U.S. Argo National Report to AST-21, March 2020

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:

- Southern Ocean Carbon and Climate Observations and Modeling (SOCCOM, Fig. 4), a regional pilot array of BGC Argo floats supported by NSF and NOAA.
- A NOPP project for validation and improvement of the 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.

The present 5-year cycle of U.S. Argo implementation began in July 2015, and extends through June 2020. A Work Plan for a new 5-year cycle of U.S. Argo, to begin in July 2020, has been submitted by the U.S. Float Consortium, externally reviewed, and accepted by NOAA. The Work Plan includes milestones and growth of the U.S. contribution toward a unified Core/BGC/Deep Argo Program (Argo Beyond 2020).

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 are that (i) Core Argo budgets will 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 may 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:

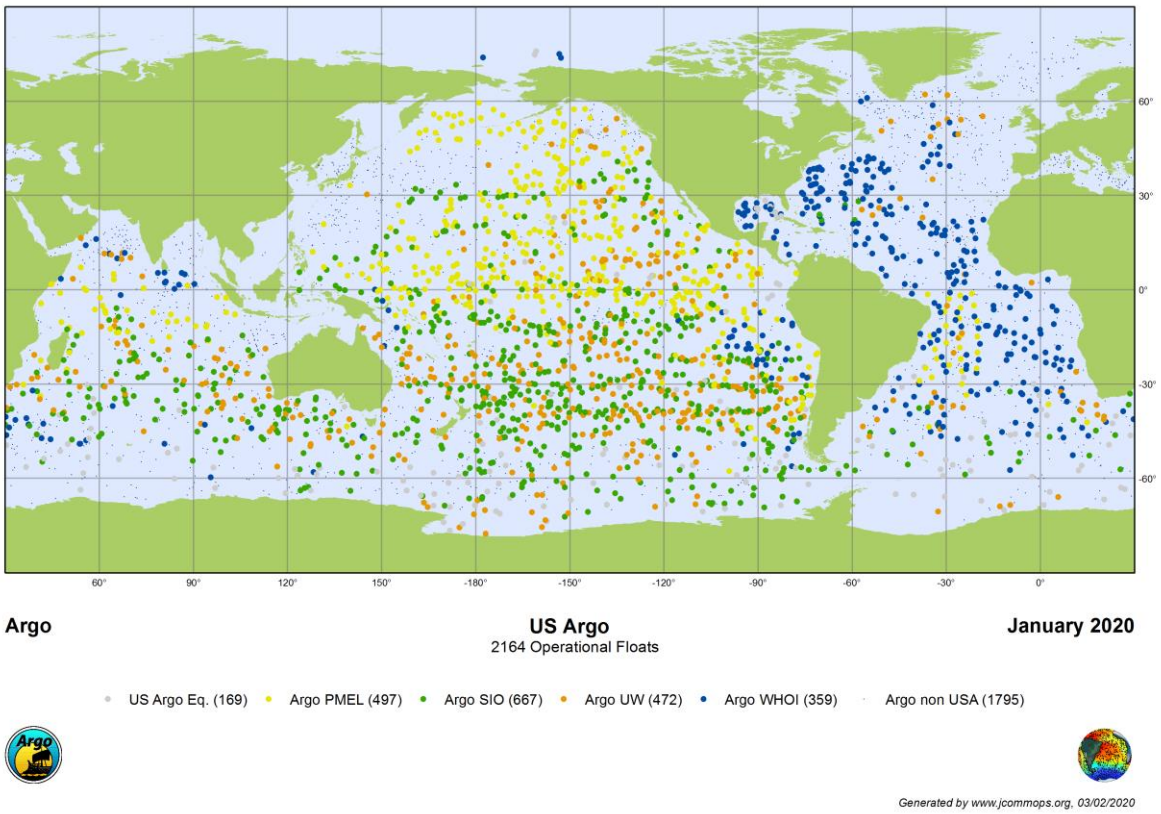

Fig. 1*: Location of operational U.S. Argo Program and U.S. Argo Equivalent floats as of January 2020. (Source: AIC)*

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 2052 operational U.S. Argo Program floats (Fig. 1) as of January 2020. A timeline of the number of operational U.S. Argo Program floats is shown in Fig. 2. Table 1 indicates the number deployed and operational for each year since 2012 (Source: JCOMMOPS).

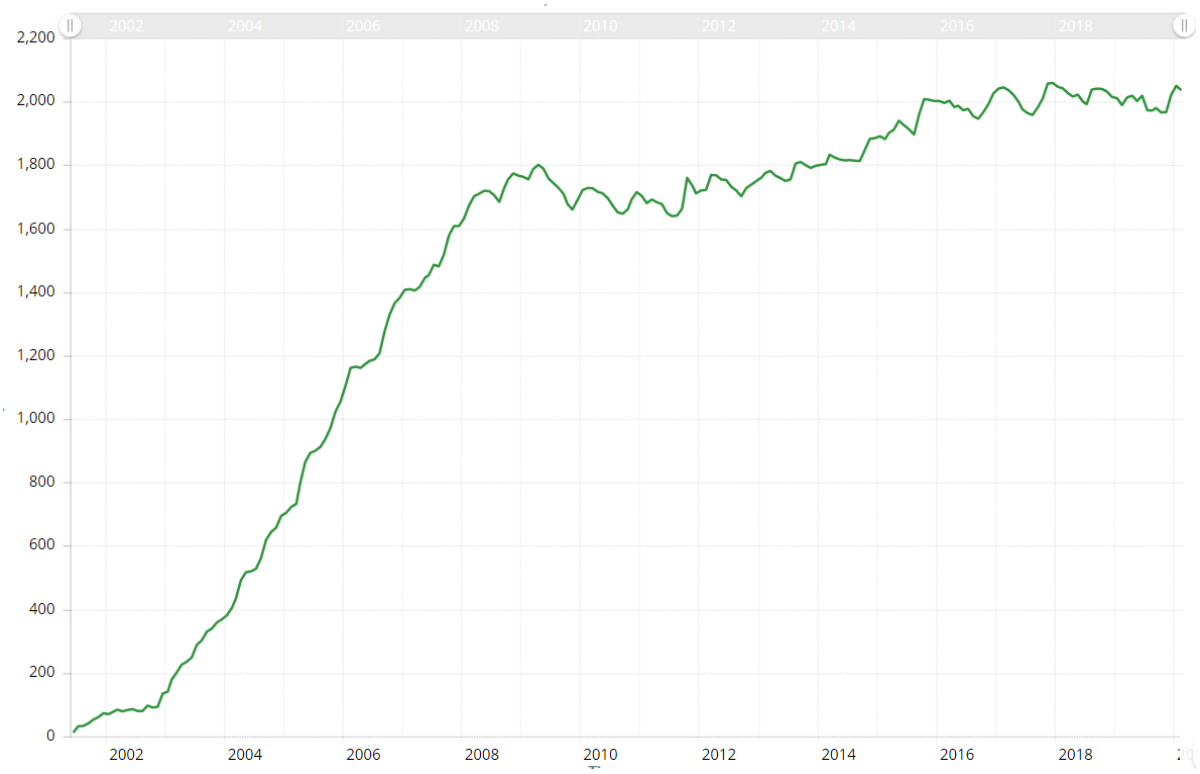

Fig. 2: *Timeline of the number of operational U.S. Argo Program floats (Source: JCOMMOPS)*

Table 1: Number of U.S. Argo Program floats deployed in each year since 2012 and the number still active as of 3/2020 (Source: JCOMMOPS). A major focus of U.S. Argo is extension of float lifetimes and reduction of early float failures.

Year deployed	Number deployed	Number active 3/2020	% active (3/2020)
2012	341	62	18%
2013	329	121	37%
2014	376	243	65%
2015	346	253	73%
2016	346	313	90%
2017	365	336	92%
2018	286	272	95%
2019	268	252	94%

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.

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 planned for 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 (Figure 3).

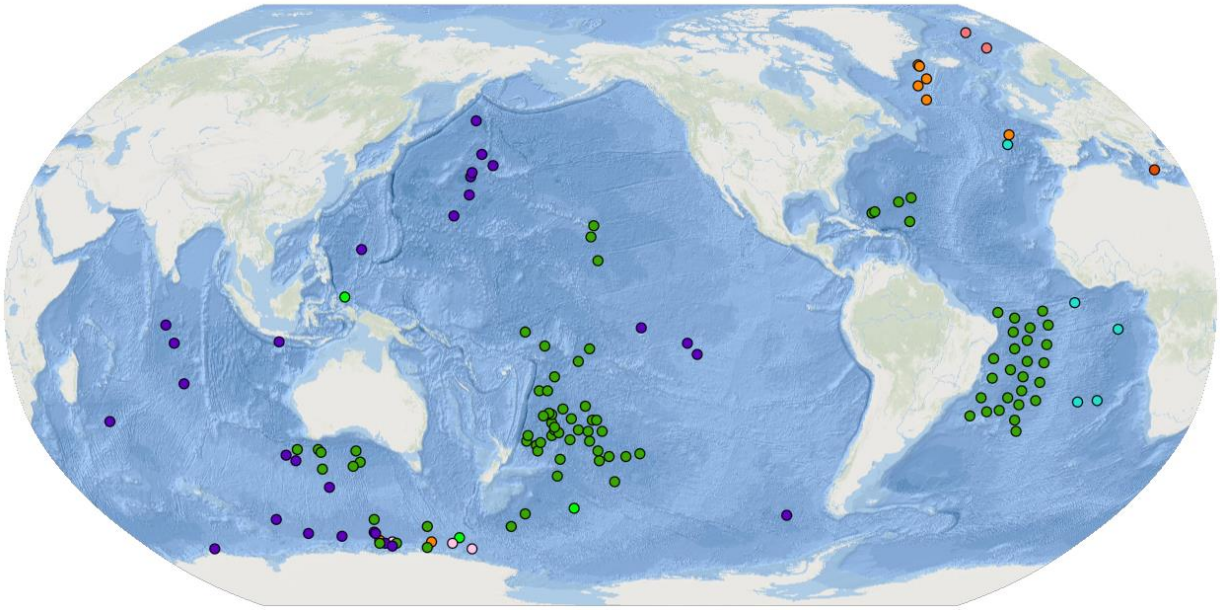

Fig. 3*: Location of all 136 active Deep Argo floats, as of 3/2020, by National Program. The 86 active U.S. Deep Argo floats floats are indicated by dark green symbols.*

Testing of deep 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 ± .001C, ±.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.

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, carry sensors for dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and particulate backscatter. The SOCCOM BGC float array in the Southern Ocean now contains 154 operational BGC floats, progressing towards a goal of 200 floats by the end of 2021 (see Fig. 4). The floats are performing well with lifetimes roughly comparable to Core Argo floats. A continuation of SOCCOM has been proposed and will be supported, and a major NSF proposal

for up to 500 BGC floats is pending. A funded NOPP proposal will develop a BGC SOLO float to increase the number of available BGC float models. As part of pilot activities, NOAA has funded two BGC-Argo floats to be deployed into the North Atlantic, and with NASA funding, a third. All of these Argo-related projects are coordinated with U.S. Argo.

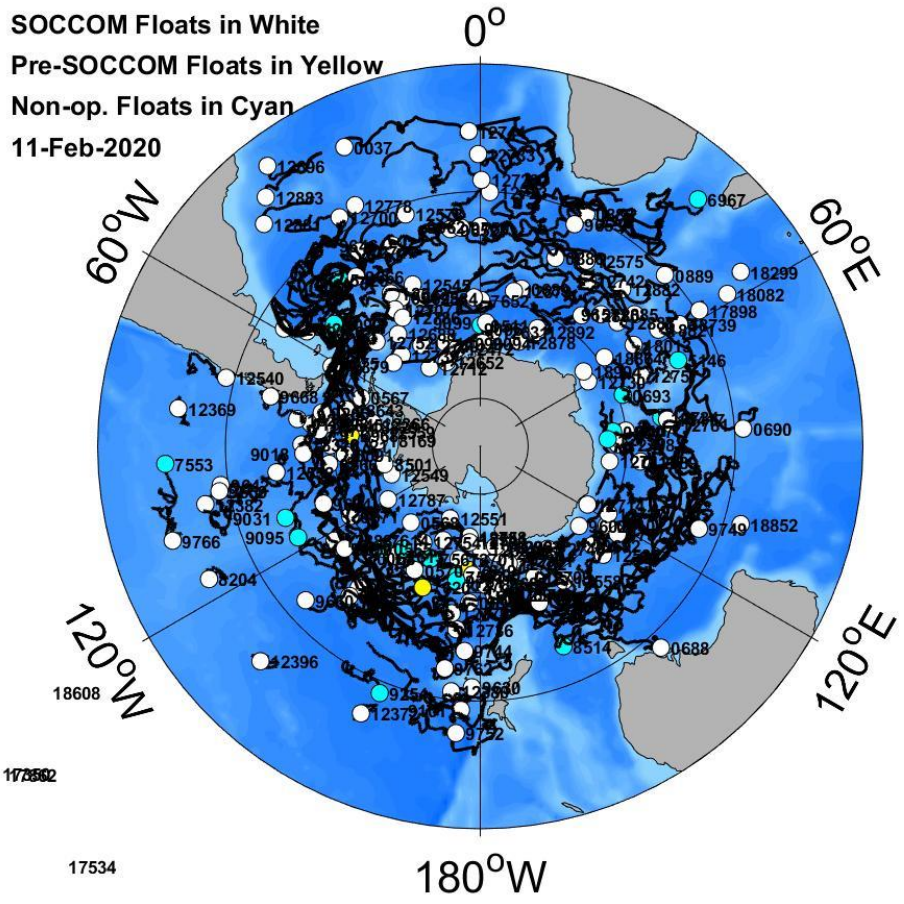

Fig. 4 *Locations of 154 active BGC-Argo floats (white symbols) deployed as part of the SOCCOM project in the Southern Ocean.*

Plans:

The highest priority for U.S. Argo is to sustain the Core Argo array. Specific plans for float deployments in 2020, as they evolve, are posted on the AIC deployment planning web page. Funding levels for the U.S. Argo Program in FY2020 are not yet set but are expected to include increases relative to FY2019 levels.

A major U.S./New Zealand/Australia Argo deployment cruise from New Zealand to Chile and back on RV Kaharoa was carried out in late-2019/early 2020. This voyage deployed 92 U.S. Core Argo floats in the South Pacific Ocean plus 10 U.S. Deep Argo floats in the SW Pacific Basin, enlarging the regional pilot array there (Fig. 3). A deployment cruise on RV Kaharoa, from New Zealand to Mauritius, is planned beginning July 2020 to deploy 5 U.S. Deep Argo

floats in the South Australian Basin, plus 100 U.S. Core Argo floats in the South Pacific and South Indian Oceans. Over 1900 Argo floats have been deployed by RV Kaharoa in 2004-2020 (Fig. 5). A Deep Argo SBE-61 CTD validation cruise is planned for October 2020 on RV Tangaroa, with support from NIWA/New Zealand, NOAA/U.S. Argo, and Seabird Scientific.

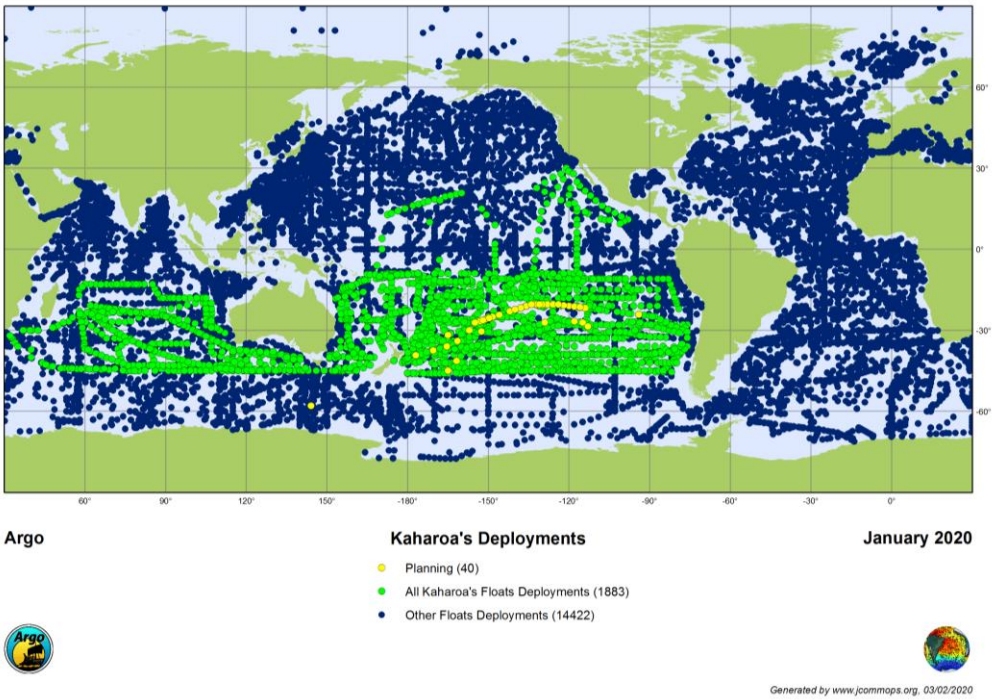

Fig. 5: *Locations of over 1900 Argo floats deployed by RV Kaharoa since 2004 (Green and yellow symbols). Those marked "planning" in the January 2020 map have been deployed. Deployment voyages are supported by U.S., New Zealand, and Australia Argo Programs. Argo could not have achieved and cannot sustain global coverage without dedicated deployment voyages in the South Pacific and South Indian Ocean. (Source: AIC)*

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.

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.