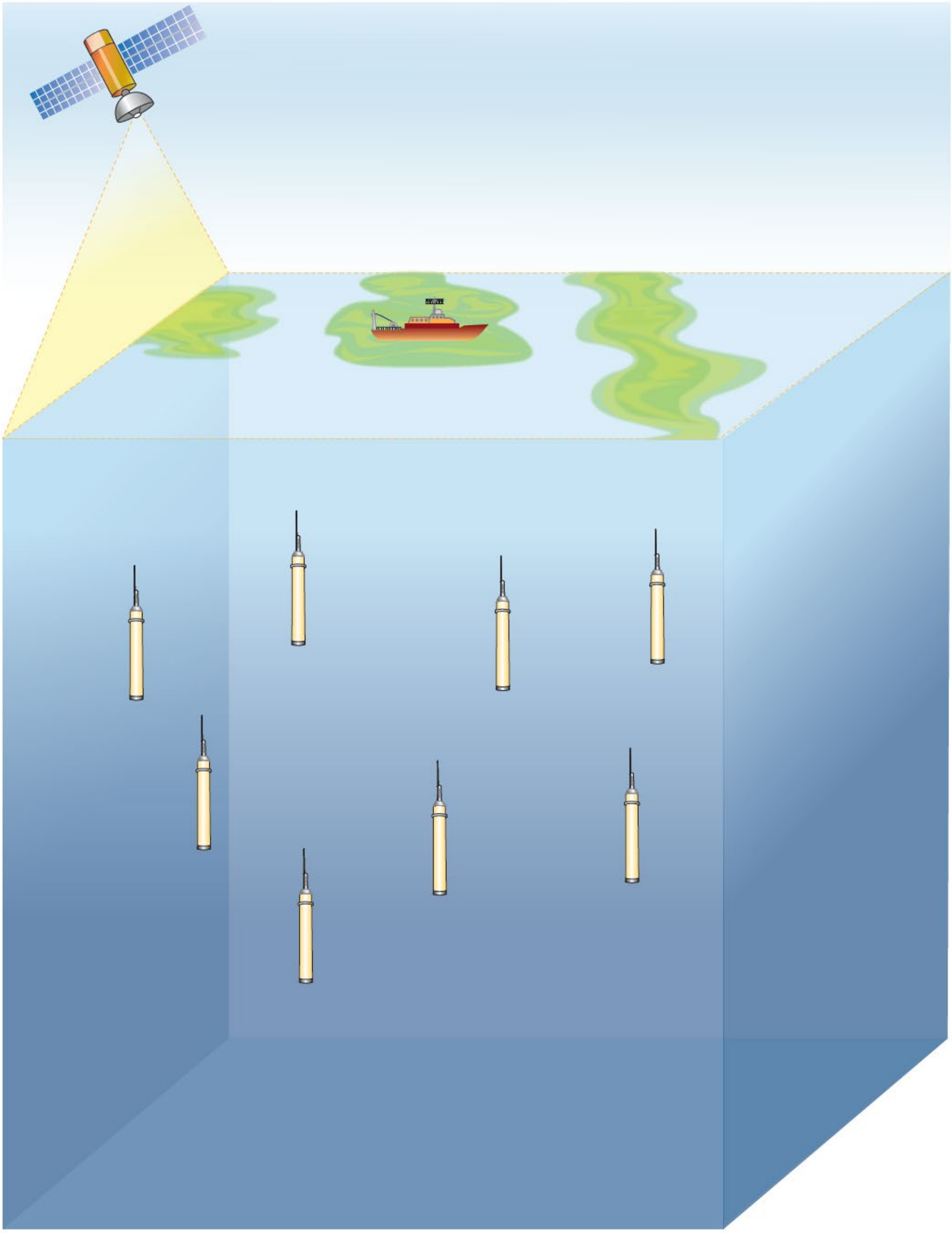
# Australian Biogeochemical-Argo workshop

5–8 November, 2018 • IMAS, UTAS



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**The Workshop Aims:**

1. To assess the current status of BGC-Argo research across Australia
2. To ascertain the directions of international BGC-Argo research in the next 5 to 10 years
3. To look at BGC-Argo in the wider context of other remote sensing (satellite and bio-loggers) and modelling initiatives
4. To mesh Australian research plans with international efforts and our regional interests in the Southern, Indian, and Pacific Oceans
5. To prepare for the creation of an IMOS BGC-Argo sub-facility

**The Workshop Agenda**

The Agenda (Appendix 1) was divided into a half-day pre-meeting on Monday November 5$^{th}$ for Australian participants to discuss these aims and prepare to produce this report, followed by 3 days of presentations and discussions.

**This Workshop Report**

1. Lists the talks that addressed the first 3 Aims of the workshop (Appendix 1).
2. Summarises Australian activities with respect to international efforts.
3. Extracts insights from the presentations and discussions regarding advances in BGC-Argo float methodologies, sensors, batteries and their application to important problems.
4. Describes priorities for structuring the initial focus of an Australian IMOS BGC-Argo sub-facility.

**Background**

BGC-Argo float capabilities have been demonstrated through projects in many ocean basins over the past decade. This activity has been united via the creation of the International Biogeochemical-Argo (iBGC) project (www.biogeochemical-argo.org) which displays the status of the current float array, collates publication outputs, coordinates best practice approaches to deployment and quality control and assessment, and promotes development of a sustained global array. Figure 1 shows a recent status map and Figure 2 reveals that Australia has contributed importantly to the development of this effort. Notably, not all floats carry the same constellation of sensors, or follow the same missions in terms of profiling depths or repeat frequencies.

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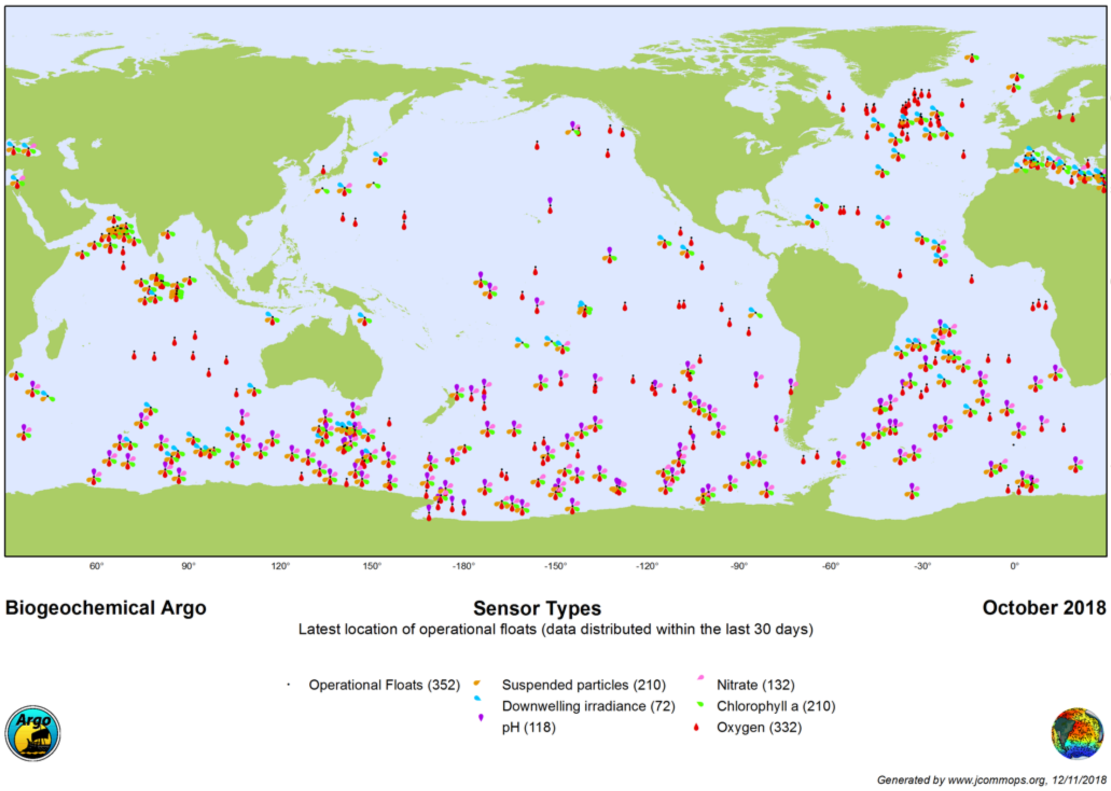
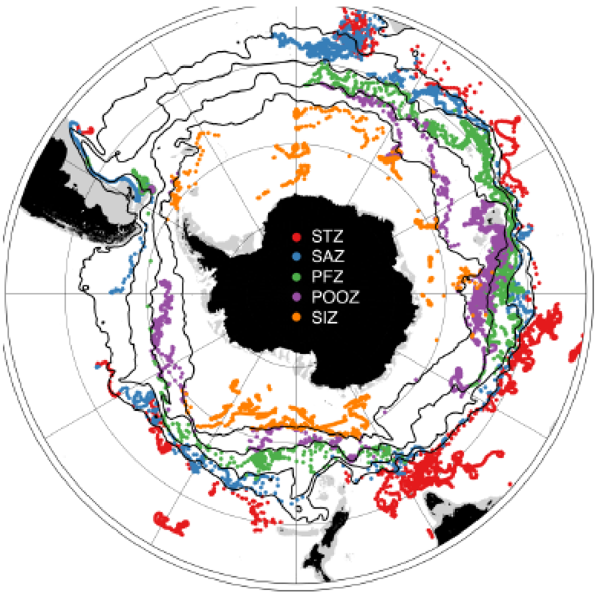



**Figure 1.** October 2018 status map for BGC-Argo floats with varying sensor configurations.




| Institution | Num. float | Num. profiles | Contribution of the total profiles (%) |
|---|---|---|---|
| AOML-NOAA | 52 | 3485 | 26 |
| CORIOLIS | 27 | 4408 | 33 |
| CSIRO | 16 | 4489 | 37 |
| INCOIS | 7 | 403 | 43 |
| TOTAL | 102 | 12785 | |

Total ≈13000 BGC-ARGO profiles
Period: 2010-09-13 until now

**Figure 2**. BGC-Argo deployments have been particularly frequent in the Southern Ocean, led by the US SOCCOM and European SOCLIM projects. Australian CSIRO contributions have been significant, especially in terms of number of profiles because of a focus on high frequency relatively shallow profiling.

In 2016 the international BGC-Argo project issued an Implementation Plan for a global array. Based on model simulations and correlation length scale assessments, in particular for the applications of constraining ocean $CO_2$ uptake and determining chlorophyll fields, the plan suggested the following array parameters:

1. A repeat frequency of 5-7 days to address timescales of ocean biomass changes
2. Profiles to at least 1000m to allow deep ocean climatology to serve as a reference (with a preference for 2000m to match core Argo protocols)
3. A constellation of 6 sensors as shown in Figure 3, to:
   3.1 allow improved validation via comparing sensors
   3.2 provide measurement redundancy for key biogeochemical processes
   3.3 address a broad range of applications

The Implementation Plan recognized that many important science advances have been and will continue to be achieved with different sensor configurations and different missions, that other sensors have merit, and that new sensors will continue to become available. But these needs and improvements must be balanced against assessment of what is achievable and affordable. Choosing optimal approaches to addressing these issues remains an important part of developing momentum towards a global BGC-Argo array, and its inclusion in a "One Argo" array which would address physical and biogeochemical research issues, and expansion to include the deep ocean (>2000m) in a synergistic way (Roemmich et al, 2019. OceanObs 2019 paper in review for Frotiers in Marine Science).

| Variable (EOV type) | Sensor Type | Accuracy/Precision | Reference |
|---|---|---|---|
| Oxygen (1,3,4) | Lifetime optode | 1% of surface $O_2$ / 0.2 µmol $kg^{-1}$ | [*Körtzinger et al.*, 2004]; [*Bittig et al.*, 2015]; [*Johnson et al.*, 2015] |
| Nitrate (1,4) | Ultraviolet photometer | 1 µmol $kg^{-1}$ / 0.1 µmol $kg^{-1}$ | [*Johnson et al.*, 2013a] |
| pH (1,4) | Ion Sensitive Field Effect Transistor | 0.01 pH / 0.0005 pH | [*Johnson et al.*, 2016] |
| Chlorophyll (2,3,4) | Fluorometer | Max (30%,0.03 mg Chl *a* $m^{-3}$)/0.025 mg Chla $m^{-3}$ | [*Boss et al.*, 2008b] |
| | Radiometer | Max (24%,0.03 mg Chla $m^{-3}$)/0.025 mg Chla $m^{-3}$ | [*Xing et al.*, 2011] |
| Suspended particles (3) | Optical back-scatter | Suspended particles: Max (50%, 1.5 µg $kg^{-1}$) /1 µg $kg^{-1}$) | [*Boss et al.*, 2015] |
| | | Backscattering coefficient: Max (10%, $10^{-5} m^{-1}$) / 4 x$10^{-6} m^{-1}$ | [*Sullivan et al.*, 2013] |
| | | POC : Max (30%, 20 mg $m^{-3}$) / 10 mg $m^{-3}$ | [*Cetinic et al.*, 2012] |
| | | PC: Max (30%, 6 mg $m^{-3}$)/ 3 mg $m^{-3}$ | [*Graff et al.*, 2015] |
| Downwelling irradiance (3,4) | Radiometer | PAR: Max (3%, 5 µmol photons $m^{-2} s^{-1}$)/1 µmol photons $m^{-2} s^{-1}$ | Manufacturer web site |
| | | Spectral: Max (3%, 5 X$10^{-3}$ µW $cm^{-2}$ $nm^{-1}$) / 2.5 X$10^{-3}$ µW $cm^{-2}$ $nm^{-1}$ | |

**Figure 3.** Sensor set recommended in the iBGC-Argo Implementation Plan. The first 3 sensors focus on biogeochemistry and measured dissolved chemical concentrations. The other three target biological particles and the light that they absorb.

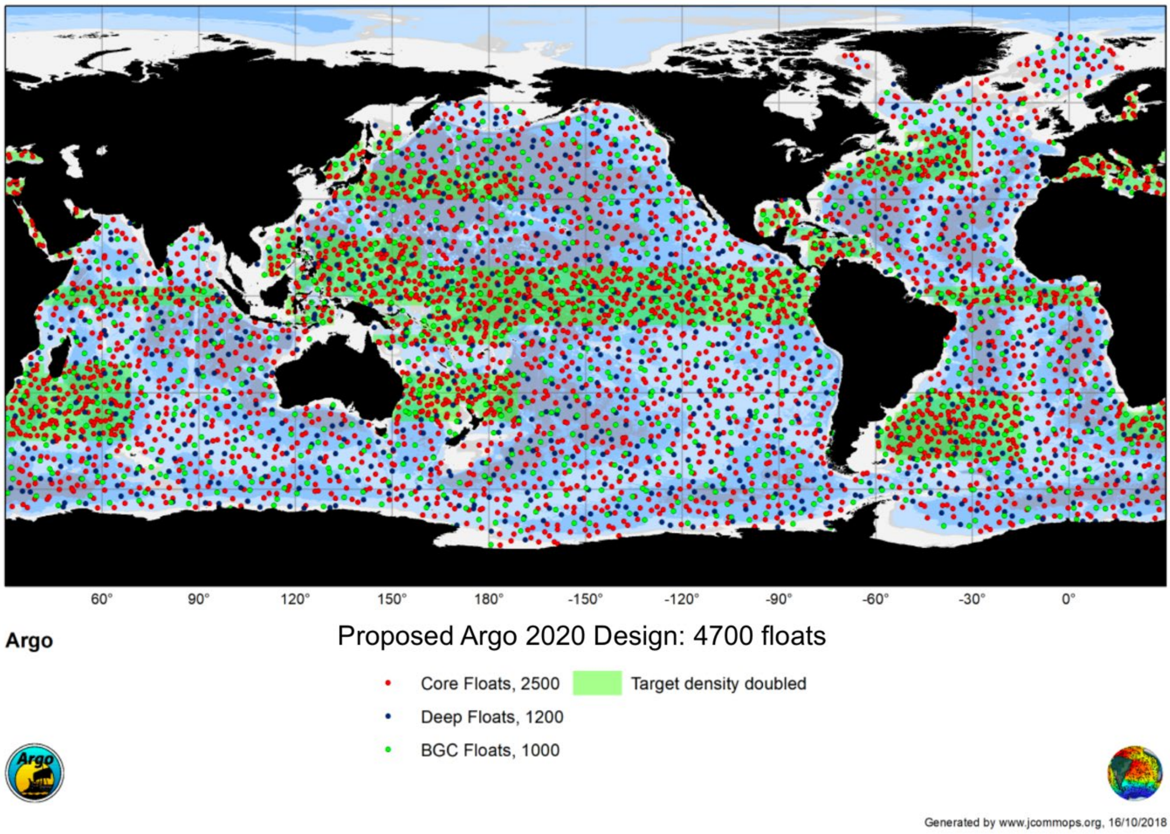



**Figure 4**: Proposed Argo 2020 (or “One Argo”) design.

<u>**Perspectives developed during the Workshop**</u>

**Day 1** of the formal workshop presentations illustrated a wide range of scientific advances from process and pilot studies. These presentations and discussions raised important issues that inform the trajectory towards the global array and how Australia might best contribute to it, including:

- new advances are arising from targeting remote regions where other observing systems are difficult to implement: under sea ice, and in the remote Southern and Indian Oceans.
- additional ecological information is achievable from bio-optical sensor records by processing profiles to extract variance and spike fields, by correlating bio-optical sensor signals and their ratios to more direct measures of ecological structure such as pigment and biovolume analyses including as achieved by autonomous samplers at time series sites such as SOTS, and by using sensors beyond the iBGC-Argo suite (e.g. beam transmissometers and upwelling radiance (Lu) radiometers).
- high frequency observations, especially when floats are deployed into eddies or other locations with relatively constant circulation structures and water mass properties, can reveal important biogeochemical rates, such as cumulative estimates of oxygen consumption.
- comparison of day and night fluorescence profiles and thus the magnitude of non-photochemical quenching may provide a window into photophysiology, including the controls on the quantum efficiency of primary productivity, which is arguably the largest uncertainty in the its determination from satellite remote sensing.

- rates of vertical mixing and entrainment processes are often limiting unknowns on the construction of biogeochemical budgets owing to their reliance on physically defined mixed layer depths which do not well define the vertical distributions of biogeochemical and biological fields.
- although far from homogeneous in time or space, animal tagging or bio-logging offers a viable, indeed in some cases a more powerful, alternative platform for biogeochemical and biological observations.
- moored time series offer a wider range of sensor observations that are complementary and extend float observations. Data streams from moorings and floats may be difficult to blend or jointly assimilate due to different sampling strategies.
- interest in extension of Argo includes the development of Deep Argo, and finding synergies across Core, BGC, and Deep observing strategies is important to all their futures.
- synergies with sensors on moorings and sensors on animals should be explored, especially for optimization of QA/QC protocols.
- other components of the global observing system are also developing new capabilities, e.g. swath altimetry and data assimilating models, and these may offer new ways to optimise BGC-Argo array design and its applications.

**Day 2** presentations showcased float observation advances in the USA, Europe, and China, and explored the reciprocal links to climate and biogeochemical models – for observing system design as well as model validation, initialization, and nudging via data assimilation. Important insights included:

- float arrays can capture the impacts of extreme events such as hurricanes. Detailed information is obtainable by switching floats to high frequency observations during an event. Realizing these sorts of opportunities requires active mission management and thus significant operator attention, and comes with costs to the overall array.
- advances in understanding ocean climate, biogeochemical, and ecological dynamics come from both observations of system state and quantification of processes, including discovery of new linkages. Float missions can be designed to target specific processes, but this may impact the coverage of system state and its evaluation. Both approaches have merit, and allocating resources across them is challenging.
- recently published analysis by Riser et al. (2018) of performance of BGC floats with 5 sensors shows that SOCCOM BGC-float survival rates are similar to under-ice floats, achieving ~250 profiles to 2000m. Power use by BGC sensors must inevitably shorten the lifetime of floats (Nitrate sensors, for example, consume about 20% of the float's power; Riser et al. 2018), but sensor durability may also restrict lifetimes and thus preserving battery life beyond a certain age (5 years?) may offer diminishing returns.
- the challenge of resource allocation extends to balancing the needs of sustained observing of essential climate, ocean, and ecosystem variables, with the exploitation of new technologies. In addition to the new sensors showcased on Day 1, examples included passive sound for wind and wave estimation, laser de-polarization for sea-ice detection, and imaging optics for food-web characterization.
- integration with modelling efforts is essential to deliver maximum benefits. This includes assessing optimal sensor choices for different science priorities and identifying deployment strategies. Biogeochemical observations provide tracer fields that disproportionately improve physical climate models, and physical climate models allow biogeochemical projections of important quantities such as ocean uptake of carbon, changing ocean

productivity, and increasingly foodweb dynamics. These synergies cement the need for BGC-Argo to be integrated into a "One Argo" design.

- Argo is an open ocean observing system, yet also seeks to deliver to the understanding and management of coastal resources. Providing ocean boundary conditions for coastal models is an obvious deliverable. Enhancing float densities in boundary current and regions of cross shelf flows can extend this contribution.
- development of observing systems is a long term (multi-year to decadal) effort, and every aspect needs commitment and engagement. Education, outreach, capability development and stakeholder interactions all require as large or larger efforts as getting the data. These are difficult challenges for emerging programs, and the generosity of existing programs in sharing insights and information is greatly appreciated.
- the international community is using BGC-Argo for different purposes. Carbon budgets (SOCCOM) do not require high frequency sampling or nutrients, on the other hand process studies need nutrients, high frequency profiling and a number of new sensors that are being developed.
- what questions does the Australian community wants to address at the short term? Nitrate provides valuable information of the penetration of Southern Ocean waters into the Tasman Sea, pH is crucial for tropical waters and the parking depth may have impact on the fate of the floats. See Canada's efforts in Baffin Bay. Similar studies could be done in the Tasman Sea to ensure floats follow the EAC or drift in to Southern Tasman Sea where iron deposition studies are under way. Lagrangian simulations could also identify the appropriate mission for floats. For instance, eddy studies might need to park at 1000m rather than 2000m
- what regions around Australia might floats help to improve model forecasts or to answer particular questions with societal impact? Candidates include the EAC and Leeuwin.

**Day 3** started with presentations on future directions, including emerging sensors and associated technologies (batteries) and emerging applications of the data. Insights included:

- chlorophyll and POC profiles help to quantify ecologically meaningful mixing depths, but (and this generally applies to float data) care must be taken if we want to interpret time series as representative of the processes in a water mass. Focussing on between profile changes rather than seasonal time scales might be one way to deal with this.
- there are many potential synergies between lab experiments and emerging Bio-Argo* deployments and proxies. But as well as having non-standard sensor suites, these approaches require non-standard profiling schedules (shallower, more frequent). There is a real need for the BGC-Argo community to maintain communication with core Argo to continually evaluate the standard 10day/2000m mission. There was some discussion of how to capture processes such as the diel cycle in upper ocean physics. Core Argo is starting to be able to resolve these processes purely because of the size (density) of the array, but it will be some time before BGC-Argo might approach this.

**We use Bio-Argo to refer to floats that have experimental or non-standard sensor suites. BGC-Argo refers to floats that have something close to the recommended suite of T, S, $O_2$, pH, $NO_3$, Flr, $b_b$, Ed.*

- techniques for distinguishing PIC from POC and their export rates are becoming well developed, but require at least one beam transmissometer if we are to directly measure PIC rather than infer it from other measurements.
- Quality Assurance/Quality Control. QA is the work that needs to happen before the float is deployed, such as choosing the manufacturer, choosing the suite of sensors, calibrating

sensors and designing workflows. QC is the attention that is paid to the data once the data streams start to flow. This includes real time, delayed mode and then revisiting the data as new high quality data become available (GO-SHIP). Automated systems exist but, particularly for BGC parameters, a trained human eye is still required. A ballpark number to QC 100 profiles of T, S and O2 from one float is 1 hour of work using the CSIRO system. The SOCCOM experience is that QC is a large part of their total personnel budget (2.5FTEs) but a smaller part of their total budget (which obviously includes hardware). A very good point was made that it's important for the QC people across different data centres to talk to each other regularly (Xing et al., 2018), and it's important that they are listened to by the rest of the program.

- SeaBird has been experimenting with rechargeable batteries. They are about the same size as a float, strapped onto the side of the float. They work by exploiting the temperature difference between the surface and the bottom of the profile so they are likely best suited to lower latitudes where temperature differences of at least 10°C can be achieved.
- the BGC-Argo community, if it is to incorporate some non-standard missions, would do well to devote effort to careful pre-planning of those missions to best exploit the bespoke data – see examples from Llort/Lacour analysis of Gateway Southern Ocean floats.
- Satellite community priorities for the coming decades:
  1. 'More of the same' to get long term data sets to detect seasonal, interannual and decadal variability. Can floats help with this? They will likely not measure chlorophyll with sufficient accuracy but they could help with vicarious calibration.
  2. Geostationary ocean color. This will help fill in the daily variability that floats can't sample. A Korean satellite exists and others have been proposed.
  3. Hyperspectral data for improved products such as phytoplankton functional types.
  4. LIDAR. Provides some depth-resolved information like floats do.
  5. Polarised observations.

  Downwelling irradiance (Ed) is almost becoming a preferred product for the satellite community and when used in conjunction with fluorescence it might provide important fluorescence quenching information without the need to do separate day and night profiles – day only might work.
- Bluelink has evolved to a 0.1° global model that includes (or will soon include?) BGC. There is potential for using it to perform Observing System Simulation Experiments to help inform BGC-Argo deployments, but this would be computationally very expensive.
- About 1000 BGC-Argo floats, which is the currently-proposed size of a global array, can reduce the uncertainty in the ocean carbon budget from 1.8 GtC year$^{-1}$ to 0.6 GtC year$^{-1}$.
- Impact of the new BGC-Argo facility: IMOS understands the pilot nature, but it is important to articulate KPIs. Not just getting floats in the water, but who is going to use the data, where are the data going to be ingested? Which models? What will those models do? What international programs? What do those programs do?
- BGC-Argo has direct relevance to the goals of many international programs around the blue economy, human and ecosystem well-being. Many philanthropic agencies are becoming involved in aspects of this effort. Diversifying the funding base has strong potential for the future. The US experience is that to pursue philanthropic money, it's useful to have funding tiers. For example, for $20million we can deliver X, for double that, we can deliver Y...

## Summary

The breadth of presentations and discussions highlighted the rapid development of global profiling float arrays, including the challenges of the maintenance of core Argo, extension to the deep and under-ice portions of the ocean, and expansion to include biogeochemical and ecological measurements, and their melding into a “One Argo” array. Key points for the structuring of the IMOS BGC-Argo effort include:

- Synergies with the existing IMOS ArgoAustralia effort are essential, and thus BGC-Argo floats should in general seek to meet the core Argo goal of profiling to 2000 meters depth every 10 days, and achieving ~200-250 profiles of this type per float lifetime.
- Data QA/QC efforts are significant and will require both large up-front investment and ongoing attention to track developing best practices.
- A facility strategy that spreads effort across the IMOS articulated innovation-pilot-mature-operational spectrum is appropriate, with the majority of effort initially focused at the nexus between pilot and mature.
- Given the costs of BGC-Argo floats and the implementation of QA/QC efforts, the prioritization of initial deployment targets depends on both science targets and co-investment for deployment logistics and scientific uptake. Deployments in the Coral Sea, East Australian Current, Tasman Sea, Great Australian Bight, Leeuwin Current, and Southern Ocean would all address science targets. Initial ship logistics and science uptake discussions have identified synergies in the East Australian Current, Tasman Sea, and Southern Ocean.
- The workshop was extremely successful in developing working relationships across the Australian community and seeding collaborations with international groups. Active investment in their maintenance via participation in international activities is important.

Overall the workshop was a tremendous success, and we are grateful for the stamina and constructive inputs from the participants.

## References

Riser, S. C., Swift, D. and Drucker, R., 2018. Profiling floats in SOCCOM: Technical capabilities for studying the Southern Ocean. *Journal of Geophysical Research: Oceans*, 123, 4055–4073. https://doi.org/10.1002/2017JC013419

Xing, X-G, Claustre, H., Boss, E. and Chai, F., 2018. Toward deeper development of Biogeochemical-Argo floats, Atmospheric and Oceanic Science Letters, 11:3, 287-290, DOI: 10.1080/16742834.2018.1457932. https://doi.org/10.1080/16742834.2018.1457932

**Appendix 1. Workshop Agenda**

**Monday 5th November: IMAS Board Room**

14:00 Pre-workshop meeting of all Australian participants to discuss current and future activities.

- Welcome and Overview of the Workshop: Philip/Tom/Pete
- The Argo Australia programme: Peter Oke on the broader vision
- BGC-Argo activities and funding: Tom and Pete
- BGC-Argo Research questions
- Regional coverage: Where should IMOS floats target?
- Links to satellite and other remote sensing: Rob Johnson, Bozena Wojtasiewicz and Ed King
- Building a research network: Getting buy-in from the broader community ... what do they want from us, bringing in other institutions like UTS/SIMS, Qld universities?
- Outlining the goals, process, and contributors for the report from the meeting
- Preparing for an IMOS BGC-Argo sub-facility: the calendar ahead
- Other pressing issues

16:30 Meeting close and mixer outside Aurora lecture theatre to welcome international visitors

**Three day workshop in IMAS Aurora Lecture Theatre (6,7, 8 November)**

**Day 1 Tuesday November 6th: BGC-Argo research in Australia**

**09:00 Introduction and welcome**

**Southern Ocean**

09:10 Joan Llort: Evaluating the Southern Ocean carbon eddy-pump from biogeochemical-Argo floats

09:30 Leo Lacour: Unexpected phytoplankton blooms in polar and subpolar environments as revealed by BGC-Argo floats

09:50 Tom Trull: Autonomous profiling float observations of the high-biomass plume downstream of the Kerguelen Plateau in the Southern Ocean

10:10 Christina Schallenberg: Non-photochemical quenching: a window into phytoplankton physiological status?

***10:30 Coffee***

11:00 Pete Strutton (on behalf of Seb Moreau): On the fate of primary production in the sea-ice zone of the Southern Ocean

11:20 Tom Trull: Floats and moored sensor system synergies at the Southern Ocean Time Series

**Indian Ocean**

11:40 Bozena Wojtasiewicz: Autonomous profiling float observations reveal the dynamics of deep biomass distributions in the denitrifying oxygen minimum zone of the Arabian Sea

12:00 Pete Strutton: Biogeochemical Argo floats reveal the vertical structure of Indian Ocean eddies

12:20 Discussion

***12:30 Lunch and meeting of report group***

**Links to remote sensing**

13:30 David Antoine: Complementarity of BGC-Argo floats and satellite remote sensing in addressing Southern Ocean productivity

13:50 Bozena Wojtasiewicz: Use of bio-optical profiling float data in validation of ocean colour satellite products in a remote ocean region

14:10 Rob Johnson: The difficulties of Southern Ocean and Antarctic ocean colour remote sensing: Can BGC-Argo help? (note: talk not presented; precis presented by David Antoine)

14:30 Christopher Watson: Current status of **SWOT swath-altimetry mission**

14:40 Discussion

***14:50 Coffee***

**Links to ecology: satellite tagged animals and the SCAR atlas**

15:20 Mark Hindell/Clive McMahon: The future of bio-logging

15:40 Nicole Hill: Ecological Texture – the SCAR ocean Atlas

**Argo, coastal, ice and deep Argo and other platforms**

16:00 Peter Oke: One Argo vision

16:20 Beatriz Pena-Molino: Deep and Ice extensions of Argo

16:40 Will Hobbs: Current and future plans for float deployments in the marginal ice zone

17:00 Elizabeth Shadwick: A moored $CO_2$ system observatory in the West Antarctic Peninsula

***17:20 Discussion and close***

**Day 2 Wednesday November 7th: International perspectives on BGC-Argo research**

09:00 Joellen Russell: SOCCOM

09:20 Griet Neukermans: Europe (SOCLIM)

09:40 Fei Chai: China

10:00 Leo Lacour: Canada/Arctic

10:20 Discussion

***10:30 Coffee***

11:00 Tom Trull: International BGC-Argo implementation plan.

11:20 Joellen Russell: SOCCOM's plans beyond the Southern Ocean

11:40 International plans: Funding more floats for the Southern Ocean? Other international priority areas? Discussion.

***12:00 Lunch and meeting of report group***

**Modelling and links to BGC-Argo Research**

13:00 Fei Chai: BGC-Argo Observations and Physical-Biogeochemical Modeling

13:20 Richard Matear: New climate re-analysis with assimilation of ocean colour

13:40 Joellen Russell: Modelling challenges – the SOCCOM experience

14:00 Discussion, coffee and close. Afternoon free for small breakouts and collaborative discussions.

**Day 3 Thursday November 8th: The Future and wider applications of BGC-Argo**

**Towards the future**

09:00 Leo Lacour: Towards a comprehensive evaluation of the biological carbon pump based on BGC-Argo floats

09:20 Philip Boyd: Designing float-to-lab-to-float experiments using BGC-Argo floats

09:40 Griet Neukermans: Coccolithophores/PIC and BGC-Argo

10:00 Peter Oke and Tom Trull: QA and QC

10:20 Discussion

***10:30 Coffee***

11:00 Fei Chai: New sensors and Battery Technologies

11:20 Pete Strutton for Helen Phillips: EM-APEX velocity measurements

11:40 Joan Llort: BGC-Argo in the mesopelagic zone

12:00 Philip Boyd: New proxies

12:20 David Antoine and Rob Johnson: Better links to other remote sensing

12:40 Fei Chai and Joellen Russell: Modelling and Data assimilation

***13:00 Lunch and meeting of report group***

**Wider societal applications of BGC-Argo**

14:00 Joellen Russell: Wider significance of the Southern Ocean BGC-Argo archive. Tracking COP21 emissions reduction pledged by reducing uncertainty in the global carbon budget

14:20 Indi Hodgson-Johnston: The IMOS perspective on data uptake and impact

14:40 Nick Hardman-Mountford (via video or proxy): Links to Sustainable Development Goals; Antarctic Treaty, and other Global Commitments

15:00 Tom Trull and Pete Strutton: Summing up, report draft.

***15:30 Coffee and close.***

***Free time for small breakouts and collaborative discussions.***

***BBQ dinner and drinks at IMAS starting around 16:30.***

**Appendix 2. Workshop participants**

David Antoine, Curtin University
Mark Baird, CSIRO
Kimberley Baldry, IMAS/UTas
Sophie Bestley, IMAS/UTas
Philip Boyd, IMAS/UTas
Fei Chai, State Ocean Administration, China
Rebecca Cowley, CSIRO
Denise Fernandez, National Institute of Water and Atmospheric Research, New Zealand
Hakase Hayashida, IMAS/UTas
Nicole Hill, IMAS/UTas
Mark Hindell, IMAS/UTas
Will Hobbs, ACE CRC
Indi Hodgson-Johnston, IMOS
Robert Johnson, BoM
Andreas Klocker, IMAS/UTas
Leo Lacour, Université Laval, Canada
Ana Lara-Lopez, IMOS
Andrew Lenton, CSIRO
Joan Llort, IMAS/UTas
Jenny Lovell, CSIRO
Clive McMahon, IMAS/UTas
Pat McMahon, CSIRO
Richard Matear, CSIRO
Klaus Meiners, AAD/ACE CRC
Griet Neukermans, Laboratoire d'Océanographie de Villefranche-sur-Mer, France
Peter Oke, CSIRO
Beatriz Pena-Molino, ACE-CRC
Joellen Russell, University of Arizona, USA
Christina Schallenberg, CSIRO
Elizabeth Shadwick, CSIRO
Pete Strutton, IMAS/UTas
Jiaoyang Su, IMAS/UTas
Tom Trull, CSIRO
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