Bluewater and Climate Node

Pete Strutton, Institute for Marine and Antarctic Studies, UTas

...with community input
Activities and observations in the region

The Bluewater and Climate Facilities:
Connecting Bluewater and the boundary current backbone
Argo shows sustained, deep ocean warming:

- Argo is now 4000 operational floats.
- Life expectancy of ~4-5 years, needs constant maintenance.
- Argo Australia manages 10% of the global array ~350 floats.
- Second largest contributor after the USA.
Argo is evolving to meet user needs

The new Argo design is global, full-depth, and multidisciplinary.

A mix of core, BGC, and deep floats.

Argo Australia is investing in all areas, and expanding our scope to meet the need.

Argo Australia deploying 20 core floats with new, low-power CTDs that may extend the life of floats by a factor of two or three.

BGC-Argo floats transit the EAC array and reveal subsurface chlorophyll unseen by satellites

Figures: Christina Schallenberg, BGC-Argo sub-facility
Deep Argo is ready

Deep Argo is growing rapidly: 12% complete

- ACE CRC and AAPP are leading an international Deep Argo experiment in the Southern Ocean.
- Early results: a sharp rebound in salinity and density of Bottom Water, after 50+ years of freshening.
- Research funding has proven the technology; deep Argo is conspicuously absent from the IMOS portfolio

Silvano et al., submitted
New insights from under-ice Argo

Under-ice floats have provided the first year-round, full-depth profiles from the Antarctic continental shelf.

The observations have been used to:
- reveal how warm water drives Totten Ice Shelf basal melt (Silvano et al., JGR, 2019).
- calculate sea ice formation rates in the Mertz Polynya (van Wijk et al., submitted)
- derive new algorithms for positioning of under-ice floats (Wallace et al., GRL, under review)
- document blooms and carbon export during ice retreat (Moreau et al., in review)
New XBT gridded product

• Machine learning approach
• Initial focus on PX30 (Sep-2020)
• Then Australian region and collaborate internationally for other lines
• This product will lower the barrier-to-entry and facilitate studies of the long term climate in the Australian region.
• Requires significant time investment to move from alpha to beta product.
Ships of opportunity SST

- Unique observations of skin and bulk SST from Investigator result in new insights into ocean cool (and warm!) skin
- Important implications for climate and weather models
- 2 new ships recruited, 3 more under discussion

Zhang, 2020. JTech, doi.org/10.1175/JTECH-D-19-0161.1
Ships of opportunity: Bio-acoustics

- Quantify the structure, function and change of mesopelagic habitats for C sequestration, marine planning and monitoring
- Lower mesopelagic acoustic backscatter increasing
- Mesopelagic ecosystems southern ocean prey and predators (MESOPP, EU funded program) developed a road map for acoustic data into models.
Indonesian Through Flow

Contribution to Indian Ocean warming (Zhang et al, GRL, 2019)

Decadal Indian Ocean warming during global warming hiatus, mostly due to enhanced ITF transport

Also calculating ITF (Peña Molino, Sloyan and Wijffels) and Leeuwin (Feng) transport based on XBT
Full annual monitoring of Subantarctic *Emiliania huxleyi* populations reveals highly calcified morphotypes in high-CO$_2$ winter conditions

A. S. Rigual-Hernández$^{1,*}$, T. W. Trull$^{2,3}$, J. A. Flores$^1$, S. D. Nodder$^4$, R. Eriksen$^{3,5}$, D. M. Davies$^{2,3}$, G. M. Hallegraeff$^5$, F. J. Sierra$^1$, S. M. Patil$^6$, A. Cortina$^7$, A. M. Ballesteros$^{11}$, L. C. Northcote$^8$, F. Abrantes$^{8,9}$ & M. M. Rufino$^{8,10}$

*SCIENTIFIC REPORTS* | (2020) 10:2594 | https://doi.org/10.1038/s41598-020-59375-8
Diel quenching of Southern Ocean phytoplankton fluorescence is related to iron limitation

Christina Schallenberg1, Robert F. Strzepek1, Nina Schulzback2, Lesky A. Clementson3, Philip W. Boyd1,4, and Thomas W. Troll2,5

1Antarctic Climate and Ecosystems Cooperative Research Centre, University of Tasmania, Hobart, Tasmania, Australia
2Swiss Polar Institute, École Polytechnique Fédérale de Lausanne, Lausanne, Switzerland
3Commonwealth Scientific and Industrial Research Organisation Oceans and Atmosphere Unit, Hobart, Tasmania, Australia
4Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, Tasmania, Australia

Correspondence: Christina Schallenberg (christina.schallenberg@utas.edu.au)

Received: 26 August 2019 – Discussion started: 4 September 2019
Revised: 10 December 2019 – Accepted: 3 January 2020 – Published: 17 February 2020

Application to Argo fluorescence
Surface ocean carbon dioxide variability in South Pacific boundary currents and Subantarctic waters

Paula C. Pardo, Bronte Tilbrook, Erik van Ooijen, Abraham Passmore, Craig Neill, Peter Jansen, Adrienne J. Sutton & Thomas W. Trull

Received: 22 October 2018
Accepted: 9 May 2019
Published online: 20 May 2019
Marine and Australian Microbiome Initiatives

OMICS observations for:
- Plankton diversity, productivity
- Temporal dynamics of microorganisms, response to climate
- Microbes in the expanding EAC
- Microbial signals in heatwaves.

Sampling at:
- IMOS NRS
- New IMOS coastal stations
- Bluewater voyages
Oceanographic boundaries constrain microbial diversity gradients in the South Pacific Ocean

Eric J. Raes\textsuperscript{a,b,c,1}, Levente Bodrossy\textsuperscript{c}, Jodie van de Kamp\textsuperscript{c}, Andrew Bissett\textsuperscript{c}, Martin Ostrowski\textsuperscript{d}, Mark V. Brown\textsuperscript{e}, Swan L. S. Sow\textsuperscript{c,f}, Bernadette Sloyan\textsuperscript{c}, and Anya M. Waite\textsuperscript{a,g}

\textsuperscript{a}Alfred Wegener Institute Helmholtz Centre for Polar and Marine Research, 27570 Bremerhaven, Germany; \textsuperscript{b}The Oceans Institute M047, University of Western Australia, Crawley, WA 6009, Australia; \textsuperscript{c}Oceans and Atmosphere, Commonwealth Scientific and Industrial Research Organisation, Hobart, TAS 7001, Australia; \textsuperscript{d}Department of Chemistry and Biomolecular Sciences, Macquarie University, Sydney, NSW 2109, Australia; \textsuperscript{e}School of Environmental and Life Sciences, Faculty of Science, University of Newcastle, Callaghan, NSW 2308, Australia; \textsuperscript{f}Institute for Marine and Antarctic Studies, University of Tasmania, Hobart, TAS 7001, Australia; and \textsuperscript{g}FB2 Biology/Chemistry, Universität Bremen, D-28334 Bremen, Germany
Animal tagging and tracking

- 13 countries deploying CTDs on seals (NZ 2019)
- Total: 543,735 profiles from 1273 tags on GTS and http://www.meop.net/
- Status 2019: 51 CTDs on seals in Southern Indian Ocean, 8 at Dumont d’Urville, 20 Ross Sea, 20 Thwaites Glacier
- Providing data in previously inaccessible regions
Improved satellite SST coverage

New IMOS Multi-sensor SST composite ingesting additional satellites to enhance spatial coverage and accuracy

1-day AVHRR L3S

1-day Multi-Sensor L3S
Satellite Altimetry Calibration and Validation

- The Bass Strait altimetry validation facility now supports the Jason-series missions, as well as Sentinel-3A and 3B.

- Preparing to support Sentinel-6A (end 2020) and SWOT (2021).

- The Bass Strait facility will provide an important connection from nadir altimetry to swath altimetry given its sustained observation.
Satellite wave facility

- Period, spectra, wave height and direction
- Spans Jul 2015 – present (DM and NRT)
- Covers mainly the wider Australian region
- Available on AODN since Jan 2020. High uptake:

Global altimeter database of wind speed and wave height

- Full global coverage from 1985 to present
- Wind speed and wave height calibrated consistently across all platforms

Young and Ribal, Science, 2019
International engagement

• GOOS coordinates the networks via which IMOS delivers
• These are stakeholders
• BWC staff serve on these coordinating bodies:
  Rebecca Cowley: SOT Executive, SOOPIP Chair, VOS Task Team
  Rob Harcourt: ISAC Ocean Tracking Network (OTN) and GOOS-Animal Research and Tracking Initiative
  Clive McMahon: GOOS-Animal Borne Sensors committee
  Peter Oke: Argo Steering Team, GODAE OceanView Science Team
  Anthony Richardson: Global Alliance of CPR Surveys Chair
  Christina Schallenberg: BGC-Argo Data Management Team
  Bernadette Sloyan: OOPC chair, IndOOS decadal review
  Pete Strutton: IndOOS decadal review and TPOS2020
  Bronte Tilbrook: GOA-ON co-chair, SOCAT, GLODAP, focal point UN SDG14.3, IOC Multistressor working group, IAPSO pH group
  Tom Trull: OceanSITES co-chair; BGC-Argo Steering Committee
International engagement
The Surface Ocean CO₂ Atlas (SOCAT)

Cited in >260 peer-reviewed papers and >80 high impact reports.

Applications:
• Ocean carbon sink
• Ocean acidification detection
• Sensor evaluation
• Model evaluation, development

IMOS SOOP BGC
International engagement: IMOS contributions to OceanObs19 papers

• Ocean acidification: Tilbrook et al.
• A surface ocean CO₂ reference network: Wanninkhof et al.
• On the future of Argo: Roemmich et al.
• IndOOS: Hermes et al.
• TPOS2020: Smith et al.
• Detecting change in the Indonesian seas: Sprintall et al.
• Boundary currents: Todd et al.
• Global plankton diversity: Batten et al.
• Others listed in the meeting agenda
International engagement

IMOS observations a key component of global ocean boundary system
Key stakeholders

**XBT**
- International groups: GOOS, WMO, IOC
- Partners: BOM, RAN, CSIRO, NIWA, IRD, Scripps

**Satellite waves**
- Domestic: Universities, BoM, CSIRO, AAD, private sector such as RPS, Oceanum, Baird
- International: IFREMER, CLS, Meteo France, NOC, ESA, ESA sea-state CCI project, CFOSat Science Team

**Animal tagging and tracking**
- GOOS, CNRS, Ant NZ, NIWA, CCAMLR, MPA managers
Key stakeholders

Altimetry cal/val
- Satellite agencies (NASA/CNES/ESA/Eumetsat) and science teams
- Science/operational users that require calibrated and validated altimetry
- Public and policy makers who require confidence in sea-level climate data record

Microbiome Initiative
- Partners: IMOS, CSIRO, Parks Aus, Bioplatforms
- Consortium members: >40 institutions
- End users: Researchers, government, industry, monitoring programs, education programs, citizen science.

Satellite and SOOP SST
- GHRSST: sharing satellite SST products and best practice
- International ship-borne SST radiometer network
- Meteorological and oceanic agencies
- Climate ocean databases and (re)analyses
Stakeholder engagement

Satellite altimetry cal/val
- Satellite agencies are well engaged and highly value the IMOS contribution
- Other stakeholders...SWOT represents an opportunity to increase visibility

SOOP BGC
- COP25, UN Decade of Ocean Science
- Pacific community: Planning for UN Decade of Ocean Science
- Intergovernmental Oceanographic Commission
- NOAA and Plymouth Marine Labs on next gen of SOOP CO₂ systems
- Panels on ocean acidification, observing system needs, and the Marrakesh Initiative to strengthen and encourage actions to limit climate impacts
Stakeholder engagement

Marine and Australian Microbiome Initiatives

- Engaged Knowledge Broker
- Established End User Strategy Working Group for data products and usage
- International
  - Global OMICS community towards best practice SOPs, interoperability

SOOP and Satellite SST

- IMOS Data User Workshops (AMOS 2019, AMSA 2019, AMOS 2020)

Deep water arrays

- EAC and Tasman Sea FRDC projects
- International collaborative project in ITF

All facilities

- Publications, OceanObs, other meetings, JCOMMOPS, workshops
Increasing stakeholder engagement and impact: What’s needed

Animal tagging and tracking
- Recent IMOS/IMAS-sponsored workshop to incorporate IMOS animal tracking into GOOS. Need to sustain this effort.

SOOP
- Continue the engagement between SOOP networks (XBT, CPR, CO₂, TSG)

Marine microbiome initiative
- End User Survey to identify ways to enhance accessibility, applicability. Refined data products/visualisations, support to action these items

Satellite SST
- More education on AODN at national workshops/conferences

SOOP Plankton
- Continued IMOS support for data-driven ecosystem assessments: The bluewater node was a major contributor to the State and Trends of Australia’s Ocean Report
Observation gaps

Animal tagging and tracking
• Deployments from Macquarie Is and Cape Hallett could address critical gaps

Marine and Australian Microbiome Initiatives
• Regional ocean gaps, e.g. Tasman Sea
• Human activity: Ocean Interface
  • Partly addressed with new east coast stations
  • Dynamic systems > temporal resolution (*in situ* sampling)
  • Management of ecosystems, aquaculture

Altimetry cal/val
• Carefully manage deployments to build redundancy and avoid observation gaps at mission-critical times
Summary

• Observations span the boundary currents to the open ocean
  ➢ Physics to biogeochemistry to ecology
• All activities are internationally connected with global scope
  ➢ Excellent international reputation
• The node is dispersed but well connected
• Science coordination happens at the global level
• High impact for science and society
  ➢ IPCC and climate data records are just two good examples
Global engagement:
The Indian Ocean and tropical Pacific observing systems

- These international projects have addressed the key science and society challenges.
- They have identified gaps in the observing systems.
- IMOS together with international partners needs to fill these gaps.
NCRIS
National Research Infrastructure for Australia
An Australian Government Initiative

IMOS is a national collaborative research infrastructure, supported by Australian Government. It is operated by a consortium of institutions as an unincorporated joint venture, with the University of Tasmania as Lead Agent. www.imos.org.au

PRINCIPAL PARTICIPANTS

UNIVERSITY of TASMANIA (Lead Agent)
Australasian Institute of Marine Science
Australian Government Bureau of Meteorology
CSIRO

SARDI
Government of South Australia

THE UNIVERSITY OF WESTERN AUSTRALIA

SIMS
Sydney Institute of Marine Science

UTS
University of Sydney

MACQUARIE University

UNSW

SIMS is a partnership involving four universities.

ASSOCIATE PARTICIPANTS

Curtin University
Australian Government Department of the Environment and Energy

DEAKIN UNIVERSITY

THE UNIVERSITY OF MELBOURNE