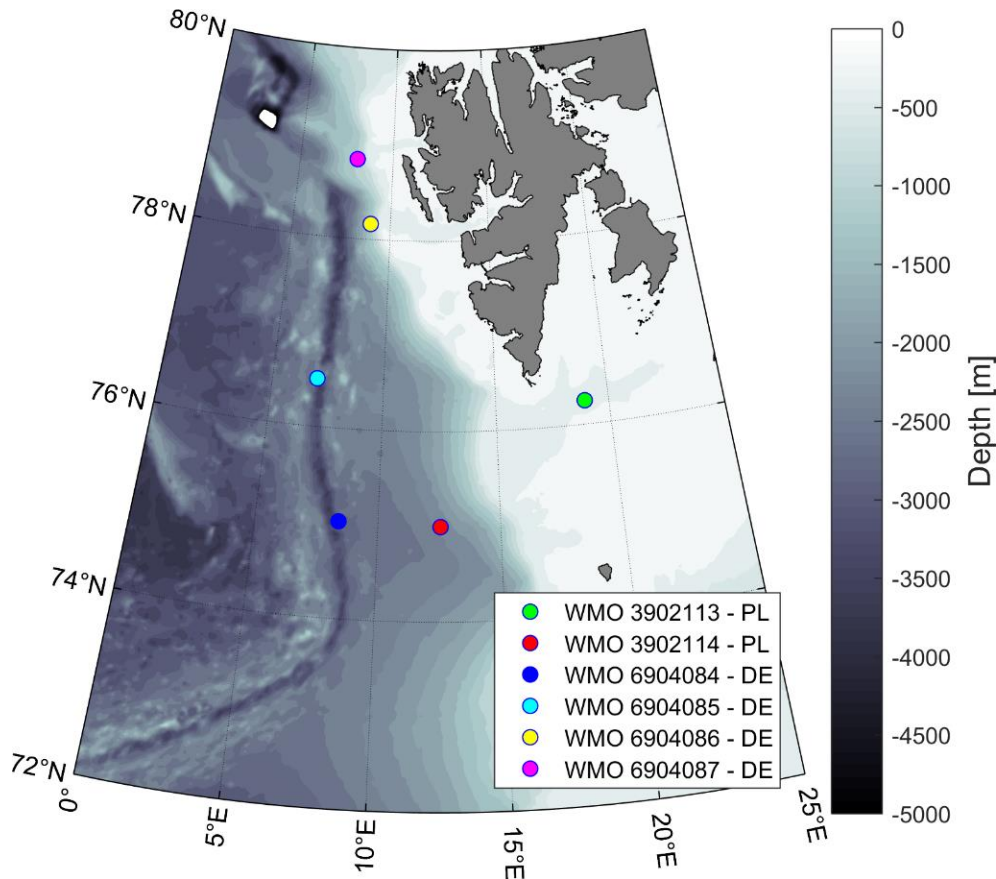


Figure 1. Argo floats launching positions during the AREX 2021 cruise.

The first Polish float (WMO 3902115) was deployed in mid-June in the Bornholm Basin at the position 55.25 °N, 16.03 °E. The parking depth was set at 300 dbars and the profiling depth at 350 dbars, both deeper than the bottom depth. The goal of the mission was to keep the float on a limited area and use it as a virtual mooring (Fig. 2). The float works in 2-days cycles. The float was operated for the whole of 2021 and has sent 98 complete sets of hydrographic data (CTD, O₂) by the end of the year.

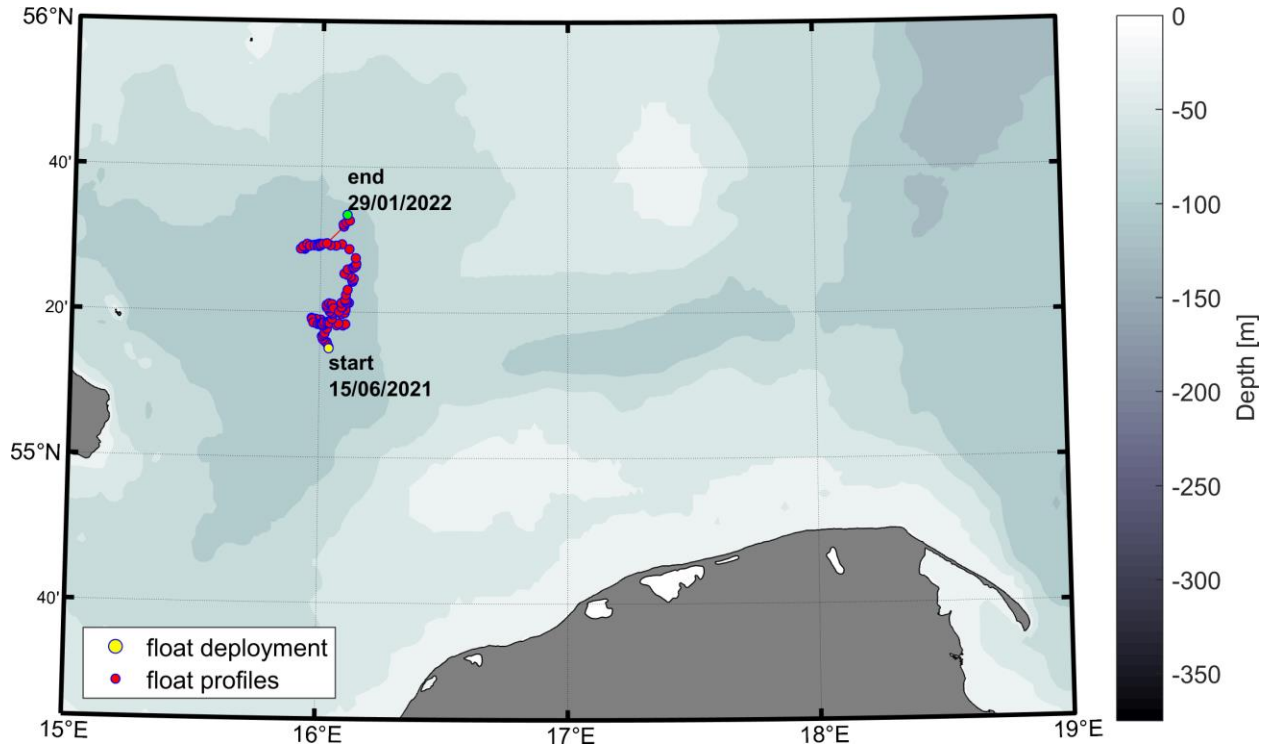


Figure 2. Position of deployment and trajectory of the Argo float WMO 3902115 deployed in the Baltic Sea (Bornholm Basin) by the Argo-Poland program in June 2021.

The second float (WMO 3902113), belonging to Argo-Poland, was experimentally launched in a shallow region south of Svalbard, Storfjordenna at the end of June (76.25 °N, 18.94 °E). This area is important for dense, cold bottom water production, that inflow from the Storfjord to the Norwegian Sea. Due to the unusual conditions, the float profiled with a frequency of 48 hours. The float worked very well until it was trawled by a Norwegian fishing vessel. The captain of the ship contacted IOPAN, it was decided to deliver the float to Tromsø. Courtesy of the Norwegian Polar Institute, in October the float was taken from the fishing vessel and loaded onto the Norwegian vessel *r/v Kronprins Haakon*. Polish oceanographers participated in the October-November cruise of this modern oceanographic vessel. During the cruise, attempts were made

to re-deploy the float, but it was impossible as it failed the tests. The float will be thoroughly inspected and launched in 2022. A series of 49 profiles, which were obtained, show great potential in the exploration of even such difficult waters by Argo floats (Fig. 3).

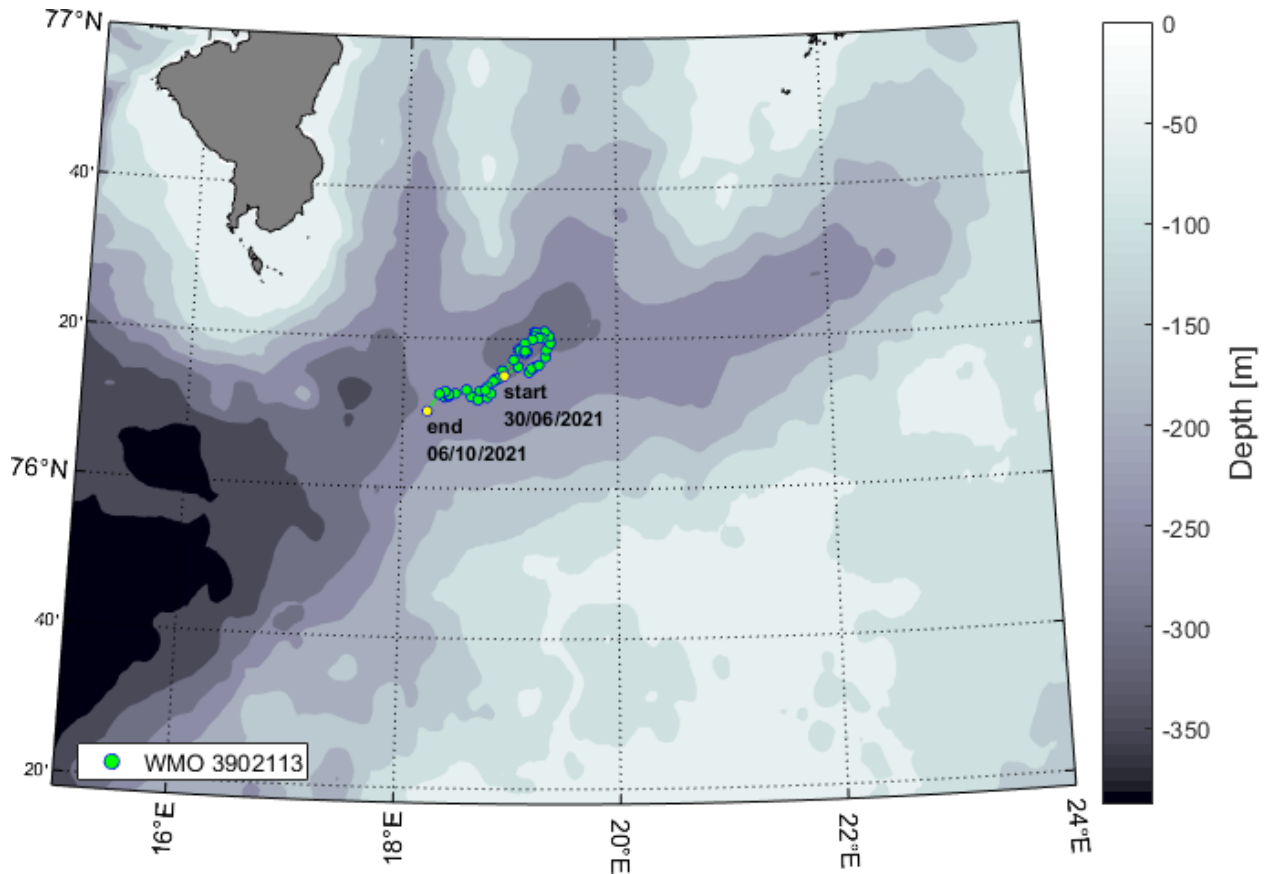


Figure 3. Position of deployment and trajectory of the Argo float WMO 3902113 deployed in the Storfjordrenna by the Argo Poland program in June 2021.

At the beginning of July, the third float (WMO 3902114) was deployed in the Norwegian Sea in the West Spitsbergen Current region (75.00 °N, 12.55 °E). The parking depth was set at 1000 dbars and the profiling depth at 2000 dbars. Float has cycles of 10 days. The float was operated for the whole of 2021 and has sent 18 complete sets of hydrographic data by the end of the year (Fig. 4).

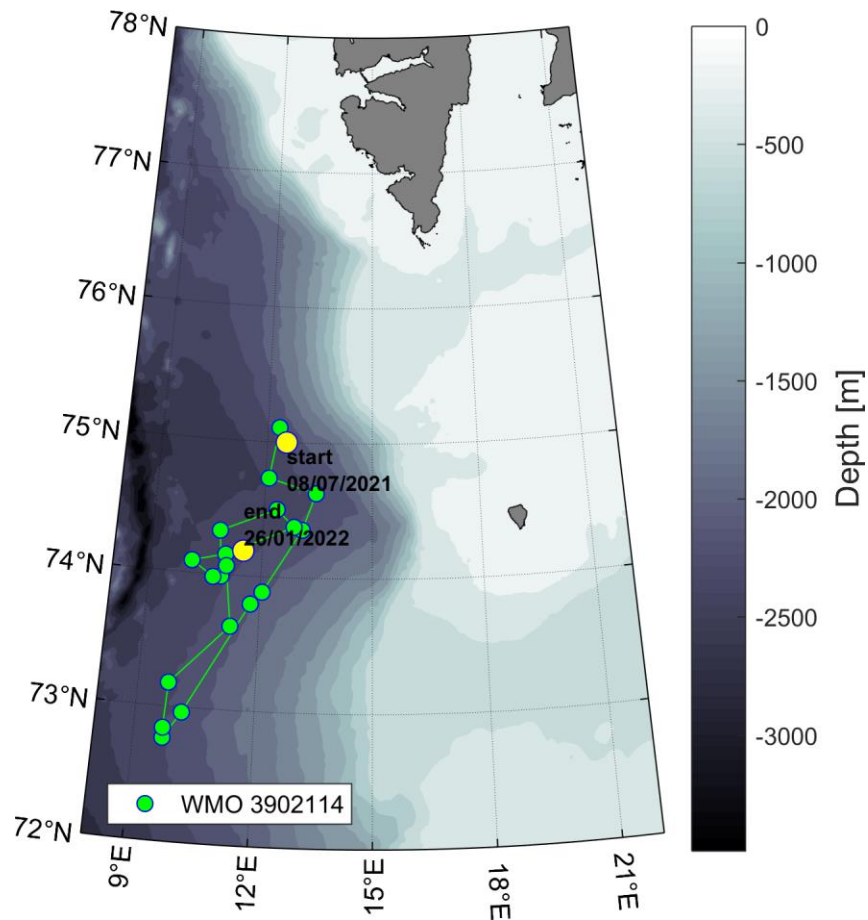


Figure 4. Position of deployment and trajectory of the Argo float (WMO 3902114) deployed in the Norwegian Sea by the Argo Poland program in July 2021.

All three instruments are the NKE manufactured ARVOR floats with an Iridium transmission system and ice avoidance algorithms. In addition to standard CTD measurements, the floats also take measurements of dissolved oxygen.

In June 2020, the Baltic float (WMO 3902109) were deployed in the Gulf of Gdansk under the H2020 Euro-Argo Research Infrastructure Sustainability and Enhancement (E-A RISE) EU project. The goal of the mission was to keep the float on the limited area and use it as a virtual mooring (Fig. 5). At the beginning of August 2021, the float was pulled out by the German Navy vessel in the Gulf of Gdansk. During the mission, the float made 500 profiles and sent a complete set of CTD data.

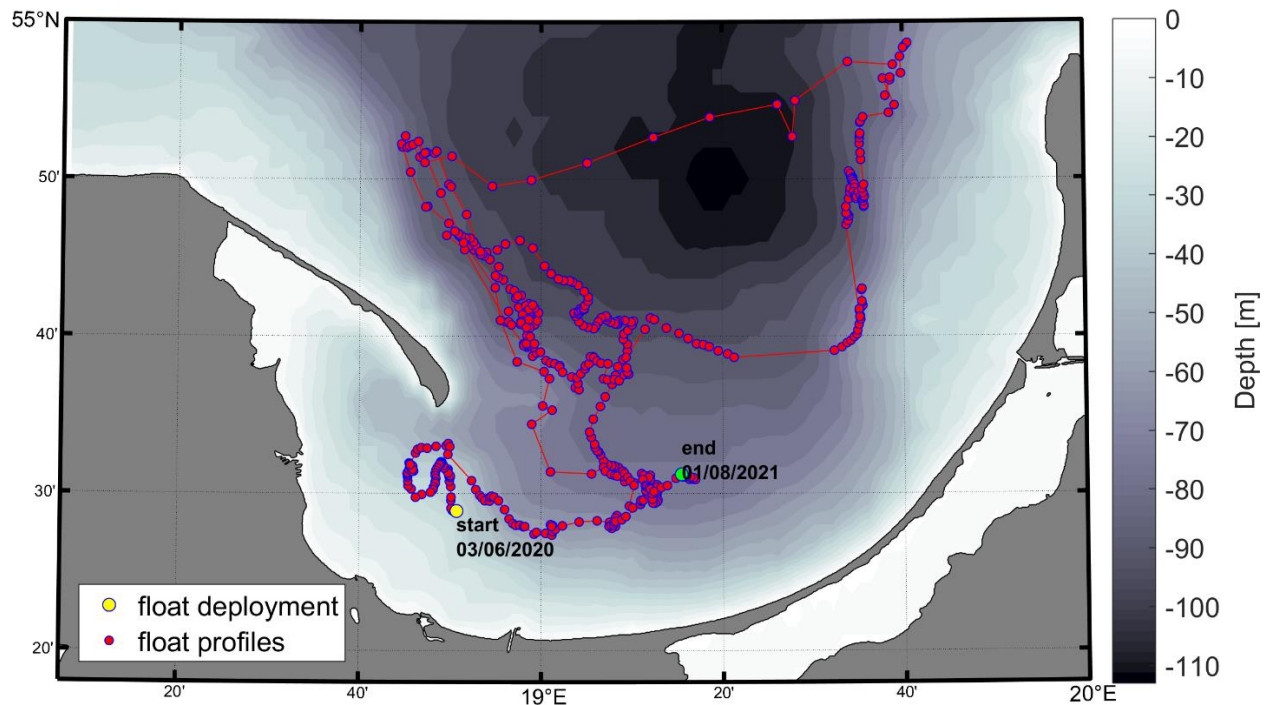


Figure 5. Position of deployment and trajectory of the Argo float WMO 3902109 deployed in the Baltic Sea (Gulf of Gdansk) by the Argo Poland program in June 2020.

b. technical problems encountered and solved

All 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 floats.

c. status of contributions to Argo data management.

Data from 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 (2016-2019) to the Argo references database.

d. status of delayed mode quality control process

Standard DMQC procedures have been used by DMQC operator from IOPAN for the following Arctic floats:

3902102 – Salinity correction was needed.

3902103 – Salinity correction was needed.

3902105 - It is fine and needs no correction.
3902107 – It is fine and needs no correction.
3902108 – It is fine and needs no correction.
3902111 – It is fine and needs no correction.
3902112 – Salinity correction was needed.

D-files were submitted on GDAC.

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

Argo-Polska was funded until May 2021 by the Ministry of Science and Education. After the announcement of a new call for funding, the Institute of Oceanology of the Polish Academy of Sciences applied to the Polish Ministry for funding the Argo-Poland consortium. The members of the consortium are the Institute of Oceanology PAN, Institute of Geophysics PAN and Polish Naval Academy. We are currently waiting for a decision regarding further funding.

3. Summary of deployment plans.

Argo-Poland plans to launch one float a year in the Baltic Sea and at least two in the European Arctic. The financing decision for 2022, however, is still under consideration.

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 seasonal variability of the water masses properties (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 Baltic Sea deep basins and current pathways are especially valuable. Argo data are also used for the modelling in the SatBaltyk project.

<http://www.satbaltyk.pl/en/>

Project SufMix (Turbulent Mixing in the Slupsk Furrow) uses Argo data as well.

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.

Table 1. List of CTD stations performed during floats deployment during IOPAN cruise AREX2021.

Float WMO	Date of deployment	Region	Vessel	Cruise	CTD/O ₂ cast	Float owner
3902113	30.06.2021	Barents Sea	r/v Oceania	AREX2021	AR21_055	PL
3902114	07.07.2021	Norwegian Sea	r/v Oceania	AREX2021	AR21_094	PL
3902115	15.06.2021	Baltic Sea	r/v Oceania	AREX2021	AR21_001	PL
6904084	07.07.2021	Norwegian Sea	r/v Oceania	AREX2021	AR21_090	DE
6904085	04.07.2021	Greenland Sea	r/v Oceania	AREX2021	AR21_075	DE
6904086	16.07.2021	Greenland Sea	r/v Oceania	AREX2021	AR21_138	DE
6904087	16.07.2021	Greenland Sea	r/v Oceania	AREX2021	AR21_143	DE

Data will be submitted.

7. Argo bibliography

Merchel M., Variability of properties and spatial distribution of deep and intermediate waters in the Nordic Seas in the years 1998–2017, PhD thesis, defended on 25 October 2021.

8. How has COVID-19 impacted your National Program's

No problems with floats deployment and recovery.



Portuguese Argo Activities

Report 2021 for the Argo Steering Team Meeting (AST23)

Submitted by A. Miguel Piecho-Santos

IPMA-Portuguese Institute for the Sea and the Atmosphere

March 2022

Activities

1. Participation in the European project "Euro-Argo Research Infrastructure Sustainability and Enhancement (Euro-Argo RISE)", namely in the WP2-Evolution of the core Argo mission / Task 2.3- Improve Argo observation of boundary regions. In this context, one of the activities was to simulate the best Argo floats configuration to maximise their retention in the same location of the deployment using the VirtualFleet software and a "genetic" algorithm (Fig.1). The best results are for the following configurations, regarding parking depth (m), vertical speed (m/s) and cycle duration (days): (1) Simulation (S) 1 (long= -8.855) - 795 m; 0.031 m/s; 10 days; (ii) S2 (long = -8.146) - 711 m; 0.049 m/s; 10 days; and (iii) S3 (long = -7.438) - 392 m; 0.09 m/s; 9 days. However, we want to extend this study because there are other issues that should be taken in consideration, as the vertical speed changes because this could have implications on the quality of the data. A article are in preparation to be published during 2022.
2. Unfortunately, Portugal failed to sign the admission to Euro-Argo ERIC and ceased to be a candidate.
3. The call for the acquisition of four core Argo floats, one full biogeochemical (BGC) Argo float and one BGC Argo float with dissolved oxygen sensor only is now finished and the vendor choose was NKE that will deliver these floats during 2022.

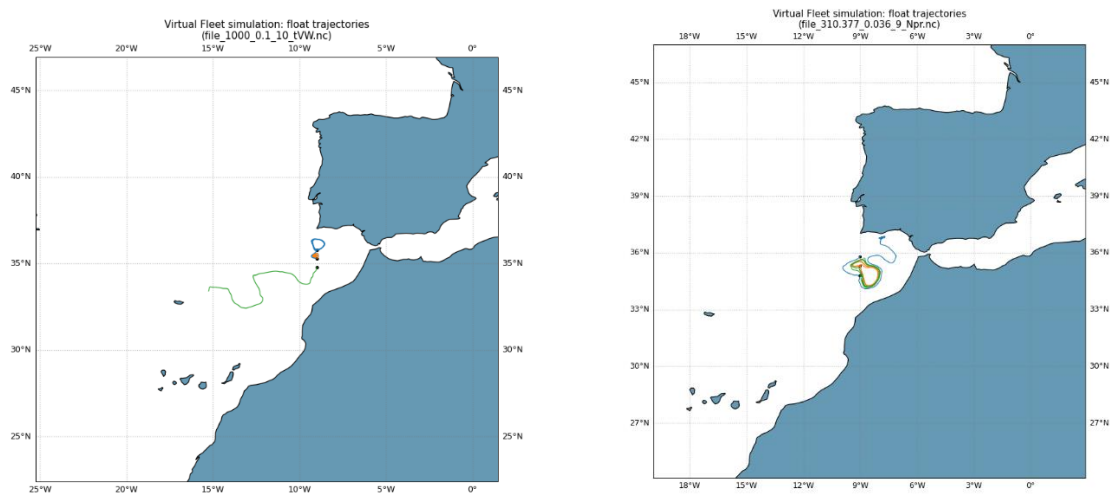


Figure 1. In the left it is the an example of a simulation with core Argo configuration and in the right with optimize parameters.

Plans for 2021

1. Potential deployment of the four core Argo floats in the Gulf of Cadiz.
2. Publish Le Jeune et al.(in preparation) paper.
3. Starting again the process for Portugal's participation as a full member of Euro-Argo ERIC.

References

Le Jeune, M., Piecho-Santos, A.M., Balem, K., Maze, G. (in preparation). Monitoring the Gulf of Cadiz, NE Atlantic, with Argo floats. To be submitted to *Oceans*.

National Report for Argo Steering Team-23 (AST-23) - 2022

South Africa

Take-over cruises = cruises to maintain bases on sub-Antarctic Islands (Marion and Gough) and Antarctica SANAE base

1. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021)

- a. Floats deployed and their performance

None procured by South Africa, however deployed on behalf of other teams:

- 2 Core Argo floats - Marion Island takeover cruise (April - May 2021)
- 13 Core Argo floats - SANAE VI cruise (December 2021 – January 2022)
- 9 Core and 3 BGC (Oxygen sensor) Argo floats - Endurance22 cruise to the Weddell Sea (February - March 2022)

- 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. Available to assist with deployment of Deep and BGC floats only where sufficiently competent Research team(s) onboard. Most deployments currently take place on take-over cruises.

- d. Status of delayed mode quality control process

n/a

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)

Present: One person on AST team (Dr. Morris). One person on BGC team (Dr. Thomalla). Limited input to data management teams. Make available deployment opportunities to assist with core mission and enhanced missions where possible.

Future: An infrastructure funding initiative has been approved through the Department of Science and Innovation (DSI) in South Africa. The initiative will allow for the potential procurement of core and BGC floats to be deployed in South Atlantic, South Indian and Southern Oceans. Discussions are underway, however the overall budgets have been cut.

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.

Take-over cruises 2022/2023:

- **Marion Island cruise:** April / May 2022. Transect goes from Cape Town to Marion Island and returns directly to Cape Town again. Floats confirmed:

2 Core Argo floats from UK MetOffice

6-8 Core Argo floats from WHOI

4-5 BGC Argo floats from University of Washington
- **Gough Island cruise:** September 2022. Transect goes from Cape Town to Tristan da Cunha, then on to Gough Island. The vessel returns via the same route. Potential floats:

6-8 Core Argo floats from WHOI
- **SANAE IV cruise:** December 2022 – February 2023. Transect goes from Cape Town along the GoodHope Line to Antarctica.

6-12 Core Argo floats from WHOI

Research cruises 2022/2023 (some are still COVID-19 dependent):

- **Resilience Cruise:** April / May 2022. The French research vessel *Marion Dufresne* is undertaking research within the Mozambique Channel. Floats confirmed:

2 BGC Argo floats (with oxygen) from Euro-Argo
- **SEAmester cruise (potential):** July 2022. Vessel will transect from Cape Town to just north of Port Elizabeth and undertake a CTD transect across the Agulhas Current. Thereafter returning to Cape Town.
- **Winter research cruise (potential):** July / August 2022. Call for research to be confirmed. But work envisaged for Southern Ocean / Marion Island. Vessel will transect from and back to Cape Town.
- **SAMBA mooring cruise:** September / October 2022. Vessel will transect from Cape Town directly westwards into the South Atlantic to service moorings.

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.

Environmental education purposes:

- 1) **Adopt-a-Float.** This was a massive undertaking for the Endurance22 project and got a lot of support from schools in South Africa, Namibia and the US.

2) Lecturing at Honours level on Ocean Observing technologies

Core Argo Standards and Best Practices paper

Research in the Greater Agulhas Current region, particularly on transport for heat, salt and mass.

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

None

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

We have been heavily restricted collecting CTD data on take-over cruises due to the number of team members that can be on the cruise (COVID protocols). Though likely outstanding for the CCHDO since the last upload.

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.

None

There is also the thesis citation list ([Thesis Citations | Argo \(ucsd.edu\)](#)). If you know of any doctorate theses published in your country that are missing from the list, please let me know. Finally, if you haven't already sent me a list of Argo PIs in your country, please do so to help improve the statistics on how many papers are published including an Argo PI vs no Argo PIs.

None

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.

Technically none, other than being unable to undertake research cruises limiting our deployment opportunities to take-over cruises only.

Argo-España

Parte de la estrategia global de observación del océano



Argo – Spain Annual Report 2021

ARGO ESPAÑA – IEO - SOCIB / 22 – 72

Argo – Spain Annual Report

Feb 15, 2022

Alberto González - Santana, Pedro Vélez - Belchí (IEO)

Lara Díaz – Barroso, Irene Lizarán - Esperilla, John Allen, Joaquín Tintoré (SOCIB)



INSTITUTO
ESPAÑOL DE
OCEANOGRAFÍA



Balearic Islands
Coastal Observing
and Forecasting
System

Argo - Spain Annual Report 2021

Present status and future plans

1. Introduction.

a. Organization.

Argo-Spain (www.argoespana.es) is a joint initiative between the *Instituto Español de Oceanografía* (Spanish Oceanographic Institute, IEO) and the *Sistema de Observación Costero y de Predicción of the Balearic Islands* (Coastal Ocean Observing and Forecasting System, SOCIB) to development and consolidation of the Spanish contribution to Argo. Its activities are mainly focused on the international core Argo program and its extension toward the deep ocean.

Thus, the following team, detailed below, coordinates all the activities of Argo – Spain:

- **IEO:** National and scientific coordinator of deployments in the Atlantic Ocean (P. Vélez) and head of quality control activities (A. González).
- **SOCIB:** Scientific coordination of deployments in the Mediterranean Sea (J. Tintoré, L. Díaz and I. Lizarán).

b. Funding.

Spain has participated in the international Argo program since its inception and is currently a member of the European Research Infrastructure Consortium Euro-Argo (ERIC). Spanish participation in Argo began in 2002 through a first European project, and a total of 100 Argo profilers have been deployed in the North Atlantic and the Mediterranean Sea since then.

The Argo Spain program does not have proper long-term funding for deployments of Argo floats. However, the minimum contribution to the Euro-Argo ERIC is secured and sustained, based on IEO's access to infrastructures calls from the Spanish Ministry of Science, Innovation, and Universities and from the SOCIB's contribution, which has ensured deployments of at least 3 floats per year since 2015. The 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. The IEO funds the scientific and the transmission costs.

c. Long-term evolution of Argo – Spain.

This has been Argo's proposal at the Spanish national level:

- 2021: Core Argo mission, temperature, and salinity (0 to 2000 m).

- 2015 – 2021: Participation in the pilot array for the extension of the Argo network to the deep ocean with Australia, China, France, Japan, New Zealand, Norway, the UK, and the USA.
- 2021-2023: Participation in the Core mission, and the pilot array for extension to the deep Ocean.

Core T/S floats are fully funded by IEO and SOCIB, while deep floats have been funded by the Ministry of Science. Argo Spain strategy will be set according to national interests and guidelines, as is shown in the Euro – Argo's long-term road map for the implementation of a new sustained phase for Argo in Europe.

d. Float development.

All the developments during 2021 with the participation of Argo Spain have been made under the frame of the EA - RISE Project (<https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022>). The IEO has participated in the development of 2 Deep Arvor floats with three heads, consisting of 3 mounted sensors (SBE41, SBE61, and RBR), especially in the deployment phase and in the comparative study phase to assess the accuracy of the sensor measurements. Under the same project, SOCIB has participated in terms of float development by improving floats sampling in shallow waters and boundary currents, optimizing configuration and life expectancy's floats, and improving technical floats' aspects in marginal seas.

2. The status of implementation.

Since the beginning of Argo Spain, 100 floats have been deployed so far, of which 24 were active at the end of 2021. All deployments are chosen based on Spanish research criteria, as well as the operational activities of each of the institutions, mainly in the Atlantic Ocean and the Mediterranean Sea.

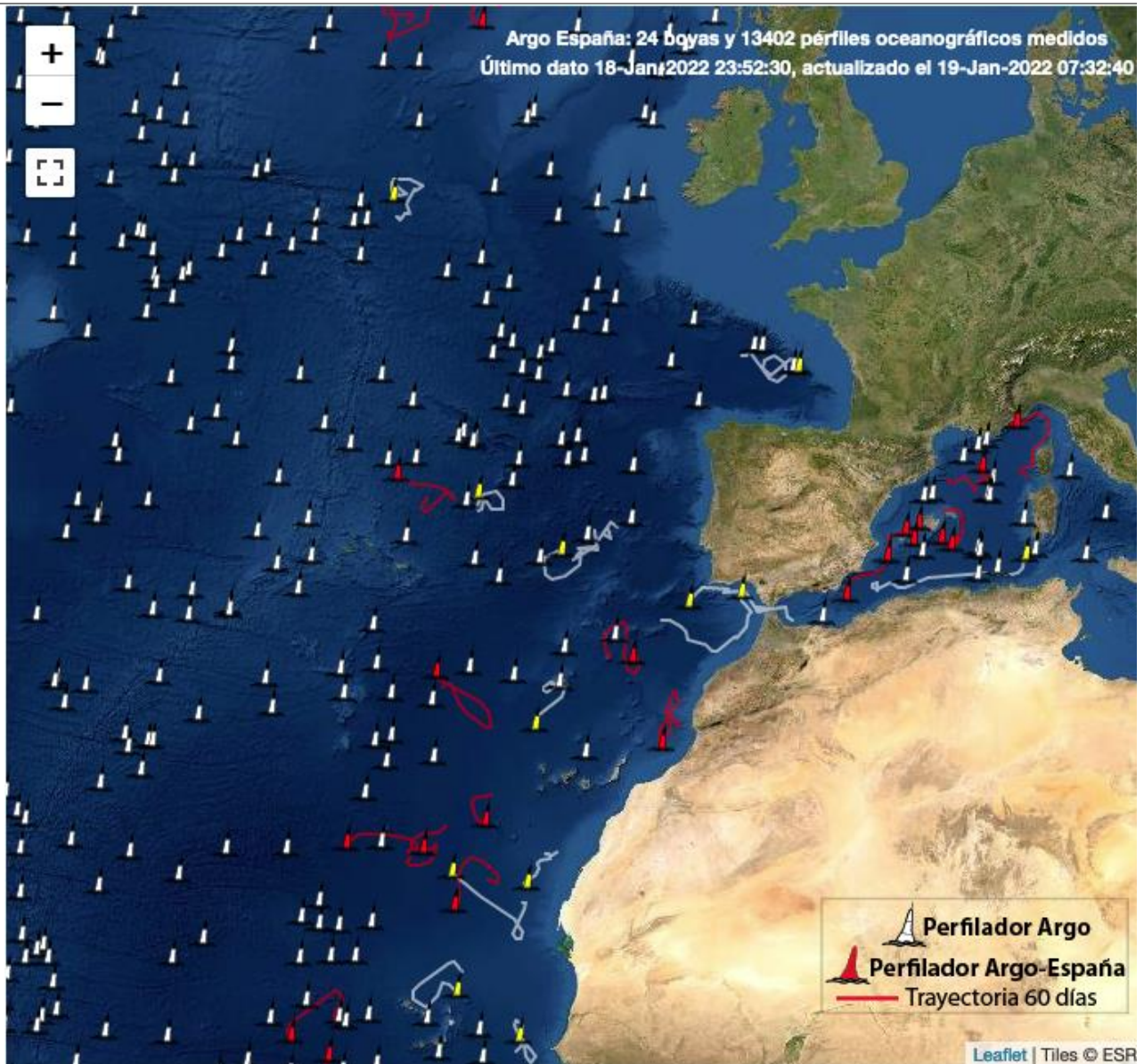


Figure 1. Status of the Argo Spain program on January 18th, 2022.

The following table shows relevant information about each Argo-Spain float. It is a database that records information of some features from the deployment until the floats stop completely.

WMO	Status	Project Name	Float Owner	Platform Type	Deployment Date
6901253	Active	Argo SPAIN	IEO	ARVOR_L	29/05/2018
6901254	Active	Argo SPAIN	IEO	ARVOR_L	15/10/2018
6901255	Active	Argo SPAIN	IEO	ARVOR_L	16/6/2019
6901256	Active	Argo SPAIN	IEO	ARVOR_L	01/06/2018
6901257	Active	Argo SPAIN	IEO	ARVOR_L	06/02/2019
6901258	Active	Argo SPAIN	IEO	ARVOR_L	04/06/2018
6901259	Active	Argo SPAIN	IEO	ARVOR_L	11/03/2019
6901262	Active	Argo SPAIN	IEO	ARVOR_L	08/06/2018
6901263	Active	Argo SPAIN	IEO	ARVOR_L	06/02/2019
6901265	Active	Argo SPAIN	IEO	ARVOR_L	10/06/2018
6901266	Active	Argo SPAIN	IEO	ARVOR_L	13/06/2018
6901268	Active	Argo SPAIN	IEO	ARVOR_L	18/03/2019
6901269	Active	Argo SPAIN	IEO	ARVOR_L	16/06/2018
6901270	Active	Argo SPAIN	IEO	ARVOR_L	18/08/2018
6901271	Active	Argo SPAIN	IEO	ARVOR_L	30/10/2018
6901272	Active	Argo SPAIN	IEO	ARVOR_L	26/03/2019
6901273	Active	Argo SPAIN	IEO	ARVOR_L	11/12/2018
6901277	Active	Argo SPAIN	IEO	ARVOR_L	31/07/2019
6901278	Active	Argo SPAIN	EA-RISE SOCIB ICTS	ARVOR_I	12/03/2020
6901280	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	12/08/2020
6901281	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	04/11/2020
6904065	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	14/08/2020
6901282	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	13/12/2021
6901283	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	14/12/2021
6901284	Active	Argo SPAIN	SOCIB ICTS	ARVOR_I	14/12/2021

Table 1. Extract of current Argo Spain floats database.

3. The status of implementation of the new global, full-depth, multidisciplinary Argo array (major achievements and problems in 2021).

a. Floats deployed and their performance.

During 2021, a total of 3 Argo floats were deployed by Argo-Spain:

- 3 ARVOR – I floats (Argo Spain in the Mediterranean Sea), un under the framework of Argo Spain’s minimum annual coverage commitment for the Euro – Argo contribution and purchased by SOCIB.

The contribution of Argo Spain to extend the international Argo network during 2021 was focused on the Med Sea, deploying a total of 3 ARVOR – I floats. These deployment missions were coordinated by SOCIB – IEO and developed by SOCIB in collaboration with partners who cooperated for the success of the missions <https://bit.ly/3nEONXv>.

As an example, the ARVOR – I float WMO 6901283 is currently diving northeast of Ibiza Island after 8 profiles developed (Fig. 3). The float was programmed to dive up to 2000 m every 5 days measuring temperature and salinity during the ascending phase, within a parking depth of 350 m.

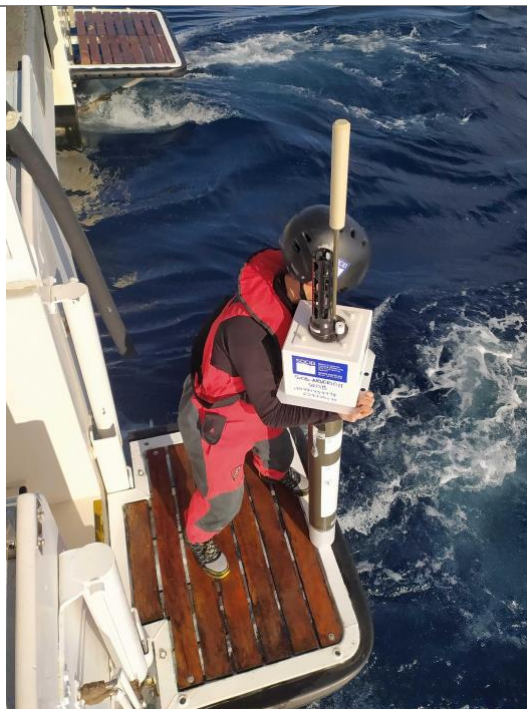


Figure 2. R/V SOCIB operator moments before the deployment of WMO 6901283 float under safety measures at *Canales Autumn 2021* survey.

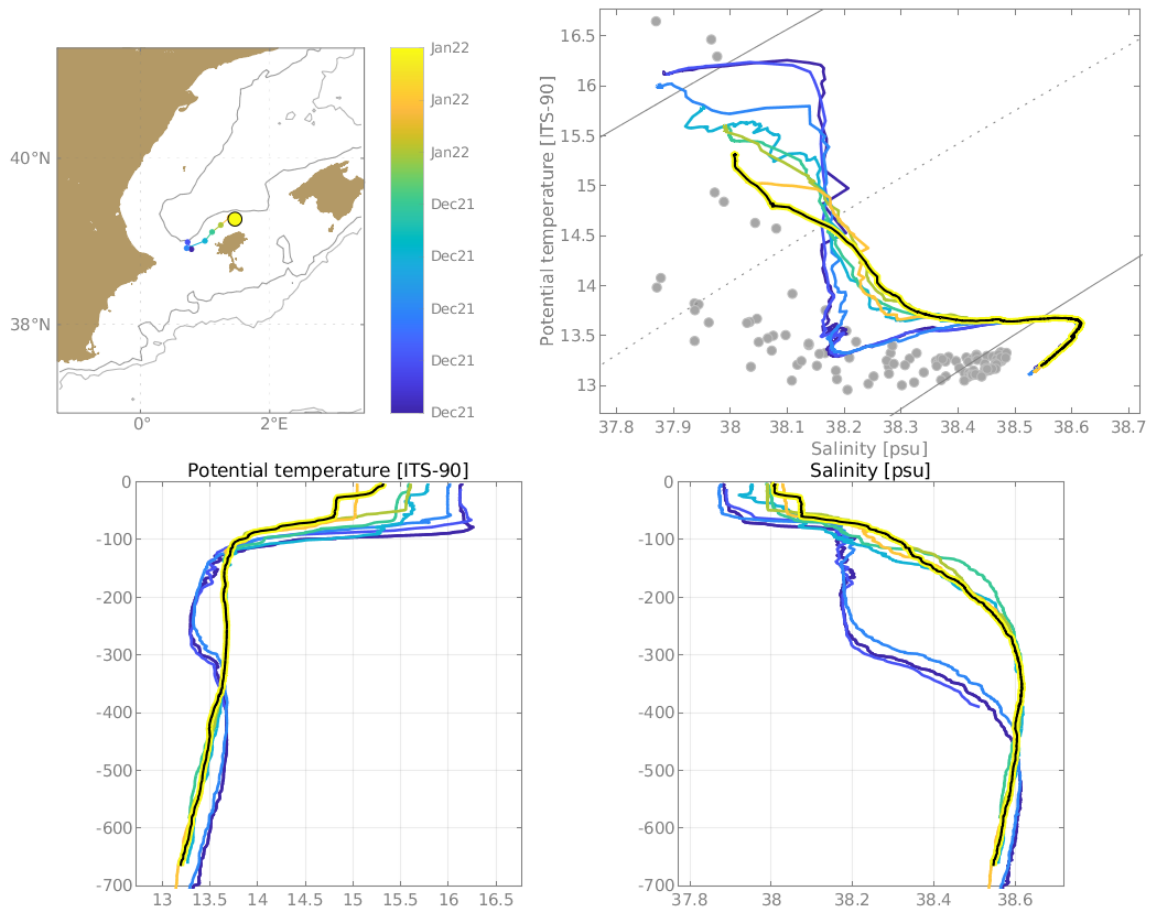


Figure 3. The trajectory of the float since the deployment is shown in the upper left side of the picture. The T-S diagram of the data collected by WMO 6901283 is shown on the upper right side of the picture. The gray points are the climatology of the area. The black line is the first profile carried out by the float. Potential Temperature and Salinity profiles are also shown on the lower side of the picture.

The ARVOR – I float WMO 6901282 also as an example, which was deployed between Mallorca and Ibiza islands, performed a southern trajectory up to the date of writing this report (fig. 4). The float was programmed following the same configuration set-up.

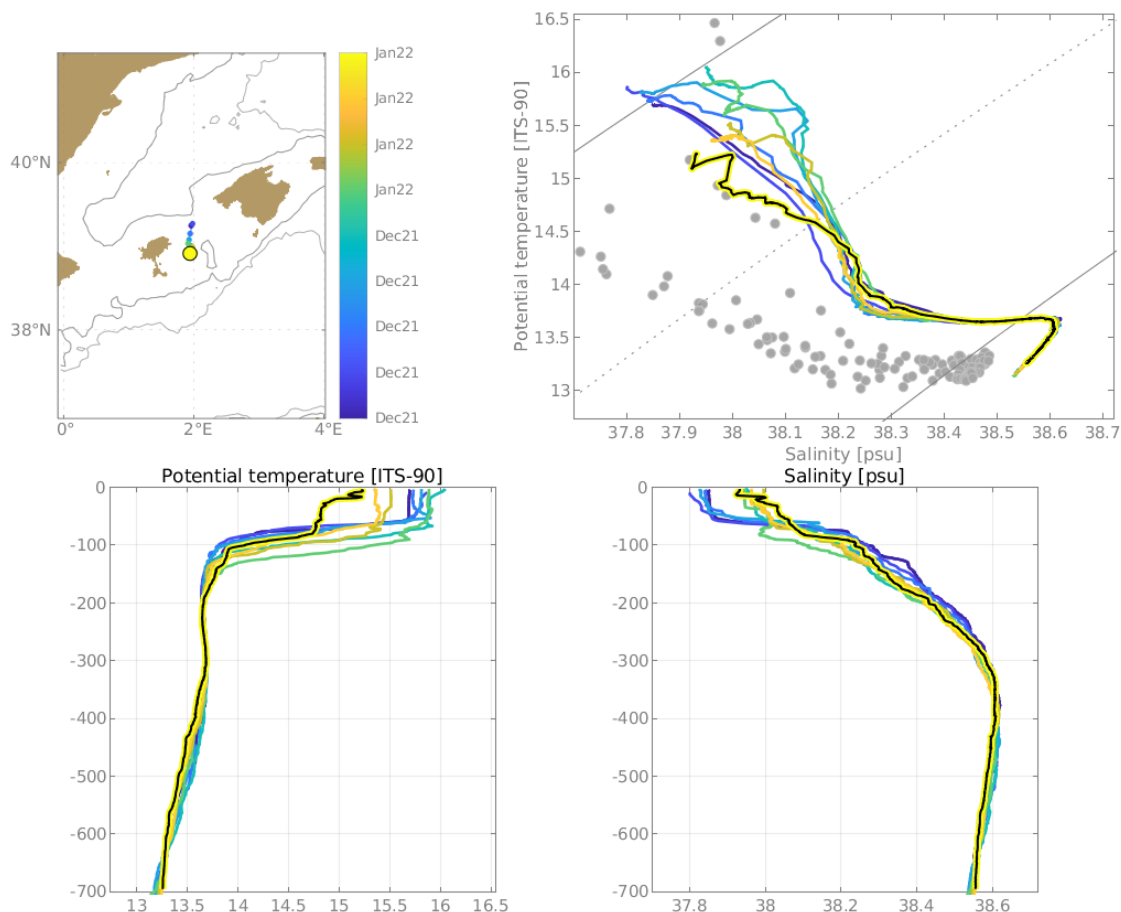


Figure 4. The trajectory of the float since the deployment is shown in the upper left side of the picture. The T-S diagram of the data collected by WMO 6901282 is shown on the upper right side of the picture. The gray points are the climatology of the area. The black line is the first profile carried out by the float. Potential Temperature and Salinity profiles are also shown on the lower side of the picture.

b. Technical problems encountered and solved.

No technical issues have been found regarding the deployments and floats monitoring.

c. Status of contributions to Argo data management (including the status of pressure corrections, technical files, etc).

After each deployment, detailed technical information is provided to the DAC in charge of the floats (Coriolis) and the AIC. The Argo-Spain program is aware of the changes in the technical and metadata data formats and is providing the necessary information.

d. Status of delayed mode quality control process.

Argo-Spain mainly deploys floats in the Atlantic Ocean and the Mediterranean Sea. In terms of DMQC, Argo-Spain manages its floats that operate in the Atlantic Ocean and the Instituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS) manages all the floats that operate in the Mediterranean Sea, including floats of Argo-Spain. The DMQC of the Argo-Spain floats that operate in the Mediterranean Sea will be assumed by Argo-Spain itself at some point, subject to personnel availability. In successive meetings, a transfer of DMQC knowledge from the IEO to the SOCIBis planned, so that SOCIBis in charge of the DMQC of the Argo Spain profilers deployed in the Mediterranean.

Currently, SOCIB is working to upload the CTD data to the Argo DataBase from 2014 to nowadays, with a 0.5 m resolution.

The Argo-Spain fleet consists of 96 floats deployed so far. A total of 63 floats have been deployed in the Atlantic Ocean and 32 floats deployed in the Mediterranean Sea (fig. 5).

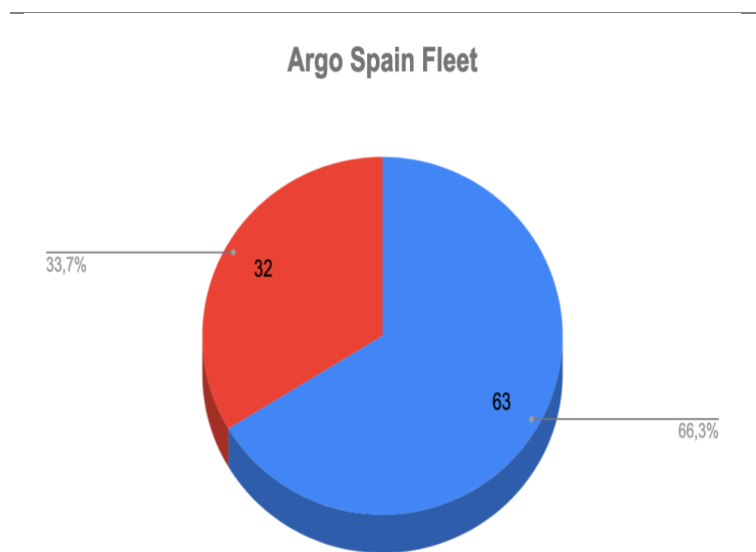


Figure 5. Argo-Spain fleet.

DMQC has been carried out for 16 floats in 2016, for 19 floats in 2017, for 4 floats in 2018, no DMQC has been developed during 2019 and 2020 and for 9 floats in 2021 (fig. 6).

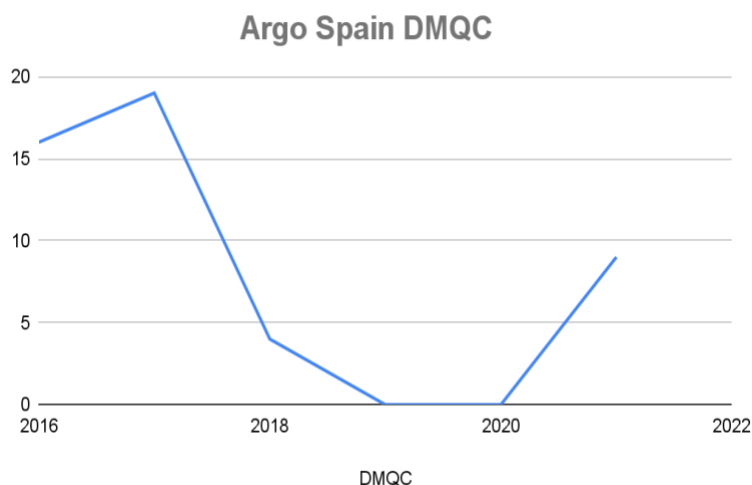


Figure 6. Number of floats that have been inspected by DMQC.

4. The present level of and future prospects for national funding for Argo including a summary of the level of human resources devoted to Argo.

No changes in Argo-Spain's manpower so far: (1) PI and (1) full-time technician (1) at IEO, another (1) technician and (2) part-time scientists at SOCIB . The knowledge transfer on the DMQC between SOCIB and IEO scheduled for 2021 is postponed until further notice. The IEO and SOCIB's funding covers float procurement in the period 2021-2022 and transmission costs. Moreover, IEO's funding covers part-time personnel support. The IEO funds the scientific coordination and delayed mode in the Atlantic (1 FTE). Besides the long-term support from the IEO, SOCIB will deploy 3 Argo floats per year in the Western Mediterranean.

Also, through competitive calls in Spain, IEO and the SOCIB have obtained funding for 10 floats/year in the Atlantic, including Deep and Bio Argo floats for the years 2022-2024, and 12 floats (CORE) in the Western Mediterranean for the years 2022-2025.

5. Summary of deployment plans and other commitments to Argo for the upcoming year and beyond where possible. Here is a link to the commitments table at OceanOPS. If you cannot edit the online table, please send a list of deployment plans for each of the columns in the table as needed.

Although the potential deployments may change following feedback from the Spanish research community, the current plan for the upcoming year is:

- 3 standard floats (ARVOR - I) to be deployed in the Mediterranean Sea during 2022 (SOCIB).
- 10 standard floats (ARVOR - I) to be deployed in the Atlantic Ocean during 2022 (IEO).

- 5 Deep Argo floats (DEEP ARVOR) to be deployed in the Atlantic Ocean during 2022 (IEO).
- 2 BGC floats to be deployed in the Atlantic Ocean during 2022 (IEO).

6. 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. Ocean and weather forecast operational models also use Argo data. The web page of the Argo Spain program is: <http://www.argoespana.es>

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

None.

8. 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. However, the data have not been submitted to the CCHDO yet.

9. 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.

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10. 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.

Yes, it has been a delay in the purchasing process of the floats to be deployed during 2021 and 2022. This has caused the proposed launch plan for 2021 to be postponed to 2022. SOCIB purchased 3 profilers which were deployed on time in 2021.

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

IFREMER, EURO-Argo, and the IEO will deploy in March 2022 two '2-Headed' a one '3-Headed' Deep Argo floats (range 4000 m depth) in the Canary basin under the framework of the EA-RISE project. Both floats are equipped with an RBR argo3 sensor.

UK ARGO PROGRAMME

REPORT FOR 23RD ARGO STEERING TEAM MEETING MARCH 2022

1. Status of Implementation

Floats deployed and their performance

During 2021 we were able to deploy 18 floats; of these 15 were standard core APEX, four were APEX Deep and one Navis BGCi (bio-geochemical) float. Deployments were still impacted by the cancellation of several cruises in the autumn due to Covid.

Since the end of the year, to end February 2022, we have deployed five core APEX and our first six-parameter PROV-BIO float.

As at 1st March the UK has 152 operational floats (i.e. for which real-time data are presently being distributed), as shown in Figure 2. This does not show the recently deployed six-parameter PROV-BIO float as processing has still to be set up.

Of the 24 floats deployed between 1st January 2021 and end February 2022 we have had three float failures, two of which failed to report after being deployed, the other while still active is not transmitting sufficient information to process. This is a higher failure rate than we would normally expect.

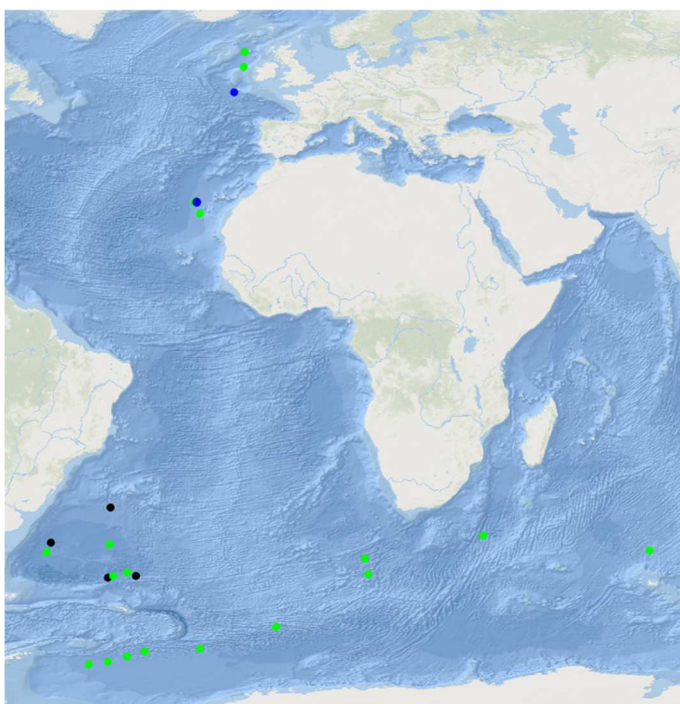


Figure 1. Showing the latest reported locations of UK Argo floats deployed between 1st January 2021 and 28 February 2022, core APEX floats in green, APEX-Deep in black, BGC floats in blue.

At end February 2022 the 152 operational floats returning data include:

- 124 core APEX with SBE CTDs
- 6 core APEX with the RBR sensor
- 1 core NAVIS
- 4 APEX with oxygen and pH
- 1 APEX with oxygen
- 8 NAVIS with oxygen
- 5 APEX DEEP
- 1 APEX DEEP with oxygen
- 1 NAVIS BGCi
- 1 PROV-BIO.

In addition, we have one active six-parameter PROV-BIO still to be set up for processing.

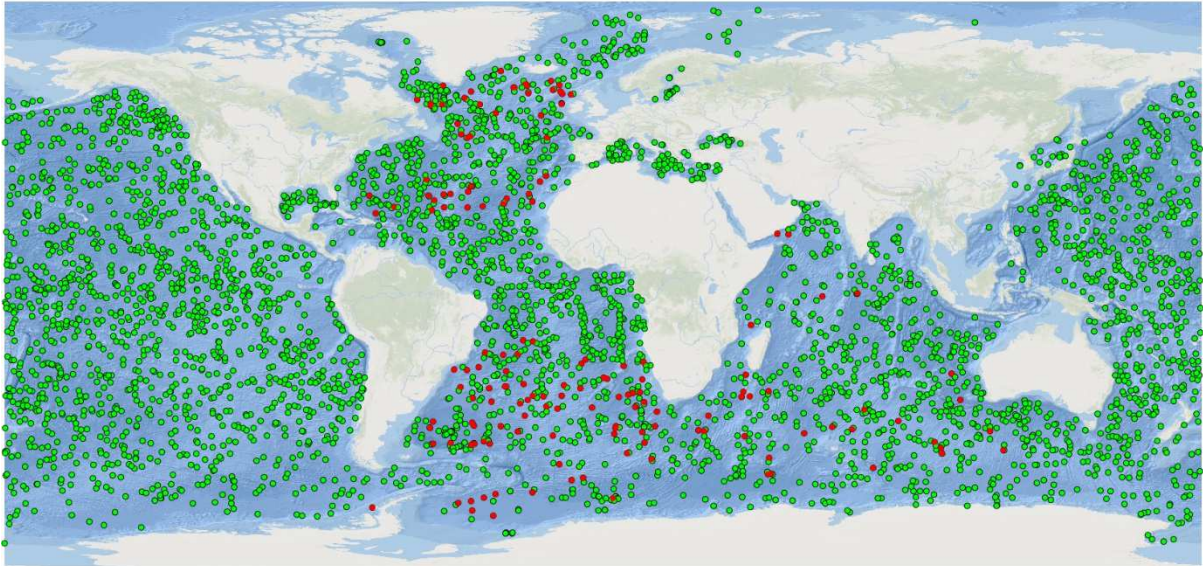


Figure 2. Showing the locations of all UK floats delivering data in red with the global network of ~3,900 floats in green, as at 1 March 2022.

Technical problems encountered

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. We still have five undeployed APEX floats that are at risk of the fast salty drift problem that have yet to be returned to Teledyne Webb (three of these are in South Africa).

APEX Deep

As noted above UK deployed four APEX Deep in 2021, all in the Argentine Basin. All four are presently working together with two APEX Deep deployed in 2020. We are still awaiting delivery of a Deep SOLO ordered last year. There are no plans to buy any more deep floats at present.

Bio-geochemical Argo

We presently have two active BGC floats. The Navis BGCi that was deployed in November 2020 near the Porcupine Abyssal Plain (PAP) mooring appears to be working well and the data look good. However, the NAVIS BGCi deployed near PAP in April 2021 failed to report, despite SeaBird engineers clearing the float for deployment when asked to review the lab test data. The 11 PROV-BIO floats purchased by PML in 2013 have all shown good longevity, with one that was deployed in December 2015 still active having made over 330 cycles. One of the floats from that batch has been recovered and awaiting refurbishment. As noted earlier we deployed our first 6-parameter PROV-BIO float in early 2022 with another two due to go in shortly. A further five 6-parameter BGC floats are in stock at NOC for deployment later this year.

APEX floats with RBR CTD

We procured our first six APEX-RBR floats in 2015. Five were deployed with three early failures, the other two are still operating having made over 200 cycles. Two RBR-L3 replacements for the early failures were provided in 2020 and the sixth was upgraded to L3, these were deployed in the North Atlantic in December 2020 alongside one new APEX-RBR-L3, all four APEX-RBR-L3 are presently operating normally. The data are being made available to Mat Dever at RBR, two of the floats have been put onto 1Hz sampling in the top 100 dBar. We have three other APEX-RBR-L3 available, two of which are out for deployment, with five new ones in the float order to be delivered in March.

Status of contributions to Argo data management

Real-time data processing

At 1st March 2022 the British Oceanographic Data Centre (BODC) were processing data from 152 active UK floats, 18 Irish floats and 59 Euro-Argo MOCCA floats. Work remains to deliver the UK BGC data to the GDACs, and this will be a high priority for the coming year.

Real-time processing is run four times a day with NetCDF files distributed to the GDACs and the Met Office, where the BUFR files are generated and disseminated on the WMO Global Telecommunications System (GTS). The capability now exists to include supplementary profiles and oxygen into the BUFR files. However, we have not yet been able to progress the extension of the BUFR capability to include other biogeochemical variables. Within the Euro-Argo RISE project, UK Argo is also developing real-time tests for BBP, as well as a technique for producing uncertainty estimates for BBP.

Delayed-mode QC processing

Core Argo

At 1st March 2022 BODC had delivered 94,684 profiles from UK floats, of which 75,992 profiles have been subjected to delayed-mode QC. This represents 80% of all profiles, and 82% of eligible profiles (i.e. all profiles from expired floats and profiles over one-year old from active floats). From February 2021 up to 9th March 2022 BODC analysed and delivered to the GDAC in delayed mode 13,294 profiles (from 93 floats).

BODC supported the UK and Irish Argo programs, data for which are managed by the BODC Argo Data Assembly Centre (DAC) function. Recently BODC performed DMQC analysis of eight Irish Argo floats and submitted them to the GDAC.

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

BODC continued development works related to the conversion of the DMQC software (OWC package) from Matlab to Python. The works were focused on improving the code performance, readability and fixing any remaining known issues that arrived during testing the floats. The next steps to finalize the project are to continue the User Acceptance Testing involving the broader Argo community, improve code readability and enhance functionality related to configuration and code design. The progress of works has been demonstrated at the 22nd ADMT meeting.

Deep Argo

NOC and BODC, have also played a key role in coordinating the development of deep Argo mission. This covers contributions in compiling the new procedures for the real-time QC flag scheme and Real-time adjustments on Deep Argo vertical profiles and procedures for DMQC of Deep Argo salinity data.

BODC has started development work on automatically applying the CpCor correction for pressure effects on conductivity data of deep Argo floats (>2000 dbar) in the real-time QC process which was recommended by the Deep Argo team earlier in 2021. This step is required to perform further analysis of deep Argo floats in delayed mode. BODC is planning to implement the delayed-mode procedures for DMQC analysis of Deep Argo floats in 2022.

BODC and NOC have been actively involved in the coordination and organisation of DMQC for deep ocean data as a part of the EuroArgo Rise WP3, Task 3.2. This involved organisation and coordination of the intermediate meeting with other European partners within the task and providing a regular update of progress to the reporting body.

BODC and NOC were strongly involved in the co-organisation of the BGC and 3rd Deep Argo workshop.

BGC Argo

BODC has not been able to make progress with DMQC of the UK BGC floats due to a long-term absence in the team, which has limited availability of staff working in the Argo group over a prolonged period.

BODC contributed to reviewing the report for the Euro-Argo RISE WP4 deliverable of enhancing the current oxygen QC.

A significant focus in the coming year will be to progress DMQC training in the analysis of Oxygen parameter to be able perform DMQC analysis of BGC floats. This activity is a part of the Euro-Argo RISE project WP4.

Southern Ocean Argo Regional Centre (SOARC)

SOARC activity has been limited to efforts that are happening towards deliverables in Euro Argo RISE WP5. BODC and NOC have been working to establish a method of regional data quality assessment in the Southern Ocean. (i) BODC reviewed and tested the currently available tools for the classification of the Argo profiles located in the Southern Ocean (SO). The classification method aims to improve the quality control analysis of Argo floats by reducing the impact of selected reference data from other zones in the SO during the quality checks of salinity data. (ii) BODC and NOC implemented and operationalized in BODC the float classification tool based on the machine learning developed in Ifremer. The method is called the PCM (Profile Classification Model) and its output is used to perform the OWC analysis. (iii) BODC and NOC are working on a quality assessment of Argo floats in d-mode, in the Southern Ocean performed by PIs and DMQC operators from various DACs. The current works aim to review the fleet from the Atlantic sector (70° W to 30°E). (iv) BODC reviewed the quality assessment method of delayed mode quality control of Argo floats used in the Coriolis Argo Regional Center and implemented some of their procedures which are also appropriate for the Southern Ocean floats.

Due to the long term absence of the BODC Argo Lead, who is also a lead of the SOARC Argo group, progress on wider SOARC Partnership activities has stalled.

Research cruise CTD data

When the UK notifies float deployments with OceanOPS, we include any information about nearby or simultaneous CTD casts if the scientists on board the deploying ship provide this. It is written in the Description free text box in the notification form.

2. Funding and human resources

The UK Argo programme is undertaken by a partnership between the Met Office, the National Oceanography Centre (NOC, which includes BODC) and Plymouth Marine Laboratory (PML). 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 PML play a leading role in the expansion of the UK programme into BGC-Argo.

Funding

UK funding for Argo comes through various channels – the Met Office, NOCS and PML. Both the Met Office and NERC (Natural Environment Research Council) funding originates from BEIS (Department for Business, Energy and Industrial Strategy).

Argo funding to the Met Office is presently provided directly from BEIS mainly through the Hadley Centre Climate Programme (HCCP), but with an additional contribution through the Public Weather Service Programme. The HCCP workplan and funding for 2021 to 2024, which has been approved by BEIS and Defra (Department for Environment, Food and Rural Affairs) includes UK Argo funding for the period April 2021 to March 2024. From 2020 onwards all new floats have been with Iridium telecoms. The regular funding for FY2021 has allowed for the purchase of 17 core APEX floats, however additional in-year funding has enabled the purchase of a further 39 core APEX floats which should be delivered in March 2022. This means we will have in stock enough floats to maintain the UK Argo contribution to core Argo for three years even if (in the unlikely event) future funding is curtailed. In addition, two PROV-BIO floats have been ordered through the Euro-Argo ERIC for the PICCOLO (Processes Influencing Carbon Cycling: Observations of the Lower limb of the Antarctic Overturning) project led by the University of East Anglia.

NERC funding for Argo is primarily directed through NOC under National Capability (NC) funding lines which cover Argo data management (through NC Environmental Data Services funding of BODC) and Argo science. In March 2021, NERC and NOC announced an investment of £3.7 million to begin building the UK Atlantic Sector BGC Argo Network (ASBAN-UK) where NOC will deploy ~30 six-parameter BGC floats in the Atlantic Ocean over the next three years as part of the UK Argo programme, the first of these was deployed in February 2022. Non-NC funding is also provided through participation in EU-funded Argo-related projects.

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 primarily from BEIS.

Human resources

Staff members working on UK Argo, their institution and effort on Argo during 2021 are given below; this will have been remained below normal years effort due to Covid-99 lockdowns and associated home-schooling demands. BODC staffing levels have been hit with the long-term absence (Sept 21 to date) of the Argo lead staff member, which has impacted the team. They have secured some additional time from another NOC team member to help meet priority deliverables, but this has not fully filled the time or skillset gap.

Met Office – 0.56 FTE
Jon Turton, Fiona Carse, John Hankins

NOC, Southampton – 0.25 FTE (estimated)
Brian King, Nathan Briggs

NOC, BODC – 3 FTE

Primarily Matt Donnelly (part of the year), Kamila Walicka, Clare Bellingham and Violetta Paba, with others providing additional support, like Clive Neil, BODC software developer team for short, 2 weeks development works

PML – 0.1 FTE
Giorgio Dall'Olmo

3. Summary of deployment and data management plans

Deployment plans

As noted earlier, at 1st March in 2022 UK Argo has deployed seven core APEX and one 6-parameter PROV-BIO float.

Other floats out for deployment presently include:

Two APEX-RBR-L3 and two 6-parameter PROV-BIO floats (March 2022)

One Navis BGCi: North Atlantic (PAP cruise April 2022)

Four APEX: South-west Atlantic (April 2022)

Two APEX: Indian Ocean (floats are with Mauritius Met Service).

At the time of writing we have 37 core APEX, one APEX-RBR-L3 and two Navis BGCi floats in stock, with a further 34 core Apex and five core APEX-RBR-L3 to be delivered in March. NOC have five 6-parameter PROV-BIO in store with another 7 to be delivered spring 2022, and PML have one older PROV-BIO float that was recovered in 2018 to be refurbished.

Other deployment opportunities later in the year will be investigated. A reasonable estimate for the year 2022 would be twenty core floats, one deep float and eight BGC floats.

4. Uses of Argo data in the UK

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).

PML have the lead for BGC Argo in the UK, where the data are used for:

- investigating different aspects of the biological carbon pump (e.g., mixed-layer pump, fragmentation, respiration of both dissolved and particulate organic matter);
- investigating export fluxes and efficiency in hypoxic ocean regions;
- providing a description of the physical environment in the framework of biological (e.g. mapping eel migration routes) and biogeochemical studies;
- developing techniques to generate 3D fields of biogeochemical variables by merging ocean-colour and in-situ data;
- investigating mesoscale structures by combining altimetry and in-situ profiles with a special focus on Agulhas rings.

At the Met Office 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. The FOAM suite now includes an improved resolution version of global FOAM with 1/12 degree horizontal resolution. This will continue to make use of Argo data to constrain the T/S fields in the same way as the original 1/4 degree resolution system.
- fields from global FOAM are also used to initialise the ocean component of coupled monthly-to-seasonal forecasts;
- 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), where the OSTIA fields are used as a lower boundary condition in numerical weather prediction models run by both the Met Office and ECMWF.

- A global coupled weather forecasting system which is initialised using coupled data assimilation is now running operationally (commenced March 2022). Argo data therefore directly contribute to operational weather forecasts as well as ocean forecasts. An assessment of the impact of Argo in a lower atmospheric-resolution version of that coupled system was detailed in King et al., 2019.

Recent Met Office research & development applications (non-operational) which have made significant use of Argo data:

- a paper was published on OSSEs to investigate potential impact of expanding the Argo array (Mao et al., 2020);
- David Ford has done some OSSEs looking at the impact of the planned BGC-Argo array of floats in a global physical-biogeochemical model where he assimilates synthetic versions of the BGC Argo profiles in conjunction with satellite ocean colour data (Ford, 2021);
- one other project where we made good use of Argo data was in the assimilation of satellite sea surface salinity data from SMOS, Aquarius and SMAP. The near-surface salinity data from Argo was used to bias correct the satellite salinity data and was crucial for the performance of the assimilation of SSS data. That work is written up in Martin et al., 2019.
- Another paper was published investigating impact in FOAM and the Mercator system of satellite SSS assimilation which used Argo for assessment (Martin et al., 2020).
- An additional recent paper has been published (Dong et al., 2021) on improving ocean reanalyses (which make use of Argo data).

In the Hadley Centre for Climate Science and Services, Argo data is used to make 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 GTSP data, and annually using delayed-mode Argo profiles (and WOD, GTSP and ASBO data). EN4 is freely available for scientific research use (see <http://www.metoffice.gov.uk/hadobs/en4/>). The latest version is EN.4.2.2, which includes a fresh download of all the source data and a substantial update to the XBT/MBT correction schemes. EN.4.2.2 contains four ensemble members where previously there was only two. There is also a new product user guide (based on both the Argo Users' Manual and the HadIOD user guide), including FAQs and example code. EN4 is also forming part of a GEWEX EEI project - comparing Ocean Heat Content calculated from reanalyses, in situ data and satellite products (the project website is <https://sites.google.com/magellium.fr/eeiassessment/dissemination/documents?authuser=0>).
- HadIOD (Hadley Centre Integrated Ocean Database) is a database of in situ surface and subsurface ocean temperature and salinity observations supplemented with additional metadata including bias corrections, uncertainties and quality flags. The dataset is global from 1850-present with monthly updates. The current version is HadIOD.1.2.0.0, the chief sources of data are ICOADS.2.5.1, EN4 and CMEMS drifting buoy data. This product has been available to the public since mid-2020 via <https://www.metoffice.gov.uk/hadobs/>.

Met Office science uses of the EN4 product include OHC analysis, contributions to BAMS, Ocean Obs'19 White Paper and an Earth Energy Imbalance paper (von Schuckmann et al., 2020).

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5. Issues from UK to be considered by AST

None.

U.S. Argo National Report to AST-23, March 2023

Organization of U.S. Argo:

The U.S. Argo Program is supported with major funding provided by the National Oceanic and Atmospheric Administration (NOAA), and additional participation of the U.S. Navy. It is implemented by a U.S. Float Consortium that 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, U.S. Argo works collaboratively with closely related programs including:

- 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.
- 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.
- 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 carried out deployment of 29 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 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 Program 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 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:

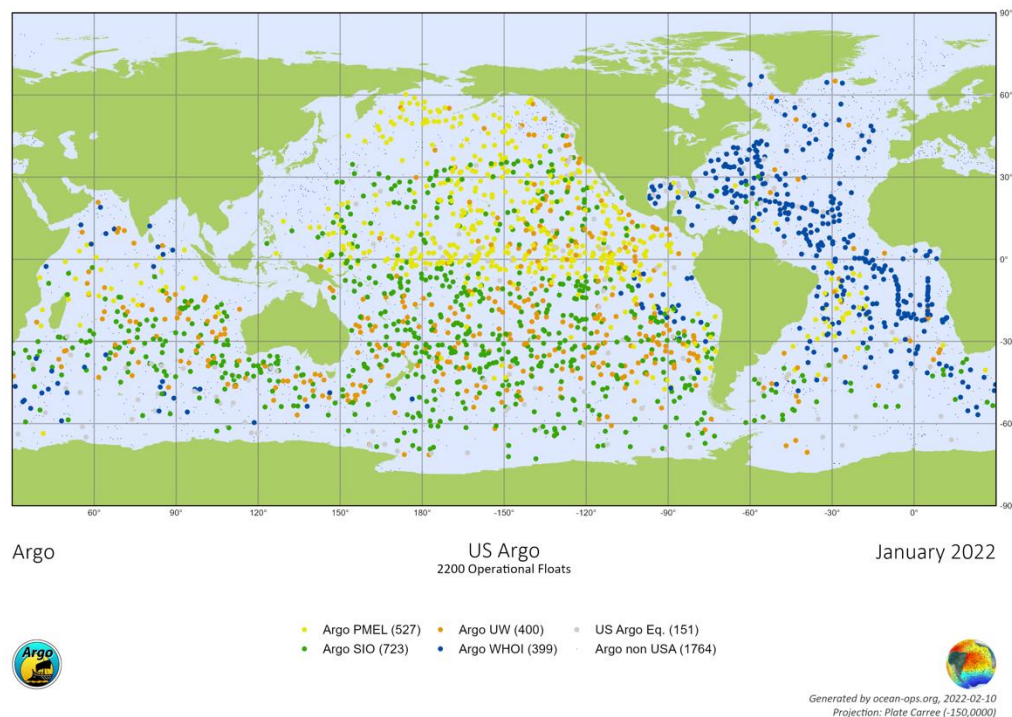


Fig. 1: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2022 (Source: OceanOPS).

There were 2049 operational U.S. Argo Program floats (Fig. 1) provided by the U.S. Argo Consortium as of January 2022. An additional 152 U.S. Argo equivalent floats were operational at that time, mostly SOCCOM and GO-BGC instruments. Support levels for Core U.S. Argo have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have been offset by increases in float lifetime, with over 80% of floats deployed as far back as 2016 still operational as of 2/022 (Table 1). Hence the number of operational U.S. Argo Program floats has been relatively steady, oscillating around approximately 2000 since about 2016 (Fig. 2).

Further increases in lifetime are expected through continuing identification of short-term and long-term failure modes and improved battery technologies. However, the present number of yearly deployments may not be sufficient to sustain the level of U.S. Argo floats.

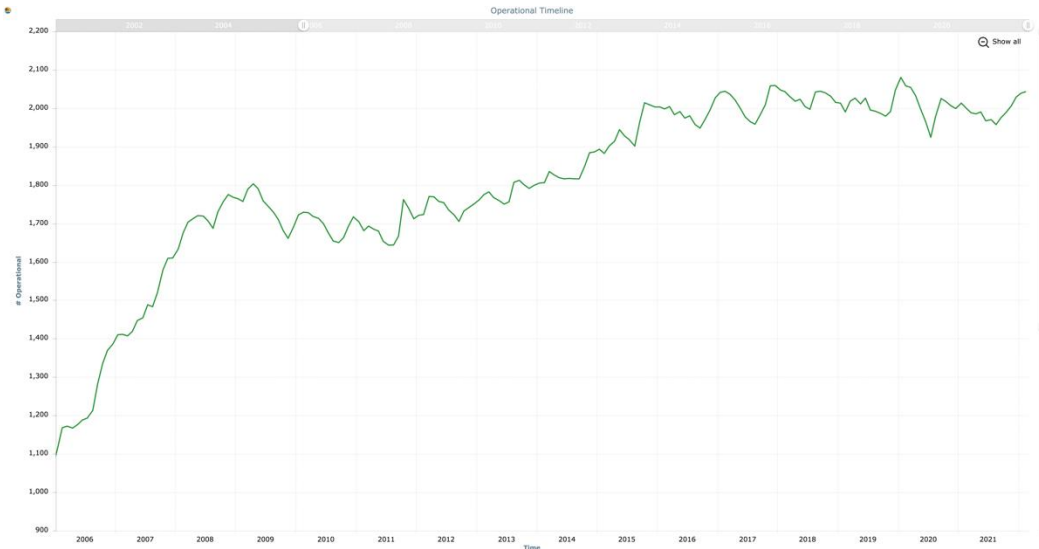


Fig. 2: Timeline of the number of operational U.S. Argo Program floats (Source: OceanOPS).

Year deployed	Number deployed	Number active as of 2/2022	% active (2/2022)
2012	341	15	4%
2013	329	17	5%
2014	376	99	31%
2015	346	225	65%
2016	346	276	80%
2017	366	301	82%
2018	284	236	83%
2019	295	252	85%
2020	284	261	92%
2021	295	264	89%

Table 1: Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 2/2022 (Source: OceanOPS). A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures.

Impacts of the Covid-19 pandemic have included limitations on all institutional laboratory activities for physical distancing, a substantial reduction in available deployment opportunities by the research fleet, supply chain difficulties that have adversely affected float manufacture, and sea freight delays. There were 295 US Argo Program floats deployed during 2021 (Table 1). Continuing limitations of the research fleet are limiting deployments in remote regions (Fig. 3). Nonetheless, the relatively long life of Argo floats mitigates the Covid-19 reduction in activities, as illustrated by the continuing nearly-constant number of active US Argo Program floats (Fig. 2).

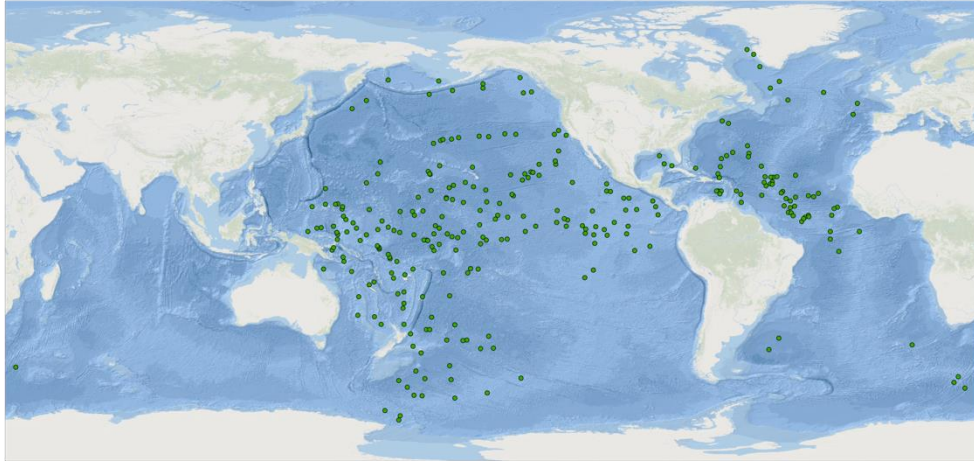


Fig. 3: Latest location of US Argo Program floats deployed during 2021 (Source: OceanOPS).

Support for U.S. Argo 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 and in technical and science workshops, 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. US Argo is actively involved in testing, quantifying sensor biases, and contributing to the pilot array of RBR CTD equipped floats.

Deep Argo:

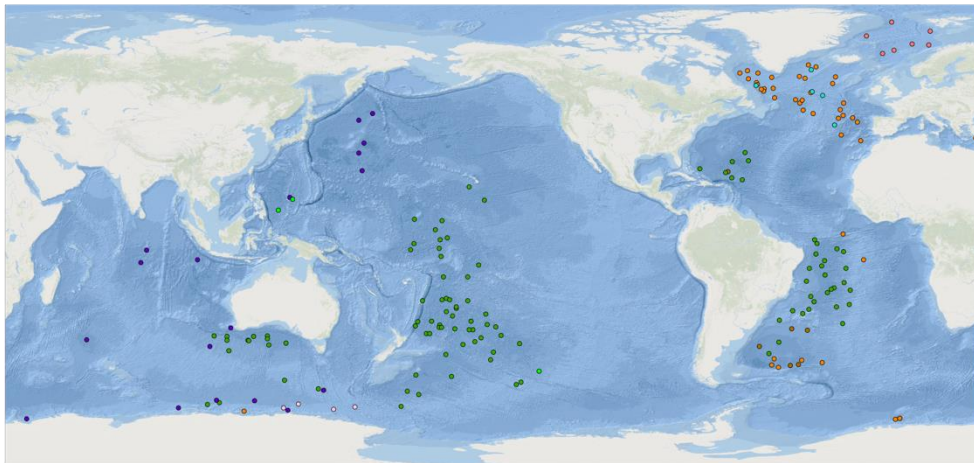


Fig. 4: Location of all 189 active Deep Argo floats, as of 2/2022, by National Program, with the 102 active U.S. Deep Argo floats indicated by dark green symbols (Source: OceanOPS).

In 2011–2015, U.S. Argo 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—present, in the South Australian Basin in late 2016 and 2020, in the Australian Antarctic Basin in early 2018, and in the western North Atlantic in early 2017. In 2019–2020, in the Brazil Basin, 29 Deep Argo floats were deployed through a partnership of PMEL/U.S. Argo and the Paul G. Allen Family Foundation, with continued U.S. Argo Deep floats deployments in the Western South Atlantic thereafter (Fig. 4).

Testing of Deep Argo float models continues as well as testing of SBE-61 CTD accuracy and stability. The SBE-61 has not yet achieved its aspirational goals of $\pm .001^{\circ}\text{C}$, $\pm .002$ psu, and ± 4 dbar, but is progressing relative to those goals. In partnership with U.S. Argo, a 3-year National Ocean Partnership Program award is funded for improvement of the SBE-61. A collaborative U.S./New Zealand/SeaBird Scientific cruise on RV Tangaroa took place in March 2021 for testing/validation of new SBE-61 conductivity and pressure sensors.

BGC Argo:

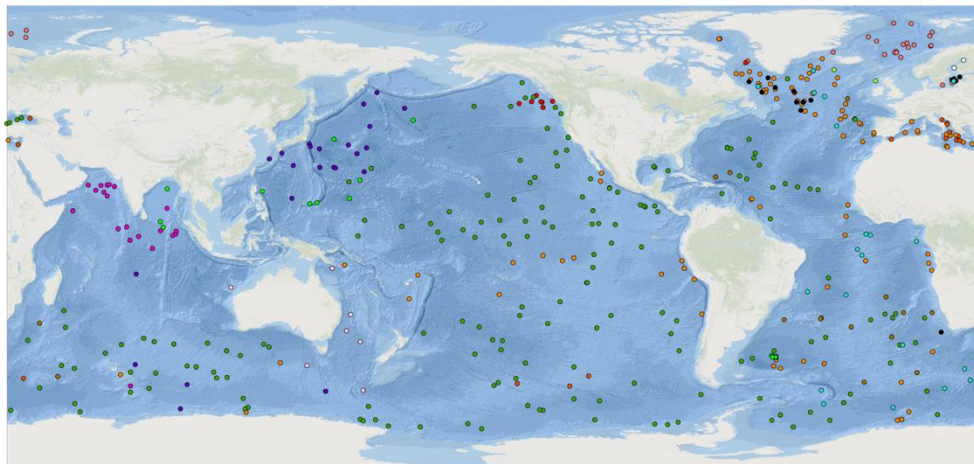


Fig. 5: Locations of 454 active BGC-Argo floats as of 2/2022, including 177 US Argo and Argo Equivalent BGC floats (mostly from SOCCOM and GO-BGC). US BGC floats are indicated as dark green symbols (Source: OceanOPS).

Since 2012 the US 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. A funded NOPP proposal is developing a BGC SOLO float to increase the number of available BGC float models. As of 2/2022, US BGC floats, mostly from SOCCOM and GO-BGC, number 177 of the total 454 active BGC Argo floats (Fig. 5) with at least 1 BGC sensor

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2022, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Program in FY2022 are not yet finalized but are expected to at least equal FY2021 levels.

A deployment cruise on RV Kaharoa, from New Zealand to Tahiti, and back to NZ (Fig. 6), is tentatively planned beginning about November 2022, to deploy about 8 U.S. Deep Argo floats in the SW Pacific Basin, about 100 U.S. Core Argo floats in the South Pacific, plus additional Australia Core Argo floats. Since 2004, 24 voyages on RV Kaharoa have deployed at least 2054 Argo floats (Source: OceanOPS).

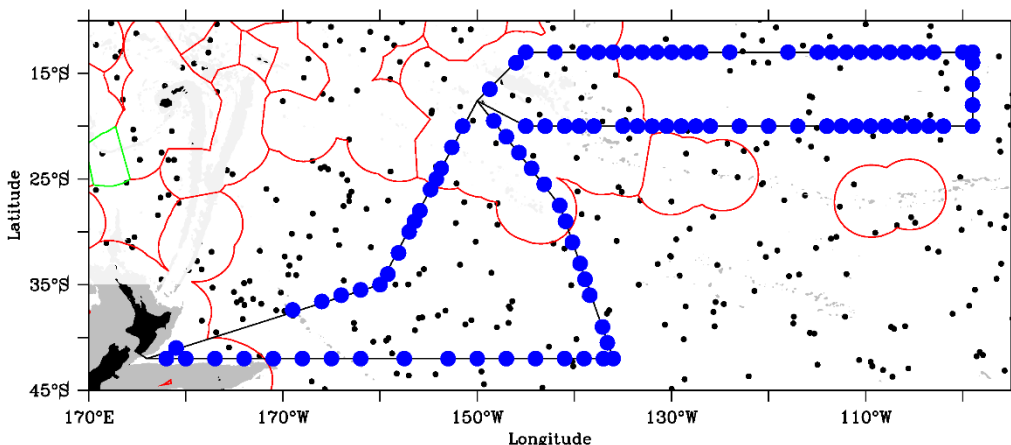


Fig. 6: Tentative cruise track and deployment plan for the Kaharoa Argo-25 voyage. Blue dots indicate Core Argo float deployments. Deep float deployment locations are not yet determined

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 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 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 the full suite BGC data from APEX-family Iridium floats. Currently, an expansion of this capability to NAVIS-type Iridium floats is underway. The U.S. Argo DAC also implemented adaptations necessary for the processing of core data from the first SOLO-type BGC float. The collaboration with SIO on this data stream is ongoing. 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. Delayed-mode quality control and some other data management functions are carried out by the float-providing institutions.

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.