**U.S. Argo National Report to AST-24, March 2024**

***Organization of U.S. Argo:***

The U.S. Argo Consortium is supported with major funding provided by the National Oceanic and Atmospheric Administration (NOAA), and additional participation of the U.S. Navy. The consortium includes principal investigators from six institutions: Scripps Institution of Oceanography (SIO), Woods Hole Oceanographic Institution (WHOI), the University of Washington (UW), the Atlantic Oceanographic and Meteorological Laboratory (AOML), the Pacific Marine Environmental Laboratory (PMEL), and the Naval Research Laboratory (NRL/Monterey). Float technology development, production, acquisition, logistics, deployment, array monitoring, and data management functions are distributed among these institutions on a collaborative basis.

In addition to the float-providing and data management activities, the U.S. Argo Consortium works collaboratively with closely related programs including:

- Global Ocean Biogeochemistry array (GO-BGC), supported by NSF to establish the baseline rates of photosynthetic production, respiration, and nutrient supply in present ocean ecosystems.
- Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM), a regional pilot array of BGC Argo floats supported by NSF and NOAA.
- Argo New Zealand is the largest deployer of U.S. Argo floats through designed deployment voyages of RV Kaharoa (jointly supported by Argo USA, New Zealand, and Australia) and deployment opportunities on RV Tangaroa.
- A NOPP project for validation and improvement of the Deep Argo SBE-61 CTD.
- A NOPP project for development of a BGC SOLO float.
- A NOPP project for the development of new BGC sensors and improvement of the SBE Navis platform.
- A partnership of NOAA/PMEL and the Paul G Allen Family Foundation that provided 33 Deep Argo floats and deployments of  many of those in the Brazil Basin.
- National Academy of Sciences Gulf Research Program's support for 25 Argo floats in the Gulf of Mexico.
- A cooperatively funded and dedicated Atlantic charter to help ameliorate COVID impacts on vessel access during 2020/2021. Euro-Argo, Argo Canada and US Argo supported the charter, which has deployed ~ 90 floats, mostly into the Southeastern Atlantic.

The contributions of these and other Argo partner projects are gratefully acknowledged.

Another 5-year cycle of U.S. Argo Consortium implementation began in July 2020, and extends through June 2024. The Work Plan for this cycle of U.S. Argo includes milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep international Argo Program termed *OneArgo*.

***Objectives:***

The U.S. Argo Consortium is funded by NOAA on a year-to-year basis. There is uncertainty in the level of funding that will be available to support the 5-year Work Plan. The projections included in the Plan are optimistic. The assumptions guiding Work Plan scenarios were that (i) Core Argo budgets should increase by 10% per year above the FY2019 institutional funding levels, and (ii) incremental funding of $1M per year will be available for each of the U.S. Consortium Deep and BGC Argo Programs. The increases for Core Argo are meant first to restore a healthy number of deployments for sustaining the Core Argo array, and second to fund coverage increases, beginning with those proposed for high latitudes and the equatorial Pacific. A distribution of institutional effort between the Deep and BGC programs has been planned by the U.S. Argo Consortium institutional partners. All float-providing institutions will participate in both Deep and BGC Programs, and the U.S. Argo DAC will carry out the corresponding data management. Actual funding levels are likely to be less than the ideal scenarios, in which case the highest priority will be sustaining the Core Argo array.

***Status of U.S. Core Argo implementation:***

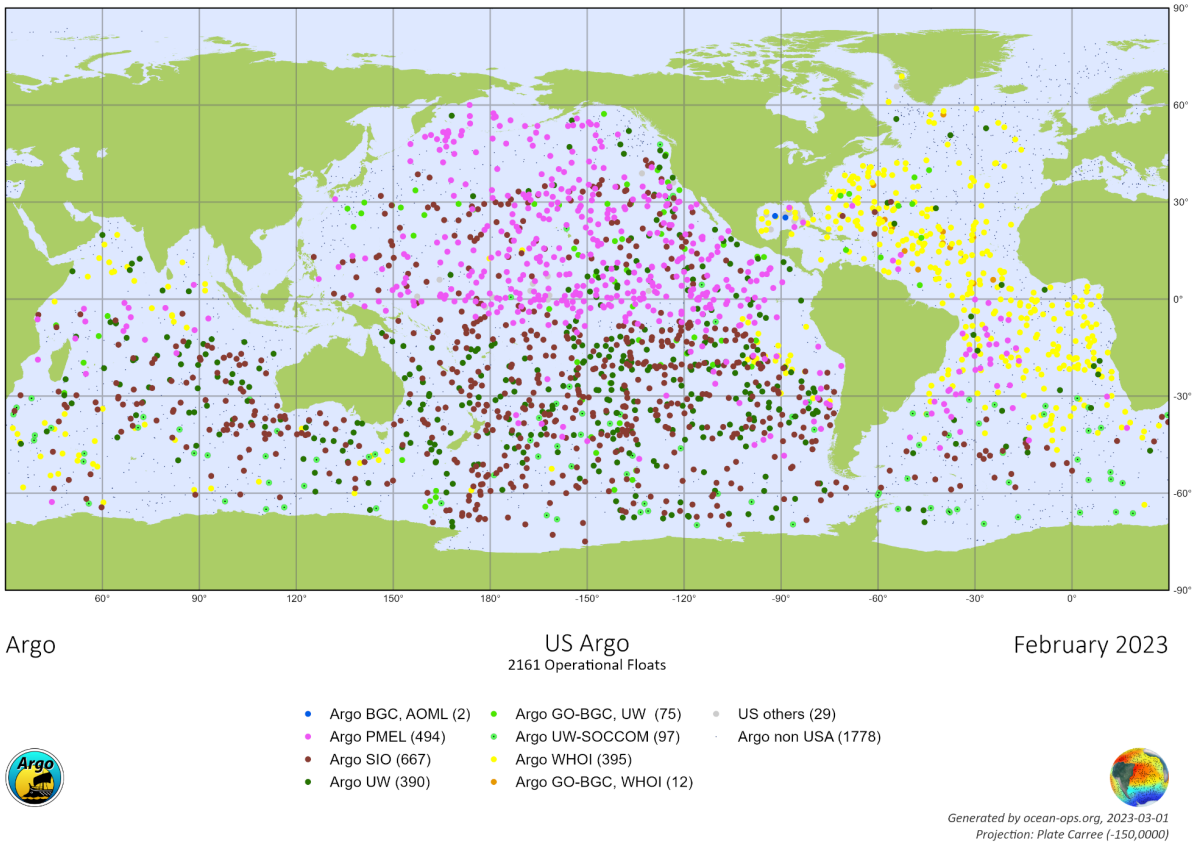


***Fig. 1****: Location of operational U.S. Argo Program, SOCCOM, GO-BGC, and other U.S. Argo Equivalent floats as of January 2022 (Source: OceanOPS).*

As of February 2023, there were 2161 operational U.S. Argo floats (Fig. 1), mostly provided by the U.S. Argo Consortium, with substantial contributions from SOCCOM and GO-BGC. Support

levels for Core U.S. Argo floats have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have nearly been offset by increases in Core Argo float lifetime, with over 75% of floats deployed as far back as 2016 still operational as of March 2023 (Table 1). Hence the number of operational U.S. Argo floats, which peaked at around 2200 in 2016 and 2017, decreased gradually to about 2150 in 2020, and has been relatively steady since then (Fig. 2).

Further increases in lifetime are expected through continuing identification of short-term and long-term failure modes and improved battery technologies. However, the present number of yearly deployments may not be sufficient to sustain the level of U.S. Argo floats.

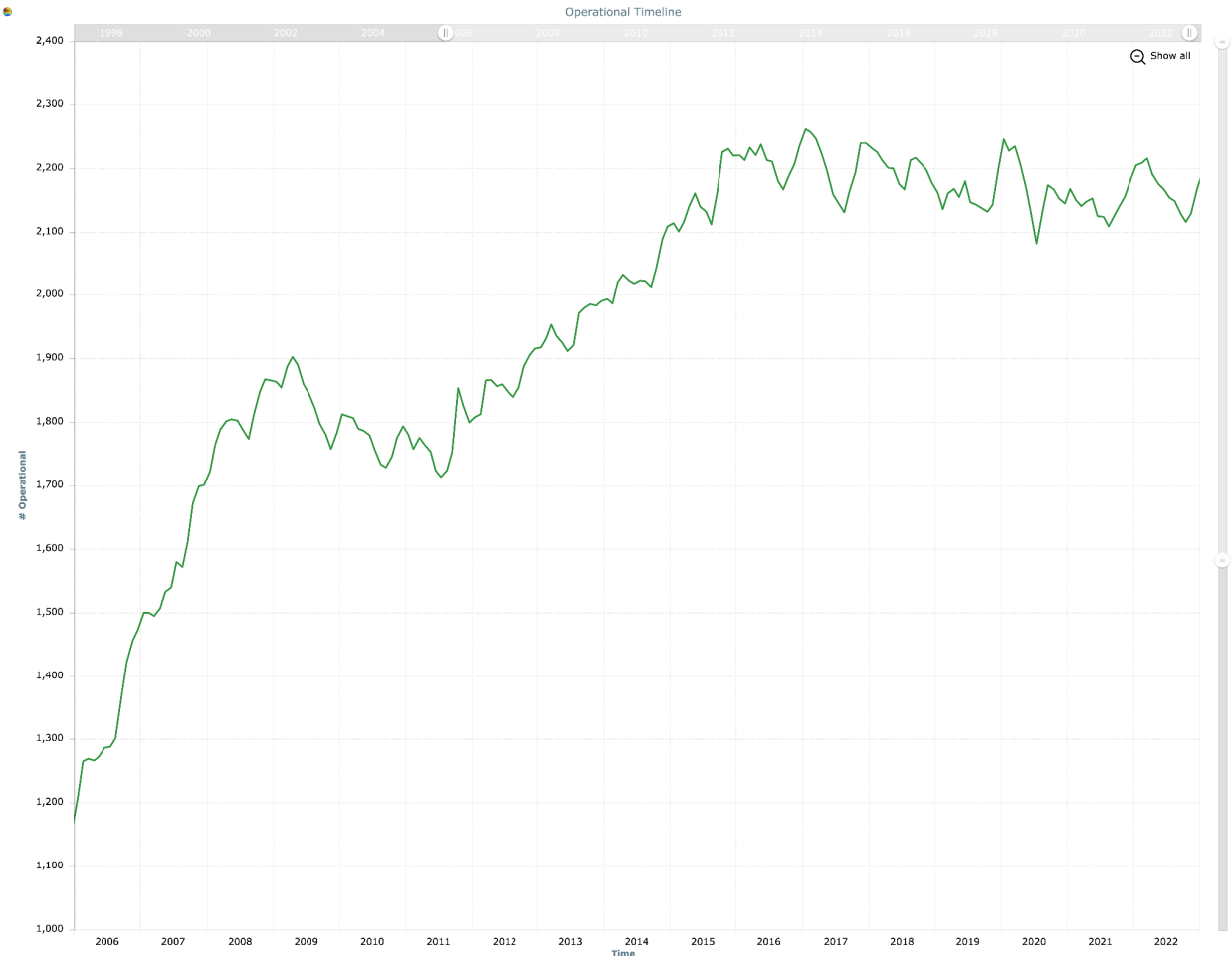


***Fig. 2:*** *Timeline of the number of operational U.S. Argo floats since 2006 as of March 2023 (Source: OceanOPS).*

| Year deployed | Number deployed | Number active as of 2/2022 | % active (2/2022) |
|---|---|---|---|
| 2013 | 306 | 2 | 1% |
| 2014 | 366 | 34 | 9% |
| 2015 | 335 | 163 | 49% |

| | | | |
|---|---|---|---|
| 2016 | 315 | 236 | 75% |
| 2017 | 331 | 261 | 79% |
| 2018 | 256 | 193 | 75% |
| 2019 | 259 | 213 | 82% |
| 2020 | 256 | 224 | 88% |
| 2021 | 257 | 218 | 85% |
| 2022 | 265 | 214 | 81% |

***Table 1:*** *Number of U.S. Core Argo floats deployed in each year from 2013 through 2022 and the number still active as of March 2023 (Source: OceanOPS). A major focus of the U.S. Argo Consortium is extension of float lifetimes and reduction of early float failures.*

Impacts of the Covid-19 pandemic included limitations on all institutional laboratory activities for physical distancing, a substantial reduction in available deployment opportunities by the research fleet, supply chain difficulties that have adversely affected float manufacture, and sea freight delays. Nonetheless, the relatively long life of Argo floats mitigated the Covid-19 reduction in activities, as illustrated by the continuing nearly-constant number of active US Argo Program floats (Fig. 2). Many of the Covid-19 impacts persist even now, but there were 265 US Argo Program Core Argo floats deployed during 2022 (Table 1, Figure 3), slightly up from the totals of the previous few years.

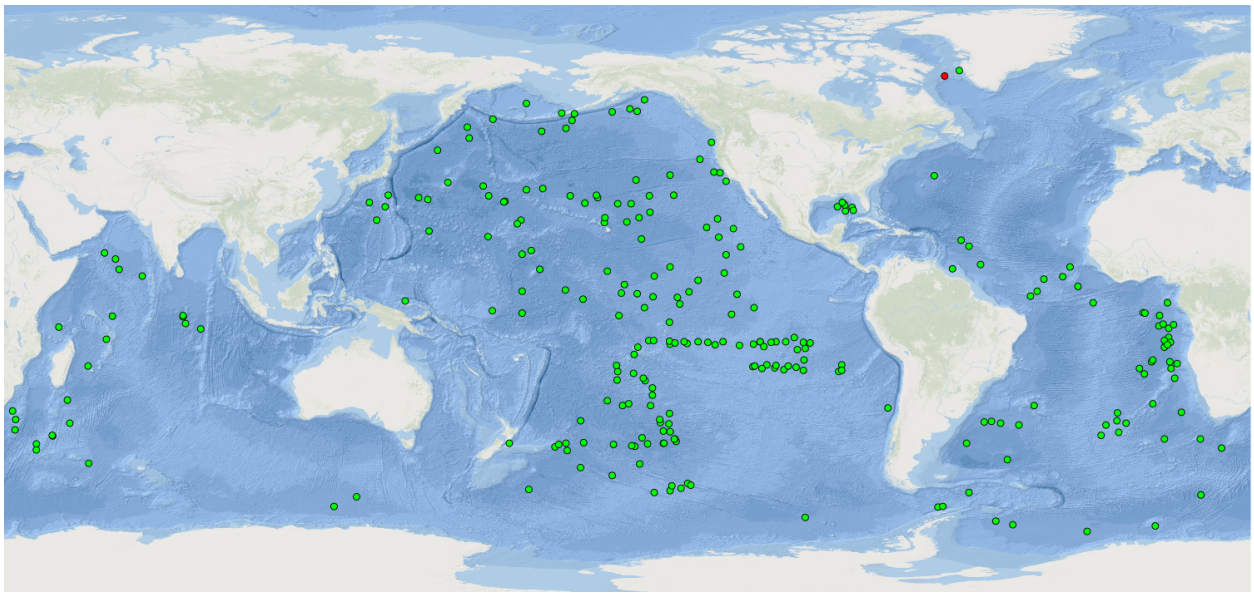

***Fig. 3:*** *March 2023 location of US Argo floats deployed during 2022 (Source: OceanOPS).*

Support for the U.S. Argo Consortium includes float production and deployment; technology improvement; communications; data system development and implementation for real-time and delayed-mode data streams; participation in international Argo coordination, technical workshop,  and science workshops; contributions to Regional Centers; and outreach activities. Work is ongoing to assess the accuracy of CTD data used for the core Argo mission. Salinity drift in recent cohorts of Argo floats is being closely monitored collaboratively with the CTD

manufacturer. An alternative Core CTD manufacturer is entering pilot status with the intent of limiting risk to the Argo Program. The U.S. Argo Consortium is actively involved in testing, quantifying sensor biases, and contributing to the pilot array of RBR CTD equipped floats.

***Deep Argo:***

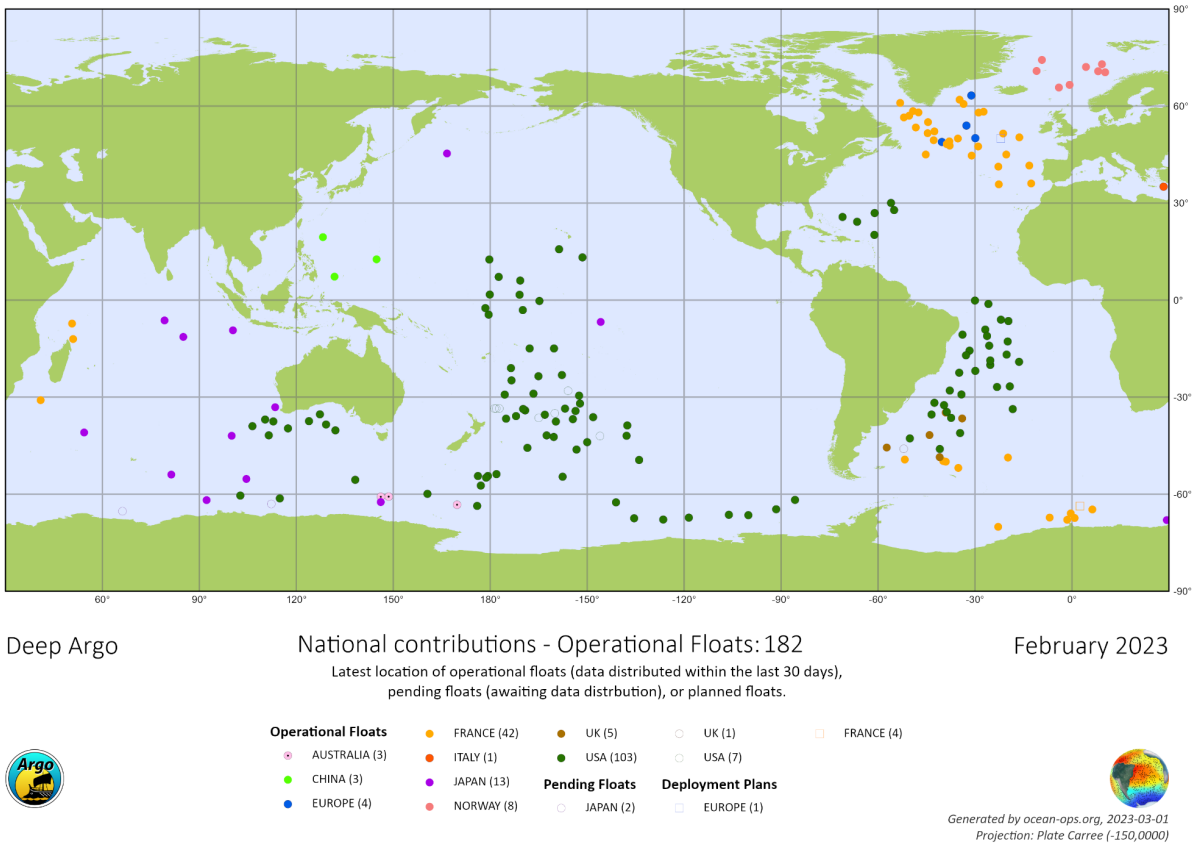


***Fig. 4****: Location of all 182 active Deep Argo floats, as of February 2023, by National Program, with the 103 active U.S. Deep Argo floats indicated by dark green symbols (Source: OceanOPS).*

In 2011–2015, the U.S. Argo Consortium carried out development and testing of Deep Argo floats, with successful prototype float deployments in 2013–2015. U.S. Deep Argo floats profile to pressures as great as 6000 dbar, and recent versions with hybrid lithium batteries are capable of more than 200 cycles. Deployment of U.S. Deep Argo regional pilot arrays began in the SW Pacific Basin in 2016, in the South Australian Basin in late 2016, in the western North Atlantic in early 2017, in the Australian Antarctic Basin in early 2018, in the western South Atlantic in 2019, and in the SE Pacific Sector of the Southern Ocean in early 2023 (Fig. 4).

Testing of Deep Argo float models continues as well as testing of SBE-61 CTD accuracy and stability. The SBE-61 has not yet achieved its aspirational goals of ± .001°C, ±.002 psu, and ± 4 dbar, but is progressing relative to those goals. In partnership with U.S. Argo, a 3-year National Ocean Partnership Program award is funded for improvement of the SBE-61. A collaborative

U.S./New Zealand/SeaBird Scientific cruise on RV Tangaroa will take place in April 2023 for testing/validation of new SBE-61 conductivity and pressure sensors.

***BGC Argo:***

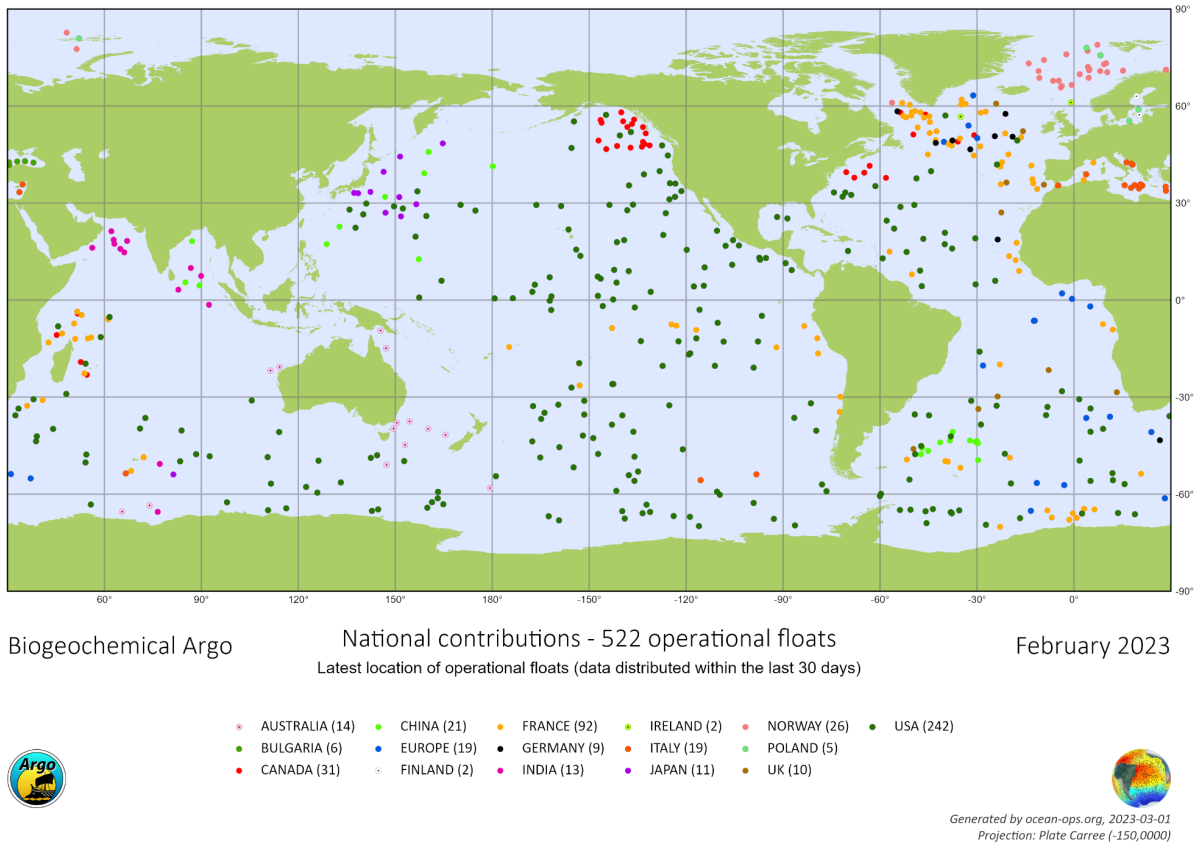


***Fig. 5:*** *Locations of 522 active BGC-Argo floats as of February 2023, including 242 US Argo floats, mostly from SOCCOM and GO-BGC. US BGC floats are indicated as dark green symbols (Source: OceanOPS).*

Since 2012 the U.S. Argo Consortium has carried out testing and deployment of Biogeochemical (BGC) Argo floats. The present versions of these floats cycle 0–2000 m at 10-day intervals and, in addition to the CTD, may carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. A major NSF proposal (SOCCOM) started in 2014 to deploy a 200-float array of BGC floats in the Southern Ocean. A second major NSF proposal (GO-BGC) has recently been funded for global deployments of up to 500 BGC floats over a 5-year period. Two funded NOPP proposals between 2020-2023 have implemented technology improvements to the BGC SOLO and BGC NAVIS Argo float models and have deployed 15 BGC floats in the equatorial pacific. As of February 2023, US BGC floats, mostly from SOCCOM and GO-BGC, with a few US Argo Consortium contributions, number 242 of the total 522 active BGC Argo floats (Fig. 5), of which 192 measure at least five BGC variables.

***Plans:***

The highest priority for the U.S. Argo Consortium is to sustain the Core Argo array, but maintenance of Regional pilot arrays for Deep and BGC Argo will continue in 2023. Specific plans for float deployments in 2023, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Consortium in FY2023 are not yet finalized but are expected to at least equal FY2022 levels.

Deployments are planned along the new RV Kaharoa delivery voyage from Spain to New Zealand(Fig. 6) tentatively planned beginning in January 2024. The ship will deploy ~150 Argo floats (mostly US floats with some float contributions from Australia) along the transit, including 6 US Deep floats. Since 2004, 25 voyages on RV Kaharoa have deployed at least 2172 Argo floats (Source: OceanOPS).

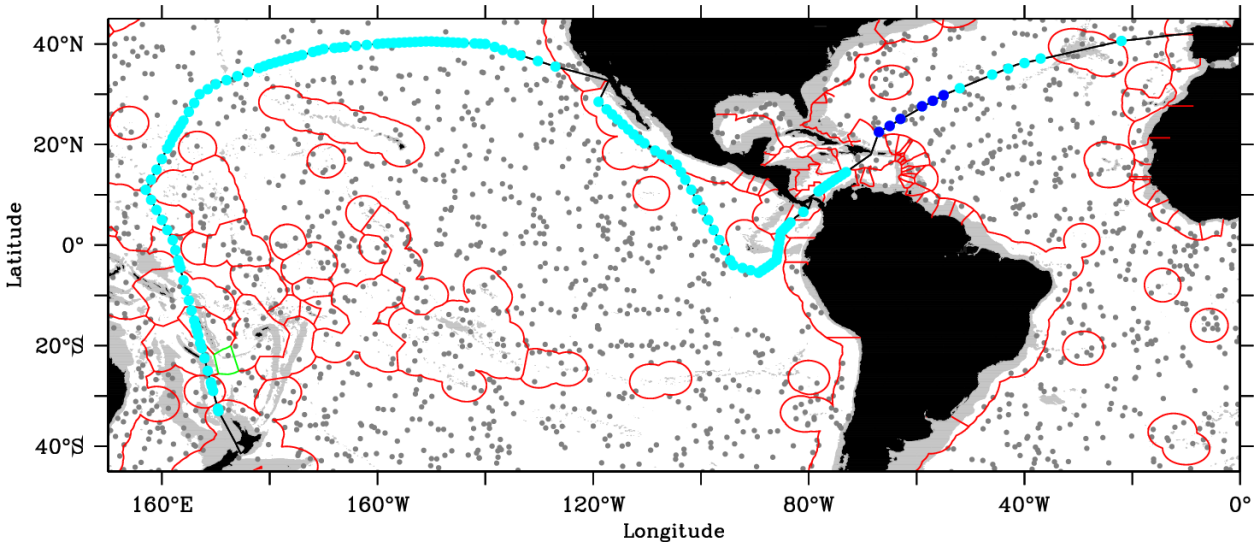


***Fig. 6:*** *Tentative cruise track and deployment plan for the New Kaharoa delivery voyage with planned core (cyan) and Deep (Blue) locations indicated. Existing float locations are shown as gray dots.*

***Data management***

The U.S. Argo Data Assembly Center (DAC) is based at NOAA/AOML. Real-time data from all U.S. Argo floats are distributed via the GTS and to the Global Data Assembly Centers (GDACs). The systems developed at AOML are operational on a primary server housed at AOML and also run on AOML's Argo mirror server at a cloud service provider. These systems apply internationally-agreed Argo-specific quality control tests and generate data files for the user communities that comply with the Argo standards. The U.S. Argo DAC has expanded its decoding and quality control capabilities to include the full suite of BGC data, currently able to accept BGC data from APEX, NAVIS and SOLO-family floats. Delayed-mode quality control and other data management functions of the core parameters are carried out by the float-providing institutions. The real time and delayed mode adjustment of the BGC parameters for GO-BGC and SOCCOM floats are performed at MBARI. The AOML data center serves as the national

focus for data management and is the conduit for delayed-mode data to pass between the PIs and the GDACs.

In addition to the national DAC, a GDAC is run as part of the GODAE server, located at the Naval Research Laboratory, Monterey. The two GDACs at NRL/Monterey and IFREMER/Brest are mirror images in their assemblies of Argo data from all international partners, and are responsible for dissemination of the data. Several U.S. institutions participate in Argo Regional Center activities.