IMOS
marinematters
Integrated **Marine Observing** System
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What have we learnt from 15 years of ocean observations with the global Argo array?

A review of the Argo array recently published in Nature Climate Change considers the progress of the programme and provides an outline of how the programme is likely to change in the future. **PAGE 3**

Where will the Weddell seals go? Deciphering the movements of marine predators.

Plankton report reveals deep knowledge on marine environments

Postgraduate Student Profile – Veda Malpress

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director's corner

Welcome to the first edition of Marine Matters for 2016.

The headline news is that the Australian Government's National Innovation and Science Agenda released in December 2015 delivers funding certainty for the National Collaborative Research Infrastructure (NCRIS) program that created and developed IMOS. This means that for the first time in several years we can again begin to make multi-year plans for the future.

Under an initiative called "Building world-class national research infrastructure", the Agenda makes an ongoing commitment to NCRIS and allocates $1.5 billion over the next decade i.e. $150 million per annum, plus indexation.

It is important for us to understand that a commitment to NCRIS is not a commitment to IMOS per se. During 2016, Australia's Chief Scientist will chair an expert group to undertake a road-mapping process to identify specific future research infrastructure capability requirements. That said, the fact that the IMOS community has established, grown and maintained a large and high-performing capability over the last decade means that we can engage in this national level planning with confidence about the long-term future.

This edition highlights delivery of high-quality, societally-relevant science outputs at global, national and local scales.

The fundamental importance of subsurface ocean observations to understanding the Earth's heat and energy budget is illustrated in the story on 15 years of Argo – the global array of autonomous profiling floats. Building on a strategic investment made by CSIRO in the early 2000's, IMOS has provided the cornerstone for Argo Australia over the last decade. This has enabled Australian scientists to play a major role in a high profile international program providing essential knowledge about climate variability, change and adaptation. Knowledge that is relevant to coastal city communities, rural farming communities, defence forces, and many others.

The power of a connected, national approach can be seen in the impressive performance of the IMOS glider facility. During 2015, our gliders traversed a total of almost 12,000 kilometres to collect valuable data on temperature, salinity, currents and other variables at a range of depths in Australian waters – north, south, east and west.

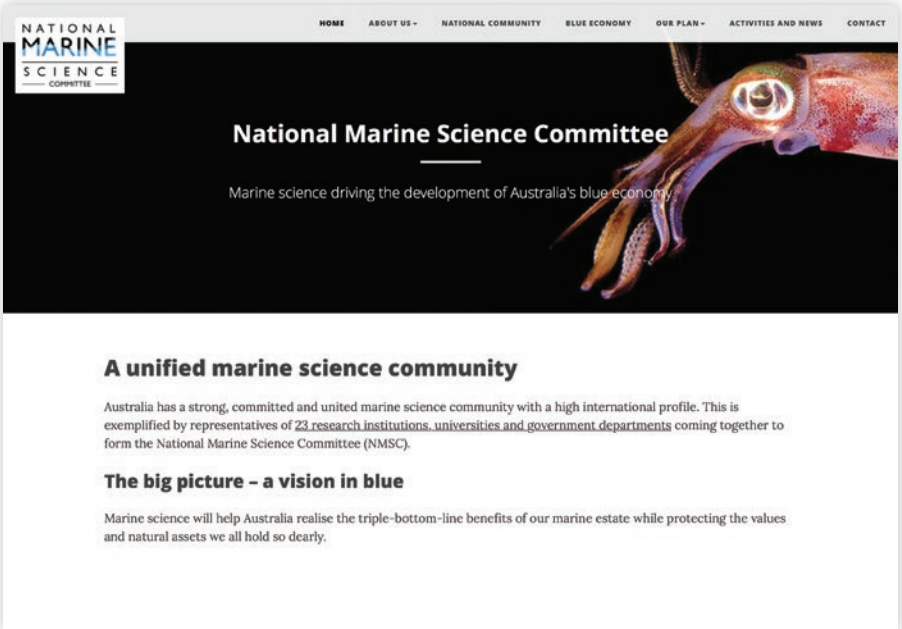
Release of Plankton 2015 is another national highlight. It is the first ever comprehensive report on the state of Australia's ocean as seen through the eyes of plankton. It is the sort of information that will enable reporting on state of the marine environment to be more robust, reliable and useful.

Local relevance is illustrated through stories on impact of the Indian Ocean on WA Climate, seasonal variability in the continental shelf waters off south eastern Australia, and tracking of upwelling off the Bonney Coast in South Australia.

We hope you enjoy this edition of Marine Matters.

Tim Moltmann

NEWS New website for the National Marine Science Committee



The National Marine Science Committee (NMSC) is an advisory body focused on promoting the nexus between high quality marine science and growth of Australia's blue economy. NMSC provides a distinctive mechanism for co-ordination and information sharing between research institutions, universities, Australian Government departments, State/Territory Governments and the broader Australian marine science community. IMOS Director, Tim Moltmann is the current chair of the Committee.

The committee has just launched their new website – **www.marinescience.net.au**.

The initial objective of the website is to capture all of the existing material and make it readily accessible and identifiable with NMSC. The website will be developed over time based on community feedback and input.

Alicia Navidad, CSIRO

...from page 1

Observing the oceans is problematic even under the most favourable of conditions. Historically, shipboard ocean sampling has left vast expanses, particularly in the Southern Ocean, unobserved for long periods of time. Within the past 15 years, with the advent of the global Argo array of profiling floats, it has become possible to sample the upper 2,000 m of the ocean globally and uniformly in space and time.

The Argo array is a major component of the Global Ocean Observing System and strives to monitor the evolving temperature and salinity fields of the upper ocean.

More than 90% of the heat energy accumulation in the climate system between 1971 and the present has been in the ocean. Thus, the ocean plays a crucial role in determining the climate of the planet.

The profiling floats used in Argo are 2 m-long, freely drifting robotic devices that adjust their depth in the ocean by changing their buoyancy.

IMOS deployments of just 30 floats per annum along with other national and international deployments have resulted in 10% of the global array of 3,900 floats delivering a continuous data stream for the Australian region.

The array provides freely available temperature and salinity data from the upper 2,000 m of the ocean with global coverage. The data are available within 24 hours of collection for use in a broad range of applications that focus on examining climate-relevant variability on seasonal to decadal timescales, multidecadal climate change, improved initialization of coupled ocean–atmosphere climate models and constraining ocean analysis and forecasting systems.

Perhaps the single most powerful metric of the value of Argo is the widespread use of the data produced by the programme: since the beginning of Argo in the late 1990s, more than 2,100 papers in the refereed science literature have used Argo observations, attesting to the array's value in expanding our understanding of the oceans and climate.

Highlights of the research using Argo data include:

Most climate models assimilate the subsurface temperature observations from Argo, leading to improved forecasts of intraseasonal waves in the atmosphere, monsoon activity, and ocean–atmosphere interactions such as the El Niño/ Southern Oscillation (ENSO).

The Argo observations have been particularly useful in examining ocean changes on timescales of decades and longer. A stunning example has used contemporary Argo observations in conjunction with data from the HMS Challenger expedition, carried out in the second half of the nineteenth century. The study reveals a warming of the ocean over the past 135 years of nearly 0.6 °C near the sea surface, tapering to near zero at depths close to 1,000 m.

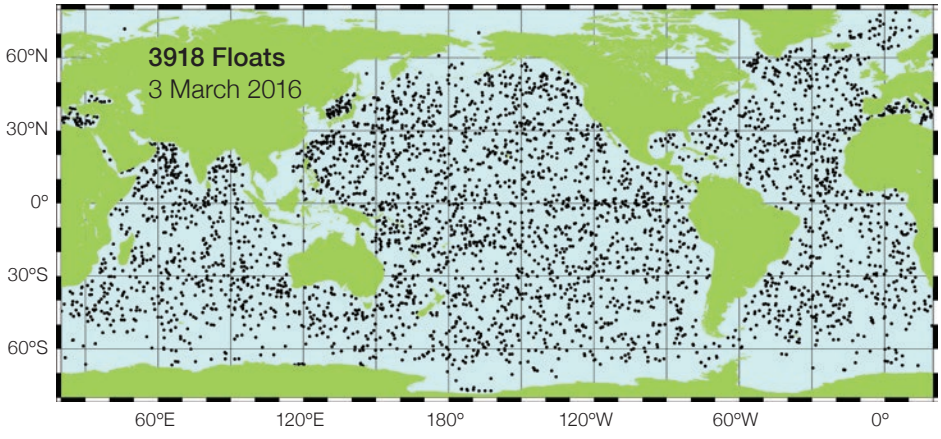
The observed increase in ocean heat content in the upper 700 m over the past 40 years, inferred from Argo and hydrographic observations, is the dominant term in the global inventory of heating changes, with over 90% of the excess heat in the climate system being stored in the oceans. Without Argo, it is unlikely that such a conclusion could have been drawn.

The data have also allowed temporal spatial variations in ocean heat content to be discerned, suggesting that most of the increase in heat content in the past decade has occurred in the Southern Ocean (which was poorly sampled before Argo); it has also been noted that ENSO variability in the tropical Pacific has for now somewhat obscured the global increase in sea surface temperature.

When Argo began in the late 1990s, it was by no means clear that the project would be successful in deploying and sustaining an array of 3,000 floats over the global ocean, as the required technology was in its infancy and the degree of international cooperation required was unprecedented in the oceanographic community. Now, in the second decade of the twenty-first century, the float technology is well proven, and over 30 countries are contributing resources to Argo, making it sensible to contemplate the expansion of its mission.

The Argo Steering Team has provided a roadmap for how the project might evolve and expand in the next decade, and some of this proposed development is now underway via test deployments or regional pilot arrays. One project is to support an increase in the spatial sampling resolution in particular parts of the world ocean where the ocean is especially turbulent (challenging the array's signal resolving power) and the interaction of the ocean and the atmosphere and the resulting climate impacts are especially strong. Improved technology also allows us to expand Argo into previously unsampled regions, such as marginal seas and the seasonal ice-zone, meaning that the array is more truly global in its coverage than its original design.

The full review article: Riser, SC *et al.* 2016 Fifteen years of ocean observations with the global Argo array. *Nature Climate Change* 6, 145–153. doi:10.1038/nclimate2872



The current coverage of the global Argo array. Map courtesy of Argo – www.argo.ucsd.edu

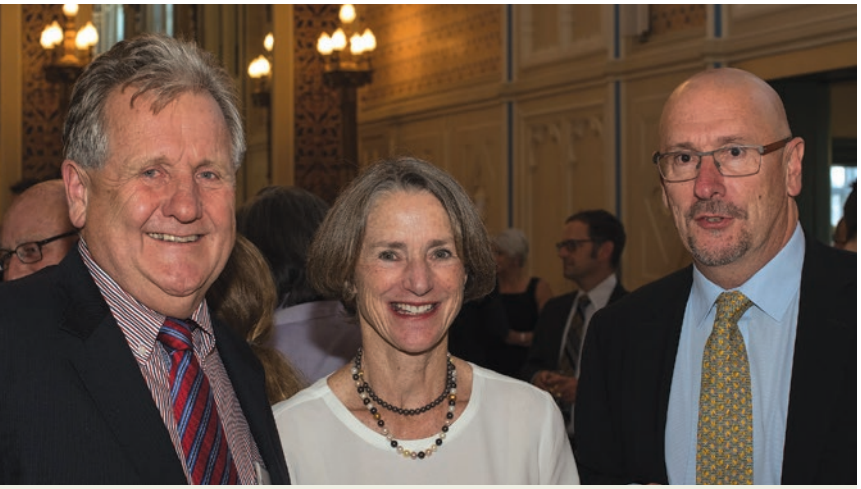
Celebrating the First Decade of IMOS

The IMOS community gathered in Hobart in early March for the 10th Annual Planning Meeting.

The IMOS Director, Facility, Sub-Facility and Node leaders at the Annual Planning Meeting.

The 94 attendees included IMOS Facility and Sub-Facility Leaders, Operator representatives, Node leaders, Directors of key Research Partnerships, IMOS Advisory Board members and IMOS office staff. The meeting agenda included presentations that reviewed the progress of the IMOS project to date and looked forward to plan for the second decade of IMOS. The meeting also considered how IMOS would prepare to engage with the road mapping process chaired by Australia's Chief Scientist, which will identify specific future research infrastructure requirements and the allocation of NCRIS funding.

The attendees were invited to Government House for an evening reception to mark the 10th Anniversary of IMOS with her Excellency Professor The Honourable Kate Warner, The Governor of Tasmania. It was timely to reflect and recognise the collaborative effort of the IMOS community, who under the leadership of founding Director Gary Meyers, and the present IMOS Director, Tim Moltmann, have built a national integrated ocean observation system, making all of the data openly accessible to the marine and climate science community, other stakeholders and users, as well as our international collaborators.



Chair of the IMOS Advisory Board, Dr Ian Poiner, The Governor of Tasmania, her Excellency Professor the Honourable Kate Warner, and IMOS Director, Tim Moltmann.

Mr Craig Steinberg AIMS, Mr David Williams AIMS, Dr Marian Wiltshire IMOS office.

Dr Daniel Ierodiaconou Deakin University, Dr Vanessa Lucieer IMAS.

Mr Alopi Latukefu DFAT, Dr Tony Press, Dr Ian Poiner.

Dr Peter Turner and Mr Simon Allen.

Mr Patrick Seares WAMSI, Prof Chari Pattiaratchi UWA, Prof Julian Partridge UWA, Assoc Prof Moninya Roughan UNSW.

Mr Warrick Glynn IMOS office, Dr Clive McMahon SIMS.

Dr Gwen Fenton AAD, Mr Wes Ford DPIPWE, Mrs Jo Neilson IMOS office.

Ms Emma Luke DIIS, Prof Peter Steinberg SIMS, Prof Stefan Williams University of Sydney, Dr Oscar Pizarro University of Sydney.

Rob Harcourt, Macquarie University

Where will the Weddell seals go?

Deciphering the movements of marine predators.

A Macquarie University researcher has tested two prominent marine animal-tracking models to determine which is better at inferring the movements of Weddell seals using IMOS tracking data.

Currently, many problems arise when scientists try to correctly locate and map the movements of an animal using satellite data, which often contains location errors. Dr Ian Jonsen, the author of the study, looked at how these two models cope with satellite errors when inferring the movements of marine predators, such as Weddell seals.

"It is a huge challenge to learn how marine predators make their living in the ocean because we can't watch them directly," Dr Jonsen explained.

"In the case of tracking Antarctic marine animals, scientists overwhelmingly use the Argos satellite tracking system, which works better at the poles than GPS tracking. However, Argos satellite tracking comes at a price, as it introduces more errors into the data.

In this study I used these large satellite tracking datasets, collected by IMOS to unravel the movement behaviours of the seals."

To test how well each of these models were able to deduce the animals' movement behaviours, Dr Jonsen fed each model simulated data that introduced satellite location errors and introduced known behavioural switching patterns, such as when a seal will move from a feeding ground to a place of rest. He then fit the two models to real data collected by Argos satellite on the movements of 10 female Weddell seals.

"I firstly tested each model by giving it simulated data where the true movement pattern was known, and compared the ability of the models to recover the true pattern. Then I did the same thing for the real movement data on the seals."

When the two models were compared, Dr Jonsen found that the first model was more precise and better at predicting the true switches in movement behaviour from the simulated data. It was also better able to identify apparent switches in behaviour of the seals.

"The findings really show that if you want to understand the movements of Weddell seals tracked by Argos satellite, or most other types of marine predator tracked this way, a joint estimation model, which looks at the grouped animal movements, is the way to go. This model performed much better in the tests than the second model which only looks at the individual movements of each animal," Dr Jonsen said.

Dr Jonsen hopes that the results will be used by scientists looking to improve their understanding of animal movement behaviour from location data collected by satellite tags.

"These models are useful in identifying where and when Weddell seals and other animals engage in different activities like foraging, resting and migrating. The more we refine these models, the better we can apply them to studies looking at how animal behavior may shift in the face of current and future environmental changes," he concluded.

The full paper is available: Jonsen, Ian. 2016 Joint estimation over multiple individuals improves behavioural state inference from animal movement data. *Scientific Reports*, 6, Article number: 20625. **doi:10.1038/srep20625**

Clive McMahon, SIMS

Plankton report reveals deep knowledge on marine environments

The first ever comprehensive report on the state of Australia's ocean, as seen through the eyes of plankton, was released in December.

The Plankton 2015 report from CSIRO and based on data from IMOS looks at why plankton are important to the health of our oceans and Australia's future prosperity.

According to the report's lead author CSIRO's Dr Anthony Richardson, how much plankton there is, and where it is, determines how many fish, marine mammals and turtles are in the sea.

"Plankton are responsible for about half the oxygen we breathe, and are critical to the marine food web. They can also impact human life, from toxic algal blooms caused by microscopic zooplankton species through to venomous jellyfish such as Irukandji that are also a species of plankton," Dr Richardson said.

The report compiles information from plankton studies and data sets from across Australia to provide a snapshot on the climate, state of global fisheries and marine ecosystem health and biodiversity.

Through the IMOS Australian Continuous Plankton Recorder (AusCPR) survey and the National Reference Stations (NRS) program, researchers are collecting and counting thousands of plankton samples, as a window into the health of our oceans.

"We are collecting important plankton data that shows the changing nature of our oceans," said IMOS Director Tim Moltmann.

"Researchers have found that on the east coast of Australia, plankton have moved southward by 300 km over the past 30 years," he said.

Changes to plankton abundance and distribution are likely to have significant repercussions up the food chain. In some environments, such as off the coast of Tasmania's Maria Island, there has been a shift from cold-water to warm-water plankton species.

"Warm-water plankton is smaller and some fish, seabirds and marine mammals just don't like the taste," said Dr Richardson.

"More carbon dioxide in the atmosphere is leading to more acidic oceans," he said, adding that although there is evidence of thinning shells in sea butterflies in northern Australia over the past 30 years, there is no general decrease in abundance of shelled animals and plants.

The report also delivers some good news on jellyfish.

"Whilst in various parts of the world that have been heavily polluted or fished there have been massive jellyfish blooms, there is no evidence that jellyfish abundance has increased in Australian waters," said Dr Richardson.

Information from Plankton2015 will be used in the next Australian State of the Environment report to highlight how our marine estate is changing. As more data is collected, our knowledge on the baseline conditions across Australia will improve.

To download the full report visit the IMOS data tools page:
http://imos.org.au/imosdatatools.html

Anita Slotwinski, CSIRO

"Plankton are responsible for about half the oxygen we breathe, and are critical to the marine food web."

IMOS in MOcean

Two new movies in our IMOS in MOcean series have been released via our website **http://imos.org.au/imosinmocean.html**

How can I get ocean data?

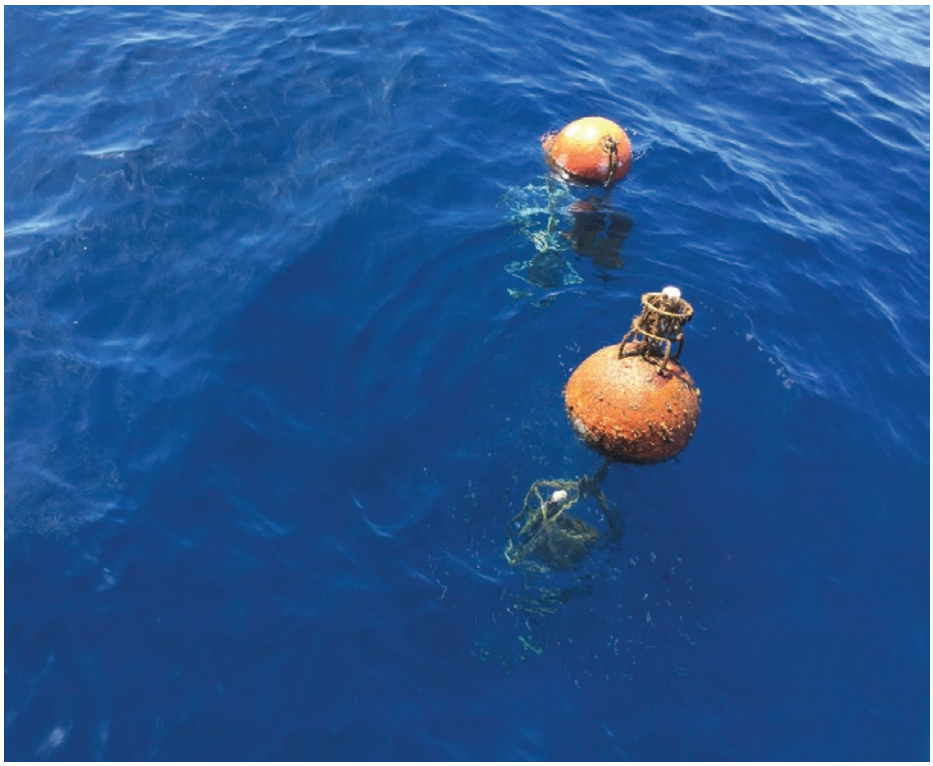
Marine data and information are the main products of IMOS. The Australian Ocean Data Network (AODN) provides an online portal for accessing the large and diverse collection of IMOS data and ocean data from other sources. Scientists, managers and the public can access desired data collections for free – and it's as easy as 1-2-3.

What do changes in the Southern Ocean mean for the Antarctic ice sheet?

The East Antarctic ice sheet and shelves, once thought to be stable, are showing signs of thinning (melting). Using data from IMOS funded moorings off the Totten and Mertz glaciers, Dr Steve Rintoul presents evidence that warm water beneath the ice shelf is causing this ice loss. Obtaining good time-series data on ocean variables near these East Antarctic glaciers will improve our understanding of processes and time frames of glacial melting.

Understanding the impact of the Indian Ocean on WA climate

This article has been adapted from the WAMSI Bulletin, *Indian Ocean creates its own flow-on effect*, 30 November 2015



Ryan Crossing, CSIRO

Recovery of the Rottnest Island National Reference Station

New research led by CSIRO has described how heavy rainfall caused the top layer of the southeast Indian Ocean to be less salty, creating a barrier layer which trapped the heat during the deadly marine heatwave – La Niña and the 'Ningaloo Niño' of 2010-11. The result was a larger volume of warmer water being driven by a stronger current down the WA coastline.

The full extent of the spatial and temporal evolution of the freshening anomalies of the Indonesian Throughflow waters are captured in the Indian Ocean for the first time, based on the Argo float data stream supported by IMOS. This is important to track water mass pathways and the large scale marine connectivity.

The finding, which is part of The Western Australian Marine Science Institution (WAMSI) Kimberley Marine Research Program, provides further scientific knowledge to help predict responses to climate change, and adds another layer to consider when forecasting extreme marine heatwave events.

According to CSIRO's Dr Ming Feng, who also leads the IMOS Western Australia moorings sub-facility, the change in salinity levels on the top 100 metres of the ocean also raises more questions, such as how it will affect some marine species.

"In the past we have followed the Pacific Ocean climate closer in evaluating WA marine environment.

"We haven't focused much attention on the Indian Ocean variables and the effect on the WA environment," said Dr Feng.

"It seems that the more we find out about the Indian Ocean, the more we realise it operates very differently to any other ocean on earth," he said.

The Leeuwin Current, the eastern boundary current of the southeast Indian Ocean, carries warm fresh tropical water southward along the west coast of Australia. The current

is stronger in Australia's winter and weaker in summer; it also tends to be stronger during La Niña events.

The latest research compared salinity observations at the CSIRO/Integrated Marine Observing System (IMOS) Rottnest National Reference Station collected during the past 60 years. Analysis of these observations revealed the unusual, but significant, freshening of the ocean's top layer during 2010-2011.

Dr Feng suspects this may not be the first or last time we experience such an event.

"Something similar probably happened in 1999/2000, so it might happen in the future, especially as we experience more frequent warmer conditions.

"It is important to maintain the IMOS national reference stations around Australia so that we are better informed about the impacts of the extreme climate events on coastal environments," he said.

It's thought that the change in salinity can take a few years to return to normal but the El Niño forecast for 2015, which was to result in a weakening in the Leeuwin Current and cooler water temperatures along the coast of WA, has not rung true.

"Typically we should be experiencing cooler temperatures off the west coast this year but the temperatures have still been warmer than normal, so this is an unusual year, and it shows we don't fully understand the impact of the Indian Ocean," Dr Feng said.

IMOS Director, Tim Moltmann, believes publication of this work is very timely.

"It is fifty years since the first international Indian Ocean expedition, and while much has been learnt over that period, many new questions have also emerged."

"The international marine science community is gearing up for a large, coordinated effort over the next five years and Australia needs to be involved. We have much to contribute, and will benefit tremendously as a country with a significant presence on the Indian Ocean Rim," said Mr Moltmann.

The full paper is available: Ming Feng, Jessica Benthuysen, Ningning Zhang and Dirk Slawinski. 2015 Freshening anomalies in the Indonesian throughflow and impacts on the Leeuwin Current during 2010–2011 Research Letters DOI: 10.1002/2015GL065848.

Seasonal variability in the continental shelf waters off southeastern Australia: Fact or fiction?

A recent study has explored the seasonality of continental shelf waters of southeastern Australia with data from two IMOS mooring arrays.

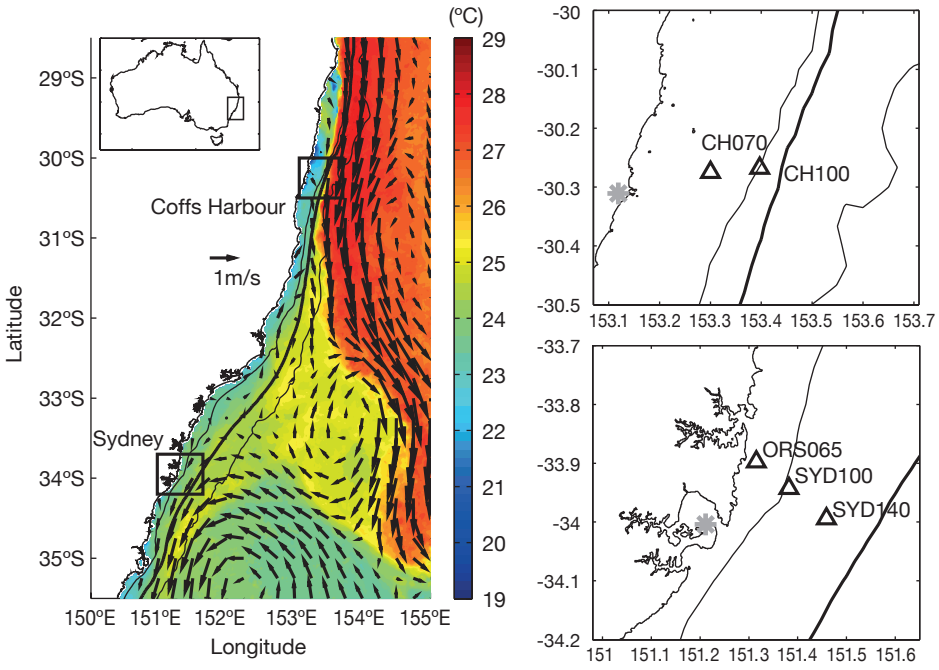
Dr Julie Wood, who completed her PhD at the University of New South Wales and was one of the first postgraduate students to include IMOS data in her research, led the study which was published in November last year in the journal Continental Shelf Research.

Seasonal changes have been shown to have a large influence on the waters of continental shelf regions globally. With processes such as annual heating and cooling, the influx of freshwater from seasonal changes in rainfall, and seasonal wind regimes known for causing changes in the circulation and hydrography on the shelf in coastal regions.

The continental shelf along the southeastern coast of Australia is quite narrow, dropping to a depth of 4000m often within 25-100km of the coast. The coast is flanked by the East Australian Current (EAC), which is the Western boundary current of the South Pacific gyre. The EAC stays close to the continental slope north of 30°S, periodically encroaching onto the shelf, and separating from the coast around 31-32°S (see figure 1). Both warm and cold core eddies are formed downstream of this separation zone.

Previous studies have shown that the EAC has a clear seasonal cycle, strengthening in summer in comparison to winter; however whether or not this leads to seasonality in the shelf circulation adjacent to the EAC has not been examined.

In 2008 IMOS deployed two mooring arrays (see figure 1) on the continental shelf of southeastern Australia both upstream and downstream of the EAC separation zone. There were no *in situ* moored time series prior to the



Map of the study site. The black triangles indicate the location of the moorings measuring temperature and velocity. The grey stars show the location of the two wind stations. Super imposed on left panel is AVHRR L3S satellite sea surface temperature (colour) and velocity (arrows) from the 19th February 2010 (14 day composite) which shows the fast flowing warm EAC waters adjacent to Coffs Harbour and a large warm core eddy just south of Sydney. The coastline, 100 m, 200 m (bold) and 2000 m isobaths are also indicated.

deployment of the IMOS moorings upstream of the EAC separation zone and with two additional arrays downstream, the IMOS data provided an unprecedented dataset of both temperature and current velocity to explore the dynamics of cross-shelf transport and the influence of the EAC in driving cold dense water uplift.

The Ocean Reference Station (ORS065) mooring has been maintained by partner Sydney Water Corporation since 1989 and the data is provided to IMOS as an in kind contribution to the program.

Whilst this study used up to four years of current velocity and temperature data from the IMOS moorings, it is important to note that these moorings are still in place and now provide eight years of time series data at some locations.

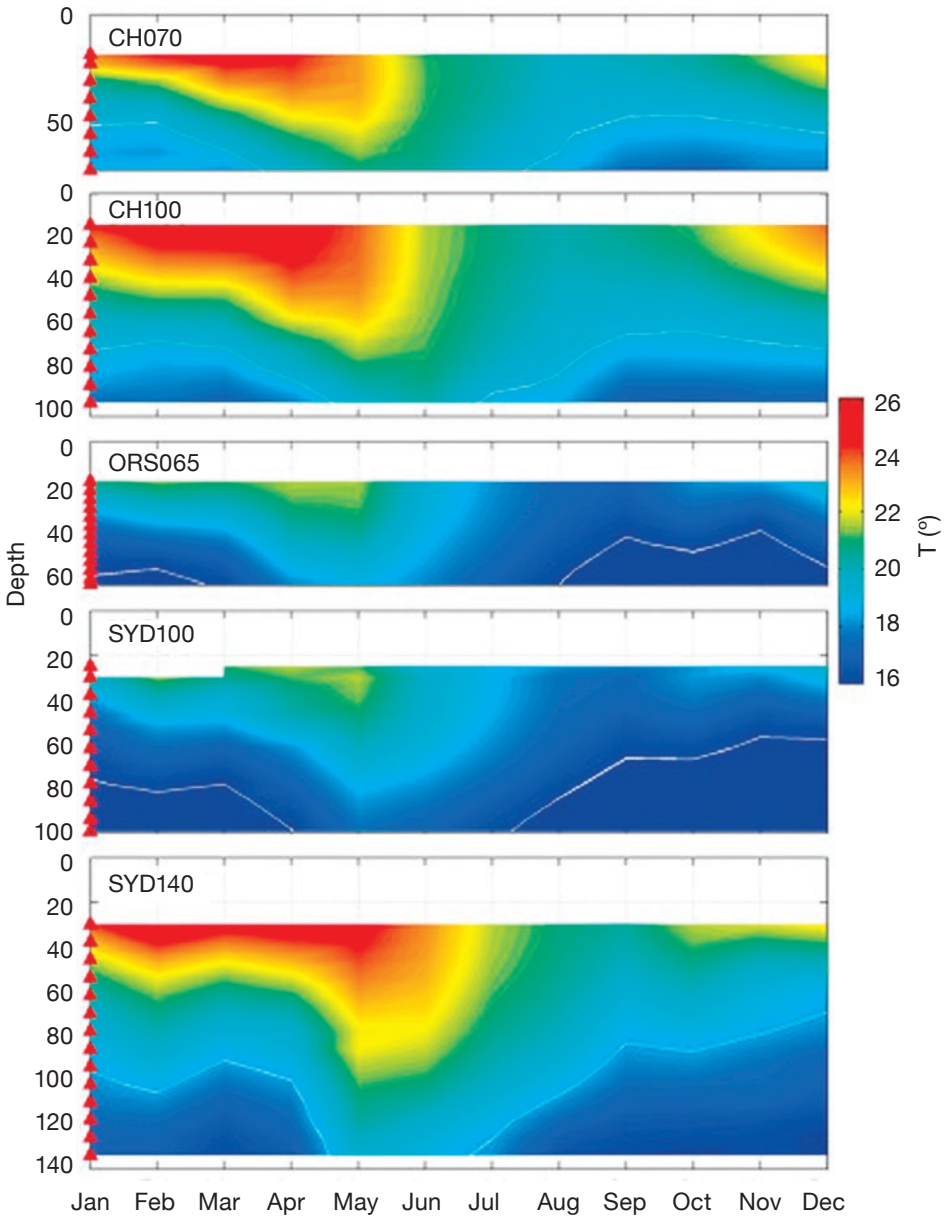
The study demonstrated that water temperature exhibits a strong seasonal cycle at both locations (at 30°S and 34°S) along the coast of southeastern Australia (see Figure 2), with the maximum bottom temperature occurring during winter (out of phase with the maximum in the interior water temperature cycle which occurs in summer) due to a well-mixed water column.

The study also identified an important difference upstream versus downstream of the EAC separation zone with the EAC causing a stronger cross-shelf temperature gradient driving a stronger vertical along-shelf velocity shear in summer compared to winter. In the absence of the EAC (downstream), this seasonal velocity shear was not detected.

Unlike the waters on other continental shelves that demonstrate seasonality, the study revealed that seasonality plays only a minor role in the circulation on the continental shelf of southeastern Australia. In fact less than 6% of the variability in the along-shelf currents could be attributed to a seasonal cycle upstream of the separation zone.

In conclusion, the study noted that the unique features of the continental shelf in southeastern Australia, such as the narrow continental shelf, a lack of consistent seasonal wind forcing, and the absence of any significant seasonal influx of fresh water, results in the major forcing mechanisms being the EAC encroachments and eddy shedding and the interaction with synoptic wind forcing. Indeed, contrary to popular belief, this combination of forcing mechanisms results in a limited response in the circulation on the shelf at seasonal time scales. These non-seasonal forcing mechanisms will have a large influence on the timing of nutrient injection onto the shelf, and therefore the abundance and composition of phytoplankton blooms.

The full paper is available: JE Wood, A Schaeffer, M Roughan, PM Tate. 2015 Seasonal variability in the continental shelf waters off southeastern Australia: Fact or fiction? *Continental Shelf Research* 112, 92-103. doi:10.1016/j.csr.2015.11.006



Monthly mean temperature at each site. For Coffs Harbour (CH) moorings (CH070 and CH100) the 19 °C isotherm is shown (super-imposed in white). For Sydney (SYD) moorings (ORS065, SYD100 and SYD140), the 16 °C isotherm is shown (super-imposed in white). The temperature scale is the same for all plots and observation depths are indicated by red triangles.

The Bonney Coast Upwelling:

biological hotspot sampled by an IMOS glider

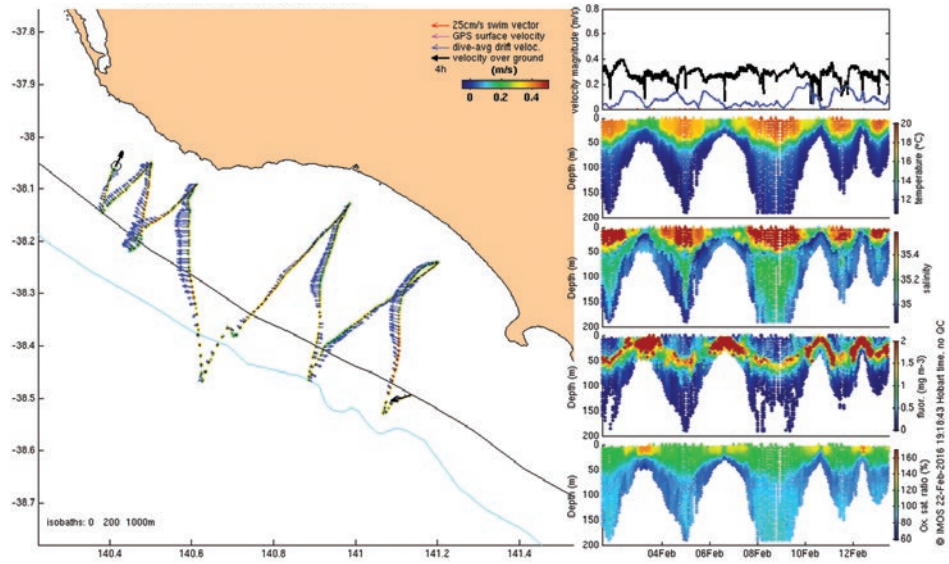
Recently an IMOS Slocum glider made the most detailed survey ever conducted of the bio-physical properties of a Bonney Coast upwelling event.

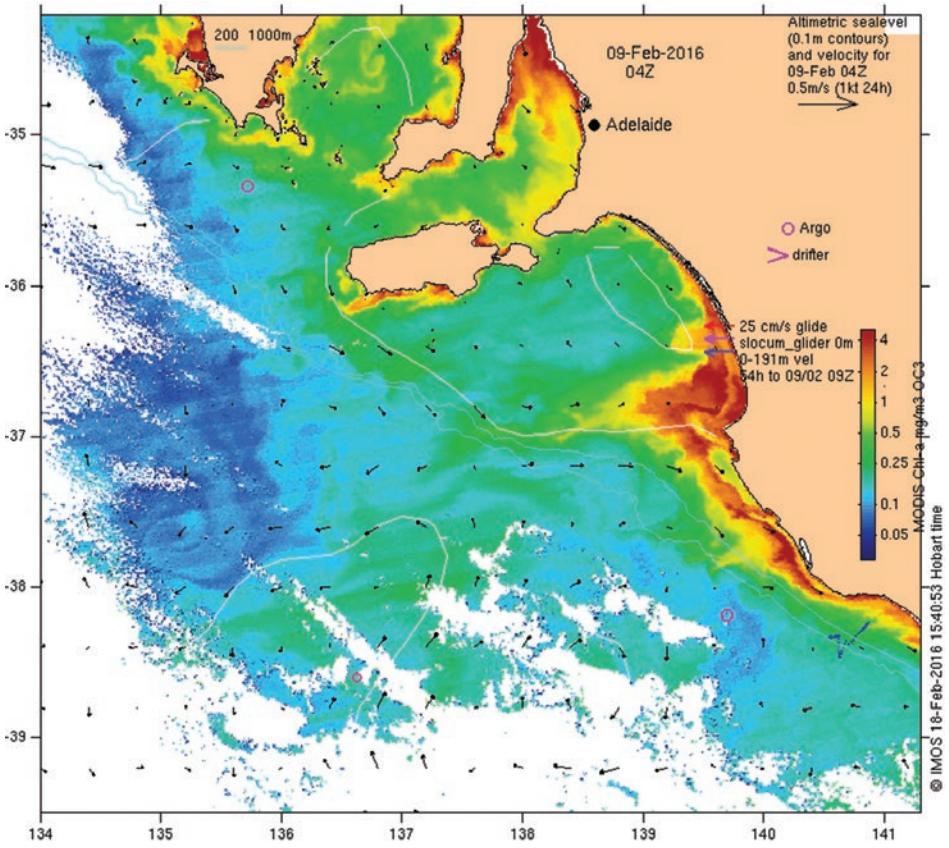
The dissolved oxygen data are perhaps the most exciting: percent saturation values exceeded 150 within the upwelled water on 3 February, confirming that the phytoplankton were very actively photo-synthesising, producing much more oxygen than was lost to the atmosphere (See the glider observations in the top figure).

Excepting some spurious measurements affected by bio-fouling, values this high have not been seen in Australian waters by the glider fleet. The closest comparison was in upwelled waters inshore of the East Australian Current near Coffs Harbour in Dec 2010, but these may have been affected by bio-fouling. The present mission dissolved oxygen data are not suspicious, because the high readings occurred early in the mission.

The Bonney Coast is the 200km-long stretch of narrow continental shelf near Portland, Victoria, that is famous for its periods of summer-time wind-driven upwelling. Upwelling events are routinely evident in satellite imagery but rarely sampled extensively at sea.

MODIS estimates of chlorophyll-a show that the present event is not an extraordinary one. The track of the glider can be seen in the bottom image as a blue line (bottom right of image).





For more IMOS *OceanCurrent* news: http://oceancurrent.imos.org.au/news.php

NSW-IMOS

SIMS Scientist for a Day

When is a marine scientist not a marine scientist? When they are too busy 'feeding the fishes' while a trained nurse, with the stomach of a sailor, steps in to take charge. That is what happened when Jen Gillott, Sydney Institute of Marine Science's "Scientist For a Day", stepped on board the RV Bombora for sampling at the Port Hacking NRS this February.

While a few local researchers were busy over the side, Jen stepped up and assisted NSW IMOS samplers to successfully complete the monthly biogeochemical run off Cronulla. Little did we realise that our friendly on-board guest was an experienced Southern Ocean sailor. Not only that but she was already familiar with the operation of CTDs (conductivity, temperature, and depth), Niskin water sampling and plankton nets having assisted aboard the Aurora Australis on a research to the ice edge years earlier. Now working within the Department of Health, Jen bid and won the prize at an auction held at the SIMS Foundation Dinner held last October, and what a prize it was!

Martina Doblin, UTS

Tim Ingleton and Jen Gillott aboard the RV *Bombora.*

WA-IMOS

Change of Node leadership for WA-IMOS

Associate Professor Julian Partridge (left) from the University of Western Australia is the new Node Leader and Prof David Antoine of Curtin University will join Dr Ming Feng of CSIRO as a Deputy Node Leaders of the WA-IMOS science node.

Julian Partridge is Principal Research Fellow at the University of Western Australia (UWA) Oceans Institute as well as Associate Professor and Business Development Manager in the UWA School of Animal Biology. Until May 2015, when he moved permanently to Perth for personal reasons, he was Professor of Zoology at the University of Bristol, UK. Julian received his doctorate from the University of Bristol in 1986 and has had a career lasting 30 years at leading UK and Australian universities, with a track record of leadership experience in teaching, research and administration, and proficiency in university, project, team, and financial management. He is highly interdisciplinary research scientist and internationally recognised in the field of sensory biology having previously led the Ecology of Vision group at the University of Bristol, a group that was identified as internationally outstanding in the last two UK Research Assessment Exercises. His multidisciplinary research interests span molecular biology, physiology, behavioural ecology, fieldwork, marine biology, biomimetics and computational methods. He has particular specialist expertise in animal vision, light and optoelectronics, image processing, and polarization imaging, especially in the context of marine biology.

Julian is an experienced ocean-going biologist (17 research cruises) and a submersible user (2 cruises), with a special interest in deep-sea biology, including the design and deployment of deep-sea benthic landers for deep ocean light measurements and observations of animals and bioluminescence. His deep-sea research was recognised by a Royal Geographical Society 'Discovery' award in 2000. At UWA he is a member of the Oceans Institute Leadership Team and is involved in several developments in marine science in the University. He also has a long term interest in the public engagement in science, has participated in citizen science smart phone app projects for tracking invasive species, and has undertaken more than 100 media consultancies, particularly with the UK natural history television industry for whom he has acted as credited scientific consultant for numerous TV productions.

David Antoine is currently head of the remote sensing and satellite research group at Curtin University. He is also a Le Centre national de la recherche scientifique senior research scientist at the Marine Optics and Remote Sensing group of the Laboratoire d'Océanographie de Villefranche in France. He received a doctorate degree in oceanography from the Université Pierre and Marie

NSW-IMOS attracts State government funding

The significance of NCRIS Infrastructure to NSW has again been recognised and given a considerable boost with the award of Research Attraction and Acceleration Program (RAAP) funds to NSW IMOS by the Chief Scientist and Engineer, Mary O'Kane, in January 2016. The proposal built on NSW IMOS strengths and identified research initiatives of keen interest to NSW Government, attracting funds to the tune of $820K.

Curie in Paris, France, in 1995. His research interests include marine optics, bio-optics, radiative transfer and applications, satellite ocean colour remote sensing including atmospheric corrections, modelling of oceanic primary production from satellite ocean colour. He has set up and maintained for 13 years a long-term time series program in the Mediterranean Sea, collecting physical, optical and biogeochemical data in support to bio-optics research and to calibration / validation of satellite ocean colour remote sensing observations.

David has been working over years on regional and global applications of ocean colour remote sensing to study long-term changes in ocean phytoplankton and primary productivity. Among many "community services", he has in particular served as chair (2007-2009) of the ocean group of the French space agency (CNES) scientific committee, and as chair (2010-2014) of the International Ocean-Colour Coordinating Group (IOCCG). He has also been a member of the European Space Agency' Earth Science Advisory Committee. He is currently associate editor for "Limnology & Oceanography", the lead journal from the Association for the Sciences of Limnology and Oceanography.

Our thanks to outgoing WA-IMOS node leader Professor Gary Kendrick who will remain involved in the science of the WA-IMOS node.

Ocean gliders

Ocean Glider missions revealed much in 2015 but were not without their challenges

The IMOS Ocean gliders facility had a busy and successful year with a total of 26 deployments and, importantly, 26 recoveries in 2015.

Equipped with a variety of sensors, ocean gliders are designed to deliver ocean profile data. Their unique design enables them to move horizontally through the water while collecting vertical profiles.

Deployments in 2015 represented 606 glider days at sea, traversing a total of 11,829 kms, to collect valuable data on temperature, salinity, currents and other variables at a range of depths in Australian waters.

New glider deployment locations included the two 'Greats': Great Australian Bight (Seaglider) and Great Barrier Reef (Slocum gliders). Glider deployments in the Pilbara and Kimberley ceased in March.

In 2015, the introduction of rechargeable batteries in the Slocum gliders allowed for a longer mission duration. As a result of this innovation a new record was set with a deployment of 30 days duration off Two Rocks in September. The extended deployment period also had a benefit in November when the formation of a sub-surface chlorophyll maximum was captured towards the end of the deployment. With the older batteries, the glider would have been recovered and this event missed.

Numbers alone don't tell the whole story of the 2015 glider missions. The effort and drama that goes into keeping the glider program running includes numerous Friday afternoon and Sunday evening emergencies, shark bites that destroy instruments and long searches to locate wayward gliders.

Professor Charitha Pattiaratchi, who leads the IMOS Ocean glider facility, reflects on 2015, describing the challenge of conducting glider missions.

"It wasn't unusual to find ourselves head scratching, trying to make sense of

AIMS

Rob Gregor from CSIRO making final adjustments to the ballast of a slocum glider before a deployment on the Great Barrier Reef.

what's happening when gliders behave unexpectedly," said Professor Pattiaratchi.

The Great Barrier Reef measurements extended from Port Douglas in the north to Townsville in the south. Regular cross shelf transects captured upwelling and verified the latest circulation models for the reef.

These missions provided a big challenge to glider piloting in an area with high shipping activity and shallow water reef systems. The gliders needed to be piloted to avoid both of these 'obstructions'.

The team has been making measurements along the Two Rocks transect since January 2009 and has documented the formation of dense shelf water cascade along this this transect. This is where higher salinity water, formed in the coastal region, is transported offshore along the sea bed (downwelling).

In February 2015, they observed the opposite phenomenon, upwelling, where deeper, cooler offshore water was moved onto the shelf due to strong winds. This was was persistent over three weeks – the entire time the glider was taking measurements.

Professor Pattiaratchi praised the IMOS Ocean gliders team of Dennis Stanley, Alessandra Mantovanelli, Kah Kiat Hong and Paul Thomson for their efforts during the year. He also acknowledged the contribution of the glider team at CSIRO in Hobart and the various node personnel across Australia who helped with local logistics.

"We could not have done this without the cooperation of such great people around the country, including our charter operators who put up with our last minute changes in plans," he said.

UWA

Bite marks and a missing sensor beneath the glider wing were attributed to a shark attack in September last year.

Satellite Remote Sensing and Australian Ocean Data Network

Accessing IMOS satellite imagery just got easier

The new "Accessing IMOS Satellite Data and Converting into CSV Format Report" provides a simple, easy-to-use process, using the open source tool Panoply, for visualising IMOS satellite imagery and extracting small subsets of data to .csv files. Several satellite datasets are available from the **Integrated Marine Observing System (IMOS) portal**. Data include sea surface temperature, chlorophyll-a concentration and sea surface height and derived geostrophic currents.

These data can be downloaded from the IMOS portal in the form of NetCDF (network Common Data Form) files. NetCDF is a file format for storing multidimensional scientific data (variables) such as temperature, and current speed and direction, and each of these variables can be displayed through a dimension (such as time).

This format is commonly used in oceanography and meteorology and widely used in applications such as MATLAB. **Panoply** is a JAVA application developed by NASA that can be used for viewing the metadata content of NetCDF files, plotting the data and capturing the image, and exporting the data into a csv or txt file.

Dr Roger Proctor, director of the AODN believes the new guide, developed by Ana Redondo Rodriguez of the South Australian Research and Development Institute, for use in the **Great Australian Bight Research Program**, will benefit anyone wishing to access and utilise satellite imagery.

"In writing this guide, we were aiming to simplify the process of getting hold of, and using these datasets.

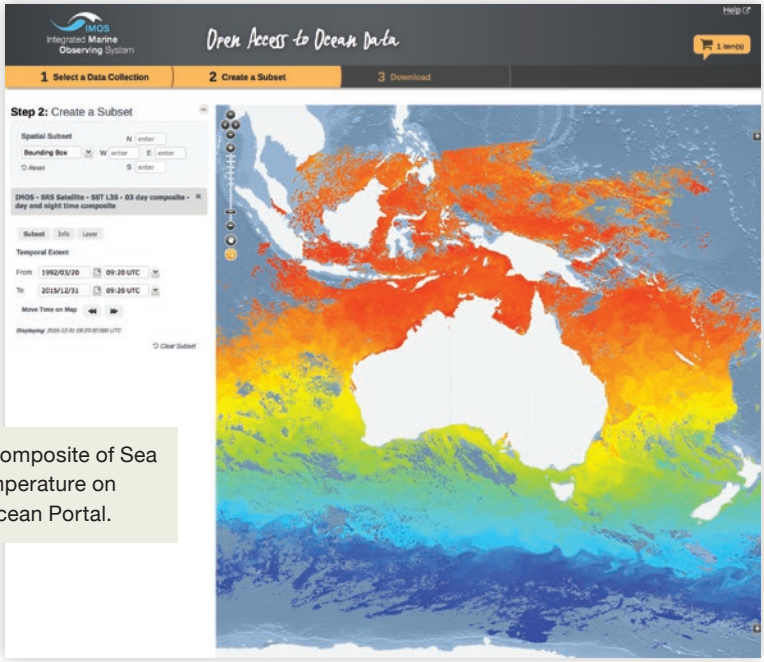
"Hopefully more people will access these data and their interpretation of the data will lead to results that will be of use scientifically and ultimately to industry and society," said Proctor.

The guide includes:

- A list of available IMOS satellite data and summary of the main characteristics
- A 'How to' guide for downloading satellite data from the IMOS portal
- A 'How to' guide for using Panoply to export NetCDF data into a csv file

New products, including a number of ocean colour parameters and temporal averages, will be added to the portal as they become available.

The guide is available via the **IMOS Data Tools page**.



Three-day composite of Sea Surface Temperature on the IMOS Ocean Portal.

Postgraduate Student Profile | **Veda Malpress**

PROJECT TITLE:

Bio-physical characterisation of East Antarctic polynyas as a key southern elephant seal foraging habitat

Institute for Marine and Antarctic Studies (IMAS) at the University of Tasmania, Antarctic Climate and Ecosystems Cooperative Research Centre, and the Australian Antarctic Division (AAD).

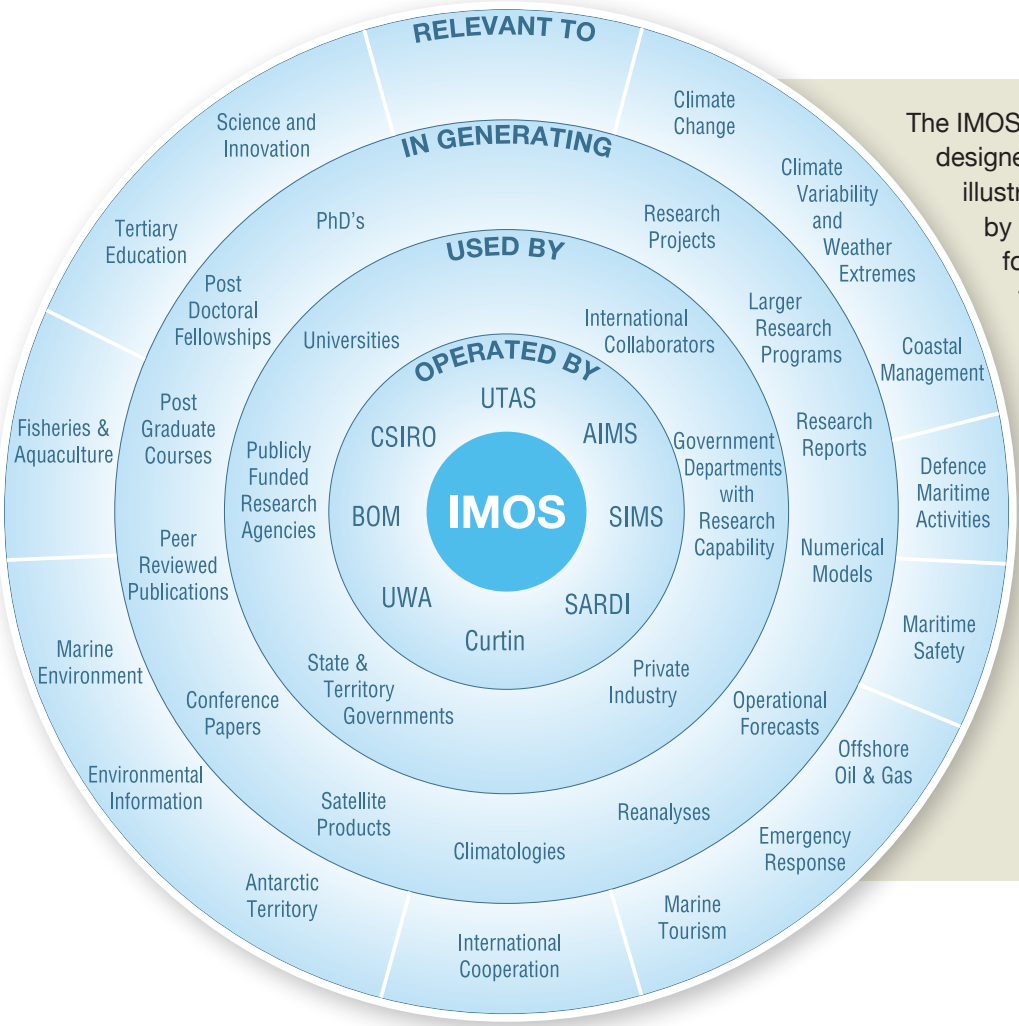
Antarctic coastal polynyas, areas of reduced sea ice cover within the ice pack, are regions of focus for marine top predators and are thought to be important foraging grounds. To understand why polynyas are important to top predators first requires an understanding of the structure of polynyas and their role in Southern Ocean circulation. These areas are now recognised as sources of Southern Ocean critical water masses as well as supporting high rates of primary production relative to surrounding habitat.

Veda's honours project aims to directly characterise the bio-physical properties of polynyas that make them such important areas for marine predators, and then contrast polynyas with other successful foraging habitats.

Veda's study will be the first to compare model output from a Regional Ocean Modeling System (ROMS) model to *in situ* CTD (conductivity, temperature, depth) data profiles collected by southern elephant seals tagged by IMOS, as well as data from the Marine Mammals Exploring the Oceans Pole to Pole database. The comparison will aim to characterise the bio-physical properties of polynyas that make them a key foraging habitat for seals and potentially other marine top predators. ROMS will be used to categorise regions of interest and specific features initially in the vicinity of Prydz Bay in Antarctica.

Using knowledge of the physical structure of the ocean gained from the initial investigation of the ROMS model output as background, Veda will then examine the seal data to explore whether conditions leading to Antarctic bottom water formation and other critical properties can be detected in the appropriate regions. Key characteristics (if identified) will initially be used to explore focal southern elephant seal habitat within and in close proximity to polynyas.

Veda's honours project is a collaboration between the Australian Antarctic Division, IMAS and the Antarctic Climate and Ecosystems Cooperative Research Centre. It uses tracking data collected from elephant seals tagged by IMOS.



The IMOS 'circle diagram' which is designed to be read from inside to out, illustrates how the system is operated by selected institutions but available for use by the entire community through open data access, generating a wide range of outputs that are relevant across portfolios and sectors.

The diagram has five layers:

1. IMOS at the core,
2. the eight operating institutions,
3. the broader research community,
4. various pathways for uptake and use of IMOS data and products, and
5. portfolios of relevance and impact.

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For more information about IMOS please visit the website www.imos.org.au

IMOS is a national collaborative research infrastructure, supported by Australian Government. It is led by University of Tasmania in partnership with the Australian marine and climate science community.

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