**U.S. Argo National Report to AST-22, March 2021**

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

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

In addition to U.S. Argo's float-providing and data management activities, U.S. Argo 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.
- 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 partnership of NOAA/PMEL and the Paul G Allen Family Foundation that provided 33 Deep Argo floats and carried out deployment of 29 of those in the Brazil Basin.
- National Academy of Sciences Gulf Research Program's support for 25 Argo floats in the Gulf of Mexico

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

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

***Objectives:***

The U.S. Argo Program is funded by NOAA on a year-to-year basis. There is uncertainty in the level of funding that will be available to support the 5-year Work Plan. The projections included in the Plan are optimistic. The assumptions guiding Work Plan scenarios were that (i) Core Argo budgets should increase by 10% per year above the FY2019 institutional funding levels, and (ii) incremental funding of $1M per year will be available for each of U.S. Deep and BGC Argo Programs. The increases for Core Argo are meant first to restore a healthy number of deployments for sustaining the Core Argo array, and second to fund coverage increases, beginning with those proposed for high

latitudes and the equatorial Pacific. A distribution of institutional effort between the Deep and BGC programs has been planned by the U.S. Argo institutional partners. All 4 float-providing institutions will participate in both Deep and BGC Programs, and the U.S. Argo DAC will carry out the corresponding data management. Actual funding levels are likely to be less than the ideal scenarios, in which case the highest priority will be sustaining the Core Argo array.

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

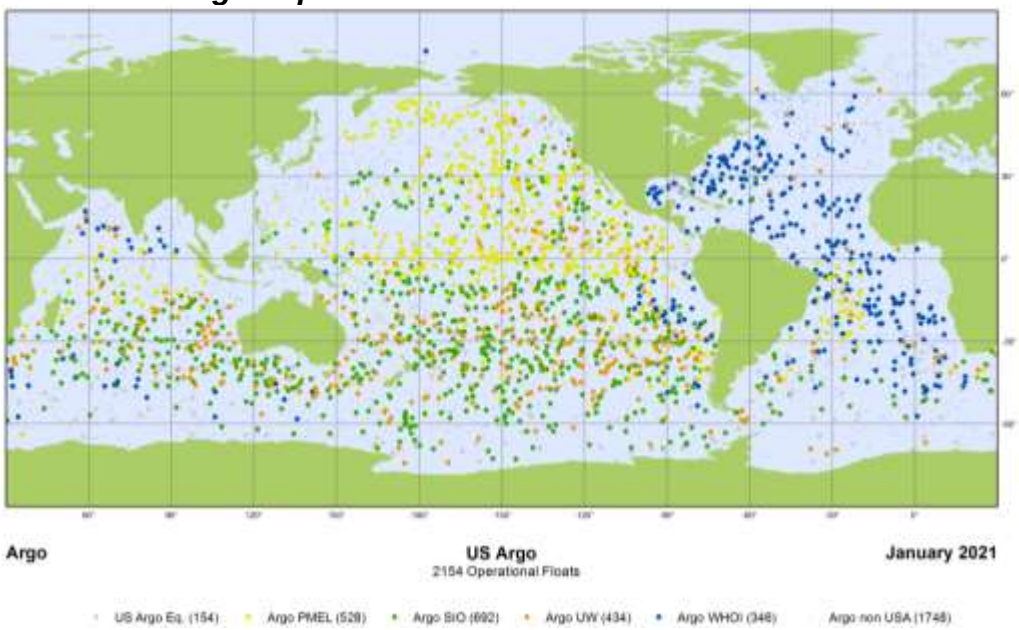


***Fig. 1****: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2021. (Source: OceanOPS)*

Support levels for Core U.S. Argo have remained relatively flat since 2004, with some recent augmentations. Inflationary losses have been offset by increases in float lifetime, so the number of operational U.S. Argo Program floats remains approximately 2000, equal to the high levels achieved since 2008. 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.

There were 2000 operational U.S. Argo Program floats (Fig. 1) as of January 2021. A timeline of the number of operational U.S. Argo Program floats is shown in Fig. 2. Table 1 indicates the number deployed in each year since 2012 and the number presently operational (Source: OceanOPS).

Impacts of the Covid-19 pandemic include limitations on all institutional laboratory activities for physical distancing, a large reduction in available deployment opportunities by the research fleet, and sea freight delays. There were 228 US Argo Program floats deployed between March 2020 and February 2021 (Fig. 3), substantially below the number of floats funded per year. Continuing limitations of the research fleet are causing some hard to reach regions to become sparsely covered. The relatively long life

of Argo floats mitigates the year-long Covid-19 reduction in activities, as illustrated by the continuing nearly-constant number of active US Argo Program floats (Fig. 2).

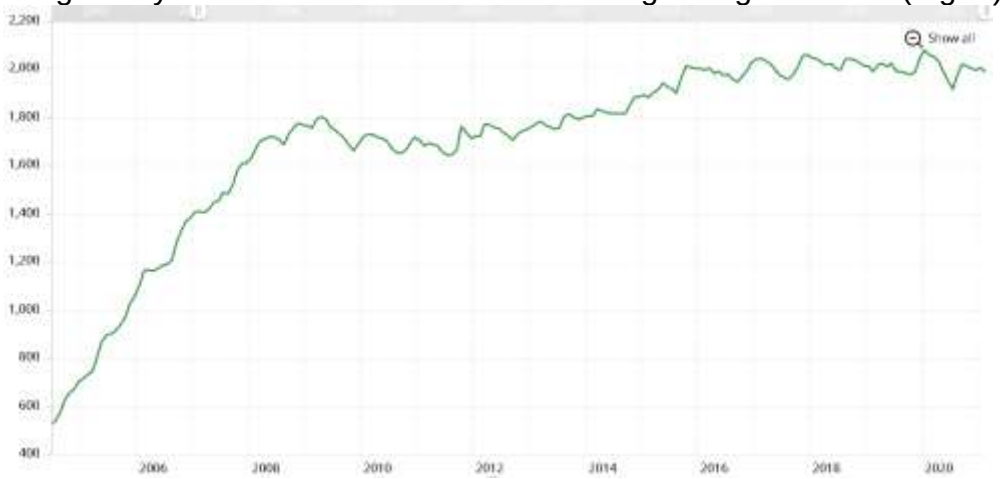


***Fig. 2:*** *Timeline of the number of operational U.S. Argo Program floats (Source: OceanOPS)*

| Year deployed | Number deployed | Number active as of 3/2021 | % active (3/2021) |
|---|---|---|---|
| 2012 | 341 | 39 | 11% |
| 2013 | 329 | 55 | 17% |
| 2014 | 376 | 180 | 48% |
| 2015 | 346 | 236 | 68% |
| 2016 | 346 | 292 | 84% |
| 2017 | 365 | 320 | 88% |
| 2018 | 283 | 259 | 92% |
| 2019 | 294 | 261 | 89% |
| 2020 | 282 | 266 | 94% |

***Table 1:*** *Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 3/2021 (Source: OceanOPS). A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures.*

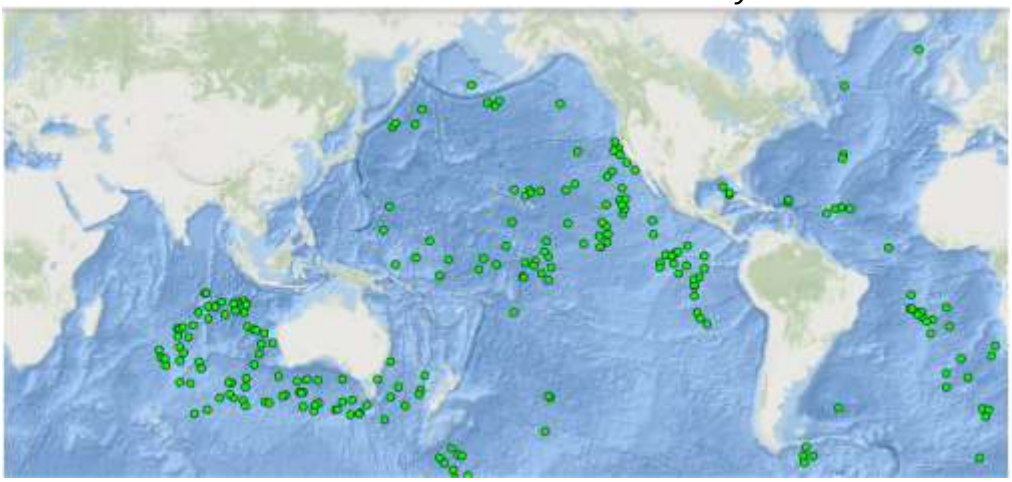

***Fig. 3:*** *Latest location of 228 US Argo Program floats deployed during the first year of the Covid-19 pandemic, March 2020 – February 2021*

Support for U.S. Argo includes float production and deployment, technology improvement, communications, data system development and implementation for real-time and delayed-mode data streams, participation in international Argo coordination and in technical and science workshops, Regional Centers, and outreach activities. Work is ongoing to assess the accuracy of CTD data used for the core Argo mission. Salinity drift in recent cohorts of Argo floats is being closely monitored collaboratively with the CTD manufacturer. An alternative Core CTD manufacturer is entering pilot status with the intent of limiting risk to the Argo Program.

***Deep Argo:***

In 2011–2015, U.S. Argo carried out development and testing of Deep Argo floats, with successful prototype float deployments in 2013–2015. U.S. Deep Argo floats profile to pressures as great as 6000 dbar, and recent versions with hybrid lithium batteries are capable of more than 200 cycles. Deployment of U.S. Deep Argo regional pilot arrays began in the SW Pacific Basin in 2016–present, in the South Australian Basin in late 2016 and 2020, in the Australian Antarctic Basin in early 2018, and in the western North Atlantic in early 2017. In 2019–2020, 29 Deep Argo floats were deployed in the Brazil Basin through a partnership of PMEL/U.S. Argo and the Paul G. Allen Family Foundation (Fig. 4).

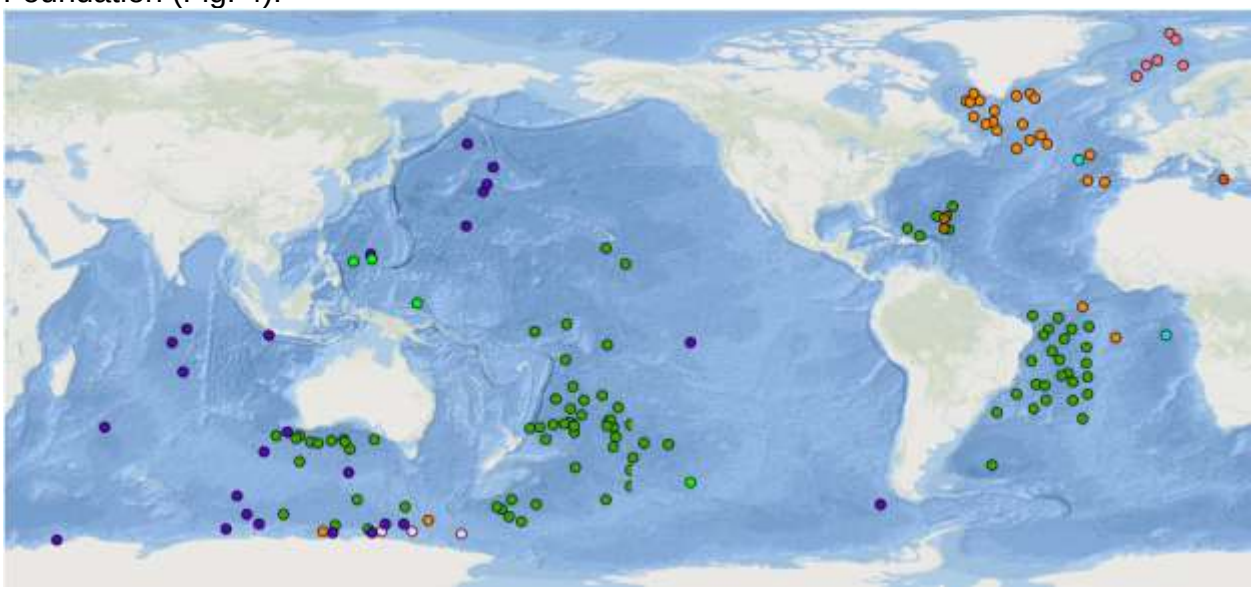

***Fig. 4****: Location of all 157 active Deep Argo floats, as of 3/2021, by National Program. The 89 active U.S. Deep Argo floats are indicated by dark green symbols.*

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 March 2021 for testing/validation of new SBE-61 conductivity and pressure sensors.

***BGC Argo:***

Since 2012 the US has carried out testing and deployment of Biogeochemical (BGC) Argo floats. The present versions of these floats cycle 0-2000 m at 10-day intervals and, in addition to the CTD, may carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. The latest positions of all (with at least 1 BGC sensor) 381 active BGC Argo floats includes the 169 active US BGC Argo and Argo Equivalent) floats are indicated in Fig. 5. A major NSF proposal (GO-BGC) for up to 500 BGC floats over a 5-year period, was awarded in late 2020 and is now underway. A funded NOPP proposal is developing a BGC SOLO float to increase the number of available BGC float models.

***Fig. 5:*** *Locations of 377 active BGC-Argo floats, including 161 US Argo and Argo Equivalent BGC floats. US BGC floats are indicated as dark green symbols.*

***Plans:***

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2021, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Program in FY2021 are not yet set but are expected to equal FY2020 levels.

A deployment cruise on RV Kaharoa, from New Zealand to Kiribati, Cairns Australia, and back to NZ (Fig. 6), is tentatively planned beginning about September 2021, to deploy 8 U.S. Deep Argo floats in the SW Pacific Basin, about 100 U.S. Core Argo floats in the South and equatorial Pacific, plus additional Australia Core Argo floats.

Since 2004, 23 voyages on RV Kaharoa have deployed 2086 Argo floats (Source: OceanOPS).

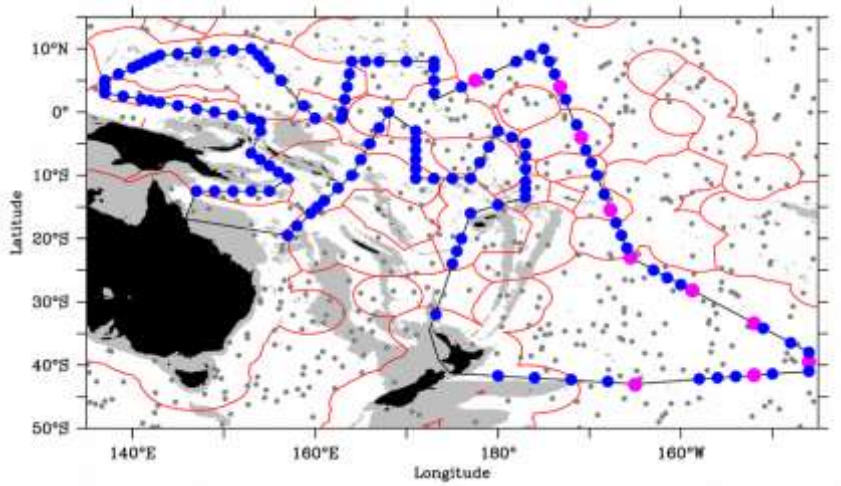


***Fig. 6:*** *Tentative cruise track and deployment plan for the Kaharoa Argo-24 voyage. Blue dots indicate Core Argo floats and magenta dots indicate Deep Argo floats.*

US Argo is teaming up with Euro Argo and Argo Canada to support a dedicated float deployment charter in the Atlantic. The present plan is sketched out below, with the charter start time in late September from Europe and leaving early October from Woods Hole.

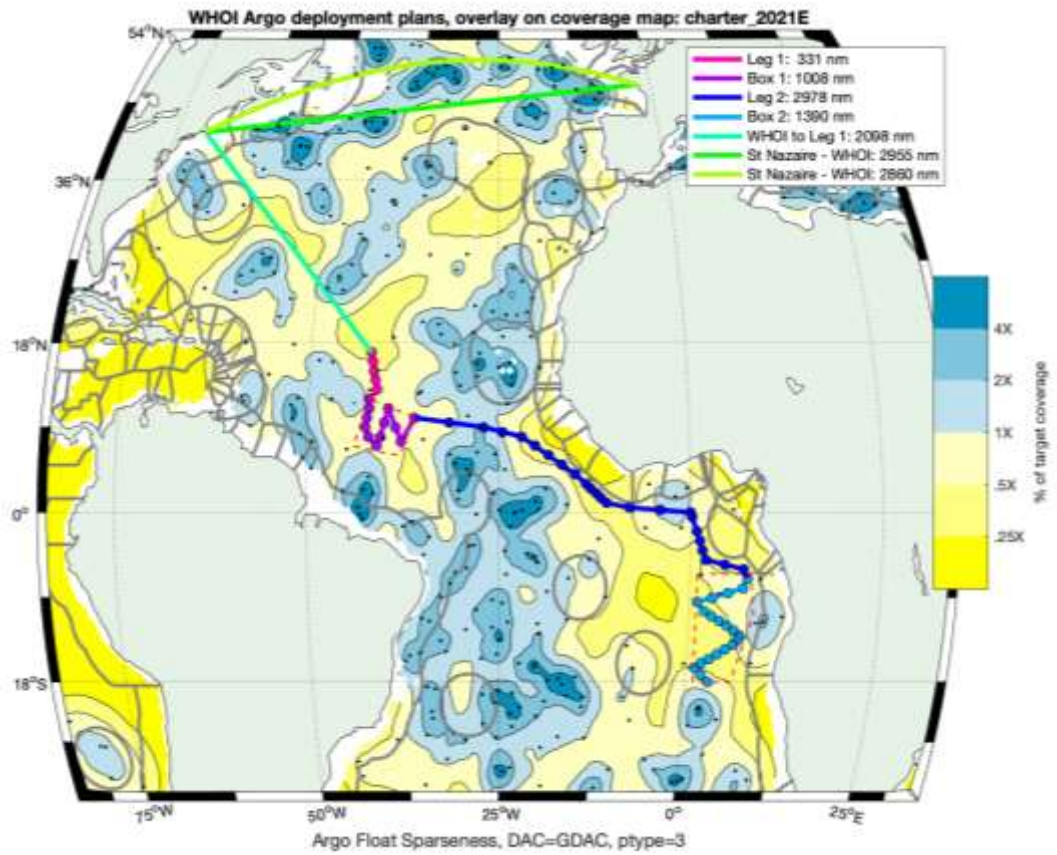


***Fig. 7:*** *Tentative cruise track and deployment plan for the cooperative Atlantic charter for core floats in late 2021.*

### *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 internet. GTS transmission uses parallel systems developed at AOML and housed at AOML and at Collect Localisation Satellites (CLS), implementing internationally-agreed quality control tests. The AOML data center serves as the national focus for data management and is the conduit for delayed-mode data to pass between the PIs and the GDACs. Delayed-mode quality control and some other data management functions are carried out by the float-providing institutions. The Monterey Bay Marine Research Institution is a partner in the real-time and delay-mode management of a large number of US BGC Argo floats. Capability to handle and distribute BGC Argo data is continuing to build up in all US Argo float deploying partner agencies.

In addition to the national DAC, a Global Data Assembly Center (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, including AOML's role as focus for the South Atlantic ARC.