



## **REPORT ON ARGO USER COMMUNITIES SPECIFIC REQUIREMENTS**

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Euro-Argo Research Infrastructure Sustainability and Enhancement  
Project (EA RISE Project) - 824131

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# 1 Executive Summary

This deliverable provides an analysis of the results from a survey on the specific requirements of the Euro-Argo user community. This is part of ongoing work in work package 7 of Euro-Argo RISE which aims to propose fit for purpose services to Euro-Argo existing users and to attract new users as well as to enhance Euro-Argo visibility towards the general public. This report focuses on improving our understanding of the specific requirements of the Argo user communities.

A questionnaire survey was developed to gather relevant information on the specific requirements of the Argo user community. A pilot hardcopy version of the questionnaire was trialled at the 7<sup>th</sup> Euro-Argo Science meeting held in Athens in October 2019. Subsequently, the structure of the questionnaire was refined with more detailed questions and split into the following six sections:

1. Respondent details in relation to their discipline and affiliation
2. Involvement with the Argo community
3. Existing Argo User
4. Use of Argo Data & Products
5. Euro-Argo ERIC Communications & Outreach

The format chosen was an online questionnaire which was more accessible for a wider audience. The survey was hosted on the Euro-Argo website. A link to the questionnaire was sent to the Euro-Argo mailing list and was promoted widely. There were 57 responses. For the analysis, the respondents were categorised as **Experienced Users** (those using Argo data for more than 12 months) and **New and Future Users** (all other respondents). There were several key findings from the report. These include:

- The majority of respondents are aware of the Euro-Argo Strategy and Five Year Plan, confirming successful dissemination and communication to Argo users.
- Increased Deep Argo floats, increased BGC Argo floats and longer battery life are the technological development that were most often mentioned among respondents, confirming the direction of technological development in the Argo Strategy
- None of the New & Future Users reported using Deep Float data.
- BGC-pH and BGC-Nitrate are the least used data sets across all respondents
- Although the majority of respondents acknowledge Argo when using Argo data, less are using the Argo DOI.
- The majority of respondents access Argo data through FTP on GDAC and work with NetCDF files.
- The Argo GDAC synchronisation service, the Thredds data server and the ERDDAP data server were accessed by very few of the respondents.
- The vast majority of respondents were satisfied with the current file formats and the outputs of the requested zipped profile files. Almost half of the Experienced User respondents reported they had encountered problems with Argo data, and almost half of the Experienced User respondents reported they had encountered gaps in Argo data. However, the majority of both user groups' respondents had not experienced any limitations in using Argo data in terms of data format, accessibility or products.

- Approximately half of New & Future User respondents and two thirds of Experienced User respondents agreed that Euro-Argo ERIC had a good communications plan across all platforms, providing opportunity for improvement.
- New & Future Users requested specific training in the general area of data formats, quality control, and data use.
- Experienced Users requested specific training on both delayed mode QC and interacting with float technologies.
- Ocean Best Practices and Cookbooks are recommended training materials to support Euro-Argo outreach and dissemination activities.

The analysis led to eight main recommendations for Euro-Argo ERIC. These are:

1. Euro-Argo to increase the visibility, awareness and promotion activities for the European Strategy for Argo and the Euro-Argo Five Year Plan among the Argo community and relevant interested stakeholders, such as funders, decision makers and policy makers.
2. Highlight the importance of the Argo GDAC synchronisation service, the Thredds data server and/or the ERDDAP server.
3. Euro-Argo to promote the awareness of the Argo DOI among the Argo community and encourage users to cite Argo data when publishing.
4. Provide a new value-added service on the Euro-Argo website that will promote uncertainty estimates associated with corrected QC data to all users.
5. Euro-Argo to increase awareness among the Argo community as to the appropriate communication channels (e.g. national and international user meetings) for reporting data problems and gaps in the Argo programme.
6. Promote the development of open-source software to increase usage of Argo data among the Argo community.
7. Euro-Argo to improve its communications plan across all platforms and to increase outreach, engagement and awareness programmes.
8. Euro-Argo to provide specific training courses tailored to each user groups expressed requirements including training on the different modes and applicability of data QC available in the Argo community.



## 2 Introduction

Euro-Argo provides open and free access to ocean data to a variety of users, including researchers, operational forecasting centres, industry and the general public. Argo data are provided to users both in real time and in delayed mode after careful analysis of the data quality and potential correction by specialists, thus targeting different user categories. The development of Euro-Argo extensions towards high latitudes, in European marginal seas, towards biogeochemistry and deeper measurements gives access to new types of data and new potential users.

The objective of work package 7 is to propose fit for purpose services to Euro-Argo existing users and to attract new users as well as to enhance Euro-Argo visibility towards the general public.

This report focuses on improving our understanding of the specific requirements of the Argo user communities.



## 3 Scope & Objective

### 3.1 Scope

The Euro-Argo RISE project (GA 824131) contains a work package (7) on communication and dissemination in the Argo user community.

The work package includes task 7.1 dedicated to interacting with the main representatives of the Argo user communities to gather information on technical requirements e.g. accessibility and use of Argo data and products, and related services such as communication and outreach.

### 3.2 Objective

The objective of Task 7.1 - An Assessment of users' needs - is to interact and gather feedback from the Argo user communities with respect to their specific requirements (e.g. areas of interest, parameters to be measured, data services, quality control, and timeliness of data provision). The Argo users identified cover the main type of users: different areas of ocean and climate research (e.g. physics, biogeochemistry), operational oceanography and technical operators of the infrastructure. Communication, dissemination and knowledge of Euro-Argo ERIC will also be analysed.

In order to gather this information the Marine Institute compiled an online questionnaire which was distributed to the Argo community.

This report (D7.4) is the summary of the responses received from the questionnaire and the results give a better understanding of the requirements of the wider Euro-Argo user community, with the aim to refine and elaborate further on the services provided to them.

### 3.3 Structure of Questionnaire

It was determined that a questionnaire would be the best tool to gather information from the Argo User community. A pilot hardcopy version of the questionnaire was trialled at the 7<sup>th</sup> Euro-Argo Science meeting held in Athens in October 2019. 13 responses were received however many of the questions were left blank. It was agreed in early 2020 to move the hardcopy version to an online questionnaire which would be more accessible and reach a wider audience. The structure of the questionnaire was revised with more detailed questions and split into six sections. The following layout was agreed:

- Section 1: Who and Where - consisted of questions about the respondent in relation to their discipline and affiliation. A number of questions were asked in order to better understand their perspective, expectations and needs in terms of their requirements.
- Section 2: Involvement - consisted of questions that focus on our links with Argo communities, engaging with new communities and establishing awareness of our Euro-Argo strategy.
- Section 3: Existing Argo User – this section determined whether or not a respondent was already an existing Argo user and whether or not they should complete Section 4.
- Section 4: Data & Products - focused on the accessibility of Argo data, types of formats, limitations and how respondents use the data.
- Section 5. Euro-Argo ERIC Communications & Outreach – focused on the Euro-Argo ERIC's engagement with respondents. We wanted to know if we were communicating effectively, to

identify what the community requires in terms of training and outreach opportunities, and expanding the Euro-Argo network.

- Section 6: Additional Information – Information here was optional e.g. name, organisation, etc.

The survey questions were in a number of different formats, including multiple choice, check boxes, and short and long text answers. Some questions were required which meant an answer must be supplied before the respondent can move onto the next question.

GDPR rules were followed as per the Data Management Plan Annex text (GDPR) and were incorporated into the questionnaire. The questionnaire was also reviewed and approved by the Marine Institute Data Protection Officer.

### 3.4 Questionnaire on Google Forms

Google Forms was identified as an appropriate tool for the online questionnaire (see Annex 1). The main advantages of using Google Forms are that it is a free tool, there are options for multiple choice questions, tick boxes or columns, short text and long text answers. In addition, the survey can be divided into sections, logos and colours can be added, links to the survey can be sent in emails or it can be embedded in a website and all responses and data can be exported into Excel.

### 3.5 Target Audience

The target audience within the Argo user community were the technical operators, industry manufacturers, members of the research and scientific communities and national Argo teams. Many of those in the target audience were reached using the Euro-Argo mailing list that contains over 400 contacts. Other EU marine organisations with weekly or monthly newsletters were approached to distribute the questionnaire to their contacts.

### 3.6 Timeline

The questionnaire was launched on the 29th May 2020 on the Euro-Argo News Brief. Respondents were asked to complete the questionnaire by the 30<sup>th</sup> June 2020. Reminders were sent on the 5th June, 17th June, and the 24th June 2020. To increase the number of respondents the deadline was extended to the 31<sup>st</sup> July 2020, with separate reminders sent on the 22nd and 29th July.

### 3.7 Communication & Dissemination

#### 3.7.1 Euro-Argo ERIC Mailing List

The online questionnaire was launched at the end of May in the Euro-Argo News Brief. The news brief included a summary of Task 7.1 and a link inviting people to complete the questionnaire (Figure 1).

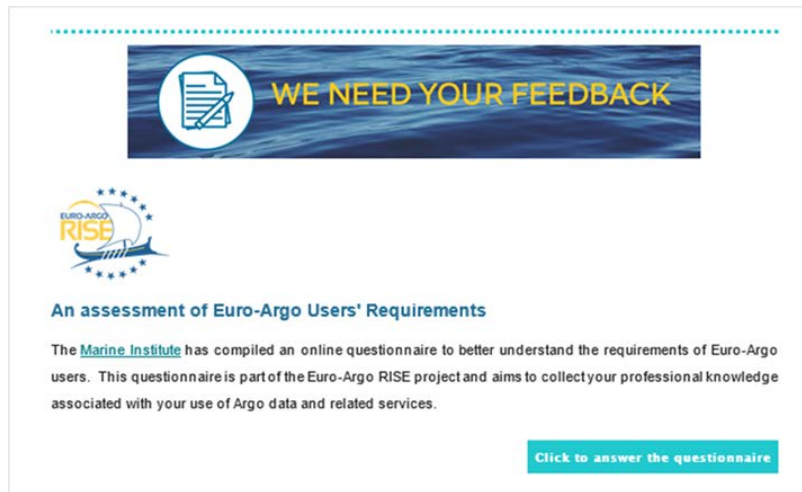


Figure 1: Print screen of questionnaire distributed by Euro-Argo in a News Brief to Euro-Argo mailing list on Friday, 29th May 2020.

### 3.7.2 Euro-Argo ERIC Website

A page dedicated to the online questionnaire was created for the Euro-Argo ERIC website. A link was provided to access the questionnaire.

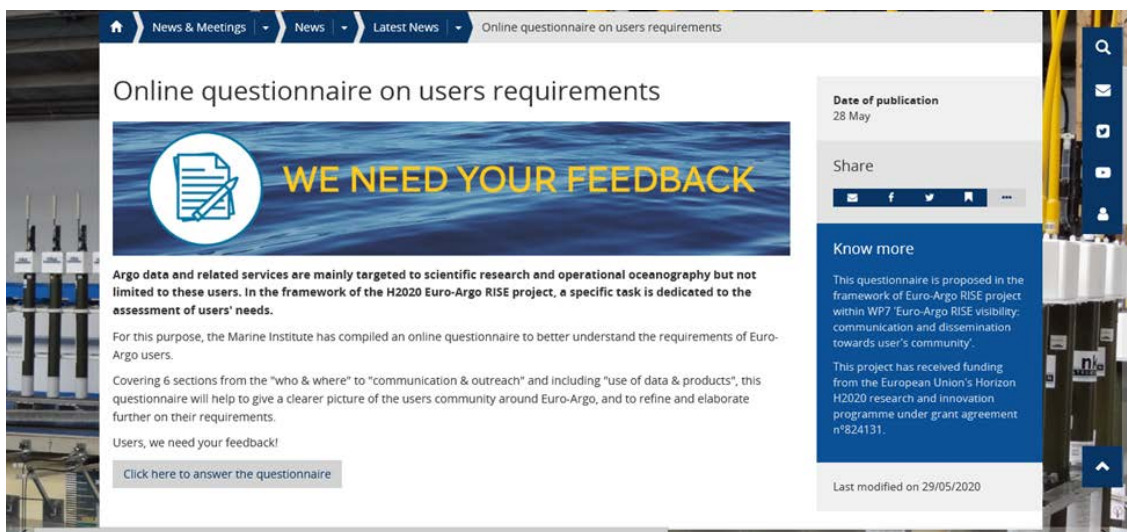


Figure 2: Print screen of EA-ERIC website with link to questionnaire

### 3.7.3 Argo Ireland & Euro-Argo ERIC Twitter Accounts

The questionnaire was promoted on the Argo Ireland twitter account and also on the Euro-Argo ERIC's twitter account. The tweets that included the link were retweeted by individual twitter accounts and other EU project accounts e.g. EuroFleets +.



Figure 3: Print screens of Argo Ireland Twitter Account

### 3.7.4 EuroGOOS Newsletter

EuroGOOS, the European Global Ocean Observing System, works towards the sustained ocean observations and fit-for-purpose products and services for marine and maritime users. They were contacted to distribute the questionnaire in their monthly newsletter. Their newsletter provides regular updates to EuroGOOS members, regional systems (ROOS), working groups and task teams as well as all those interested in their activities. The questionnaire featured in the newsletter distributed to members on the 19<sup>th</sup> June 2020.

### 3.7.5 European Marine Board Newsletter

The European Marine Board is a unique strategic pan-European Forum for seas and ocean research and technology. It provides a platform to advance marine research and to bridge the gap between science and policy. Once a week it provides a newsletter to its members on its activities and events. The questionnaire was distributed in their newsletter on the 19<sup>th</sup> June 2020.

## 4 Results of the Questionnaire

A total of 57 people responded to the online questionnaire. Table 1 captures the response rate to each question depending on whether it was required (must provide an answer) or not and the type of question e.g. multiple choice, check box, text (respondents can provide any answer they choose without forcing them to select from specific options) etc.

Table 1: The response rate to the types of required or non-required questions in the questionnaire.

Section	Question No.	Answer Required Y/N	Type of Question	No. of Responses
<b>Section 1</b>	1	Y	Multiple Choice	57
	2	Y	Check Box	57
	3	Y	Text	57
	4	Y	Multiple Choice	57
	5	Y	Text	57
<b>Section 2</b>	6	N	Multiple Choice	57
	7	N	Text	28
	8	N	Multiple Choice	56
	9	N	Text	30
	10	N	Multiple Choice	56
	11	N	Multiple Choice	57
	12	N	Text	44
<b>Section 3</b>	13	Y	Multiple Choice	57
<b>Section 4</b>	14	Y	Multiple Choice	49
	15	Y	Multiple Choice	49
	16	N	Multiple Choice	48
	17	Y	Check Box	49
	18	Y	Text	49
	19	Y	Multiple Choice	49
	20	Y	Multiple Choice	49
	21	Y	Multiple Choice	49
	22	Y	Multiple Choice	49
	23	Y	Check Box	49
	24	N	Text	12

	25	Y	Multiple Choice	49
	26	N	Text	6
	27	Y	Text	49
	28	Y	Text	49
	29	N	Text	17
	30	Y	Multiple Choice	49
	31	N	Text	19
	32	Y	Multiple Choice	49
	33	Y	Text	49
	34	Y	Check Box	49
	35	Y	Multiple Choice	49
	36	N	Text	17
<b>Section 5</b>	37	Y	Multiple Choice	57
	38	Y	Multiple Choice	57
	39	N	Text	19
	40	Y	Check Box	57
	41	N	Text	21
	42	Y	Text	57
	43	N	Multiple Choice	49
	44	Y	Multiple Choice	57
	45	N	Text	16
<b>Section 6</b>	Additional Information (optional)	N	Text	

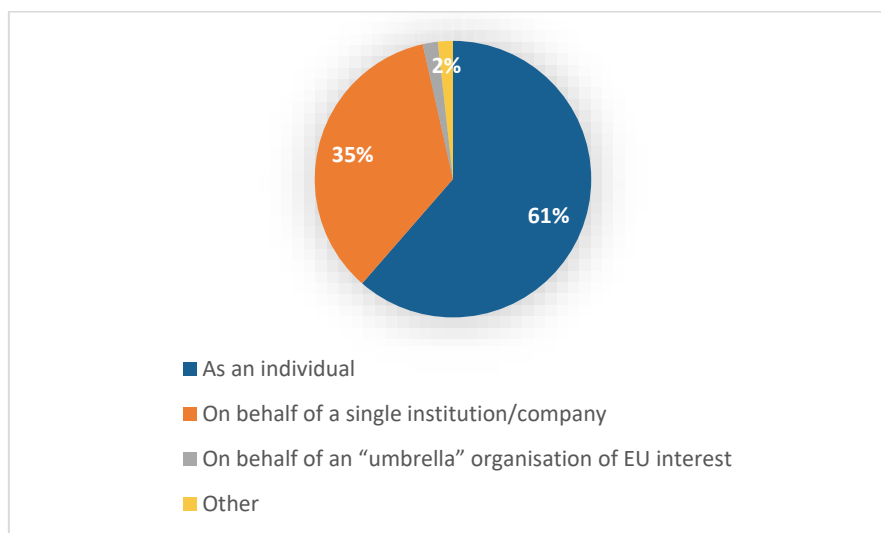
## 4.1 Section 1: Who and Where

Section 1 consisted of questions about the respondent. A number of direct questions were asked to better understand their perspectives, expectations and requirements.

All the questions posed in Section 1 were required to be answered and consisted of a mix of multiple choice, check boxes and text questions. There were five questions in this section.

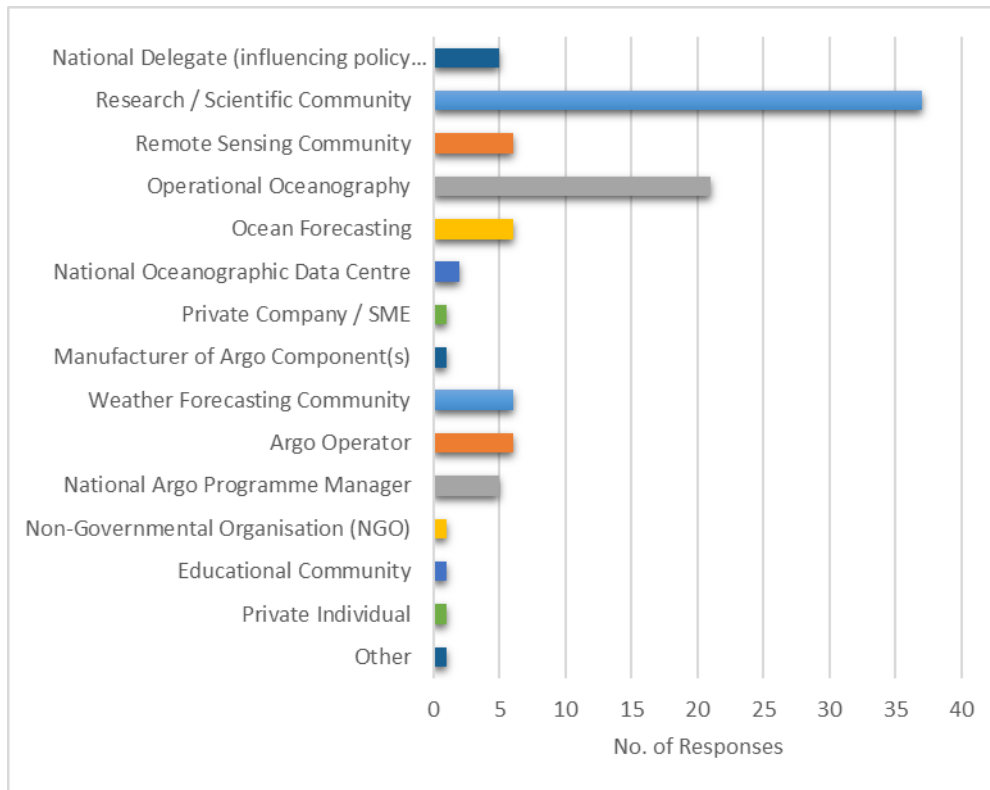
### Q1. I am responding:

This was a required multiple choice question and there were 57 responses.



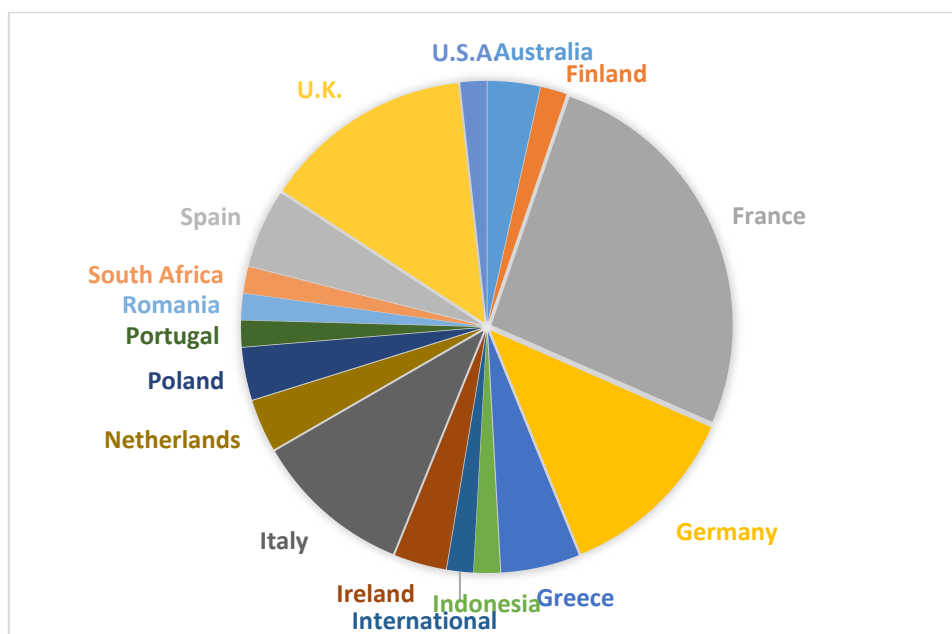
### Q2. What type of organisation do you represent?

This was a required checkbox question and there were 57 responses.



**Q3. What country are you from?**

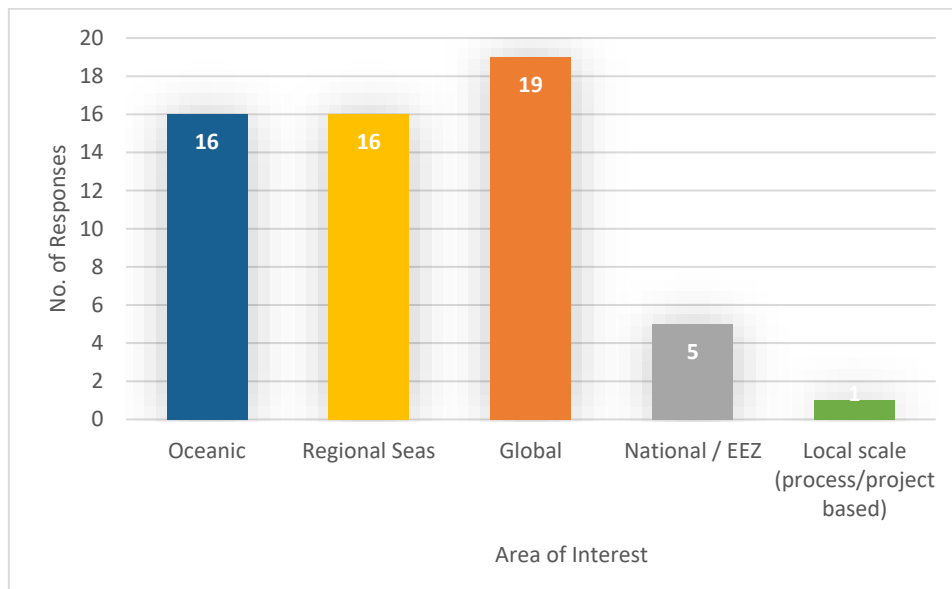
This was a required text question and there were 57 responses.





**Q4. At what scale is your area of interest?**

This was a required multiple choice question and there were 57 responses.



**Q5. Please specify your specific geographical area of interest.**

This was a required text question and there were 57 responses.

A summary of the responses included:

Atlantic	North Atlantic	North-East Atlantic	Eastern North Atlantic
North West Atlantic	North Atlantic to Arctic	Arctic Seas	Subpolar North Atlantic
North and Baltic Sea	Baltic Sea	Eastern North Atlantic and Bay of Biscay	European Arctic
European Seas	North East European Shelf	Mediterranean Sea	Western Mediterranean Sea
Eastern Mediterranean	Aegean Sea - Mediterranean Sea	Adriatic Sea, Levantine Sea, Ionian Sea	Black Sea
Red Sea	South West Indian Ocean and Agulhas Current	Indian Ocean	North West Africa
Tropical Atlantic & Pacific	Southern Ocean	Oceans around Australia	East Australian Current (EAC)

Tropical Pacific	Southern Pacific	South Pacific Gyre	Subtropics
Global Ocean	Upper Ocean	Ocean Heat Content	

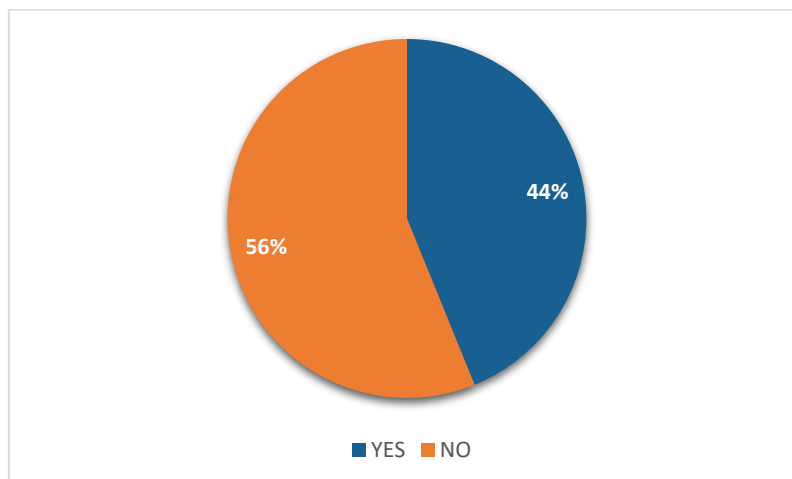
## 4.2 Section 2: Involvement

Section 2 consisted of questions that focus on links with Argo communities, engaging with new communities and establishing awareness of the Euro-Argo strategy.

This section contained seven questions, some of which were required, and consisted of a mix of multiple choice and text questions.

### Q6. Do you have input into the overall Argo network implementation i.e. float procurement and locations planning?

This question was not required, it was multiple choice and there were 57 responses.



### Q7. Please expand on Question 6.

This question was not required, it was a text question and there were 28 responses.

A summary of the responses included a range of responsibilities including float deployments (e.g. part of fieldwork or within the framework of projects), location planning, testing of floats, funding and procurement of Argo floats and implementation of national Argo programmes. Other responses were outlining decoding, data accessibility and management only and highlighted the importance of global BGC extension of the Argo network.

Some direct quotes are as follows:

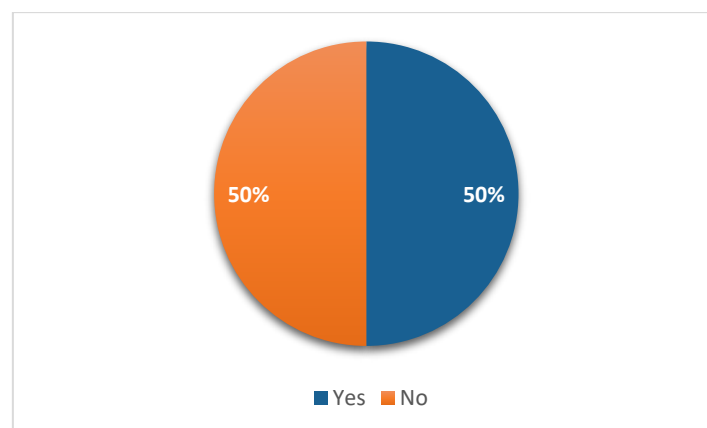
*“Arctic Sea having ever longer periods of sea-ice free time of year will need an expansion with more capable floats. Arctic changes are potential tipping points and monitoring these is crucial. This is all in a context of sustaining Arctic Observing Networks really trying to strengthen the Arctic Observing System overall”.*

*"1) There is a large number of BGC-Argo profiles that are not qualified (between 30 and 50 %), these data are crucial for the validation of ocean models. 2) As soon as a BGC-Argo profile is collected, the quality control should be rapid and accurate with a proper estimation of the observational error. This is important if we want the profile to be assimilated in the forecast systems. 2) A user-friendly BGC-Argo database that would be mirrored with the standard BGC-Argo database would be a great addition. 3) There are currently no observations in the equatorial band. Yet, this is the region of the ocean where most of global BGC models (in a lot of institutes) experiment large errors when T and S observations from satellites and Argo are assimilated. There is a need for observations in this region to better understand what goes wrong. "*

*“No input into the process of procurement or locations at present - float procurement has been an issue as previously have wanted to purchase Argo floats for research but it was significantly cheaper for the [named research institute redacted] in [country name redacted] to do this as my own institute could not avail of the discounts available to Euro-Argo members and in the end the proposal was shelved due to cost. I have participated in expeditions deploying both regular Argo and Deep Argo floats”.*

**Q8. Do you have an input into the deployment of Argo floats in your country i.e. deployment operations and logistics?**

This question was not required, it was multiple choice and there were 56 responses.



**Q9. Please expand on Question 8.**

This question was not required, it was a text question and there were 27 responses.

Most responses outlined individual’s involvement in the deployment of Argo floats. Responsibilities include coordination of national Argo programmes (e.g. South Africa, France, Greece, Australia and UK) and management of teams. Other responses include deployment of floats on behalf of their own

institution, in collaboration with European colleagues, or during fieldwork for scientific projects (e.g. researchers). Some respondents are responsible for deployment planning and logistics, identifying certain cruises or areas of interest for deployments while others are involved in the funding and legal requirements.

Other respondents are responsible for managing data and metadata.

Some direct quotes include:

*“I am an official who cooperates with the scientists taking part in Euro-Argo, making decisions we ask for their opinion”.*

*“[named research institute redacted] -owned [named research vessel redacted] deployed one Argo float in the Black Sea during FP7 PERSEUS (2015)”.*

*“Very good coordination by and collaboration with [named research institute redacted]”.*

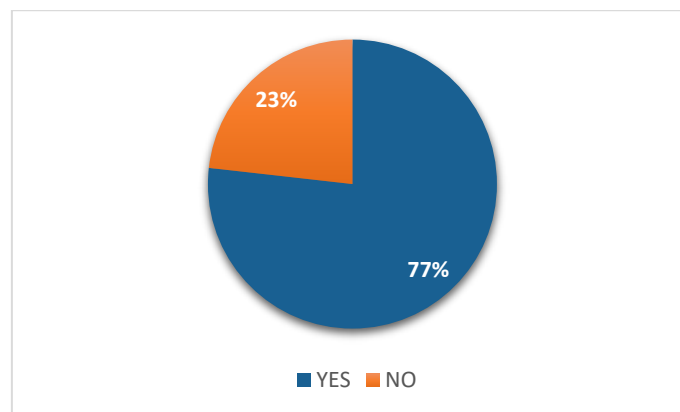
*“No direct input currently as this is all handled by the [named research institute redacted] in [country name redacted], though we can provide input to them regards local regions of interest”.*

*“A global cooperation for Argo floats deployment is important”.*

*“At [named research institute redacted] we coordinate the different requirements of the float deployment and also on what kind of sensors are useful in a specific area”.*

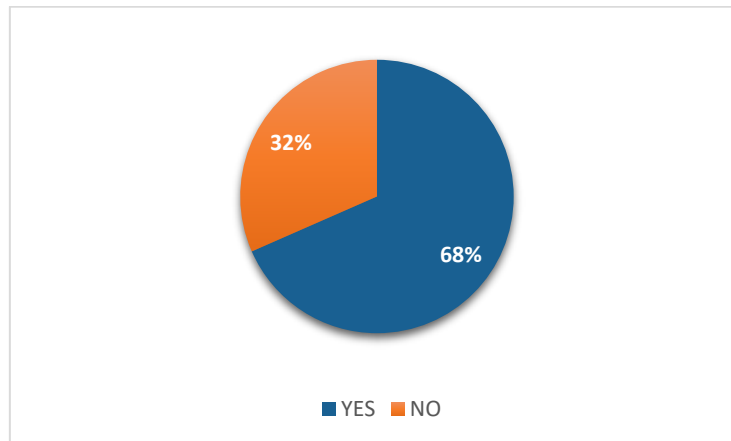
**Q10. Are you aware of the European strategy for Argo (DOI: <https://doi.org/10.13155/48526>)?**

This question was not required, it was multiple choice and there were 56 responses.



**Q11. Are you aware of the Euro-Argo ERIC Five Year Plan 2019 - 2023 (DOI: <https://doi.org/10.13155/71936>)?**

This question was not required, it was multiple choice and there were 57 responses.



**Q12. What technological development would you like to see introduced and why (including new parameters)?**

This question was not required, it was a text question and there were 44 responses. The majority of respondents highlighted the importance of Deep Argo and BGC floats. A summary of the responses included:

**Deep Argo**

- Deep Argo plan required (i.e. below 2000m) - climate change signals are found below 2000m
- Interested in the vertical extension of the network (> 2000 m) to analyse deep ocean water masses variability at inter-annual and at shorter scales

**Biogeochemical (BGC) & New Parameters**

- New parameters: pCO<sub>2</sub>, vertical diffusion, vertical velocity, and that each BGC-Argo float measures the same number of variables
- Fluorescence stimulated at different wavelengths
- BGC parameter (O<sub>2</sub> pH) - essential for water masses mixing - impact of climate change
- Hyperspectral radiometry would enable to develop a new generation of biogeochemical products useful for Argo objectives, and will operate in connection with current and future hyperspectral satellite missions

**Carbon Parameters**

- Carbon parameter other than pH (e.g. pCO<sub>2</sub> or DIC)
- CO<sub>2</sub> flux measurements > role of ocean in carbon cycle

**Longer Battery Life**

- Increase of Argo floats lifetime which will result in cost reduction and higher battery capacity for more frequent sampling.

**Under Sea-ice Profiles**

- Under ice floats connected with an antenna above the ice or communicating through sea-ice stations without surfacing.

- Better under ice navigation and survival, smaller and cheaper floats for MIZ zone and shelf seas research.

#### Float Recovery

- Using an inflate balloon actioned by a remote command.
- Apply a system to protect the bottom of the case for example with expanded polystyrene to dampen the grounding effect.
- Lowering of environmental impact of floats and the design of recovery systems to preserve the ocean.

#### Acoustics

- Underwater sound to be included in the parameters of Argo floats measurements. This will be a valuable contribution for modellers to validate sound maps at different depths and will boost MSFD implementation as regards Descriptor 11.
- Acoustics and biology: they are the next logical extension of a global passive in situ ocean observation

#### Other Observations & Sensors

- More optical and acoustical sensors included as standard and the development of more chemical sensors for use on Argo.
- More nitrate and pH sensors implemented.
- Chlorophyll sensors for when the floats pass through the surface 100m and to see more T/S recording while underway at depth.
- The ability to measure radionuclides
- Mission parameter adaptations to deal with fast-moving currents and shelf regions.
- More frequent observations of the upper ocean to improve the accuracy of the ocean component of coupled weather forecasts.
- Focus on the fastest dissemination possible of the observations as improvements here would allow new operational science to be done.
- T and S observations: a) bottom avoidance, to allow floats to stray into shallower water without contacting the seabed, and b) a greater portion of the fleet able to profile deeper e.g. 3000m.

#### Particle Cameras

- It is important to understand how optical properties relate to particle size and morphology and with the power of artificial intelligence we have the capacity to disentangle images into community composition. This is not able to be reliably done on ships by comparing water samples to bio-optical measurements because the sampling is performed over different spatial scales. This will allow us to study detritus and microscopic organisms. FRRF may also be a cheaper adaption that could have benefits for estimates of primary production from floats.

#### Data Management

- Real-time data quality flagging using machine learning techniques.

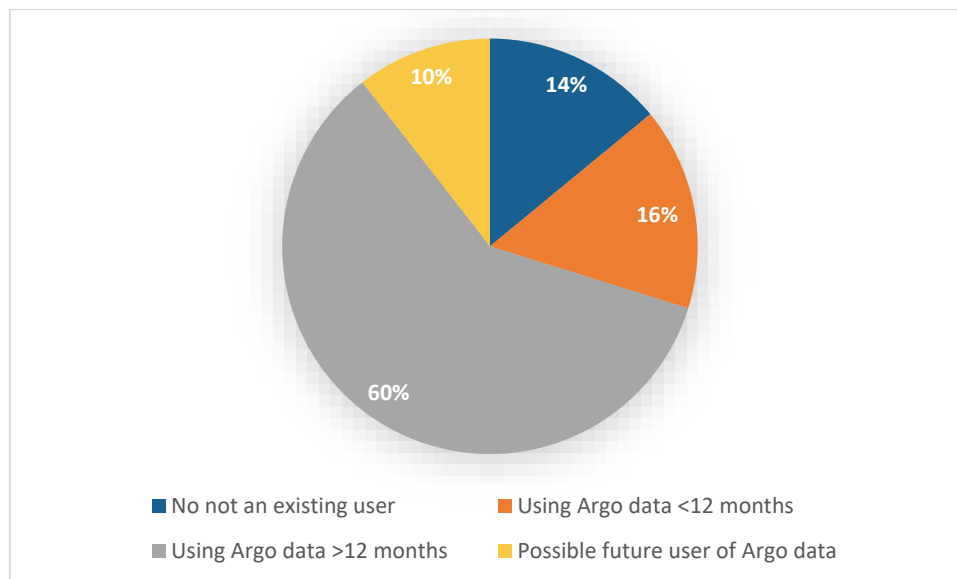


- Faster DMQC on biological parameters
- SOPs for pH data from floats, QC routines for pH and NO<sub>3</sub>
- Better timeliness for data delivery is important for operational users

### 4.3 Section 3: Existing Argo User

Section 3 determined whether a respondent would go straight to Section 4 Data & Products or to Section 5 Communications & Outreach depending on whether or not they were an existing Argo user. There was only one question and it was a required multiple choice question and there were 57 responses.

#### Q13: Are you an existing Argo data user?





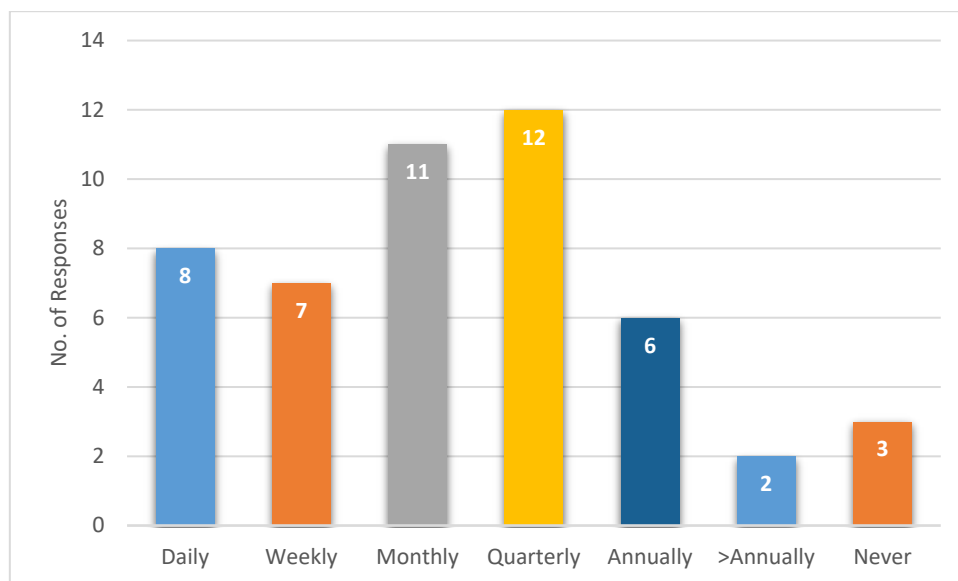
#### 4.4 Section 4: Data & Products

Section 4 focuses on the accessibility of Argo data, types of formats, limitations and how respondents use the data.

This section contained 23 questions, some were required and consisted of a mix of multiple choice and text questions.

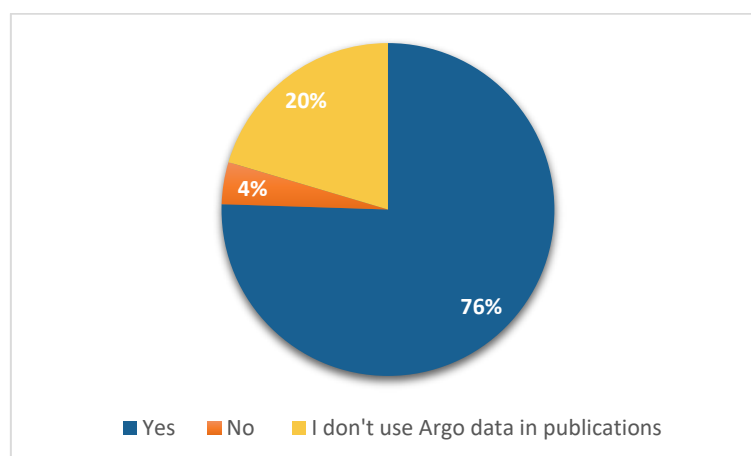
##### Q14. How often do you download Argo data?

This was a required multiple choice question and there were 49 responses.



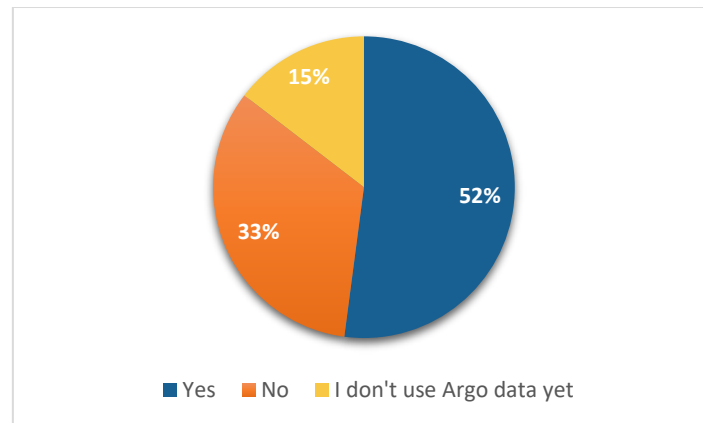
##### Q15. Do you acknowledge Argo when using Argo data in publications?

This was a required multiple choice question and there were 49 responses.



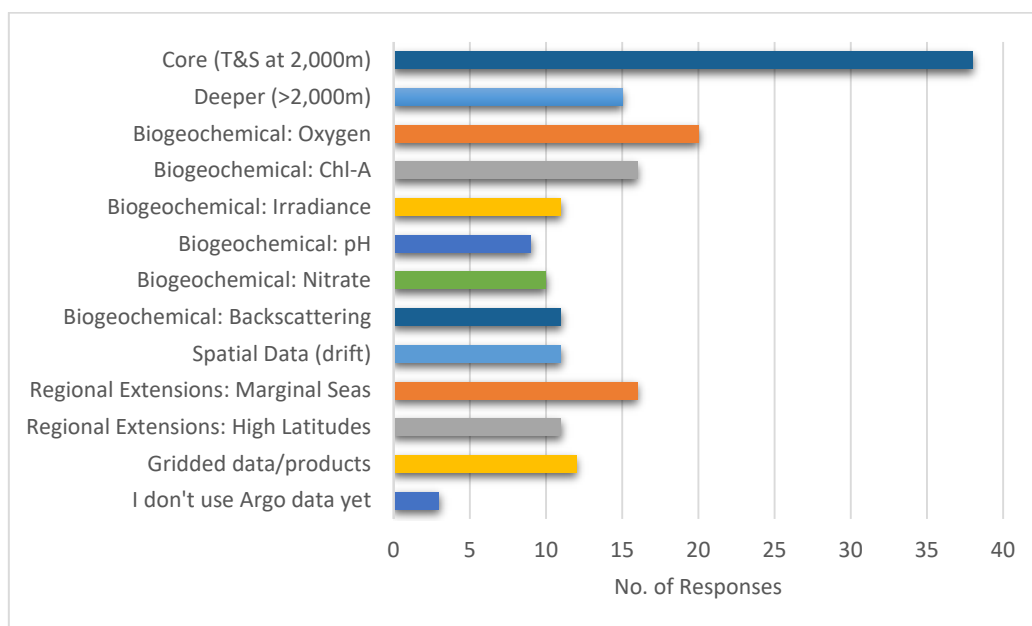
**Q16. If yes, do you use the Argo DOI (<http://doi.org/10.17882/42182>) to reference Argo data?**

This was not a required question, it was multiple choice and there were 48 responses.



**Q17. What Argo data do you use?**

This was a required checkbox question and there were 49 responses.



**Q18. Do you have specific vertical sampling requirements for CTD Argo profiles?**

This was a required text question and there were 49 responses.

There is an overall requirement for high resolution in the surface layer (ideally 10m or less).

Other comments on the requirements included:

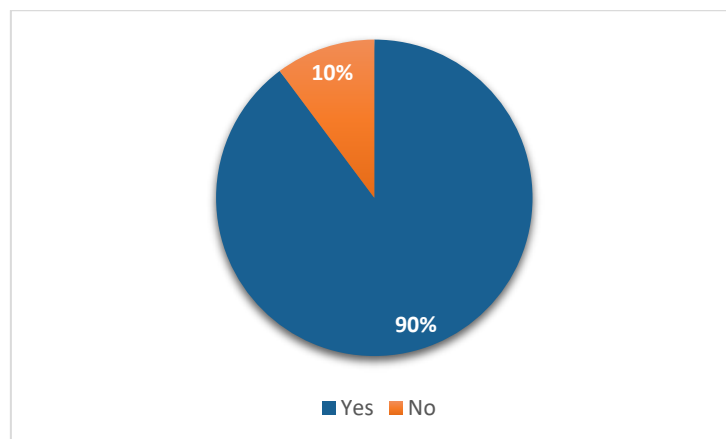
- A capability to measure and deliver from under sea-ice is desirable.
- Full resolution (sampling at 1 or 2 decibars)
- Complete profile (0-2000m) with different vertical resolution for near surface, intermediate and deep waters
- First 100 dbar @2 dbar, 100-700 dbar @10 dbar, 700-2000 dbar @25 dbar
- 1 m in the euphotic zone, 10 m deeper
- Estimate heat content at 1 deg x 1 deg resolution
- Metric resolution for BGC must be possible
- Diel cycles in the euphotic zone would be a useful addition if technically possible.

A direct quote:

*“In the Southern Ocean it is becoming evident that sampling resolutions >5 m of biogeochemical measurements likely miss deep biomass accumulations which can form at the pycnocline with ~10m thickness. The ecological implications of this are being explored within my PhD”.*

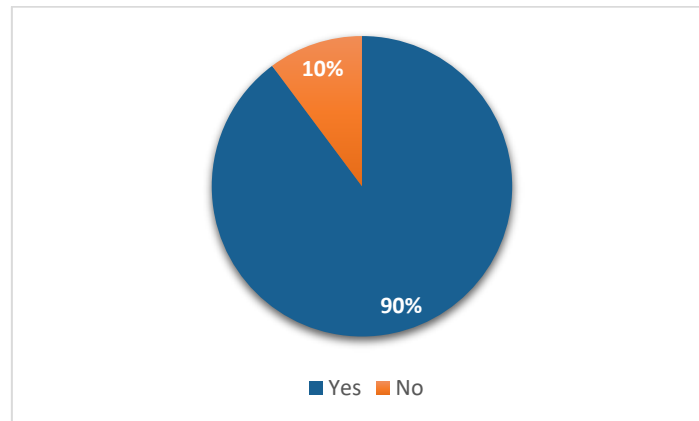
#### Q19. Are you aware of quality flags associated with Argo data?

This was a required multiple choice question and there were 49 responses.

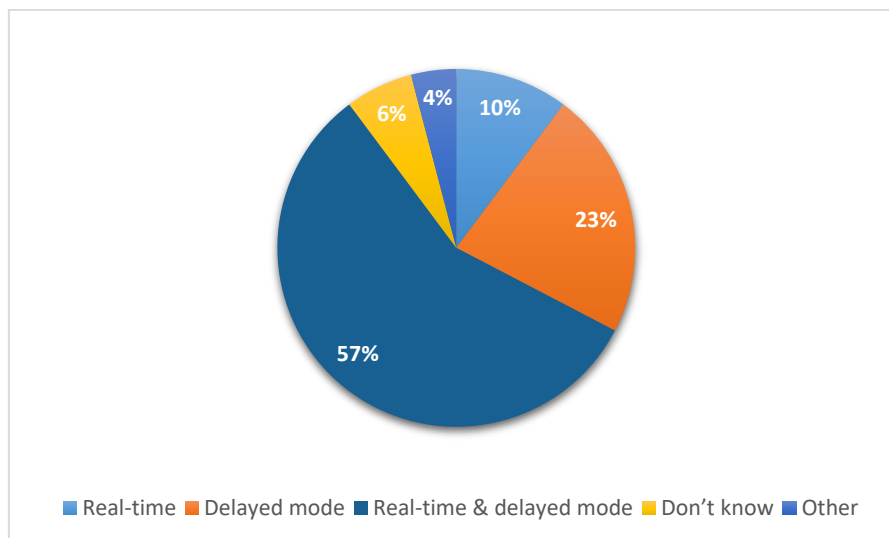


#### Q20. If you ticked yes, do you know how to use quality flags associated with Argo data?

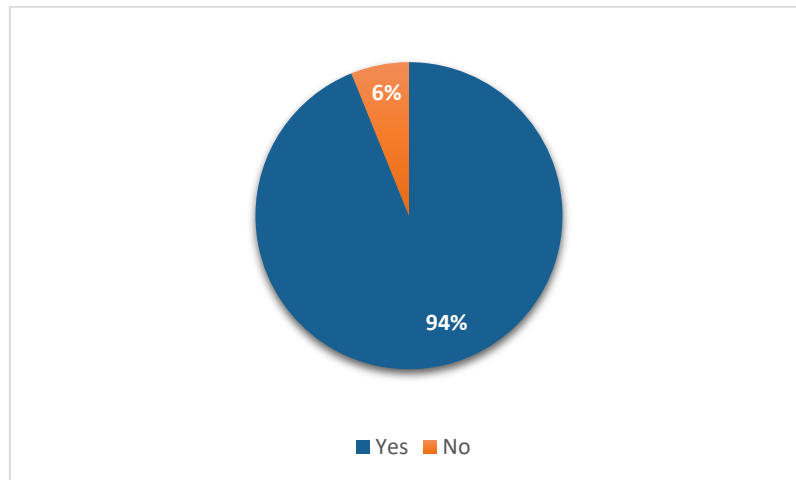
This was a required multiple choice question and there were 49 responses.

**Q21. What Argo data QC mode do you use?**

This was a required multiple choice question and there were 49 responses.

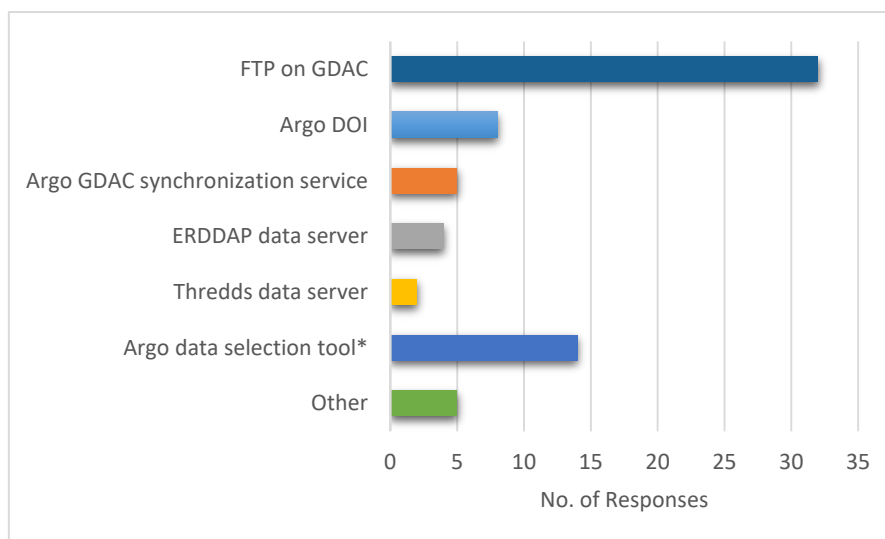
**Q22. Would you be interested in getting uncertainty estimates associated with corrected data?**

This was a required multiple choice question and there were 49 responses.



**Q23. Where do you access Argo data?**

This was a required checkbox question and there were 49 responses.



**Q24. If you are using the Argo data selection tool, which additional index would you like to select your data? (Presently available is parameter, quality, processing level).**

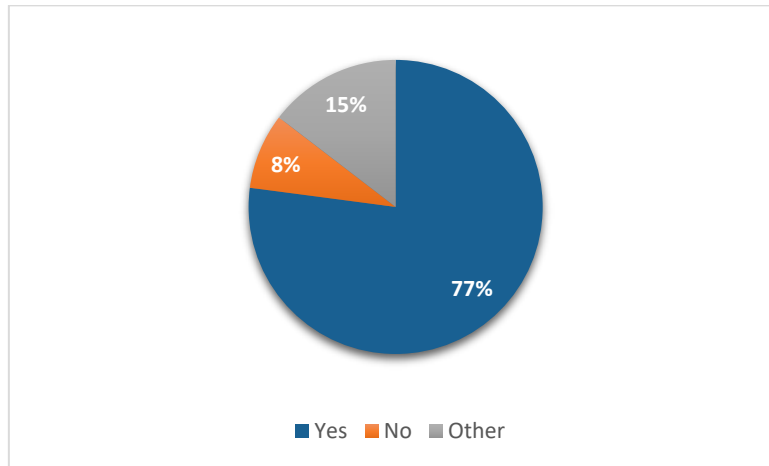
This was not a required question, it was a text question and there were 12 responses. A summary of responses included:

- Float number
- Spatial and time windows
- Ocean basin
- Lat and Long, time

- Multiple geographical selection option
- The system on Google Earth was perfect
- Quality

#### Q25. Are you satisfied with the present output of the request (zip of profile files)?

This was a required multiple choice question and there were 49 responses.



There were 49 responses to this question. 14% of respondents clicked other and added the additional following comments:

- I use raw data
- I have direct access from Coriolis
- I am not using Argo data directly
- Not using the Argo data selection tool. As long as files are 1:1 as on the GDAC, it should be fine.

#### Q26. If you ticked No to Question 25, please specify

This was not a required question. It was a text question and there were 6 responses. A summary of the responses is provided below:

- Need zarr format
- Allowed package too small
- For the moment BGC-Argo NetCDF files are too complicated for a user that is not necessary familiar with all the flags and QC methods
- I would like to have the possibility to download one big NetCDF file with all the profiles from a specific region
- Everything works fine

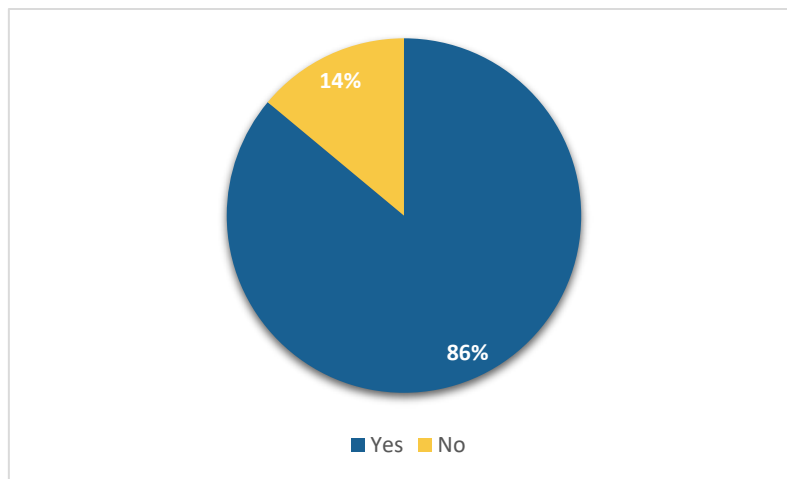
**Q27. What existing Argo file formats are you working with?**

This was a required text question and there were 49 responses.

Out of 49 responses the majority of people are using NetCDF. A small percentage highlighted gridded, BUFR, SBD files and synthetic profiles. An issue was raised that file formats vary and one ends up using whichever system is up at that time.

**Q28. Are you satisfied with the formats currently available?**

This was a required text question and there were 49 responses.



Some respondents commented:

- Yes since synthetic format are available
- Profiles are ok, trajectory is cumbersome to have two files
- The multiple profiles (core/primary, secondary and near surface) add some complexity to the files when using them.

**Q29. What type of data (format/formatting) would you like to see provided by the Argo community?**

This was not a required question, it was a text question and there were 17 responses.

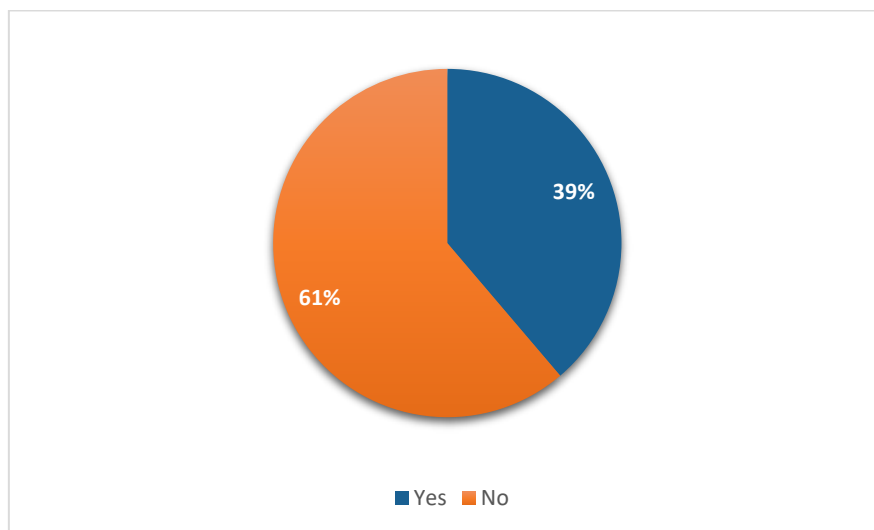
The majority of respondents are satisfied with Argo NetCDF. Other comments included:

- A curated, simplified version for pure scientific analysis, no technical data (and yes a QC flag is technical)
- Format between older and new data is not consistent
- GRIB data
- Normalised NetCDF to improve interoperability
- .nc files are fine but .txt files as proposed by <https://www.mbari.org/science/upper-ocean-systems/chemical-sensor-group/soccomviz/> could also be useful

- simple text files of Sfiles would be super to engage students; i.e. such as could be read into ODV
- Timeseries in TECH files
- Depth interpolated data (bin averaged)
- Google Earth
- No mixing of sampling scheme with several profiles in dac indiv files, please, just 1 core complete profile, + other sampling scheme separated
- NetCDF is great for me. Maybe if you wanted to engage with non-scientists, you could provide a simplified 2d dataset from floats in something like Excel - gridded depth, gridded time - maybe people would like to plot up some of your more interesting floats which have been on an adventure!

**Q30. Have you encountered any problems with Argo data?**

This was a required multiple choice question and there were 49 responses.



**Q31. If so, how did you fix or overcome them?**

This was not a required question, it was a text question and there were 19 responses.

Respondents either deleted data or contacted DACs and Principle Investigators (PIs) to report the data. Other comments included:

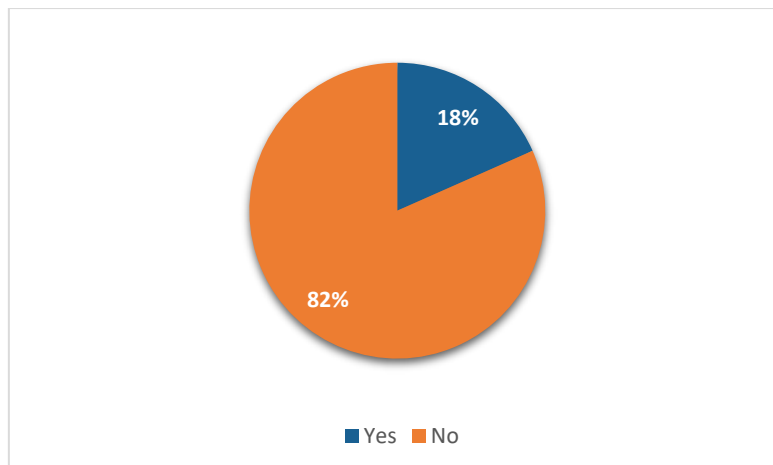
- Locations of floats were wrong in the Ross Sea (interpolated around the globe instead of across the 180 meridian), I contacted the Argo responsible and pointed the issue.
- The old m-files were clunky to work with and needed a lot of manipulation to study biogeochemical variables - the s-files are much better. Also fluorescence varies highly in the Southern Ocean so conversions to ug/L chlorophyll may not be meaningful - we are attempting to quantify the uncertainties of fluorescence in this region.



- There's still a few older floats kicking round in your system which don't have the PSAL variable in them at all. To avoid catch clauses in our read scripts, it would be helpful to absolutely standardise the core variables in float files. Fill PSAL with NaNs if necessary.
- Occasional bad reports in the NRT stream, they were blacklisted.
- PARAM\_DATA\_MODE in .nc files do not correspond with argo\_synthetic-profile\_index\_no\_header.txt. I use the information in the .txt file instead
- Contacting the quality control technical manager
- Argo file contents differ between DACs
- The usual problem is finding which site is up at the time for downloading data - hence a wide range used. That having been said it is still an amazing system.
- Check BGC-Argo guide paper, ask [named researcher redacted]/[named research institute redacted], ask other expert by personal contact
- In real time often bad data are collected

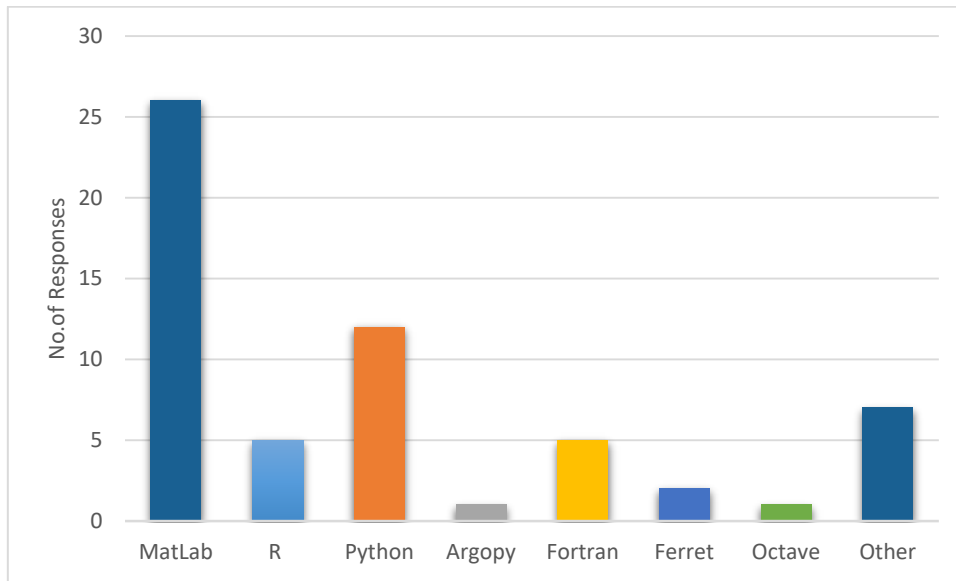
**Q32. Have you encountered any limitations when using Argo data in terms of data format, accessibility & products?**

This was a required multiple choice question and there were 49 responses.



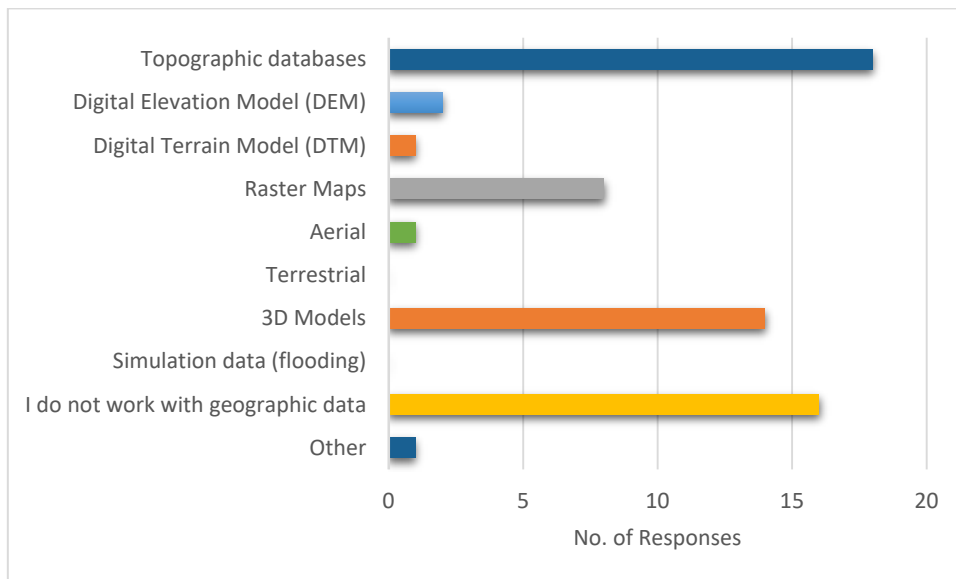
**Q33. Please specify the software that you are using in your application environment.**

This was a required text question and there were 49 responses.



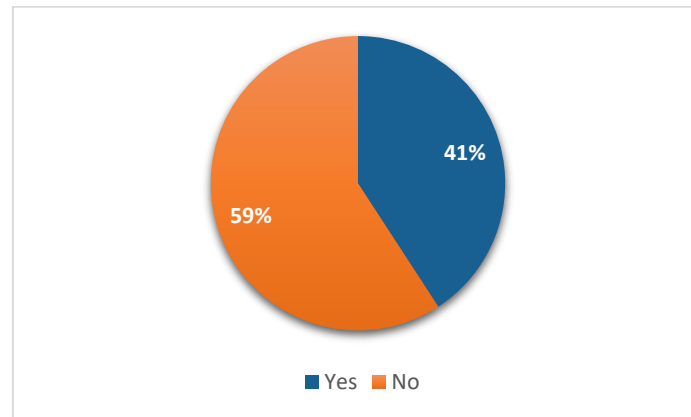
**Q34. What type of geographic data do you work with?**

This was a required checkbox question and there were 49 responses.



**Q35. For your specific applications, do you encounter any gaps in Argo data (temporal or spatial)?**

This was a required multiple choice question and there were 49 responses.



### Q36. If yes, do you know how and who to report information?

This was not a required question, it was a text question and there were 17 responses.

Six respondents stated No they did not know how or who to report information on gaps in Argo data and three respondents said Yes and one respondent highlighted DAC/GDAC/Coriolis. Other respondents detailed the gaps:

- Lack of data in ice covered area
- Gaps are most likely associated with under-ice measurements
- I work through the AST and encourage procurement in [named country redacted] and deployment by other nations to the regions where there are gaps.
- Only in that Argo floats don't hang around in the Rockall Trough...
- Higher temporal resolution would be an improvement
- BGC coverage in some of my areas of interest is poor (EAC and GAB around Australia)
- High latitude Southern Ocean
- Gaps in shallow areas of Baltic Sea (<40 m depth)

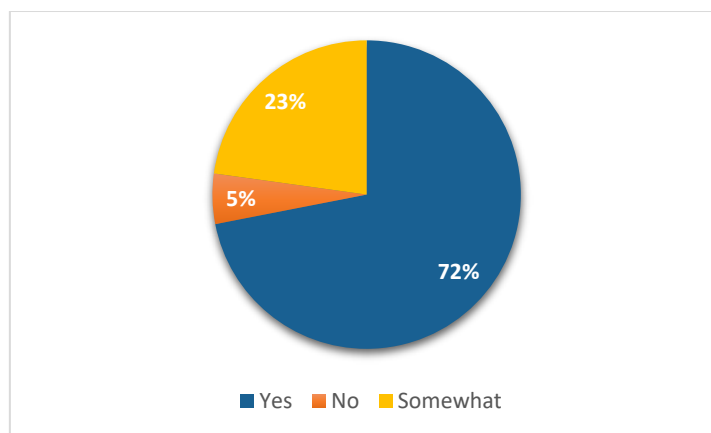
## 4.5 Section 5. Euro-Argo ERIC Communications & Outreach

Section 5 focused on the Euro-Argo ERIC’s engagement with respondents. The aims of this section was to determine if Euro-Argo are communicating effectively, to identify what respondents required in terms of training and outreach opportunities, and how to expand the Euro-Argo network.

There were 9 questions, some of which were required and they consisted of a mix of multiple choice, check boxes and text questions.

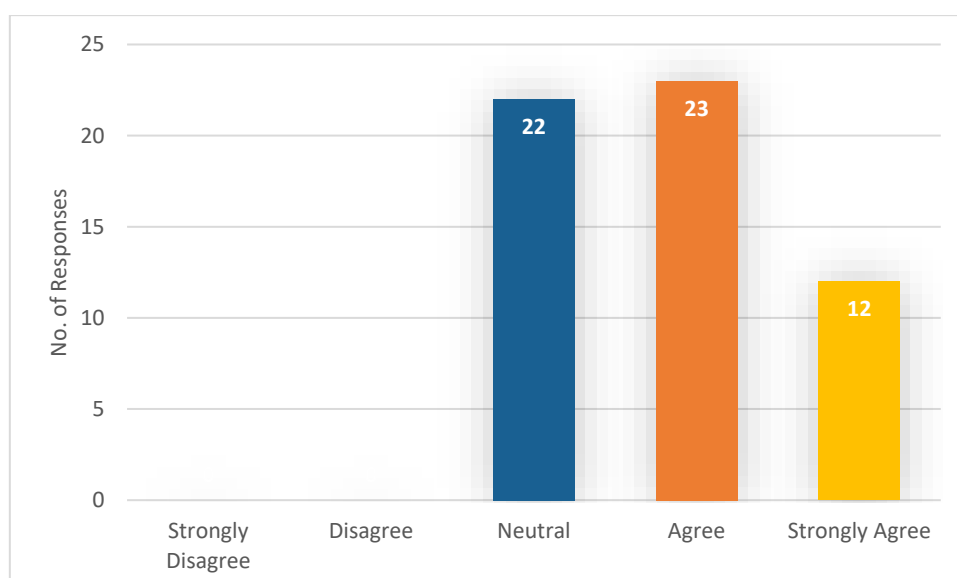
### Q37. Are you aware of Euro-Argo ERIC and its role in the global Argo programme?

This was a required multiple choice question and there were 57 responses.



### Q38. Would you agree that the Euro-Argo ERIC has a good communications plan across its multiple platforms including website, social media, newsletters, annual reports, press releases, policy briefs, etc.?

This was a required multiple choice question and there were 57 responses.



**Q39. What communication aspects could be improved?**

This question was not required, it was a text question and there were 19 responses.

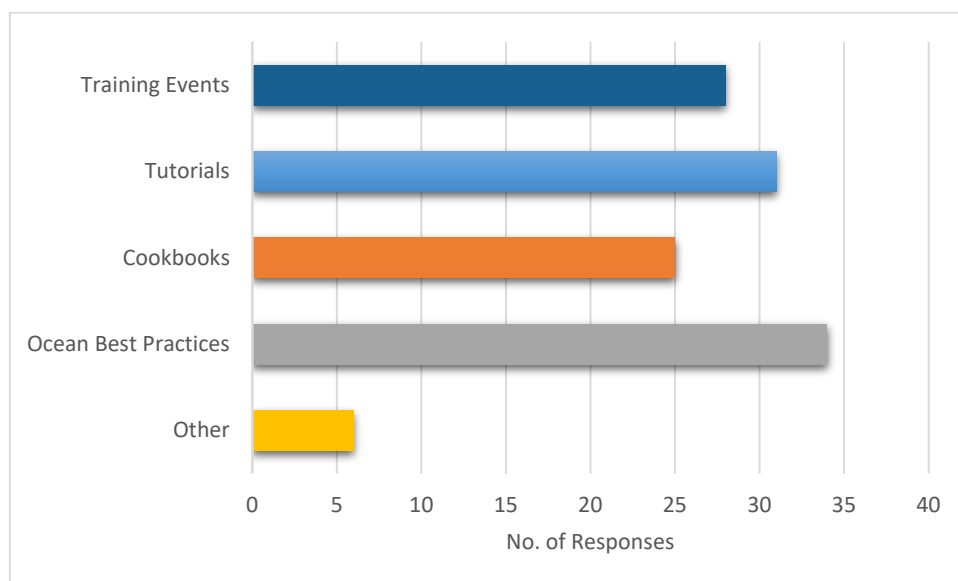
A summary of responses include improved communication to researchers, reaching a wider oceanographic community, establishing links with national policy makers and national organisations e.g. UK Met Office.

Other requirements included more pages in French language in order to increase the French outreach of this project, more communication of annual and strategy plan reports when they are published, routine catch up video conferences (every few months) to act as an open forum of discussion and more near real time updates on products and reports with continuous web content.

Within-network communication; trickle-down of information from top (ERIC) to bottom (potential contributors / users as us; but we're new, too) via national contacts etc. and aim to strengthen the visibility in the global community.

**Q40. Euro-Argo ERIC are developing a number of outreach and dissemination activities for the Argo community. Please tick any of the relevant activities that you would be interested in.**

This was a required checkbox question and there were 57 responses.



Respondents were asked to expand on the answer if they selected the “Other” option. Some responses include:

- New perspectives and developments in newsletters or other material
- Ready made products to showcase wealth of data to non-expert users
- Software tools on github
- Software or tools for calibration

- Material that can be used in high schools

**Q41. Please specify what kind of training you require.**

This question was not required. It was a text question and there were 21 responses.

- Technical training on floats and sensors and best practice guidance for float preparation/deployment
- A refresher on which Argo products are available other than the core profile data
- Using the Argo database
- Effective data access and correct data usage; Limitations of the programme/network/floats that are present and affect data use; Guidance on what is the responsibility of an Argo float operator and where one can get help within Europe/Euro-Argo ERIC for which aspects.
- Training for how to access all data, including metadata using Python, R or Matlab
- Delayed Mode Quality Control and raw data processing
- It would be great to have a solid tutorial / cook book for our undergrad and postgrad students who are new to the Argo system.
- To allow better understanding of both the economic benefit and geo political aspects of the data

**Q42. Are there any other communications, outreach and dissemination activities or services that you require from the Argo community?**

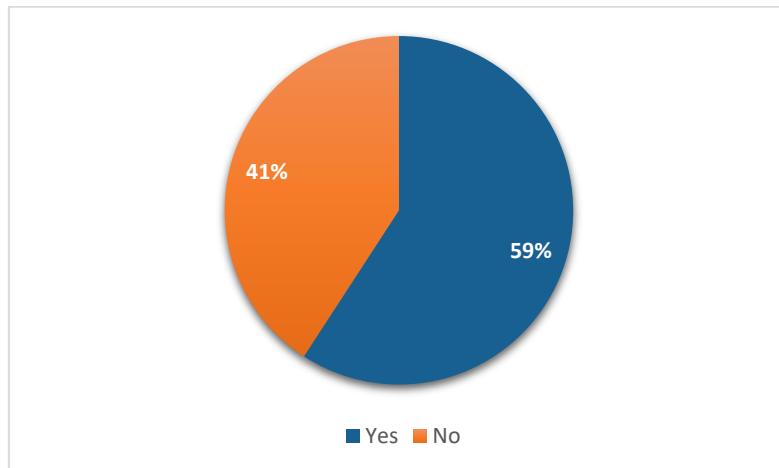
This was a required text question and there were 57 responses.

The majority of respondents require outreach material to use in schools and colleges e.g. learning modules for teachers and public events for children. Other requirements include tutorial videos and online webinars, short movies on data types and QC, and tracking Argo usage through a complete value tree.

Respondents would also like to continue technical and science meetings, strengthen links with research communities e.g. non-physical oceanography community, national stakeholders and policy makers. It was noted the increased communication in the Black Sea is also needed. In addition, updates on the geopolitical and economic issues associated with the Argo programme and a shared and integrated dissemination strategy towards the general public were also mentioned.

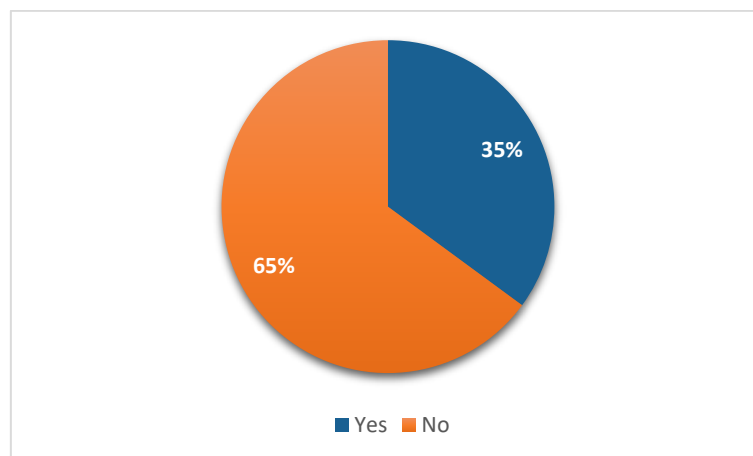
**Q43. Would you be willing to take part in Euro-Argo activities (e.g. occasionally act as an expert for specific topics, help in finding deployment opportunities, etc.)**

This question was not required, it was multiple choice and there were 49 responses.



**Q44. Are you in contact with teams in countries outside of Euro-Argo who could be interested in the Argo programme?**

This was a required multiple choice question and there were 57 responses.



**Q45. If yes, would you be willing to help us in trying to set up an Argo programme in this/these countries?**

This question was not required, it was a text question and there were 16 responses. The majority of respondents said yes. Other comments included:

- This is planned in Euro-Argo RISE project, where we are involved
- I'm talking about [named country redacted], and we already have a program
- Q44: [named country redacted]; Possible, but need to get started ourselves first



- Yes - there are likely opportunities for this through existing networks in SCOR and POGO. Previously I have taught international students at sea about the ARGO network and how to access data.



## 4.6 Section 6: Additional Information (Optional)

Respondents were given the option to complete this section at their discretion. Any personal information e.g. names, organisations, and email addresses provided will not be published in any form.

Respondents were asked to provide any additional details they felt were relevant, some of those being:

- I enjoy working with the Euro-Argo Team and look forward to greater interactions in the future.
- I am interested in the governance and the economics behind Argo in general and Euro-Argo specifically.
- The Argo network has revolutionised how we work with data in the oceanographic community. When the access route work it is amazing. There are times when the various access sites are a bit unstable, but when Argo teamed up with Google Earth access was great. It enabled us to get students (from schools through to postgrad) to access and use the data in a simple and easily accessible way.
- Argo should resign from deployments, in particular in marginal seas with large conservation areas. Waste from monitoring and research is still waste. The potential damage especially in marginal seas exceeds the benefit by far, in particular in light of more modern, higher quality data, and reusable devices.

## 5 Analysis of Results

### 5.1 Identifying User Groups - Experienced Users vs New & Future Users

The following analysis compares two identified user groups from the respondents that participated in the online survey. In Section 3 Question 13, respondents were asked to identify themselves in one of the following categories:

1. Not an existing Argo user
2. Possible future user of Argo data
3. Using Argo data <12 months
4. Using Argo data >12 months

For this analysis, those respondents who identified as “Using Argo data > 12months” will be referred to as **Experienced Users**. Those who selected “Not an existing Argo user”, “Possible futures user”, and those “Using Argo data < 12months” will be referred to as **New & Future Users**.

Out of 57 respondents, 34 (60%) are “Experienced Users” and 23 (40%) are “New & Future Users”.

During the analysis of all the feedback received from respondents a number of recommendations were identified.

### 5.2 Community Engagement & Awareness.

Section 2 of the questionnaire consisted of questions that focus on links with Argo communities, engaging with new communities and establishing awareness of the Euro-Argo Strategy. The section also enquired into what new technological developments the community would like to see.

#### 5.2.1 Involvement with Argo Programme

Only 35% of New & Future Users had input into the overall Argo network implementation (i.e. float procurement and deployment location planning) compared to 50% of Experienced Users.

On the other hand, 61% of New & Future Users had input into the operations and logistics of deploying Argo floats compared to only 42% of Experienced Users (Table 2).

This suggests that the New & Future Users are given more ‘hands-on’ opportunity in float deployments to familiarise themselves with the float technologies, than in the strategic planning of the related programme(s).

Of the 17 Experienced Argo users who had input into the overall Argo network implementation, 11 also had a role in the deployment and logistics of float deployments.

Of the 8 New & Future Users who had input into the overall Argo network implementation, all 8 also had a role in the deployment and logistics of float deployments

Table 2 Summary of responses for New &amp; Future Users vs Experienced Users on their involvement in the Argo programme

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q6. Do you have input into the overall Argo network implementation i.e. float procurement and locations planning	Yes	8	17	35%	50%
	No	15	17	65%	50%
		<b>23</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q8. Do you have an input into the deployment of Argo floats in your country i.e. deployment operations and logistics?	Yes	14	14	61%	42%
	No	9	19	39%	58%
		<b>23</b>	<b>33</b>	<b>100%</b>	<b>100%</b>

### 5.2.2 Awareness of Euro-Argo Strategy and Five Year Plan

82% of Experienced Users are aware of the European Strategy for Argo compared to only 68% of New & Future Users. In relation to the current Euro Argo Five Year Plan 74% of Experienced Users are aware of this plan compared to only 61% of New & Future Users (Table 3).

Table 3 Summary of responses for New &amp; Future Users vs Experienced Users on awareness of the European strategy for Argo and the Euro-Argo ERIC Five Year Plan 2019-2023.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q10. Are you aware of the European strategy for Argo?	Yes	15	28	68%	82%
	No	7	6	32%	18%
		<b>22</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q11. Are you aware of the Euro-Argo ERIC Five Year Plan 2019-2023?	Yes	14	25	61%	74%
	No	9	9	39%	26%
		<b>23</b>	<b>34</b>	<b>100%</b>	<b>100%</b>

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## Recommendation 1

Euro-Argo to increase the visibility, awareness and promotion activities for the European Strategy for Argo and the Euro-Argo Five Year Plan among the Argo community. The Strategy and Five Year Plan should also be made available to relevant interested stakeholders, such as funders, decision makers and policy makers.

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### 5.2.3 Technological Developments

Respondents were asked about the technological developments they would like to see introduced (including new parameters) and their reasoning. Of the new technological developments requested, Deep Argo floats were mentioned most frequently amongst all respondents.

Both user groups are interested in technological improvements to BGC floats, increased battery life, sensors to measure carbon parameters, biological sensors, and bottom avoidance. They have also highlighted acoustic sensors, under sea ice Argo profiles with good positioning and ability to communicate without surfacing and better ice navigation and survival.

Experienced Users highlighted the need for improved recovery systems (e.g. an inflatable balloon actuated by a remote command) and floats for shelf research while New & Future Users highlighted particle cameras and optical sensors, chlorophyll, radionuclides and post calibration.

## 5.3 Argo Data & Products

This section focused on the accessibility of Argo data, types of formats, limitations and how respondents use the data.

It is important to note that in this part of the analysis the number of respondents in the New & Future Users group is smaller as respondents who do not use Argo data were not required to complete this section on data products.

### 5.3.1 Types of Data used

Respondents were asked what types of data they used. In total, 78% of all respondents used Core (T&S at 2000m data). Analysing each user group separately showed that 85% of the Experienced Users group used Core (T&S at 2000m data) but only 60% of the New & Future Users used the dataset.

Other than Core T&S data, the four next most common types of data used by the Experienced Users were Deep Floats (44% of respondents), BGC – O<sub>2</sub> (42%), Regional Extension – Marginal Seas (38%) and BGC-ChlA (29%) and for New & Future Users were BGC – O<sub>2</sub> (40% of respondents), BGC-ChlA (40%), BGC-Irradiance (40%), and Regional Extension – Marginal Seas (33%). It is noteworthy that none (0%) of the New & Future Users reported using Deep Float data. The findings also show that both BGC-pH and BGC-Nitrate are the least used data sets across both the Experienced Users and the New & Future Users groups

The following chart (Figure 3) presents the usage of the different data set types by User Group.

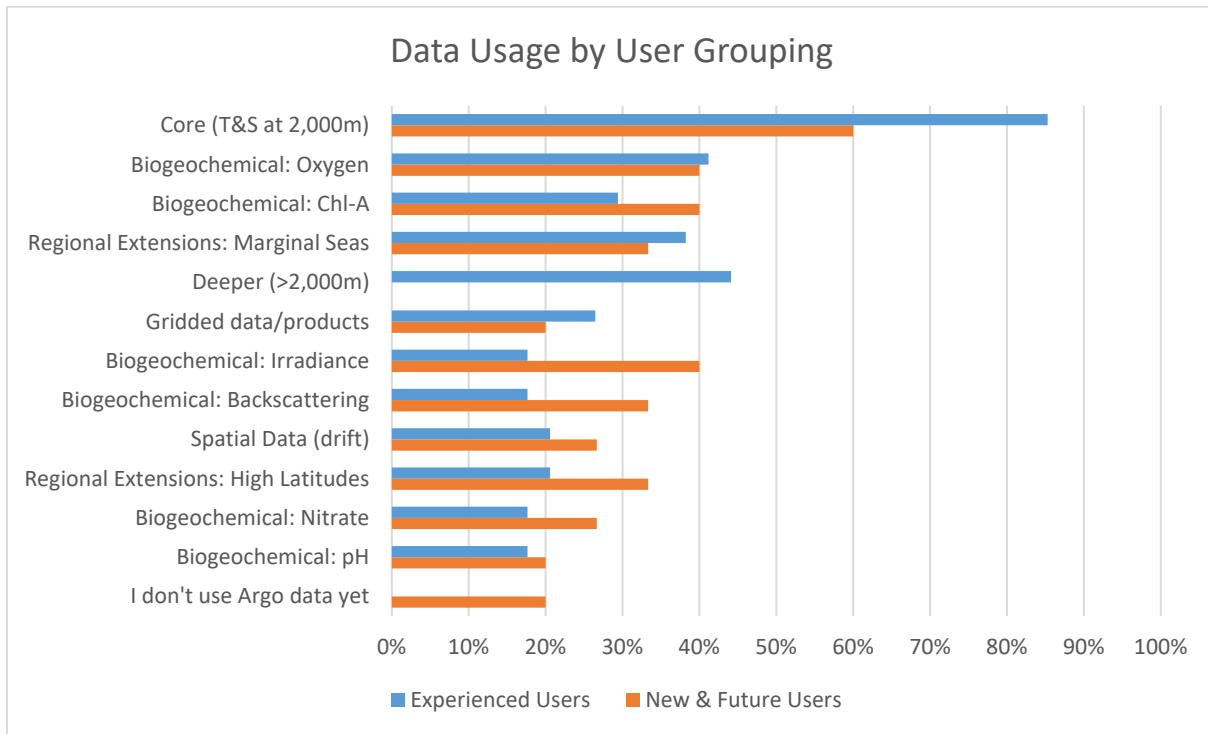


Figure 3 Frequency of data type usage by both Experienced Users and New & Future Users.

The related question on specific requirements for vertical profile sampling of the core (CTD) argo profiles prompted no relevant responses from the New & Future Users group, suggesting that they have yet to fully exploit the possibilities of core Argo float data (noting only 60% of respondents in this group reported using the Core (T&S at 2000m) data set).

50% of the Experienced Users had no specific requirement for vertical profile sampling. Of the 50% that expressed a specific requirement the general consensus was for high resolution (1 dbar) in the surface/euphotic zone and thereafter at 10 dbar resolution.

### 5.3.2 Data Accessibility

Respondents were asked how often they accessed Argo data and were given the options of a daily, weekly, monthly, quarterly or annual basis. Of the 34 Experienced Users who responded to the question data was accessed predominantly on either a quarterly (29%) or a daily (23%) basis, with less frequent access on monthly (18%), weekly (15%), or annual (15%) basis.

Of the 15 New & Future Users, the majority (50%) accessed Argo data on a monthly basis. Data was not downloaded on a daily basis by any of the New & Future Users.

The following pie charts (figures 4 and 5) show the frequency of access to Argo data by both user groups.

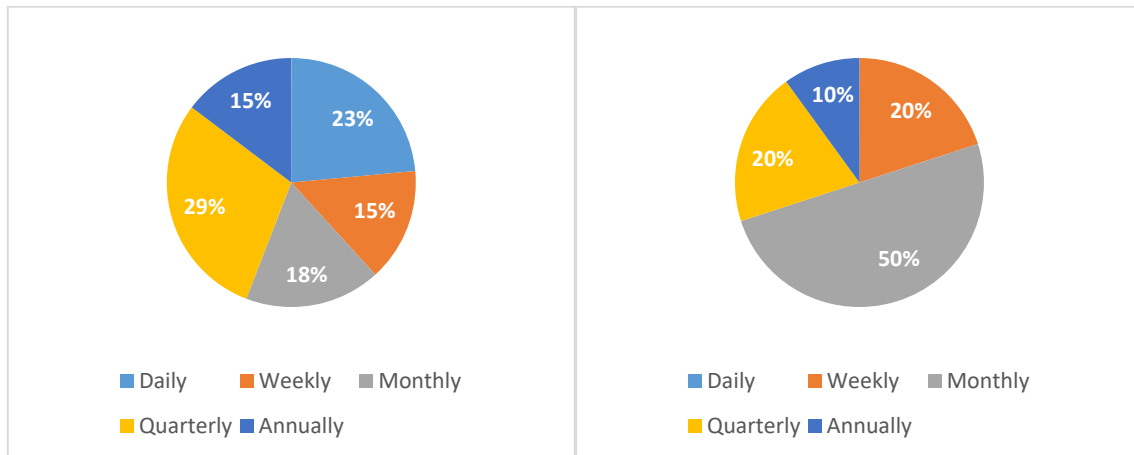


Figure 4 Frequency of access by Experienced Users    Figure 5 Frequency of access by New & Future Users

FTP on GDAC was cited the most by both Experienced Users (70%) and New & Future Users (53%) as a source for their Argo data, with the Argo Data Selection Tool being the next most popular Argo data source; cited by 26% of Experienced Users and 33% of New & Future Users (Figure 6).

Notably both the Argo GDAC synchronisation service and the Thredds data server were cited by only 6% of Experienced Users as a source for Argo data, with the Thredds server not cited by any of the New & Future Users as a source of Argo data. Only 12% of Experienced Users cited ERDDAP server as a source of Argo data, with no New & Future Users citing ERDDAP servers as a source of data. The reason for the low percentage of users citing these servers may be due to the fact that they are not aware of where the data is coming from.

Amongst the “Other” locations cited by both user groups from which Argo data was sourced were: Argopy (x1), Coriolis/CMEMS (x3), UK Met Office/HadObs EN4 (x2), Google Earth pro (x1).

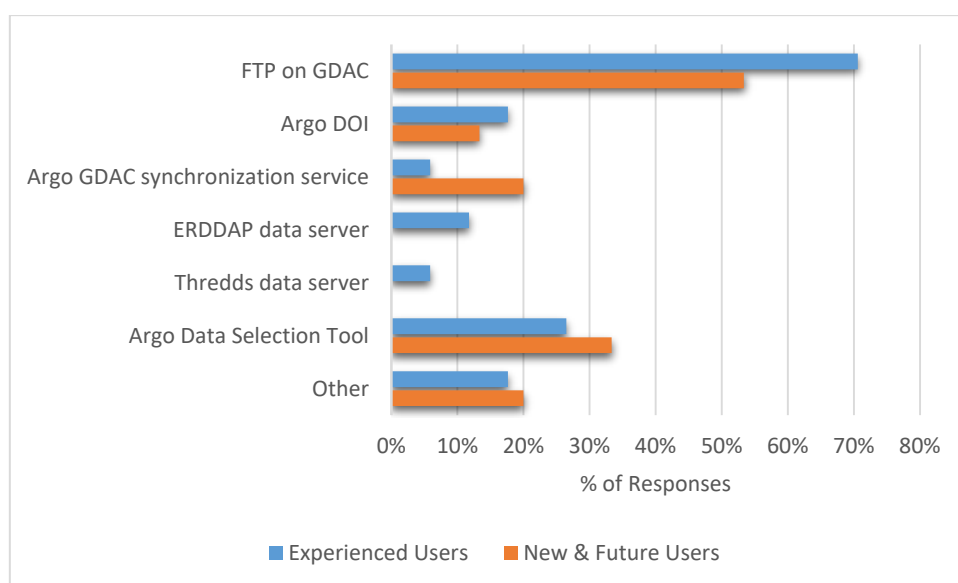


Figure 6 Location of Argo data accessed by Experienced Users vs New & Future Users.

## Recommendation 2

Highlight the importance of the Argo GDAC synchronisation service, the Thredds data server and/or the ERDDAP server.

### 5.3.3 Acknowledging Argo Data

Of the 82% of Experienced Users who use Argo data in publications, 76% acknowledge the source of Argo data but 6% do not (18% of Experienced Users do not use Argo data in publications).

Of the 73% of New & Future Users who use Argo data in publications, all 73% acknowledge the source of Argo data (27% of New & Future Users do not use Argo data in publications).

64% of the Experienced Users who both use Argo data in publications and acknowledge the source of Argo data use the Argo Digital Object Identifier (DOI) to reference the data compared to only 44% of New & Future Users (Table 4).

This suggests that the New & Future Users may not be as aware of the Argo DOI as the Experienced Users group. This represents an opportunity for Euro-Argo to promote the usage and awareness of the Argo DOI among the Argo community, and in particular amongst the New & Future Users.

Table 4 Summary of Responses for New & Future Users vs Experienced Users on acknowledging Argo data in publications and use of the Argo DOI.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q15. Do you acknowledge Argo when using Argo data in publications?	Yes	11	26	73%	76%
	No	0	2	0%	6%
	I don't use Argo data in publications	4	6	27%	18%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q16. If yes, do you use the Argo DOI ( <a href="http://doi.org/10.17882/42182">http://doi.org/10.17882/42182</a> ) to reference Argo data?	Yes	4	21	44%	66%
	No	5	11	56%	34%
	<b>Total</b>	<b>15</b>	<b>33</b>	<b>100%</b>	<b>100%</b>

## Recommendation 3

Euro-Argo to promote the awareness of the Argo DOI among the Argo community and encourage users to cite Argo data when publishing.

### 5.3.4 Quality Control (QC)

Almost all thirty four Experienced Users of Argo QC data were aware of the quality flags associated with Argo data (97%) and knew how to use them (100%). Of the fifteen New & Future Users who responded, 73% were aware of the Argo data quality flags but only 67% knew how to use them. This finding suggests that New & Future Users may not have sufficient knowledge of Argo data QC process to properly apply the data to their applications.

The vast majority of Experienced Users (73%) use both the Real-time and Delayed QC modes. 18% of Experienced Users only use Delayed mode with 9% of Experienced Users only using Real-time mode.

QC mode use is more variable amongst the New and Future Users, with 14% reporting only using Real-time QC, 36% only using Delayed mode QC, 29% using both Real-time and Delayed model QC, with another 21% not knowing what (if any) data QC mode they use.

This suggests that the New & Future Users may not have sufficient knowledge of the most appropriate mode of data QC to use for their applications.

Additionally, 100% of New & Future Users and 91% of Experienced Users would be interested in getting uncertainty estimates associated with corrected QC data (Table 5).

Table 5 Summary of Responses for New & Future Users vs Experienced Users on what Argo data QC mode they use.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q19. Are you aware of quality flags associated with Argo data?	Yes	11	33	73%	97%
	No	4	1	27%	3%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q20. Do you know how to use the quality flags associated with Argo data?	Yes	10	34	67%	100%
	No	5	0	33%	0%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q21. What Argo data QC mode do you use?	Real-time	2	3	14%	9%
	Delayed mode	5	6	36%	18%
	Real-time & delayed mode	4	24	29%	73%
	I don't know	3	0	21%	0%
	<b>Total</b>	<b>14</b>	<b>33</b>	<b>100%</b>	<b>100%</b>

## Recommendation 4

Provide a new value-added service on the Euro-Argo website that will promote uncertainty estimates associated with corrected QC data to all users.



### 5.3.5 Data Formats

The majority of New & Future Users (100%) and Experienced Users (88%) are satisfied with the present output of the requested zipped profile files. (Table 6).

Table 6 Summary of responses for New & Future Users vs Experienced Users on the present output of requests.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q25. Are you satisfied with the present output of the request (zip of profile files)?	Yes	9	28	100%	88%
	No	0	4	0%	13%
	<b>Total</b>	<b>9</b>	<b>32</b>	<b>100%</b>	<b>100%</b>

The majority of New & Future Users (91%) and Experienced Users (91%) use NetCDF files. A very small percentage of Experienced Users also use BUFR and synthetic profiles with some New & Future Users using gridded formats.

The majority of New & Future Users (91%) and Experienced Users (87.5%) are satisfied with the file formats that are currently available (Table 7).

Table 7 Summary of responses for New & Future Users vs Experienced Users on how satisfied they are with the current Argo file formats.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q28. Are you satisfied with the Argo file formats currently available?	Yes	10	28	91%	87.5%
	No	1	4	9%	12.5%
	<b>Total</b>	<b>11</b>	<b>32</b>	<b>100%</b>	<b>100%</b>

Respondents were asked what type of data (format/formatting) they would like to see provided by the Argo community and the response to those questions are included in Q29 in Section 3 previously.

### 5.3.6 Data Limitations, Problems and Gaps.

Feedback was provided on any problems or limitations experienced by users for Argo data.

80% of New & Future Users responded that they had no problems with Argo data, but almost half (47%) of Experienced Users responded that they had encountered some problems with Argo data. Of the Experienced Users who encountered problems, all except one either solved the problem, or contacted persons responsible to report the issue.

Specific comments of note from Experienced Users who experienced problems are included in response to Q31 in Section 3 previously.

This finding suggests that New & Future Users may not be using the Argo data to its full potential, only using basic datasets, or only using those data sets and sources that have well established and robust pipelines. Experienced Users may be using datasets or sources of more recent provenance that may not have as robust processing pipelines.

Although almost half the Experienced Users expressed problems with Argo data, the majority of both user groups (82% of Experienced Users, 80% of New & Future Users) have not experienced any limitations is using Argo data in terms of data format, accessibility or products (Table 8).

Table 8 Summary of Responses for New & Future Users vs Experienced Users on problems with Argo data.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q30. Have you encountered any problems with Argo data?	Yes	3	16	20%	47%
	No	12	18	80%	53%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q32. Have you encountered any limitations when using Argo data in terms of data format, accessibility & products?	Yes	3	6	20%	18%
	No	12	28	80%	82%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>

Gaps in the spatial or temporal coverage of Argo data was the focus of specific questions, and both user groups have encountered gaps (Table 9). Almost half (44%) of the Experienced Users and 33% of New & Future Users reported gaps in Argo data.

None of the New & Future Users, who experienced data gaps, knew to whom to report data gaps, nor the process to do so. Less than quarter (23%) of Experienced Users, who experienced gaps, knew how and to whom to report the information.

Communicating with Argo data users to identify spatial or temporal gaps in Argo data will help plan future campaigns to fill those gaps where possible.

Table 9 Summary of Responses for New & Future Users vs Experienced Users on gaps in Argo data.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q35. For your specific applications, do you encounter any gaps in Argo data (temporal or spatial)?	Yes	5	15	33%	44%
	No	10	19	67%	56%
	<b>Total</b>	<b>15</b>	<b>34</b>	<b>100%</b>	<b>100%</b>

Q36. If yes, do you know how and who to report information?	Yes	0	3	0%	23%
	No	4	4	100%	31%
	Other	0	6	0%	46%
	<b>Total</b>	<b>4</b>	<b>13</b>	<b>100%</b>	<b>100%</b>

## Recommendation 5

Euro-Argo to increase awareness among the Argo community to the appropriate communication channels (e.g. national and international user meetings) for reporting data problems and gaps in the Argo programme.

Figure 7 looks at the type of geographic datasets (if any) that both user groups work with. 40% of New & Future Users do not work with any geographic dataset, compared to only 26% of Experienced Users.

The most common geographic datasets used by both user groups showed the same rank ordering, and were:

- Topographic databases (cited by 35% of Experienced Users and 40% of New & Future Users)
- 3D models (cited by 29% of Experienced Users and 27% of New & Future Users)
- Raster Maps (cited by 15% of Experienced Users and 20% of New & Future Users)

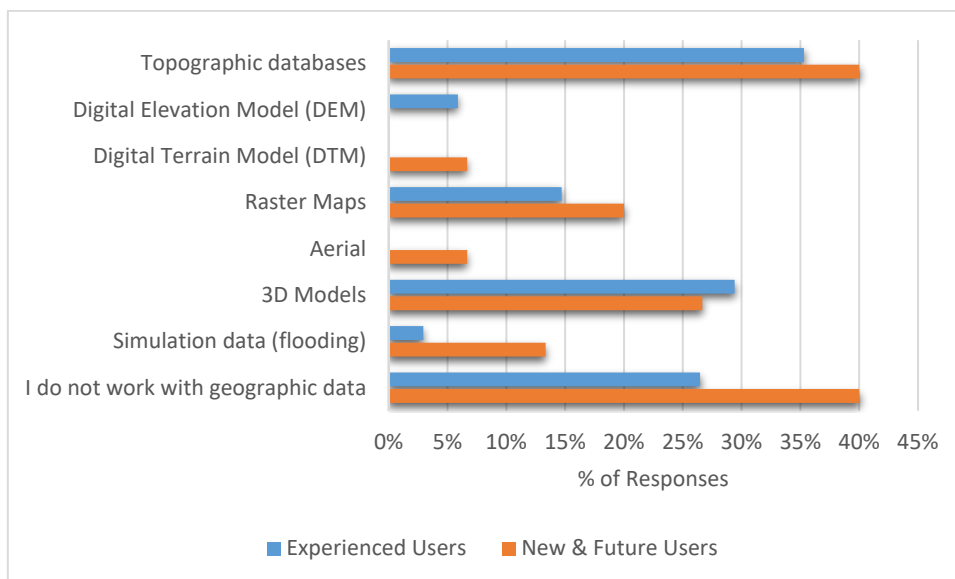


Figure 7 Type of geographic data used by Experience Users vs New & Future Users

Users were also asked, through multiple choice, what software they use in their application environments. The majority of the New & Future Users (70%) and Experienced Users (58%) cited Matlab.

Python (& argopy) was mentioned by 33% of Experienced Users, but by only 20% of New & Future Users. Only three software applications were used by New & Future Users; Matlab, Python and R.

Both Fortran and Other (cdo, octace, ferret, IDL) were referenced by 18% of the Experienced Users, but not by any of the New & Future Users group. This suggests that, in addition to using Matlab, Experienced Users have used their software/programming application of choice to interact with Argo data writing custom code (Table 10).

Table 10 Summary of responses from New & Future Users vs Experienced Users on the different types of software used.

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q33. Please specify the software that you are using in your application environment?	Matlab	7	19	70%	58%
	Python	2	11	20%	33%
	R	2	4	20%	12%
	Fortran	0	6	0%	18%
	Other	0	6	0%	18%

## Recommendation 6

Promote the development of open-source software to increase usage of Argo data among the Argo community.

### 5.4 Euro-Argo ERIC Communications & Outreach

The objective of this section is to establish how effective Euro-Argo ERIC's engagement is with the Argo community and to identify what the community requires in terms of training and outreach opportunities, and what is required to expand the Euro-Argo network across the identified user groups. The comparison of responses from Experienced Users versus New & Future Users is presented in Table 11.

The majority of both the New & Future Users (61%) and Experienced Users (79%) were aware of Euro-Argo ERIC and its role in the global Argo programme. This finding, though encouraging, indicated that there is an opportunity for Euro-Argo ERIC to increase its outreach, engagement and awareness programme across all users to improve global brand awareness of the ERIC.

Approximately half of New & Future Users (52%) and two thirds of Experienced Users (67%) either Agreed or Strongly Agreed that Euro-Argo ERIC had a good communications plan across all platforms. This finding again indicated that there is opportunity for Euro-Argo ERIC to improve its communications plan across all platforms to raise awareness of activities of the ERIC.

Specific suggestions on how to improve Euro-Argo ERIC communications were included in response to Q 39 in Section 3 previously.

## Recommendation 7

Euro-Argo ERIC to improve its communications plan across all platforms, and to increase outreach, engagement and awareness programmes.

### 5.4.1 Training

In general, and across the outreach and education activities, between 20- 30% of all Experienced Users expressed an interest in attending the proposed offerings of Training Events, Tutorials, Cookbooks, Ocean Best Practices.

Interestingly one third of all New & Future Users (33%) who responded expressed interest in Ocean Best Practices activities, but only 12% expressed interest in Cookbook related activity.

In addition to the outreach and education activities presented in Q40 of Table 11, New & Future Users also requested specific training in the general area of data formats, quality control, and data use. Experienced Users requested specific training on both delayed model QC and interacting with float technologies.

Table 11 Summary of responses for New & Future Users vs Experienced Users on communications and outreach

Question	Response	No. of Responses		% of Responses	
		New & Future Users	Experienced Users	New & Future Users	Experienced Users
Q37. Are you aware of Euro-Argo ERIC and its role in the global Argo programme?	Yes	14	27	61%	79%
	No	3	0	13%	0%
	Somewhat	6	7	26%	21%
	<b>Total</b>	<b>23</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q38. Would you agree that the Euro-Argo ERIC has a good communications plan across its multiple platforms including website, social media, newsletters, annual reports, press releases, policy briefs, etc.?	Neutral	11	11	48%	32%
	Agree	9	14	39%	41%
	Strongly Agree	3	9	13%	26%
	<b>Total</b>	<b>23</b>	<b>34</b>	<b>100%</b>	<b>100%</b>
Q40. Euro-Argo ERIC are developing a number of outreach and dissemination activities for the Argo community. Please tick any of the relevant activities that you would be interested in.	Training Events	12	15	29%	21%
	Tutorials	11	17	26%	24%
	Cookbooks	5	18	12%	26%
	Ocean Best Practices	14	20	33%	29%

	<b>Total</b>	<b>42</b>	<b>70</b>	<b>100%</b>	<b>100%</b>
Q43. Would you be willing to take part in Euro-Argo activities (e.g. occasionally act as an expert for specific topics, help in finding deployment opportunities, etc.)	Yes	13	16	62%	57%
	No	8	12	38%	43%
	<b>Total</b>	<b>21</b>	<b>28</b>	<b>100%</b>	<b>100%</b>
Q44. Are you in contact with teams in countries outside of Euro-Argo who could be interested in the Argo programme?	Yes	9	11	39%	32%
	No	14	23	61%	68%
	<b>Total</b>	<b>23</b>	<b>34</b>	<b>100%</b>	<b>100%</b>

## Recommendation 8

Euro-Argo to provide specific training courses tailored to each user groups expressed requirements including training on the different modes and applicability of data QC available in the Argo community.

### 5.4.2 Outreach & Dissemination Activities

All respondents were asked to outline any other communications, outreach or dissemination activities or services that they require from the Argo community. New & Future Users have stated that the continued organisation of technical and science meetings are important, as are public events for children, updates on geopolitical and economic issues associated with the Argo programme and short movies on data types and QC.

Experienced Users focused on strengthening links with the non-physical Oceanography community, research communities, national stakeholders, and policymakers. They also highlighted tracking Argo usage through a complete value tree, learning modules for teachers, outreach activities in schools and colleges, online webinars, tutorial videos and a shared and integrated dissemination strategy towards the general public.

## 6 Conclusion & Recommendations

The key findings of the survey were:

- The majority of respondents are aware of the Euro Argo Strategy and Five Year Plan, confirming successful dissemination and communication to Argo users.
- Increased Deep Argo floats, increased BGC Argo floats and longer battery life are the technological development that were most often mentioned among respondents, confirming the direction of technological development in the Argo Strategy
- None of the New & Future Users reported using Deep Float data.
- BGC-pH and BGC-Nitrate are the least used data sets across all respondents
- Although the majority of respondents acknowledge Argo when using Argo data, less are using the Argo DOI.
- The majority of respondents access Argo data through FTP on GDAC and work with NetCDF files.
- The Argo GDAC synchronisation service, the Thredds data server and the ERDDAP data server were accessed by very few of the respondents.
- The vast majority of respondents were satisfied with the current file formats and the outputs of the requested zipped profile files. Almost half of the Experienced User respondents reported they had encountered problems with Argo data, and almost half of the Experienced User respondents reported they had encountered gaps in Argo data. However, the majority of both user groups' respondents had not experienced any limitations in using Argo data in terms of data format, accessibility or products.
- Approximately half of New & Future User respondents and two thirds of Experienced User respondents agreed that Euro-Argo ERIC had a good communications plan across all platforms, providing opportunity for improvement.
- New & Future Users requested specific training in the general area of data formats, quality control, and data use.
- Experienced Users requested specific training on both delayed model QC and interacting with float technologies.
- Ocean Best Practices and Cookbooks are recommended training materials to support Euro Argo outreach and dissemination activities.

The key recommendations from the analysis are to:

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## Recommendation 1

Euro-Argo to increase the visibility, awareness and promotion activities for the European Strategy for Argo and the Euro-Argo Five Year Plan among the Argo community. The Strategy and Five Year Plan should also be made available to relevant interested stakeholders, such as funders, decision makers and policy makers.

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## Recommendation 2

Highlight the importance of the Argo GDAC synchronisation service, the Thredds data server and/or the ERDDAP server.

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## Recommendation 3

Euro-Argo to promote the awareness of the Argo DOI among the Argo community and encourage users to cite Argo data when publishing.

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## Recommendation 4

Provide a new value-added service on the Euro-Argo website that will promote uncertainty estimates associated with corrected QC data to all users.

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## Recommendation 5

Euro-Argo to increase awareness among the Argo community to the appropriate communication channels (e.g. national and international user meetings) for reporting data problems and gaps in the Argo programme.

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## Recommendation 6

Promote the development of open-source software to increase usage of Argo data among the Argo community.

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## Recommendation 7

Euro-Argo ERIC to improve its communications plan across all platforms, and to increase outreach, engagement and awareness programmes.

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## Recommendation 8

Euro-Argo to provide specific training courses tailored to each user groups expressed requirements including training on the different modes and applicability of data QC available in the Argo community.

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## 7 Annex 1 – Questionnaire

# An Assessment of Euro-Argo Users' Requirements

## INFORMATION ON THIS QUESTIONNAIRE

This questionnaire is meant to collect your professional knowledge related to your Argo data use for the Euro-Argo RISE project. As we can also collect your name, position and professional position and potentially other personal information, it is important that you understand the reason and procedure of this questionnaire. Further information on Euro-Argo RISE project:

(<https://www.euro-argo.eu/EU-Projects/Euro-Argo-RISE-2019-2022>)

\* Required

**Euro-Argo RISE (Euro-Argo Research Infrastructure Sustainability and Enhancement)** is a H2020 EU project starting on 1st January 2019 for a duration of 4 years. The project involves 19 partners across Europe and is coordinated by the Euro-Argo ERIC. The Euro-Argo RISE project is needed now to allow Europe to timely develop its contribution to this new phase of Argo. The primary objective of Euro-Argo RISE is to secure its original/core mission (monitoring temperature and salinity in the top 2,000m of the ocean) as well as to set up and organise new components within the network, including extending Argo observations towards biogeochemistry, greater depth, partially ice-covered and shallower water regions within a long-term, sustainable plan supported by Member States and funding agencies. The overarching objective of Euro-Argo RISE is to enhance and extend the capabilities of the Argo network to provide essential ocean observations to answer new societal and scientific challenges and support 1) ocean and climate change research, 2) climate change monitoring (characterizing climate change impact on the ocean physics and chemistry, 3) seasonal and climate change forecasting by improving the 4D description of the ocean state, 4) ocean analysis and forecasting and associated ocean services including Copernicus Services.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement no 824131. Call INFRADEV-03-2018-2019: Individual support to ESFRI and other world-class research infrastructures.

Responsible person for this questionnaire: Deirdre Fitzhenry, [EARISEProject@gmail.com](mailto:EARISEProject@gmail.com), Marine Institute, Ireland. You can always ask for further information from the responsible person above or from the Euro-Argo project office: [euroargo@ifremer.fr](mailto:euroargo@ifremer.fr)

The questionnaire aims at understanding the technical requirements of users of Argo data and related services. Answering the questionnaire is voluntary and you can stop answering at any moment. The questionnaire will be done using Google Forms, and will take approximately 10-15 minutes to answer. You have been selected to answer the questionnaire in your professional capacity as the representative of the Institute you are working with.

No personal data is requested, although you have an opportunity to optionally leave your contact information for further information, if needed.

All data will be stored securely on a Marine Institute server and will only be used within the framework of the Euro-Argo RISE project. Access to the answers is restricted to the responsible person and the data analyzers selected by him/her. The answers will be analyzed offline. The questionnaire technical results and conclusions deduced from the results can be published within the Euro-Argo RISE project deliverables, reports and documentation, however no personal information will be published in any form. All questionnaire answers will be deleted latest at the end of the Euro-Argo RISE project. If your contact information is stored with your answers, you can also request to be informed on the reports and documents generated from the information collected in this questionnaire.

Procedures for data collection, storage, protection, retention and destruction, the EU Directive adopted in 1995, which regulates the processing of personal data within the European Union (Directive 95/46/EC) will be followed.

## Section 1: Who & Where

Section 1 consists of questions about the respondent. We would like to know who our respondents are in order to better understand their perspective, expectations and needs in terms of their requirements.

### 1. Q1. I am responding: \*

*Mark only one oval.*

- As an individual
- On behalf of a single institution/company
- On behalf of an "umbrella" organisation of EU interest
- Other: \_\_\_\_\_

### 2. Q2. What type of organisation do you represent? \*

*Check all that apply.*

- National delegate (influencing policy decisions)
- Research / Scientific Community
- Remote Sensing Community
- Operational Oceanography
- Ocean Forecasting
- National Oceanographic Data Centre
- Private Company / SME
- Manufacturer of Argo Component(s)
- Weather Forecasting Community
- Argo Operator
- National Argo Programme Manager
- Non-Governmental Organisation (NGO)
- Educational Community
- Private Individual

Other:  \_\_\_\_\_

3. Q3. What country are you from? \*

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4. Q4. At what scale is your area of interest? \*

*Mark only one oval.*

Local scale (process/project based)

National / EEZ

Regional Seas

Oceanic

Global

5. Q5. Please specify your specific geographical area of interest. \*

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**Section 2:  
Involvement**

Section 2 consists of questions that focus on our links with Argo communities, engaging with new communities and establishing awareness of our Euro-Argo strategy.

6. Q6. Do you have input into the overall Argo network implementation i.e. float procurement and locations planning?

*Mark only one oval.*

Yes

No

7. Q7. Please expand on Question 6.

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8. Q8. Do you have an input into the deployment of Argo floats in your country i.e. deployment operations and logistics?

*Mark only one oval.*

Yes

No

9. Q9. Please expand on Question 8.

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10. Q10. Are you aware of the European strategy for Argo (doi: <https://doi.org/10.13155/48526>)?

*Mark only one oval.*

Yes

No

11. Q11. Are you aware of the Euro-Argo ERIC Five Year Plan 2019–2023 (doi: <https://doi.org/10.13155/71936>)?

*Mark only one oval.*

Yes

No

12. Q12. What technological development would you like to see introduced and why (including new parameters)?

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### Section 3: Existing Argo Data User

13. Q13. Are you an existing Argo data user? \*

*Mark only one oval.*

No not an existing user      *Skip to question 37*

Possible future user of Argo data      *Skip to question 14*

Using Argo data >12 months      *Skip to question 14*

Using Argo data <12 months      *Skip to question 14*

### Section 4: Data & Products

Section 4 focuses on the accessibility of Argo data, types of formats, limitations and how respondents use the data.



14. Q14. How often do you download Argo data? \*

*Mark only one oval.*

- Never
- Daily
- Weekly
- Monthly
- Quarterly
- Annually
- >Annually

15. Q15. Do you acknowledge Argo when using Argo data in publications? \*

*Mark only one oval.*

- Yes
- No
- I don't use Argo data in publications

16. Q16. If yes, do you use the Argo doi (<http://doi.org/10.17882/42182>) to reference Argo data?

*Mark only one oval.*

- Yes
- No
- I don't use Argo data yet

## 17. Q17. What Argo data do you use? \*

*Check all that apply.*

- Core (T&S at 2,000m)
- Deeper (>2,000m)
- Biogeochemical: Oxygen
- Biogeochemical: Chl-A
- Biogeochemical: Irradiance
- Biogeochemical: pH
- Biogeochemical: Nitrate
- Biogeochemical: Backscattering
- Spatial data (drift)
- Regional Extensions: Marginal Seas
- Regional Extensions: High Latitudes
- Gridded data/products
- I don't use Argo data yet

## 18. Q18. Do you have specific vertical sampling requirements for CTD Argo profiles? \*

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## 19. Q19. Are you aware of quality flags associated with Argo data? \*

*Mark only one oval.*

- Yes
- No

## 20. Q20. Do you know how to use the quality flags associated with Argo data? \*

*Mark only one oval.*

- Yes
- No

21. Q21. What Argo data QC mode do you use? \*

*Mark only one oval.*

- Real-time
- Delayed Mode
- Real-time & delayed mode
- Don't know
- Other: \_\_\_\_\_

22. Q22. Would you be interested in getting uncertainty estimates associated with corrected data? \*

*Mark only one oval.*

- Yes
- No

23. Q23. Where do you access Argo data? \*

\* Please note the Argo Data Selection Tool is currently being redesigned, please get in touch with [euroargo@ifremer.fr](mailto:euroargo@ifremer.fr) if you would like to interact with us on new functionalities. \*\* If you tick Other please specify (may include integrated data systems containing other types of data).

*Check all that apply.*

- FTP on GDAC
- Argo DOI
- Argo GDAC synchronization service
- ERDDAP data server
- Thredds data server
- Argo data selection tool\*

Other:  \_\_\_\_\_

24. Q24. If you are using the Argo data selection tool, which additional index would you like to select your data? (presently available is parameter, quality, processing level).

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25. Q25. Are you satisfied with the present output of the request (zip of profile files)? \*

*Mark only one oval.*

Yes

No

Other: \_\_\_\_\_

26. Q26. If you ticked No to Question 25 please specify.

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27. Q27. What existing Argo file formats are you working with? \*

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28. Q28. Are you satisfied with the Argo file formats currently available? \*

*Mark only one oval.*

Yes

No

Other: \_\_\_\_\_

29. Q29. What type of data (format/formatting) would you like to see provided by the Argo community?

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30. Q30. Have you encountered any problems with Argo data? \*

*Mark only one oval.*

Yes

No

31. Q31. If yes, how did you fix or overcome them?

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32. Q32. Have you encountered any limitations when using Argo data in terms of data format, accessibility & products? \*

*Mark only one oval.*

Yes

No

33. Q33. Please specify the software that you are using in your application environment. \*

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34. Q34. What type of geographic data do you work with? \*

*Check all that apply.*

- Topographic databases
- Digital Elevation Model (DEM)
- Digital Terrain Model (DTM)
- Raster Maps
- Aerial
- Terrestrial
- 3D Models
- Simulation data (flooding ...)
- I do not work with geographic data

Other:  \_\_\_\_\_

35. Q35. For your specific applications, do you encounter any gaps in Argo data (temporal or spatial)? \*

*Mark only one oval.*

- Yes
- No

36. Q36. If yes, do you know how and who to report information?

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## Section 5: Euro-Argo ERIC Communications & Outreach

Section 5 focuses on the Euro-Argo ERIC's engagement with respondents. We would like to know if we are communicating effectively, to identify what you require in terms of training and outreach opportunities, and expanding the Euro-Argo network.

37. Q37. Are you aware of Euro-Argo ERIC and its role in the global Argo programme? \*

Mark only one oval.

Yes

No

Somewhat

38. Q38. Would you agree that the Euro-Argo ERIC has a good communications plan across its multiple platforms including website, social media, newsletters, annual reports, press releases, policy briefs, etc? \*

Mark only one oval.

1      2      3      4      5

Strongly Disagree      Strongly Agree

39. Q39. What communication aspects could be improved?

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40. Q40. Euro-Argo ERIC are developing a number of outreach and dissemination activities for the Argo community. Please tick any of the relevant activities that you would be interested in. \*

*Check all that apply.*

- Training events
- Tutorials
- Cookbooks
- Ocean Best Practices

Other:  \_\_\_\_\_

41. Q41. Please specify what kind of training you require.

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42. Q42. Are there any other communications, outreach and dissemination activities or services that you require from the Argo community? \*

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43. Q43. Would you be willing to take part in Euro-Argo activities (e.g. occasionally act as an expert for specific topics, help in finding deployment opportunities, etc.)

If yes, please ensure you provide your contact details in Section 6.

*Mark only one oval.*

Yes

No

44. Q44. Are you in contact with teams in countries outside of Euro-Argo who could be interested in the Argo programme? \*

*Mark only one oval.*

Yes

No

45. Q45. If yes, would you be willing to help us in trying to set up an Argo programme in this/these countries?

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**Section 6:  
Additional  
Information  
(optional)**

Please feel free to complete this section at your discretion. The technical results and conclusions deduced from the results of this questionnaire can be published within the Euro-Argo RISE project deliverables, reports and documentation, however no personal information will be published in any form.

All questionnaire answers will be deleted latest at the end of the Euro-Argo RISE project.

If your contact information is stored with your answers, you can also request to be informed about the reports and documents generated from the information collected in this questionnaire by emailing [EARISEProject@gmail.com](mailto:EARISEProject@gmail.com).

46. First Name

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47. Last Name

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48. Role / Position

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49. Organisation

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50. Address

---

51. Email Address

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52. Do you give you consent for your email address to be added to the Euro-Argo ERIC mailing list (if not already)?

*Mark only one oval.*

Yes

No

53. Please provide any additional details you think are relevant.

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