11/30/2016

A proposal for an OCB topical subcommittee focused on Biogeochemical-Argo

Kenneth Johnson, Emmanuel Boss

## Summary

There is a growing, international consensus that development of a global, Biogeochemical-Argo observing system is an essential next step for ocean science and marine resource management (Biogeochemical Argo Planning Group, 2016). This consensus has been developed through a series of working groups (Gruber et al., 2007) and international meetings(Claustre et al., 2010; Gruber et al., 2010; Johnson et al., 2009), and AGU Town Hall meetings in 2012 and 2016. Many of these activities were sponsored by OCB.

As a result of this planning, an International Steering Team is in development (www.biogeochemical-argo.org) and a Biogeochemical Argo Science and Implementation Plan has been developed. However, the primary structure of the Argo system is a federation of national systems. There is currently no formalized structure for US Biogeochemical-Argo. We are proposing that the OCB establish a topical subcommittee for Biogeochemical-Argo (US Biogeochemical-Argo Steering Team) to support and focus US efforts in this area. This would include support for a series of initial meetings that establish and refine the operation of this committee.

## Background

Biogeochemical-Argo is the extension of the Argo array of profiling floats (Riser et al., 2016) to include floats that are equipped with biogeochemical sensors for pH, oxygen, nitrate, chlorophyll, suspended particles, and downwelling irradiance with real-time, public data access (Johnson and Claustre, 2016). A Biogeochemical-Argo array would enable direct observation of the seasonal to decadal-scale variability in net production, the supply of essential plant nutrients from deep-waters to the sunlit surface layer, ocean acidification, hypoxia, and ocean uptake of carbon dioxide. It would extend ocean color remote sensing observations deep into the ocean interior and throughout the year in cloud and ice covered areas or during polar winter. The system would drive a transformative shift in our ability to observe and predict the effect of climate change on ocean ecology, metabolism, carbon uptake, and marine resource modeling. These capabilities match closely with the overarching themes of the Ocean Carbon and Biogeochemistry program: ocean uptake of $CO_2$ and environmental sensitivities of biogeochemical cycles and marine ecosystems.

Planning to implement a global, biogeochemical observing system has been approved by the Argo Steering Team (AST). The AST is an international group with representation from 20 nations (http://www.argo.ucsd.edu/members.html) that provides scientific leadership and oversight for operation and technical development of the Argo program. The AST does not provide funding for this planning. This is accomplished primarily through national programs of the member countries (over 30 in total). The AST works with these national programs to ensure that the array of floats meets its primary objectives of observing ocean heat content and salinity and determining subsurface velocity, as well as approved extensions such as Biogeochemical-Argo.

Following approval to begin planning for Biogeochemical-Argo, a meeting was held 11-13 January 2016 in Villefranche-sur-Mer, France with attendees from Australia, Canada, China, Japan, France, Germany, the United Kingdom, and the United States. This meeting was self-funded by the participants, which speaks to the depth of their interest in the concept of a global system. The attendees at the meeting (the Biogeochemical Argo Planning Team) developed a Science and Implementation Plan that was built on the discussions in Villefranche. Draft copies of this report were distributed to the OCB mailing list and a session on Biogeochemical-Argo was held at the US OCB summer workshop. Responses to input from the OCB community were incorporated into the draft and a copy of the report is available at www.biogeochemical-argo.org. The detailed rationale and capabilities of such a system are discussed in this report. International support for the plan was acknowledged at the Group of Seven (G7) Science Ministers meeting that preceded the meeting of the leaders of the G7 nations in late May at Ise-Shima in Japan (http://www8.cao.go.jp/cstp/english/others/communique_en.html). In the case of Biogeochemical-Argo, the AST would work with the national programs to ensure that the objectives outlined in the Science and Implementation Plan are being credibly met.

At this point, it is the responsibility of each national program to begin consideration of how it might implement a program that can operate within the framework outlined in the Science and Implementation Plan. In the US, the core Argo program (temperature and salinity) is focused through the activities of four primary laboratories (WHOI, SIO, UW and PMEL) that prepare and deploy US floats, AOML which hosts the US data center, and Naval Research Laboratories/Monterey which hosts one of the two Argo Global Data Assembly Centers. This group does not have a formal structure and meets only irregularly. Funding for the core US Argo program comes from the NOAA budget and much of the internal US planning is developed as each 5 year NOAA proposal is created. The primary US contributions to International Argo planning occur through US leadership on the AST and participation in ADMT (Argo Data Management Team) meetings.

The process supporting the core US Argo program has been highly successful. The US supports just more than half of the profiling floats in the Argo fleet. This global project has resulted in more than 2500 peer-reviewed publications. However, while an informal structure works well for the core US Argo program, we believe that a more comprehensive process would benefit the development a US contribution to a biogeochemical observing system, particularly during its initial phase.

A US Biogeochemical Argo program will likely grow with funding from a variety of agencies, rather than the single role that NOAA plays in the core US Argo program. For example, the SOCCOM program (soccom.princeton.edu; Southern Ocean Carbon and Climate Observations and Modeling) operates with primary funding from NSF and additional contributions from NOAA and NASA. Biogeochemical profiling floats directly funded by NASA are operating for the NAAMES project and this may also be the case for the EXPORTS program. In addition, biogeochemical profiling floats have been deployed by at least five more US groups through individually funded projects. If a US program is to evolve, it will likely require a broad base of support that meets the needs of all of these PI's, agencies, and the community of scientists that use the data. The highly focused process that now sustains the core US Argo program through a single proposal to NOAA is not well suited for US Biogeochemical-Argo.

The authors of this proposal believe that OCB could play a critical role in the development of Biogeochemical-Argo by acting as the focal point with a topical subcommittee on this topic. As noted above, the major objectives of the global system, which are outlined in the Biogeochemical-Argo Science and Implementation Plan, are closely allied with OCB's

overarching themes and its current research priorities. This includes climate and human impacts on ocean chemistry such as deoxygenation and acidification, ocean carbon uptake, and the biological carbon pump.

Steering Team Objectives

The US Biogeochemical-Argo Steering Team will be focused on biogeochemical float operations that are generally compatible with Argo protocols and the additional goals outlined in the Biogeochemical Argo Science and Implementation Plan. These are floats that operate on multi-year missions with a global distribution for the complete array. The Argo program operates under IOC Resolution XX-6, which mitigates many of the requirements for international clearances. One of the requirements of this resolution is that "the data and data products derived from those floats will be freely available in real-time and delayed mode through IOC and WMO data exchange systems". The requirement to make data available through these systems puts a fairly large burden on float deployers, in terms of data transfer. It also removes a large burden in terms of international clearances, which can be problematic for a drifting float. To ensure compliance with the requirements of Resolution XX-6, this committee will focus on operations that follow the Argo protocols for float operation, which make data available in near real time with no restrictions.

Within those parameters, the major functions of the committee would be as follows:

1) Serve as a focal point for US community input on the global, biogeochemical float array. The main function of the system is to make data available to the broader community for analysis and for outreach activities. The committee would ensure a venue for input on such activity and carry such input to the International Biogeochemical-Argo Steering Committee.
2) Provide for guidance for data processing. The US Argo Data Assembly Center will not, now, process biogeochemical float data. As a result, a Biogeochemical Data Assembly Center is now in operation for the SOCCOM program at MBARI. For small projects that wish to enter data in the Argo system, processing data to the Argo standards is not very practical. The committee will provide guidance for such programs and work to ensure that there is a capacity for operators who wish to make data available following Argo standards.
3) The committee can serve as a focal point for float science program development. It is possible that a US program will evolve as a series of focused science projects such as SOCCOM. The committee would ensure coordination between such programs.
4) Argo operates under Resolution XX-6. Within that framework, biogeochemical sensors are in a grey area as they are not explicitly recognized. Efforts are now underway to resolve this and the committee could provide significant assistance in this area.
5) As noted above, the committee will provide US input to the International Biogeochemical-Argo steering committee.
6) Through workshops and other venues, the committee can provide advice and assistance to sensor developers wishing to interact with the Argo system.
7) The committee can provide a focal point for community and industry interactions, such as efforts to incorporate novel sensors on float platforms.
8) The committee can assist funding agencies with planning and efforts to establish capacity (e.g. centralized data hubs and QC as for Argo).
9) The committee will report to OCB and to the Argo Steering Team on US and international activities.

Finally, the committee will consider developing a workshop that follows on the successful OCB Scoping Workshop "Observing Biogeochemical Cycles at Global Scales with Profiling Floats and Gliders". This workshop would have development of the US contribution to a global Biogeochemical-Argo observing system as its major focus. We are not proposing this workshop now, but consider it as a task that the proposed Steering Committee should consider at its first meeting.

Benefit to OCB

This program will have direct benefit to OCB by contributing to the establishment of an effective, international ocean observing program that addresses the major themes and research priorities of OCB. It will provide data to the community in an open and unrestricted manner that will greatly improve our understanding of ocean processes and our ability to predict future trajectories of ocean change.

Potential Committee Structure and Membership

The committee serves as a conduit between the community of oceanographers interested in Biogeochemical-Argo, Federal Agencies, OCB, the Argo program and technologists developing platforms and sensors. The US Biogeochemical-Argo Steering Committee should consider all of these groups in its membership. A final committee size of about 10 is probably appropriate, but we also consider that an initial planning meeting of the committee may involve a larger group to help ensure appropriate consideration of viewpoints. Following this initial meeting, an operating committee would form. We will seek members from academic and NOAA laboratories. There would be ex-officio links to OCB, AST, the Argo Data Management Team and the GO-SHIP Steering Committee. The committee would include an Executive Committee of 2 or 3 individuals that coordinate day to day interactions with agencies and other organizations as appropriate.

The following is a list of potential attendees at the initial planning meeting, with a short note on their background. This list seeks a balance of interests, committee needs, institutional backgrounds, career level, and diversity. An appropriate size for the initial meeting would be 15 to 20 individuals. That meeting would then select a Steering Committee of about 10 persons going forward. Note that we have not contacted most of these persons, but they would likely be on the invitation list.

Kenneth Johnson, MBARI, Sensor developer, data user, Co-Chair International Biogeochemical-Argo
Emmanuel Boss, U Maine, leads of biooptic float efforts in SOCCOM and NAAMES
Brendan Carter, NOAA PMEL, data user
John Dunne, NOAA GFDL, float data in models
Steve Emerson, UW, O2 on floats and operating ~20 biogeochemical floats
Meg Estapa, Skidmore College, float deployer, data user
Alison Gray, UW (starting 2017), data user
Todd Martz, SIO, sensor developer, float data user
Matt Mazloff, SIO, assimilating float data into state estimate models
Melissa Omand, URI, sensor developer, data user
Steve Riser, UW, AST member, float technologist, data user
Joellen Russell, U Arizona, SOCCOM float data models, data user
Jorge Sarmiento, lead of SOCCOM program
Yui Takeshita, MBARI, float data user

Scott Doney, WHOI, ex-officio link to OCB,
Megan Scanderbeg, SIO, ex-officio ADMT Co-Chair
Lynne Talley, SIO, ex-officio link to GO-SHIP
Federal Agency representatives from NSF, NOAA, and NASA

Budget

The US Argo Biogeochemical Steering Team will operate with one meeting per year. In out years, the goal would be to link these meetings to either an OCB Summer Workshop or an Ocean Sciences Meeting to minimize travel costs. However, in years 1 and 2 we believe it will be most effective to have a dedicated meeting each year to ensure rapid implementation of the program. A 2-year budget therefore calls for 1 meeting each year with a nominal cost of $20,000 in year 1 and $10,000 to $15,000 in year 2 (travel costs at ~ $1,000 per person average, 15 to 20 persons in year 1, 10 to 12 persons in year 2). The meeting would be held at a cost effective venue on the east or west coast.

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