IMOS

marinematters

Integrated **Marine Observing** System

ISSUE 32 | APRIL 2019

IMOS New Technology Proving capability launched

IMOS plankton and nutrient data used to validate eReefs model

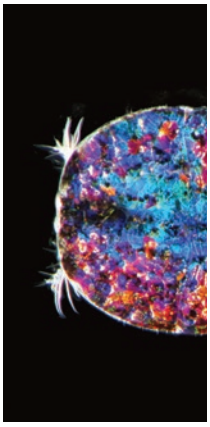
Great Barrier Reef gets a reprieve from the heat this year.

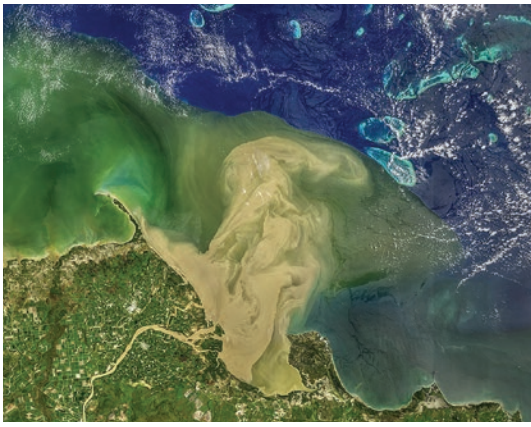
The Australian Microbiome Initiative was launched this month.

Our new IMOS Facility the Marine Microbiome Initiative will manage our participation in this collaborative research project.

Julian Uribe-Palomino, CSIRO-IMOS

director's corner





Welcome to the first edition of Marine Matters for 2019.

This edition features information on a number of new activities being undertaken with NCRIS funding provided under the Australian Government's commitment to implement the Research Infrastructure Investment Plan, informed by the 2016 National Research Infrastructure Roadmap.

These activities include enhancements to existing IMOS Facilities to do new things, in new places – Argo, Ships of Opportunity, National Mooring Network, and Ocean Gliders. They also include additional activities being undertaken for the first time, with new partners – *in situ* surface wave measurements, management of reef monitoring data (including from the Reef Life Survey citizen science program), and coastal sampling, DNA extraction and bioinformatic analysis for the Marine Microbiome initiative.

We are also very excited to have established a New Technology Proving capability in IMOS that will provide direct investment in piloting new technologies, methods, and approaches within the program.

Related to the above, IMOS has evolved its Node-based science advisory process to include additional expertise and provide a clearer national mandate that goes beyond the sum of regional priorities. The Science and Technology Advisory Committee played a key role in framing advice to the Board on investment of new funding, and its next task is to evaluate expressions of interest in New Technology Proving pilot projects.

All of the above was discussed at the thirteenth IMOS Annual Planning Meeting, held in Brisbane on 12–14 February. With up to 120 people in the room, the level of energy and engagement was very exciting, and we all came away confident that the IMOS community will deliver great things in 2019 and beyond.

Adding value to IMOS observations and data, and even bigger marine data through AODN, is key to realising this potential. Stories on the State of Climate, ocean warming, improved satellite products, and *OceanCurrent* provide examples of how this can be done across days, years, and decades.

We hope you enjoy reading the edition of Marine Matters.

Tim Moltmann

The IMOS Annual Planning Meeting 2019

This year's successful and positive IMOS Annual Planning Meeting was a testament to the hard work from all those across the community. With the 2018 Budget announcement of sustained investment in IMOS and other NCRIS capabilities out to 2029, the meeting focused on growth and new initiatives within IMOS, and strategies to ensure our sustainability into a third decade.

The meeting again attracted a large attendance of over 120 people. The meeting included the IMOS Community of Facility operators, Node leaders, operator representatives, research partners, operational partners, and representatives from the ocean modelling community. We also welcomed several colleagues from New Zealand, Indonesia and the Pacific Islands.

The meeting held in Brisbane from 12-14 February had several themes – the growth and extension of IMOS capability, program updates, and planning for use and impact. We also had overviews from program leaders, including from our new IMOS Board Chair, John Gunn and the new AODN Director, Sebastien Mancini.

Topics related to the themes were interspersed across the agenda and included:

THE GROWTH AND EXTENSION OF IMOS CAPABILITY

New activities

The meeting discussed the enhancement of IMOS through new initiatives enabled by the increased and stable funding announced in the 2018 Budget. These included new investment in waves observations, event-based sampling, engagement with the National Reef Monitoring Network, and the launch of our new technology proving capability.

Growth activities

The community heard from leaders of facilities with planned growth out to 2022, including the enhancement of the Argo facility to include BGC Argo, a reconfiguration of the animal tracking network, and increase capability within the AUV and Moorings facilities. We also heard from the team at IMOS *OceanCurrent*, who have refreshed the utility and visual appearance of the website to enable greater access to IMOS data.

PROGRAM UPDATES

Reporting activities

In light of our new funding and ongoing pursuit of impact, it was opportune that the IMOS Office presented on the reporting requirements between IMOS and the Department of Education and Training, and with the IMOS Advisory Board.

QA-QC

The IMOS Scientific Officer gave an update on QA-QC procedures and advancement, noting that the quality assurance of IMOS data is a core Facility role, while quality control was a shared responsibility across the program.

PLANNING FOR USE AND IMPACT

User information

The IMOS Office presented ongoing work to ensure the uses of IMOS data are captured. The new 'Impact Database' is part of a broader strategy to ensure that we can communicate and measure the impact of IMOS.

Stakeholder engagement

The strategy of 'pathways to impact' was outlined in an overview of our stakeholder engagement approach. Many in the room were representatives of national-scale research and operational partnerships, whose research priorities help ensure the uptake of observations from IMOS-derived facilities for the benefit of all Australians.

The IMOS Office would like to thank all those who travelled to the meeting, and for their positive contributions to this important annual event. All of the powerpoint presentations from the meeting are available here. ■

IMOS New Technology Proving capability launched at the Annual Planning Meeting

A highlight of the Annual Planning Meeting was the launch of a New Technology Proving capability.

The establishment of a New Technology Proving capability in IMOS is an exciting development that will provide direct investment in piloting new technologies, methods, and approaches within the program. If successful, pilots will be matured to become part of IMOS on an ongoing basis. Due to uncertainty about funding over many years, IMOS has not been in a position to invest in piloting new technologies for some time. Establishment of a New Technology Proving capability therefore presents a significant, new opportunity for the IMOS community.

Full details can be found on the IMOS website **here**.

A brief summary of the process is as follows:

Stage one EOIs are to be submitted via an online by no later than Friday 3 May 2019.

- The IMOS Science and Technology Advisory Committee (STAC) will assess the EOIs and make recommendations to the IMOS Office by no later than Friday 14 June 2019.
- Proponents of priority EOIs will then be asked to develop project plans and budgets for approval and funding by no later than Friday 26 July 2019.
- STAC will assess the project plans and budgets during August 2019 and make recommendations to the IMOS Office for approval with a view to having agreements in place for projects to start from 1 October 2019.
- To initiate the process, $1M of IMOS 2018-22 funding for New Technology Proving will be provided to back this first call for EOIs.
- Projects can be proposed for up to two years in length, and up to a maximum value of $333K over the two years (excluding co-investment). The intention of the funding limit is to ensure we have the capacity to support at least three projects from the initial $1M investment.

Enquiries should be directed to the IMOS Director in the first instance – tim.moltmann@imos.org.au ■

Stefan Williams, the University of Sydney

Introducing the IMOS Science and Technology Advisory Committee

IMOS has evolved its Node-based science advisory process to include additional expertise and provide a clearer national mandate that goes beyond the sum of regional priorities. The recently-created Science and Technology Advisory Committee has played a key role in framing advice to the Board on investment of new funding, and its next task is to evaluate expressions of interest in New Technology Proving pilot projects.

Going forward the IMOS Science and Technology Advisory Committee will continue to play a critical role for IMOS. The Committee represents the scientific opinion of the marine and climate research community, and will work to advise the IMOS Office on the scientific rationale and direction of a national observing system.

The Committee will also provide advice and assessments to the IMOS Office on the technical implementation by facilities and sub-facilities, and on the scientific merit of research undertaken with IMOS data.

Further, the committee will work to advise the IMOS Office on the development, application and implementation of new technologies within the national observing system.

Current membership of the Committee consists of:

- An independent chairperson: Louise Newman (SOOS).
- The leader of each of the Regional Nodes: Nicole Jones (UWA), Paul Van Ruth (SARDI), Richard Brinkman (AIMS), Justin Seymour (SIMS/UTS) and Dan Ierodiacanou (Deakin).
- Three representatives from the Bluewater and Climate Node community (physics, biogeochemistry, biology and ecosystems): Bea Pena-Molino (CSIRO), Andrew Lenton (CSIRO), Jess Melbourne-Thomas (AAD).
- Two marine technology experts from IMOS operating institutions: Lyndon Llewellyn (AIMS), Mark Underwood (CSIRO).
- AODN Director: Sebastien Mancini (IMOS/AODN).
- Additional members from the broader Australian marine science community to address disciplinary gaps and ensure diversity: Diana Greenslade (BOM), David Antoine (Curtin), Michelle Heupel (AIMS), Martina Doblin (UTS), Bronwyn Gillanders (Adelaide), Nicole Hill (UTAS), Vanessa Lucieer (UTAS), Emily Ogier (UTAS/FRDC).
- IMOS Scientific Officer: Ana Lara-Lopez.
- IMOS Director (observer): Tim Moltmann.
- IMOS Assistant Director (observer): Indi Hodgson-Johnston.

For more information about the IMOS Science and Technology Advisory Committee visit the IMOS website **here**. ■

Ocean observations inform the state of our climate

The 2018 State of the Climate Report for Australia was released by the Bureau of Meteorology (BOM) and CSIRO in December.

The report highlights that oceans play a vital role in modulating the rate and pace of our changing climate. And that as a consequence, the oceans around Australia are warming and acidifying.

This fifth **State of the Climate Report** focuses on climate observations and monitoring carried out by the Bureau and CSIRO in the Australian region and draws on the best available peer-reviewed information. Some of the key messages from this year's Report include:

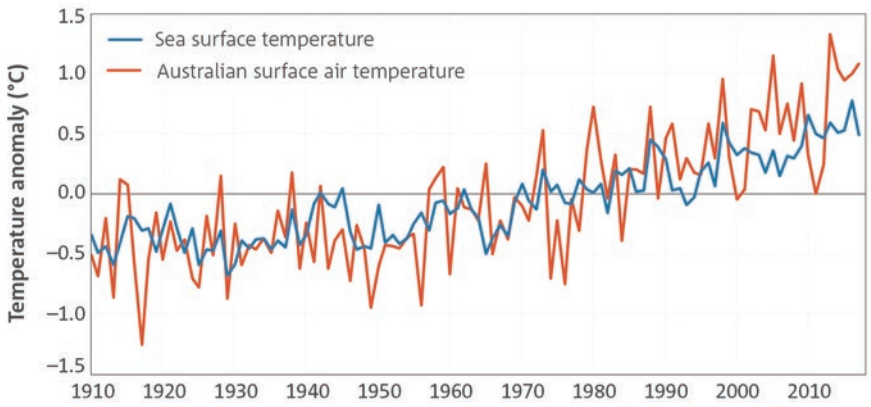
- Continuing climate changes that are consistent with the previous reports – Australia is experiencing climate change now.
- The world's oceans continue to take up extra heat from the atmosphere caused by enhanced greenhouse gas concentrations, with Southern Hemisphere oceans playing a major role.
- The increasing frequency and intensity of marine heatwaves pose a major threat to coral reef ecosystems.
- Over the coming decades Australia is likely to experience further warming, more hot days and fewer extremely cool days, and ongoing sea level rise.

Ocean observations and data provided by IMOS have informed several sections of the report, covering sea surface temperature, ocean heat content, sea level and ocean acidification.

"The CSIRO and Bureau of Meteorology are major partners in the IMOS national collaboration" says Tim Moltmann, IMOS Director. "Together they operate several of our observing facilities that measure essential ocean variables from the surface to depths of 2,000 meters and beyond."

IMOS facilities contributing to the ***2018 State of Climate Report*** include **Argo profiling floats, Ships of Opportunity, Satellite Remote Sensing** and **Ocean Acidification moorings**.

"The research infrastructure of IMOS provides critical data for this biennial assessment of Australia's climate" says Dr Helen Cleugh, Director of the CSIRO Climate Science Centre. ■



Oceans around Australia have warmed by around 1 °C since 1910, contributing to longer and more frequent marine heatwaves.

Source: Bureau of Meteorology.

Lea Walpole

NEWS

IMOS plankton and nutrient data used to validate eReefs model

A new study provides the first analysis of the planktonic and nutrient dynamics simulated by the eReefs biogeochemical model, driven by catchment flow and nutrients from 21 rivers.

The dynamics of nutrients, phytoplankton, zooplankton and water clarity of the iconic Great Barrier Reef World Heritage Area (GBRWHA) are influenced by seasonal variation in coastal and oceanic conditions, and anthropogenic inputs.

The greatest impacts to the GBR region over the past 30 years have been damage from cyclones, reductions in water clarity and, for coral reefs, crown of thorns starfish outbreaks and marine heat waves causing mass coral bleaching.

Recent events have emphasised the vulnerability of the GBRWHA with two consecutive years of severe coral bleaching caused by anomalously warm water temperatures, and, the emerging risk of ocean acidification.

In this newly published study the authors present a comparison of the eReefs model conducted against a range of in situ observations that included 24 water quality moorings, two nutrient sampling programs (with a total of 18 stations) and time-series of taxon-specific plankton abundance. The model encompasses the 2300 km long Great Barrier Reef from coast to Coral Sea.

The study used observations from the IMOS National Reference Station moorings at North Stradbroke Island and Yongala to validate the eReefs model. These two sites have high frequency measurements of chlorophyll fluorescence and turbidity form in situ sensors, as well as monthly water sampling for phytopigments, nutrients, phyloplankton and zooplankton species counts.

In addition, the study used data from six other IMOS moorings (Lizard Island, Myrmidon Reef, One Tree East, Palm Passage, Capricorn Channel, Heron South) and Continuous Plankton Recorder surveys.

The comparison of the spatially-resolved statistical model of zooplankton based on >900 observations in the region showed similarities in the relationship and spatial distribution of simulated and observed biomass. Both show zooplankton biomass is greatest inshore, biomass is highest around shallow reef areas and in the southern and central GBRWHA, and greater in summer than winter.

The eReefs simulation contributes to the understanding at a high spatial and temporal resolution of where and how nutrients and plankton originate and interact within the Great Barrier Reef.

eReefs is producing powerful visualisation, communication and reporting tools, and the model simulations, such as those presented in this study, will benefit government agencies, Reef managers, policy makers, researchers, industry and local communities.

To read the full paper: **https://www.sciencedirect.com/science/article/pii/S0924796317304529#s0185**

eReefs simulations were developed as part of the **eReefs project**, a public-private collaboration between Australia's leading operational and scientific research agencies, government, and corporate Australia. ■

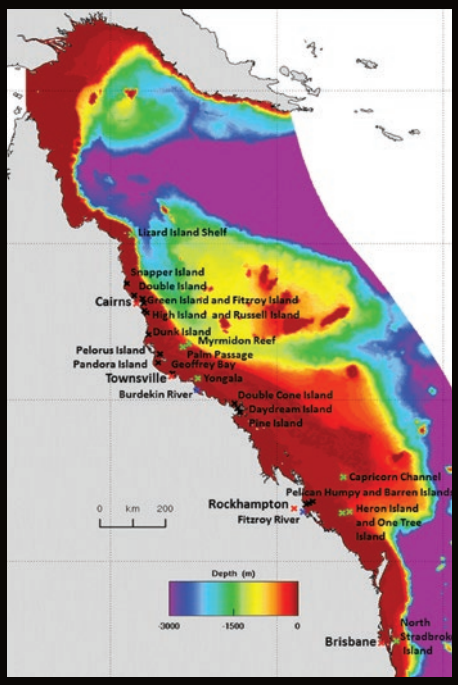
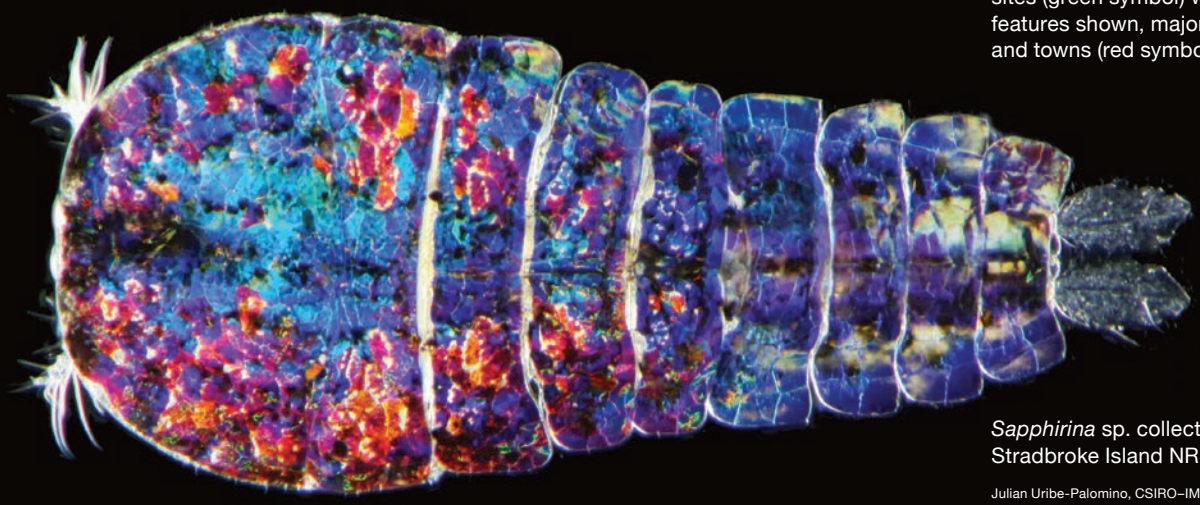


Figure courtesy of Journal of Marine Systems.

Sample sites: Marine Monitoring Program sensor locations (black symbol) and IMOS sites (green symbol) with major geographic features shown, major rivers (blue symbol) and towns (red symbol) and depth (m).



Sapphirina sp. collected at North Stradbroke Island NRS.

Julian Uribe-Palomino, CSIRO–IMOS

Revealing the hidden diversity of Australian microbes in the environment

A new Australia-wide research framework initiative, the 'Australian Microbiome', brings together researchers from more than 40 institutions and government organisations across Australia to advance the understanding of the function of microorganisms in natural Australian environments.

The nationally inclusive program is supported by **Bioplatforms Australia** and the Integrated Marine Observing System (IMOS) through the Australian Government's **National Collaborative Research Infrastructure Strategy** (NCRIS), Parks Australia through the **Bush Blitz** program funded by the Australian Government and BHP, and **CSIRO**.

Microbes are the living fabric of our soils, rivers and seas. They play a major role in controlling the function and health of our marine and terrestrial environments. These miniature powerhouses impact our climate by making and breaking greenhouse gases. They are also integral to the prosperity of our agriculture, livestock, fisheries and textile industries; are intimately involved in our health as agents of disease or as potential treatments, they provide clean drinking water, and the means to mitigate waste and pollution.

Martin Ostrowski, University Technology Sydney

Series of Niskin bottles ready to be deployed for seawater sampling at the IMOS National Reference Station of Port Hacking in June 2011.

Despite the key ecological importance of these microorganisms, the environmental drivers supporting their abundance and diversity are still largely undefined. The '**Australian Microbiome**' builds on the critical continental resources established by the '**Biomes of Australian Soil Environments**' (BASE) and '**Marine Microbes**' initiatives that focussed on soil, ocean and coastal microbiomes.

"The nationally inclusive consortium approach of the BASE and Marine Microbes initiatives, involving over 40 organisations, has been highly successful and facilitated the development of two valuable efforts with impactful deliveries both in terms of data resource and analysis abilities." said Andrew Gilbert, Bioplatforms Australia's Chief Executive. "Combining and extending these efforts will create a resource of greater value and impact."

'Australian Microbiome' will enhance existing activities that have built robust protocols and a database housing microbial diversity in both terrestrial and marine environments, associated with rich contextual information on physical and chemical characteristics of the studied sites.

The key partners in this initiative are already utilising positive outcomes from existing efforts. "The Australian Microbiome initiative will strengthen the existing assets and significantly augment the value of previous initiatives to support national research efforts. It will help to define the primary drivers of environmental productivity, while aiding efforts to monitor the health of our environment for more efficient management and drive conservation" stated Dr Sue Fyfe, Director of the Biodiversity Science Section at Parks Australia.

"This project will create a research resource that we simply could not have imagined just a few years ago. By combining field-based sampling, sequencing and bioinformatics we can look for future opportunities for using these techniques to understand Australia's marine environment, which is vast, valuable, and changing rapidly" added Tim Moltmann, Director of Australia's IMOS.

The initiative uses a time series of microbial data sampled each month and at different depths at the IMOS **National Reference Stations**. These stations are located at seven sites around Australia's coastline and positioned to cover different geographic and environmental regions. In addition to marine water sampling and analysis, IMOS is making new investments in DNA extraction and bioinformatics.

The initiative has broad national and international utility for academic researchers, industry and government agencies. The dataset produced through the initiatives is a publicly available national resource for all researchers to use.

"The value of the 'Australian Microbiome' initiative ranges from addressing questions around biodiversity discovery, biogeography and evolution, effects of land-use and climate change, and phytoplankton bloom prediction, through to more applied purposes, such as in the areas of biosecurity, mineral prospecting and revegetation success. All of these provide fundamental information for management and monitoring." said Dr Andrew Young, CSIRO. ■

Australian Microbiome

New IMOS Multi-Sensor Sea Surface Temperature Composites provide better coverage and accuracy

WRITTEN BY: HELEN BEGGS, CHRISTOPHER GRIFFIN AND PALLAVI GOVEKAR

Sea surface temperatures from the NOAA-19 satellite have exhibited larger than usual errors since 3rd September 2018, associated with the satellite passing for the first time into a fully sunlit orbit. The new operational IMOS Multi-Sensor L3S products, incorporating Suomi-NPP and NOAA-18 data are recommended for use, and are now available via the AODN.

IMOS has produced a 27-year suite of satellite-based sea surface temperature (SST) composites on a 0.02° x 0.02° grid, using locally received data from AVHRR sensors aboard the series of NOAA Polar-Orbiting Environmental Satellites (NPOES). From 2018, NOAA officially replaced the AVHRR sensor program with the Visible Infrared Imaging Radiometer Suite (VIIRS) sensor program, after a long trial which began with the first VIIRS sensor launch in 2012 aboard the Suomi National Polar-orbiting Partnership (NPP) platform.

IMOS has, since 16th November 2018, included the VIIRS SST from NPP in a new suite of Multi-sensor operational real-time SST products, resulting in improvements to overall quality, accuracy and coverage. This new product is intended to be a drop-in replacement for the existing AVHRR-only product set, with similar file format. For further information and data access please read this short **article**.

NOAA-18 and NOAA-19 are the last in the series of operational NPOES satellites to carry AVHRR sensors, starting with NOAA-6 in 1981, although they are still carried on the European Space Agency (ESA) MetOp series of polar-orbiters. Orbital decay of NOAA-18 and NOAA-19 during recent years has affected the accuracy of the real-time IMOS AVHRR SST products during some months. The AVHRR sensor on NOAA-19 was adversely affected by passing for the first time into a fully sunlit orbit on 13th September 2018, and from 29th September 2018 SSTs from this satellite have not contributed to the IMOS AVHRR-only L3S products. NOAA-18 is expected to pass into a similar full-sun orbit in late February 2019, with degradation in SST accuracy expected. It is therefore recommended that users requiring accurate 2 km SST composites over the Australian region consider using the new IMOS Multi-sensor L3S. ■

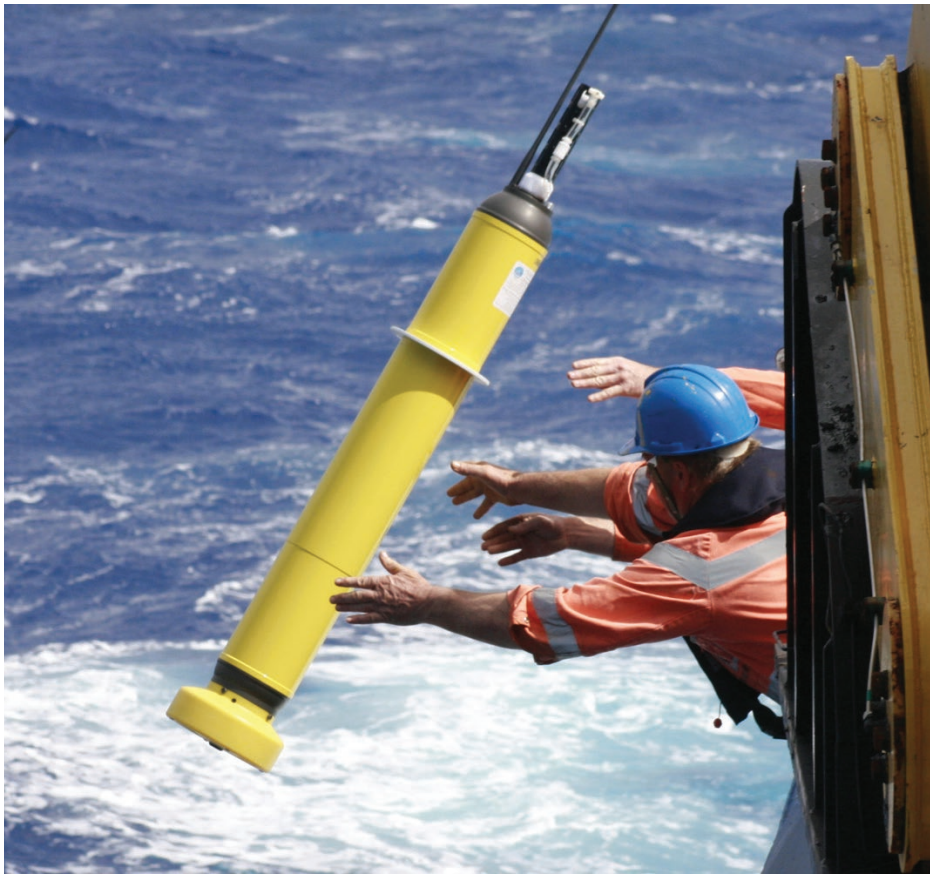
Argo floats tell us how fast the ocean is warming

A major international study published in the journal **Science** in January demonstrates that the ocean is warming faster than we thought. It has several implications, including on the projected rate of sea level rise.

This discovery was based on radical improvement in the availability of sub-surface observations via the global 'Argo' network of autonomous, profiling floats. There are 4,000 Argo floats measuring the global ocean from the surface to a depth of 2 kilometres, all day, every day.

The IMOS Argo Australia Facility (operated by CSIRO) manages 400 floats in the Australian region, or 10% of the global network.

This is a significant contribution by our nation to international monitoring of the global ocean. It is an even more significant benefit to our nation. Australian scientists, students, policy-makers, managers, and marine industries have open access to ocean information from the entire global network (4,000 floats), and the modelling and analysis products that it produces. ■



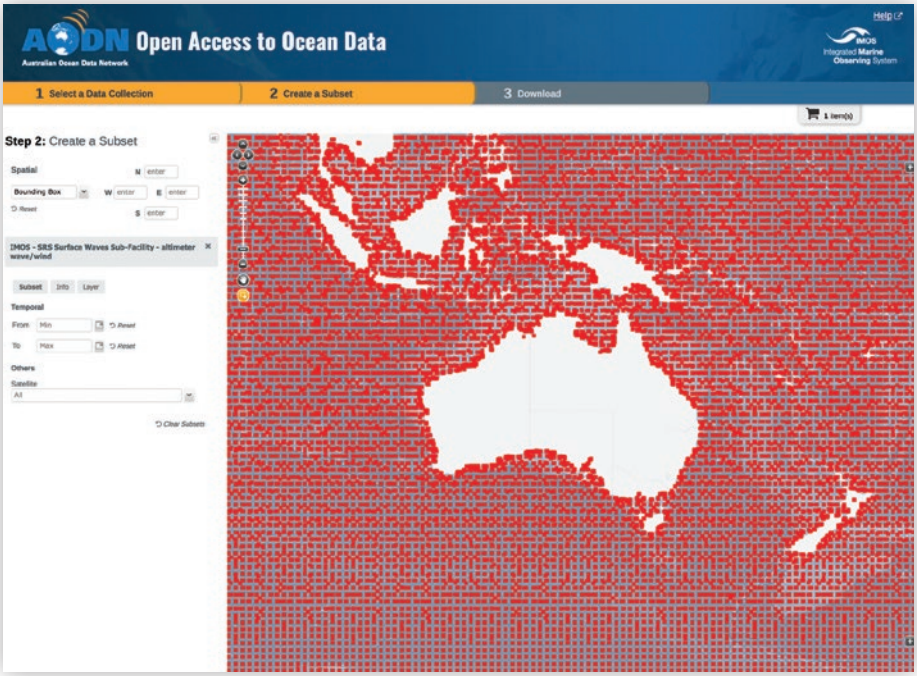
Alicia Navidad CSIRO

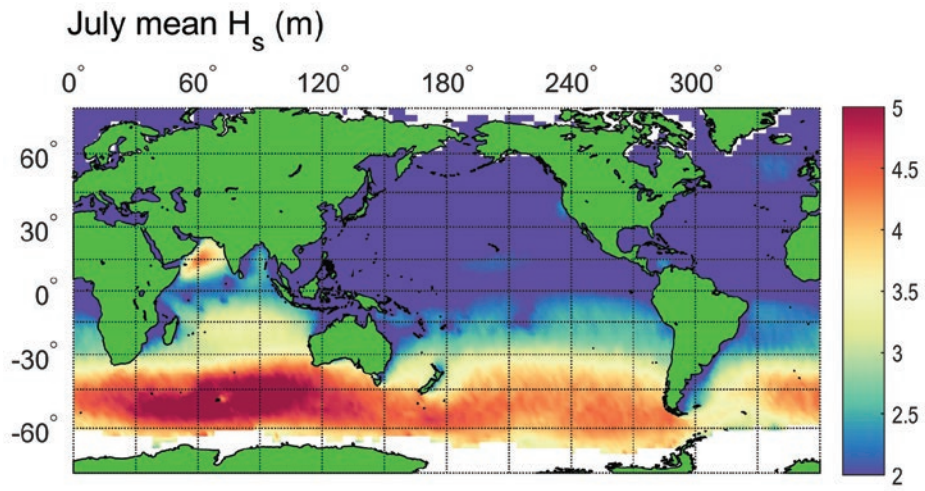
Altimeter wind and wave database on AODN

The new Surface Waves sub-facility has published its first data collection in the AODN Portal; a global database of wind speed and wave height obtained from all the altimeter missions which have flown since 1985.

The IMOS Satellite Remote Sensing Facility Sub-Facility Surface Waves (which IMOS formed in 2017) is calibrating, collecting and distributing ocean surface wind and wave data from current and next-generation satellite missions. The sub-facility has just published its first data collection in the AODN Portal, a global database of wind speed and wave height obtained from all the altimeter missions which have flown since 1985.

Satellite altimeters have now been in operation for 33 years, providing global data of wind speed and wave height. The altimeter data is invaluable for many applications, including: design of coastal and offshore structures, the operation of ports and harbours, the routing of ocean-going ships, studies of coastline erosion and investigations of changing climate, to name a few.





This image shows the mean monthly global significant wave height during the month of July, as an example of the data use. This example is during the Southern Hemisphere winter when the strong westerly winds in the Southern Ocean generate large waves, as can be seen in the image. These waves propagate into the Indian and South Pacific as swell. Also clear in the image are local influences like the Somali jet which blows along the Horn of Africa at that time of year.

However, over this 33-year period a total of 13 different satellites have been operational. The data from these satellites is available from a range of different agencies, is in a range of formats and have all been calibrated independently. As a result, it is extremely difficult for users to obtain access to long duration records in a convenient format.

The global database of wind speed and wave height

Integrated Marine Observing System (IMOS) engaged researchers at the University of Melbourne to compile a combined database from all these satellite missions. Importantly, the altimeter observations have all been calibrated against extensive buoy measurements in a consistent manner. As part of this process, any changes in calibration or discontinuities or drift in satellite measurements has also been removed.

Finally, every one of the more than 3 billion observations of wind speed and wave height in the database has been assigned a flag indicating the quality of data. The data is for the entire globe from 80S to 80N and is available for 24 hours per day over the 33-year period.

Data use and access

For ease of access, the large database has been split into files each of 1 degree by 1 degree. Users accessing the AODN Portal can specify a region and desired time period and obtain the requested data. At present, the database spans the period 1985 to 2018. The database will be regularly updated as new observations become available.

Thank you to Ian Young and Augustinus Ribal of the University of Melbourne for their contribution towards this story. ■

NEW BOOK

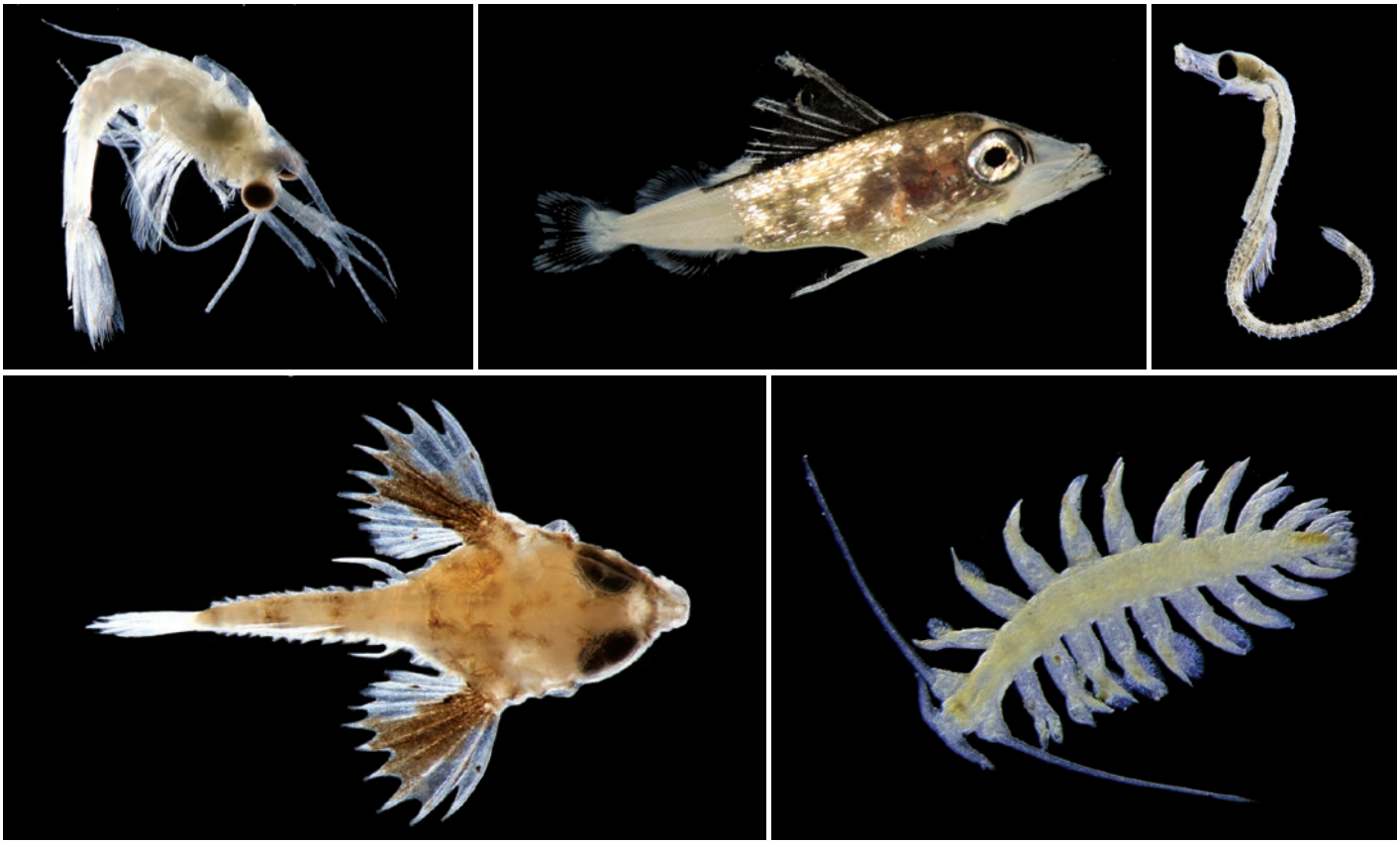
PLANKTON: A Guide to Their Ecology and Monitoring for Water Quality

Healthy waterways and oceans are essential for our increasingly urbanised world. Yet monitoring water quality in aquatic environments is a challenge, as it varies from hour-to-hour due to stormwater and currents. Being at the base of the aquatic food web and present in huge numbers, plankton are strongly influenced by changes in environment and provide an indication of water quality integrated over days and weeks. Plankton are the aquatic version of a canary in a coal mine. They are also vital for our existence, providing not only food for fish, seabirds, seals and sharks, but producing oxygen, cycling nutrients, processing pollutants, and removing carbon dioxide from our atmosphere.

This Second Edition of Plankton is a fully updated introduction to the biology, ecology and identification of plankton and their use in monitoring water quality. It includes expanded, illustrated descriptions of all major groups of freshwater, coastal and marine phytoplankton and zooplankton and a new chapter on teaching science using plankton. Best practice methods for plankton sampling and monitoring programs are presented using case studies, along with explanations of how to analyse and interpret sampling data.

The Editors would like to thank IMOS, and particularly Tim Moltmann, for their support of plankton work in Australia. Tim was provided with a signed copy by the Editors at the IMOS Annual Planning Meeting in Brisbane in February. The chapters on marine phytoplankton and zooplankton identification and ecology draw heavily on IMOS data and expertise.

The book is available now via CSIRO publishing: **https://www.publish.csiro.au/book/7808/** ■



Julian Uribe-Palomino, CSIRO–IMOS

IMOS *OceanCurrent*: Great Barrier Reef gets a reprieve from the heat this year

WRITTEN BY: CRAIG STEINBERG AND MADELEINE CAHILL

The GBR has had a welcome reprieve from the heat this year with below-average Sea Surface Temperatures particularly in January and February (see right, 17 Feb SST Percentiles), the time when water temperatures on the reef are usually at their maximum.

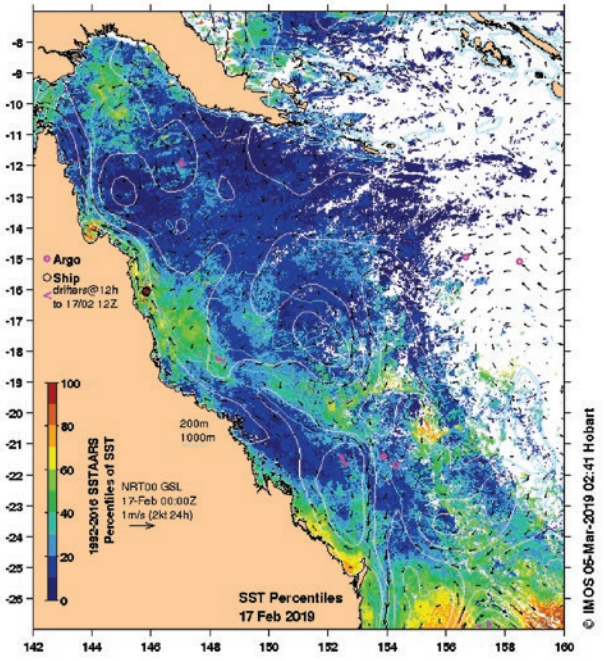
Since the damaging coral bleaching summers of 2016 and 2017 on the GBR, researchers and managers have paid close attention to the seasonal forecast for SST as summer approaches. Coming into this summer, the November outlook was for moderate warming (0.5°C above average) throughout the GBR but by **early December**, SST percentiles indicated temperatures turned out to be significantly warmer (in the highest 20%) than the forecast.

Cyclone Owen, however, put a stop to that when it passed through the region just a few days later and then again on Dec 15. Further heating throughout the summer was limited by the stable monsoon trough that developed over North Queensland and then Tropical Cyclones Penny, Oma and now Trevor. The cyclones and the monsoon both provide heavy cloud cover that blocks solar heating and the strong winds cool the surface by vertically mixing cool water from below the thermocline.

Of course, monsoons and cyclones also bring rain and this season the rainfall was unprecedented. There was runoff onto the reef all along the coast but particularly from the Burdekin River which has a catchment area west of the Great Dividing Range. On Feb 11, the sediment laden plume was seen to extend 60km across the shelf (Figure 2) and a few days later, after the wind turned offshore, it reached all the way to Gould Reef on the outer shelf.

Inshore regions often feel the effects of the runoff plumes but it is unusual for them to affect the outer reef. The sediment in the river plumes will eventually settle out, potentially smothering seagrasses and corals. The plume waters themselves bring nutrients and often result in large increases in microbial and planktonic blooms. On the positive side, benefits include increased prawn production and food for other larvae.

Recent flooding of Queensland, Australia's Burdekin River has sent a large plume of turbid water into Upstart Bay and beyond. When this Landsat 8 image was collected on February 11, 2019, the plume had reached all the way to Old Reef at the inside edge of the Great Barrier Reef — some sixty kilometers from the river's mouth. ■



NASA-OBPG's Landsat 8 image of the Burdekin plume, 11 Feb 2019, showing the boundary of the flood plume against the clear ocean waters.

New IMOS activities

IMOS announced in November that the IMOS Governing Board met and considered the recommendations for the 2018-22 funding. A number of new activities have been funded by IMOS. Each new activity is outlined below as well as an introduction to the key staff who will be leading these projects.

Biogeochemical Argo, Pete Strutton and Tom Trull

The core Argo program will be continued and enhanced to include ice capable floats. The new IMOS Biogeochemical Argo Sub-Facility will deploy floats in areas of high scientific significance in Australia's EEZ and the Southern Ocean, and will contribute to data to national and international biogeochemical models.

Pete Strutton is a biological oceanographer at the Institute for Marine and Antarctic Studies (IMAS). His field of research is the interaction between physical and biological processes in the ocean, and the consequences for ocean productivity and air-sea CO_2 exchange. He has a PhD in Marine Science from the Flinders University of South Australia and has held positions at the Monterey Bay Aquarium Research Institute, Stony Brook University and Oregon State University before joining UTAS as an ARC Future Fellow in 2010. He has also led the IMOS Bluewater and Climate Node.

Tom Trull has led the Antarctic and Antarctic Climate Ecosystems (ACE) CRC biogeochemistry programs since 1997 focusing on ocean carbon uptake, acidification, and fertilisation. He has longstanding experience with moored biogeochemical sensors, and currently serves as co-chair of the OceanSITES global network of time series moorings. In the last 5 years, has expanded these interests to autonomous profiling floats, with the aid of an excellent series of postdoctoral fellows including Melanie Grenier, Bozena Wojtasiewicz, and Christina Schallenberg. Those efforts have delivered novel outcomes from biogeochemical Argo floats, including assessment of the fraction (f-ratio) of Southern Ocean biomass respiration likely to sequester CO_2 and the development of optical backscatter as a proxy for the magnitude of denitrification in oxygen minimum zones. In 2018 he joined the international biogeochemical Argo Steering Committee. He is a senior principle research scientist in the CSIRO Oceans and Atmosphere Climate Science Centre and co-leader of the Carbon and Ecosystems Program in the ACE CRC.

Southern Ocean Plankton, Kerrie Swadling

In collaboration with the Australian Antarctic Division, IMOS will count Continuous Plankton Recorder samples from the Southern Ocean, one of the most climate sensitive regions on Earth, including samples on the route to the Southern Ocean Time Series deep water mooring site.

Kerrie Swadling is a plankton ecologist at IMAS and the ACE CRC. She specialises in Southern Ocean zooplankton, with particular interests in energy flow through lower trophic food webs, sea ice ecosystems, and autecology of key species. Kerrie will co-lead the new Southern Ocean sub-facility of the SOOP facility with Dr So Kawaguchi (Australian Antarctic Division). She aims to work closely with the AusCPR program to create stronger ties between IMAS, the AAD and CSIRO and help promote plankton work within IMOS.

Ocean Gliders: Event-based sampling, Jessica Benthuysen

This year IMOS commenced a new project for Event Based Sampling. Two Slocum gliders have been deployed in the first half of 2019 for targeted observations of marine heatwaves. Decisions on where and when to deploy them have been developed through a multi-institution approach. On 13 February 2019, a Slocum glider was deployed off Eastern Tasmania to coincide with the ongoing 2019 Tasman Sea marine heatwave. The glider sampled water properties over the four weeks, as it progressed southward from St. Helens to Hobart. A second glider was deployed on 16 March 2019, following a similar path, with near real time data and plots available on the **AODN Portal** and on **IMOS *OceanCurrent***. The findings are being communicated with the local oyster and salmon industries.

Jessica Benthuysen is a research scientist in physical oceanography at the Australian Institute of Marine Science (AIMS), investigating ocean temperatures and currents around tropical Australia. Since 2014, Dr. Benthuysen has worked at AIMS in Townsville and Perth. She is also the sub-facility leader of the IMOS Ships of Opportunity: Sensors on Tropical Research Vessels. Her research interests include the connections

Pete Strutton

Tom Trull

Kerrie Swadling

Jessica Benthuysen

between the coastal ocean and the large-scale circulation, marine heatwaves, and understanding relationships between the marine environment and the health of marine ecosystems.

National Reef Monitoring Network, Rick Stuart-Smith

IMOS is investing in a reef monitoring data Facility to handle all data obtained during shallow reef surveys, including those conducted by Reef Life Survey and State conservation management agencies. All data holdings will be discoverable and accessible through the AODN. This will support the National Reef Monitoring Network's contribution to establishing and supporting National Marine Baselines and Long-term Monitoring to develop a comprehensive assessment of our estate, and to help manage Commonwealth and State Marine Reserves.

Rick has been working at IMAS as a field ecologist for the last 13 years, mostly working on rocky and coral reefs around the world. He has contributed to the long-term monitoring programs for Marine Protected Areas across southern Australia with Graham Edgar and Neville Barrett, and co-founded the Reef Life Survey program (RLS) with Graham at the end of 2007. Through RLS he has trained >200 divers to undertake detailed quantitative biodiversity surveys of rocky and coral reefs on SCUBA, and has built an extensive knowledge of reef fishes across temperate and tropical regions in all ocean basins. He published a book on tropical reef fishes of Australia and created a website of the world's reef fauna (Reef Species of the World), built on RLS data. His research focusses on how different pressures shape patterns in reef biodiversity, and aims to provide more effective mechanisms for sharing these with management agencies, policy-makers and the public.

Wave Buoys, Diana Greenslade

A new Wave Buoy Sub-Facility will be established to deploy directional wave buoys in the Australian coastal zone, addressing key gaps identified through a national prioritization process for Australian wind-waves research. Priority areas identified were Eastern Tasmania and the Northern Territory. The existing network (operated predominantly by state-based agencies) is relatively sparse for most of Australia's continental shelf and approximately 20% of the existing buoys in the network do not measure wave direction, which is an important parameter for most wave applications. Research activities that would be supported through this infrastructure include: calibration and validation of new satellite instruments, wave model development and verification and wave climate analysis.

Diana Greenslade has been at the Bureau of Meteorology for more than 20 years and is currently a Principal Research Scientist leading a small team responsible for research and development of the Bureau's marine forecast systems, which includes waves, storm surges, tsunamis and coastal hazards in general. While numerical modelling is generally the main component of work at Bureau, Diana has always had an interest in marine observations, both in situ and remotely sensed, starting with her postgraduate degrees which were focussed on remotely-sensed wind-waves and data assimilation. She recently took some time out from the Bureau and spent two years at the International Science Council in Paris, working with the Future Earth interim Secretariat and consuming copious baguettes.

Larval Fish, Iain Suthers

Larval Fish Monitoring is a new Sub-Facility of the Moorings Facility. Larval fish are sensitive to environmental changes, with many oceanographic processes influencing their distribution, abundance and survival. Most species have eggs and larvae that can be sampled with simple plankton nets in the upper mixed layer of the water column resulting in the capture of a broad suite of larval fishes. The sensitivity to ocean oceanographic processes, and the ease of capture, make larval fish useful indicators of change. Larval fish monitoring will occur at five of the seven National References Stations (NRS).

From 2007-2012 Iain was the node leader of NSW-IMOS. His day-job is at UNSW and may sometimes be found at the Sydney Institute of Marine Science (SIMS) working with DPI-Fisheries colleagues. He completed his PhD on post-larval cod off eastern Canada and post-doctoral work in Norway and back at Sydney Uni before taking up a lectureship at UNSW

Rick Stuart-Smith

Diana Greenslade

Ian Suthers

in 1991. He has recently completed four research voyages off eastern Australia on RV Investigator, aided by his nearly 40 PhD students and over 50 honours students on projects from red tides to larval fish ecology, fish age and growth, artificial reefs and marine food webs. His recent research concerns eddies of the East Australian Current, salp ecology, and larval retention of Atlantic herring. He teaches a third year fisheries and oceanography course; and has a laboratory of 4 PhD students in collaboration with Jason Everett, Hayden Schilling and Matt Taylor (NSW-DPI). His professional raison d'etre is IMOS, which has completely transformed the way he thinks about marine science.

Victoria moorings, Daniel Ierodiaconou

The Bonney Coast had been identified as a gap in the national backbone of IMOS observations. The area encompasses shelf waters between Cape Jaffa in South Australia and Cape Otway in Victoria, and is influenced by a strong seasonal upwelling that supports one of the most productive marine regions in Australian coastal waters. The region is therefore of high ecological and economic importance to both South Australia and Victoria. IMOS will deploy a mooring in 100 m of water off Cape Bridgewater, Victoria that will collect a range of physical measurements, as well as associated Conductivity, Temperature, Depth (CTD) profiles on a cross shelf transect.

Daniel Ierodiaconou is a marine ecologist interested in understanding the physical and biological processes that influence biogeographic patterns in marine and coastal ecosystems at both ecological and geological timescales. He leads temperate reef monitoring programs in Victoria for State agencies including diver based visual surveys, towed video, baited video, unmanned aerial vehicles, AUVs and geophysical data acquisition using Deakin's inhouse multibeam sonar capabilities. Projects include using marine imagery with seafloor terrain characteristics to predict the distribution of benthic habitat and demersal fish communities. This has included programs with the FRDC to understand the primary drivers of productivity on local geographical scales, the resilience of fishing stocks, and threats associated with environmental change with collaborators from Deakin University, University of Melbourne, La Trobe University, James Cook University, Parks Victoria and the Victorian Fisheries Authority.

Marine Microbiome Initiative, Jodie van de Kamp and Andrew Bissett

The Marine Microbiome Initiative is a new IMOS Facility that will manage our participation in the Australian Microbiome Initiative (see main article for more details). The Australian Microbiome Initiative is a nationally inclusive program is supported by Bioplatforms Australia and IMOS through the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), Parks Australia through the Bush Blitz program funded by the Australian Government and BHP, and CSIRO.

The initiative uses a time series of microbial data sampled each month and at different depths at the IMOS National Reference Stations. These stations are located at seven sites around Australia's coastline and positioned to cover different geographic and environmental regions. In addition to marine water sampling and analysis, IMOS is making new investments in DNA extraction and bioinformatics.

Jodie van de Kamp has applied molecular biology and metagenomics within a broad range of contexts since the beginning of her research career. From bioprospecting and discovery of novel microorganisms in sub-Antarctic and Antarctic environments to investigating microbe-mineral interactions in geological formations, e.g. cave speleothems and desert varnish. She joined CSIRO as a Molecular Biologist in 2005, investigating genetic controls for invasive fish species. For the past 10 years her research has focussed on the marine environment, specifically, the use of metagenomics for the study of microbial ecology and its utility for ecological monitoring, particularly in our coastal systems, in relation to anthropogenic impacts and determining long-term trends in ocean health.

Andrew Bissett's research utilises metagenomics analysis tools to improve our understanding of microbial biodiversity patterns and dynamics and their effects on ecosystem processes in a range of environments (soil, water, organismal microbiomes). His research interests include all aspects of microbial ecology, particularly relationships between microbial identity and function. These interests include the roles of microbial communities in the broader environment and also as members of higher organisms' microbiomes. To investigate microbial communities and their functions he employs primarily culture independent methods reliant on amplicon based and amplicon free metagenomic sequencing, functional gene microarrays and biogeochemical methods. ■

Daniel Ierodiaconou

Jodie van de Kamp

Andrew Bissett

Postgraduate Student | **Phil Dyer**

PROJECT TITLE:

Modelling Marine Communities to Produce the First Global Data-Driven Bioregionalisation and Inform Conservation

The University of Queensland

The vast size of the marine biosphere makes comprehensive biological sampling impossible, and the available survey data is patchy in time and space. To help meet the need for reliable information about the patterns of biodiversity in the oceans, Phil is building large-scale, data-driven and biologically-informed bioregionalizations. The bioregionalization could be used to support conservation planning and marine research. To build the bioregionalization, Phil is investigating statistical approaches to bring together high-resolution, remote-sensed environmental data with biological samples from a wide range of surveys, covering microbes, plankton and fish.

Copepods in particular are excellent for mapping out bioregions in a data driven way. Copepods are found everywhere, are much easier to speciate than microbes, and can be sampled more reliably and consistently than fish or large invertebrates. The IMOS Continuous Plankton Recorder (including the Southern Ocean) and National Reference Stations datasets will be invaluable for building the bioregions, particularly in the pelagic ocean. The copepods will probably provide the majority of the information for a pelagic bioregionalization. The microbial data, fisheries data and additional plankton data from the IMOS data will help refine and reinforce the bioregionalization.

The statistical technique Gradient Forest shows a lot of promise for building the large-scale bioregionalizations because it is capable of combining unrelated surveys with relatively few assumptions. Gradient Forest generates a set of functions that give the expected "species compositional turnover" between two sites when the environmental conditions at each site are known. Phil uses the set of functions to generate maps showing areas of similar biology, and cluster the maps into bioregions.

The three maps here show patterns of biodiversity in copepod distributions (Figures 1 and 2), and patterns of biodiversity considering copepod, phytoplankton and fisheries data together (Figure 3). Figure 1 is a continuous compositional map, similar colours indicate similar biology. Figures 2 and 3 have been divided up into bioregions, areas of similar biology. 50 bioregions are shown, which explains most of the structure in the data while still being readable.

Figures 1 and 2 show two dominant trends in copepod assemblage distributions. The first is temperature, creating a clear north south pattern in assemblage distribution. Distance from the coast is the other visible trend, as coastal processes add nutrients and create habitats that are not available in deeper water. Dividing the space up into 50 bioregions (Figure 2) makes these trends easier to see, as well as showing how the strong circumpolar current creates long narrow bands of habitats. Adding in phytoplankton and fisheries data (Figure 3) creates a smoother map with the same general trends. As more datasets are added, noise from each dataset is balanced by information from other datasets.

Phil will continue to work on ways of finding an appropriate number of bioregions given the data, and how best to apply the Gradient Forest technique over very large scales, up to global in scope. ■

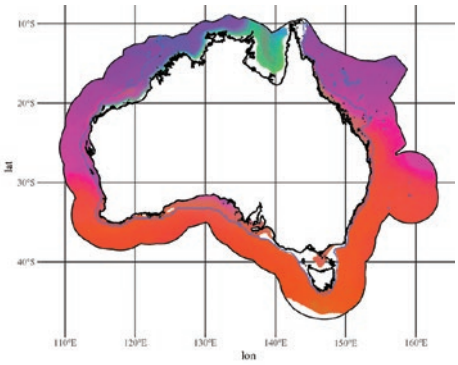


Figure 1: Copepod composition map around the Australian Exclusive Economic Zone. Similar colours between points indicate a similar species set.

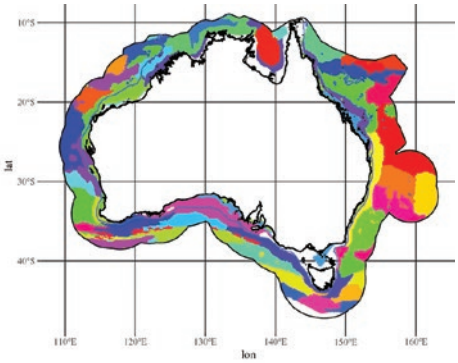


Figure 2: Copepod bioregions map. 50 bioregions are shown, which balances explanatory power with simplicity.

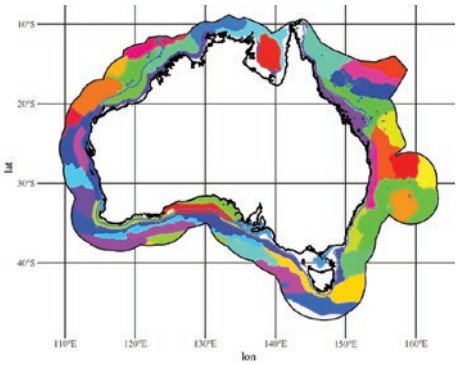
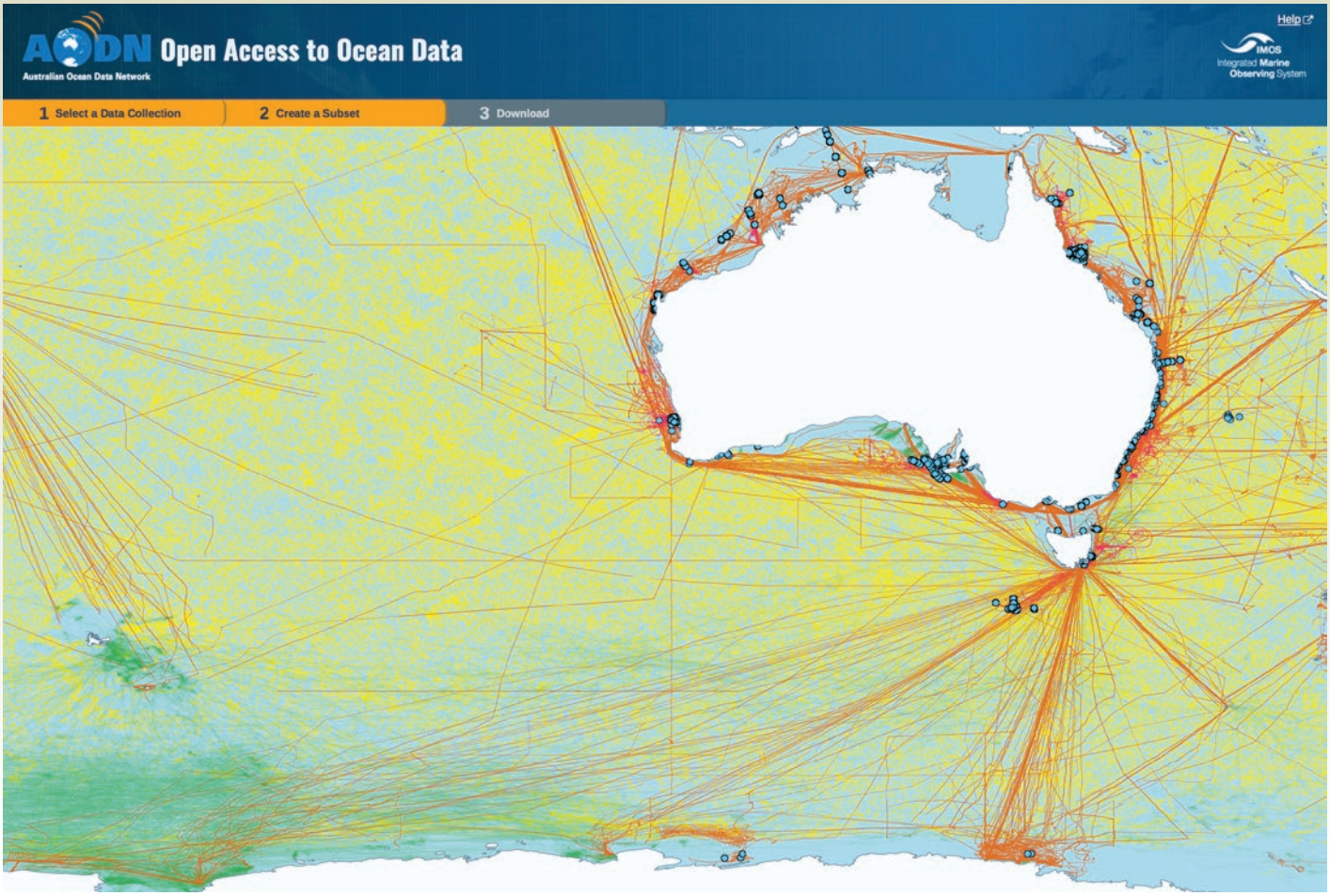


Figure 3: Bioregion map combining phytoplankton, copepods, and fisheries data on pelagic species. 50 bioregions are shown, which balances explanatory power with simplicity.



The AODN Portal provides access to all available Australian marine and climate science data and provides the primary access to IMOS data including access to the IMOS metadata.

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IMOS

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