

## **Summary of Indian Ocean GOOS workshop on Bio Argo: technology advances, applications and future role in sustained measurements of the Indian Ocean.**

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The oceans are undergoing remarkable stresses, including warming, acidification, deoxygenation, melting of sea ice, circulation changes and changes to nutrient supply. The challenge is to systematically observe these changes at the global scale. Ship-based observations of the interior ocean peaked in the 1970s to 1980s and have been in steady decline since, with the current number of ship hydrocasts per year lower than at the beginning of the 20<sup>th</sup> century. Since the early 1990s, autonomous profiling floats equipped with conductivity, temperature and depth probes (CTDs) have enabled a revolution in temperature and salinity observations that, through the global Argo program, have countered and exceeded the decline in ship-based observations, creating a new paradigm for oceanographic sampling. Since the early 2000s, these advances have also been applied to marine biogeochemical observing with the addition of oxygen sensors on profiling floats. Ongoing developments in sensor technology have provided float-enabled sensor packages to measure dissolved oxygen, nitrate, pH, chlorophyll fluorescence, particle backscattering and downwelling light simultaneously, along with temperature and salinity. Thus, the technological basis now exists for a Global Biogeochemical-Argo program with the potential to revolutionise our view of ocean biogeochemistry in the same way that Argo has for ocean physics.

Building on the recommendations of community white papers, technical reports and research publications, several pilot programs using biogeochemical profiling floats have been established internationally. Within the Indian Ocean region, both Australia and India have been engaged in such float deployments through a bilateral project with joint funding from Australian and Indian governments ([research.csiro.au/iobioargo/](http://research.csiro.au/iobioargo/)). The targets of these deployments have been biogeochemical hotspots in oxygen minimum zones, island wakes, enhanced-productivity eddies and subtropical convergence zones. About 40 biogeochemical Argo floats have been deployed in the Indian Ocean to date, providing insights into productivity and carbon cycling, oxygen distributions, phytoplankton community composition and eddy nutrient dynamics. The radiometric and chlorophyll data from these floats have been further applied to satellite ocean colour validation. The outcomes from this pilot study and others in the Atlantic, Pacific and Southern Oceans have been used to inform the development of an implementation plan for Global Biogeochemical-Argo (see [www.biogeochemical-argo.org](http://www.biogeochemical-argo.org)). Community collaboration with the Argo Data Management Team (ADMT) has enabled the development of manuals and protocols for handling data streams from biogeochemical floats, including recommendations and tools for quality control procedures and file formats. A global program of ~1000 floats globally is proposed, equating to around 200 floats in the Indian Ocean. With standard mission configurations, each float can undertake ~250-300 profiles and last for ~4 years.

This workshop was convened to share the learnings from this project in order to inform the current Indian Ocean Observing System (IndOOS) review. Around 35 participants from 10 different nations met in Perth, Australia, alongside the International Indian Ocean Science Conference, during 2-3 Feb 2017. The goals of the workshop were as follows:

- Bring together Indian Ocean researchers interested in Biogeochemical Argo observations
- Present findings from Indian Ocean region deployments of Biogeochemical Argo floats
- Discuss logistical and data management considerations of maintaining a Biogeochemical Argo program

- Formulate recommendations for the implementation of Biogeochemical Argo as part of the review of the Indian Ocean Observing System
- Discuss potential coordination of future research initiatives and funding

The meeting was organised into 4 sessions with talks from 12 different speakers, addressing the role of biogeochemical Argo within the Indian Ocean observing system, emerging science from biogeochemical profiling float observations in the Indian Ocean region, user communities and impact areas for Indian Ocean biogeochemistry and observing system design for biogeochemical Argo in the Indian Ocean. The workshop agenda is given below.

Presentations will be available here: <https://research.csiro.au/iobioargo/>

Agenda - IOGOOS Bio-Argo Workshop, 5th Floor Boardroom, IOMRC, Perth, Western Australia, 2-3 Feb 2017	
<b>Day 1 Thursday 2nd February</b>	
12:00	Lunch
13:00 Peter Klincken, Chief Scientist of Western Australia	Welcome to the workshop and acknowledgement of traditional owners
13:15 Nick Hardman-Mountford (CSIRO)	Introduction to workshop
<i>Chair: Andreas Schiller (CSIRO)</i>	<b>Session 1: Introduction to Bio-Argo: the role of autonomous biogeochemical observations within the Indian Ocean Observing System</b>
13:30 Nick Hardman-Mountford (CSIRO)	Introduction to Bio-Argo
13:50 Nick Hardman-Mountford (CSIRO)	Global Biogeochemical Argo Implementation Plan
14:10 Nick Hardman-Mountford (CSIRO) / S. Prakash (INCOIS)	Summary of Bio-Argo progress in the Indian Ocean: the Indian Ocean Bio-Argo project
14:45	Afternoon Tea
<i>Chair: Catherine Schmechtig (OOV)</i>	<b>Session 2: Emerging science from biogeochemical profiling float observations in the Indian Ocean</b>
15:15 Tom Trull (CSIRO)	Autonomous profiling float observations of the high-biomass plume downstream of the Kerguelen Plateau in the Southern Ocean
15:35 Satya Prakash (INCOIS)	Oxycline variability in the central Arabian Sea: An Argo-oxygen study
15:55 Malika Kheireddine (KAUST)	Autonomous bio-optical float observations in the Red Sea: resolving the biological response to physical forcing
16:15 Uday Bhaskar (INCOIS)	Float observations of oceanic chlorophyll response to the progression of a cyclone track in the Bay of Bengal
16:35 Bozena Wojtasiewicz (CSIRO)	Float-based insights to ocean carbon uptake and controls on the biogeochemical carbon pump
16:55 Francois Dufois (UWA)	Observational insights into chlorophyll distributions of subtropical South Indian Ocean eddies from floats
17:15	Close day 1
<b>Day 2 Friday 3rd February</b>	
<i>Chair: Burton Jones (KAUST)</i>	<b>Session 3: User communities and impact areas for Indian Ocean Bio-Argo</b>
9:00 Raleigh Hood (U. Maryland)	Key biogeochemical problems in the Indian Ocean as seen by SIBER
9:30 Richard Matear (CSIRO)	Using Bio-Argo to constrain ocean forecast models
9:50 Bozena Wojtasiewicz (CSIRO)	Application of Bio-Argo float data to validation of satellite ocean colour radiometry
10:10 Catherine Schmechtig (OOV)	Data handling and stewardship for Bio-Argo: processing, QC, dissemination, archiving
10:30	Morning Tea
<i>Chair: Louise Wicks</i>	<b>Session 4: What does Bio-Argo for the Indian Ocean look like?</b>
11:00 Nick Hardman-Mountford (CSIRO)	Observing system design: models, bioregional approaches etc.
11:20 Group discussion	Discussion towards recommendations
12:40 Nick Hardman-Mountford (CSIRO)	Workshop summary
13:00	End of workshop
13:00	Lunch