marinematters

IMOS

issue twenty March 2015

Integrated **Marine Observing** System

IMOS News

> For more news from all the IMOS Facilities check the IMOS website **imos.org.au/news.html**

Distinct rise in global ocean temperatures detected by Argo floats

A comprehensive view of world oceans afforded by the global array of profiling Argo floats reveals the ongoing and steady rise of global climate system heat content.

The global Argo network of profiling floats has provided scientists the most accurate means of observing energy accumulation in the climate system has detected an increase in the temperature of the world's oceans over a recent eight-year period.

Researchers led by Dean Roemmich, a physical oceanographer at Scripps Institution of Oceanography, UC San Diego, found that the top 2,000 meters of the world's oceans warmed at a rate of 0.4 to 0.6 watts per square meter (W/m^2) between 2006 and 2013. The rate translates to a warming of roughly 0.005°C per year in the top 500 meters of ocean and 0.002°C per year at depths between 500 and 2,000 meters.

"The rate of ocean heat gain during the past eight years is not unusual – indeed many studies of ocean data over the past 50 years and longer have produced similar rates," said Roemmich.

"What is new is that the rate and patterns of ocean heat gain are revealed over a period as short as eight years, thanks to the **Argo array**, that the warming signal is shown to extend to 2,000 meters and deeper, and that it is occurring predominantly in the Southern Hemisphere ocean south of 20°S."

"When we measure globally and deep enough, we see a stead rise in the earth's heat content, consistent with the expected greenhouse gas-driven imbalance in our planet's radiation budget," said study co-author Susan Wijffels, CSIRO oceanographer and Argo Facility leader.

Deploying an Argo.

The study puts a widely reported "hiatus" in global surface air temperatures since 1998 into context. Roemmich said the study illustrates that the hiatus in warming of the sea surface and the lower atmosphere is not representative of the steady, continuing heat gain by the climate system. Scientists measure that heat gain in terms of increasing temperature averaged over the water column.

The science team reports its findings in the Feb. 2 issue of the journal ***Nature Climate Change*** in a paper entitled "Unabated planetary warming and the spatial structure of ocean warming since 2006."

The data comes from the global Argo array, a network of 3,750 floats funded by **NOAA**, **Australia's Integrated Marine Observing System** (IMOS deployments of just 30 floats per annum along with other national and international deployments have resulted in 10% of the global array of 3,800 floats delivering a continuous data stream for the Australian region), the **National Institute of Water and Atmospheric Research** in New Zealand, and other international agencies that allows scientists to observe the basic physical state of all world oceans simultaneously.

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director's corner

Tim Moltmann

Welcome to the first Marine Matters of 2015. It is shaping up to be a make or break year for the IMOS national collaboration.

A highlight over the last few months was the ninth Annual Planning Meeting held in Melbourne in mid-February. It was attended by 100 people from across the national community, as well as collaborators from the US and New Zealand. Our focus this year was on IMOS as an end to end system: from deployment of equipment, to the impact of research using the observations and data. A series of high quality invited talks, panel discussions and presentations gave us plenty to think about as we plan for a second decade of operation. The potential of what we've created together is truly amazing, and there was tremendous energy in the room throughout the meeting. This edition features some nice examples of the big science and big impact we are now capable of delivering.

Measurement of increased ocean heat content by Argo illustrates the global significance of our observing program. It's essential to understand ocean heat content if we are to understand Australia's weather and climate. But it's a global science question requiring a global ocean observing system. IMOS enables us to play our part through Argo Australia, and to benefit from science undertaken by the entire international community. Australia can't do this kind of science by itself, and the international community needs us to implement the observing program in our region. This is a win-win outcome.

The need to better understand distribution and abundance of shark species is a high profile, national issue. By implementing the first ever animal tracking and monitoring network at national scale around Australia, IMOS is enabling new discoveries such as the long-range movement of bull sharks which was previously unknown. This new knowledge will assist in improved management of shark species, including management of human interactions.

As many of you would be aware, IMOS is funded through the National Collaborative Research Infrastructure Strategy (NCRIS). The May 2014 Federal Budget included a further $150M for NCRIS in 2015-16, and commissioned a series of evaluations and reviews designed to provide recommendations on long term funding of national research infrastructure. This was seen as very positive at the time. Release of the 2015-16 funds was then tied to the passage of higher education reform legislation which was being debated up to mid-March 2015. This meant that all NCRIS capabilities including IMOS were coming under intense pressure during the first quarter of 2015 in terms of planning their operations and retaining their staff. The IMOS Office and Advisory Board worked closely with the Education and Training Department, the Minister's Office and other key stakeholders in the research sector to resolve this situation, and it became increasingly clear that support for NCRIS and IMOS was very strong. Fortunately, just before going to print, the Minister guaranteed NCRIS funding for 2015-16 which is a great relief. This decision, coupled with the review of longer-term funding for national research infrastructure currently underway, gives us considerable cause for optimism. I hope to have more detail to report in the next edition of Marine Matters.

Tim Moltmann

IMOS recently launched its Facebook page

The IMOS Facebook page was created to increase openness and accessibility and to provide a new publicity platform for IMOS data and IMOS news and events. It also positions IMOS within broader discussions of issues affecting the marine science community.

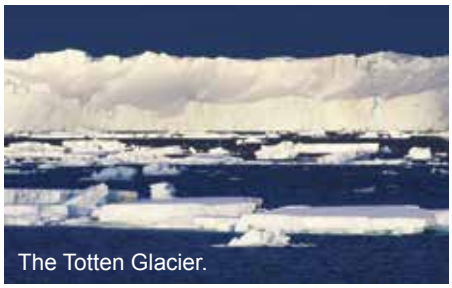
It provides IMOS partners with a forum for highlighting and discussing aspects of their work, thereby enhancing the IMOS brand. Once IMOS partners begin using the Facebook page it is expected to grow as a communication platform. Facebook is a useful way to connect with specific or broader communities of practice and a great place to share online resources, discuss current issues, show off your photos of recent work and generally stay abreast of what's happening in your professional world.

IMOS has created guidelines for engaging with social media in the workplace. Those who have been engaging with social media for a while will no doubt be aware of the protocols and acceptable behavior but 'newbies' to social media are likely to benefit from a 'heads-up' on a few tips on social media etiquette and how to make the most of these platforms.

Anyone can post to the IMOS Facebook timeline and a selection of these posts will be highlighted on the IMOS 'wall'. Visit the page at **www.facebook.com/IntegratedMarineObservingSystem** and start sharing, commenting and most importantly 'liking'!

Warm ocean water melts largest glacier in East Antarctica

Warm ocean water is melting the largest glacier in East Antarctica from below, according to new Australian Antarctic research.


The Totten Glacier.

Esmee van Wijk, CSIRO

The team of 23 scientists and technicians from the **Australian Antarctic Division** (AAD), the **Antarctic Climate and Ecosystems CRC** (ACE CRC), the University of Tasmania's **Institute for Marine and Antarctic Studies** and **CSIRO Oceans and Atmosphere Flagship**, returned to Hobart in late January on Australia's icebreaker *Aurora Australis*, after taking the first water samples ever collected alongside the Totten Glacier.

Voyage Chief Scientist Dr Steve Rintoul, from the ACE CRC, said that until this voyage no oceanographic measurements had been made within 50 kilometres of the glacier.

"At 120km long and more than 30 km wide the Totten Glacier is one of the world's largest and least understood glacial systems," Dr Rintoul said. "It drains 538,000 square kilometres of East Antarctica, an area more than twice the size of Victoria. 70 billion tonnes of ice flow out of it every year, enough to fill Sydney Harbour every two and a half days."

"It was thought that glaciers on the East Antarctic ice sheet were relatively immune to the kind of melting taking place on the much smaller West Antarctic ice sheet. But satellite data show that the Totten has been thinning faster than other glaciers in East Antarctica and until now we have not known why."

The researchers used new instruments, such as autonomous floats and gliders, designed to sample the ocean beneath sea ice and traditional oceanographic tools like Conductivity, Temperature and Depth (CTD) profilers lowered from the ship.

"We will use the data gathered from these instruments at the Totten Glacier to assess how much ocean heat is available to melt the base of the Totten Glacier."

As warm ocean waters melt the Totten and other floating glaciers around the edge of Antarctica, more glacial ice can flow into the ocean, raising sea level. This study will help address one of the biggest questions concerning future sea level rise: how will warming of the ocean affect the Antarctic ice sheet? The Totten Glacier alone contains an amount of ice equivalent to 6 metres of global sea level rise. Glaciers grounded on bedrock below sea level, like the Totten, are particularly vulnerable to changes in ocean temperature and currents, because the ocean can penetrate deep under the glacier.

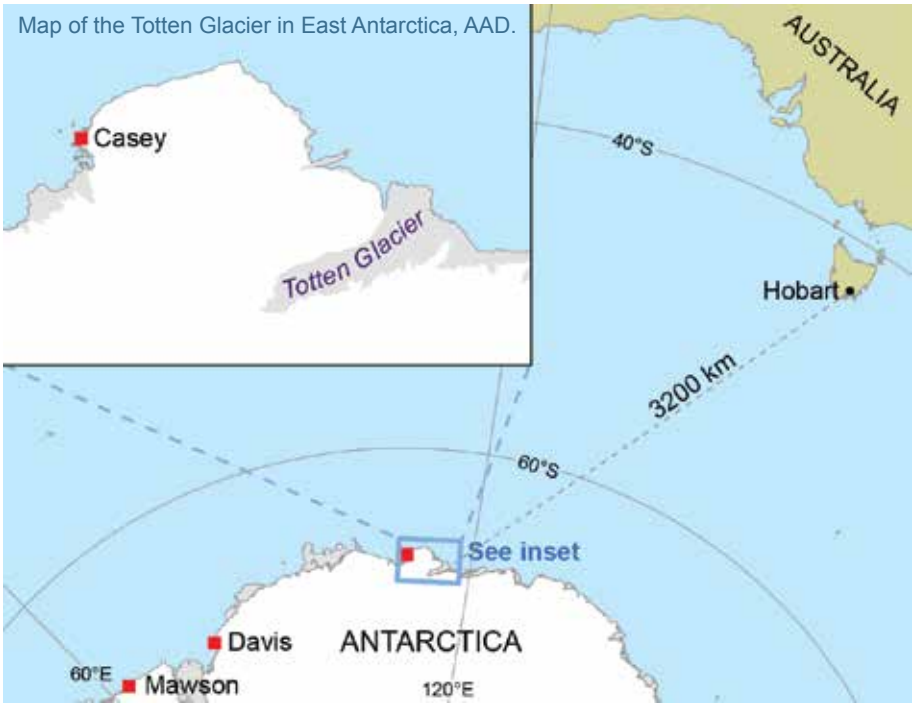
A highlight of the voyage was the successful recovery of US and Australian moorings on the sea bed for up to two years at six different locations adjacent to the Totten glacier. The Australian moorings are part of IMOS. The instruments were deployed by the US icebreaker *Nathaniel B. Palmer* and recovered by the Australian icebreaker *Aurora Australis* as part of an ongoing international collaboration.

"The mooring records will provide the first ocean measurements spanning the full year in this area, giving us an idea of what happens during the long cold winter months when access to the region is impossible. The measurements we've collected here are crucial for setting a benchmark that can be used to assess future change," Dr Rintoul said.

"IMOS was established to provide sustained observations from the oceans around Australia," says IMOS Director, Tim Moltmann. "This is new information that is clearly important for the future. It's only been possible to obtain because we've had the IMOS national collaborative research infrastructure in place."

The seven week marine science voyage was funded through the Australian Research Council's Special Research Initiative for Antarctic Gateway Partnership, the AAD, the ACE CRC, CSIRO and IMOS.

Map of the Totten Glacier in East Antarctica, AAD.



Introducing the Australian Forum for Operational Oceanography (FOO)

Lea Crosswell

In developed countries around the world, Government agencies, R&D providers and marine industries are realising the potential advantages of creating a systematic focus on operational ocean observing, short-range prediction, and delivery of services – covering marine and coastal environments, and physical and biogeochemical properties. This has come to be described as operational oceanography. Recent efforts in the UK to establish a Forum for Operational Oceanography are one good example of what can be achieved.

As an island nation deriving massive social, economic and environmental benefits from its coasts and oceans, Australia has good reason to be keenly interested in these developments. A team of scientists and managers from across industry, government and academia have therefore come together and formed a Steering Committee to bring an Australian Forum for Operational Oceanography (FOO) into existence. IMOS Director Tim Moltmann and Jan Flynn Senior Metocean Engineer at Shell Australia are co-chairs of the steering committee.

Initially the steering committee has been formed with the specific purpose of holding the first Australian Forum for Operational Oceanography Conference on 21-23 July 2015 with generous support from the Australian Government Department of Science and Industry. Please note that the FOO 2015 conference is an invite only event.

FOO provides an opportunity for IMOS to 'close the loop' with important stakeholders in offshore industry, renewable energy, fisheries, ports and shipping, the Australian Maritime Safety Authority (AMSA), the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA), Bureau of Meteorology Operations, State Governments, and Coastal Councils.

Forum for Operational Oceanography

Please direct any enquiries about FOO to:

FOO Co-chair, Tim Moltmann **Tim.Moltmann@imos.org.au**
or Executive Support Emma Sommerville **emma.sommerville@utas.edu.au**
or see **www.foo2015.com** for more information.

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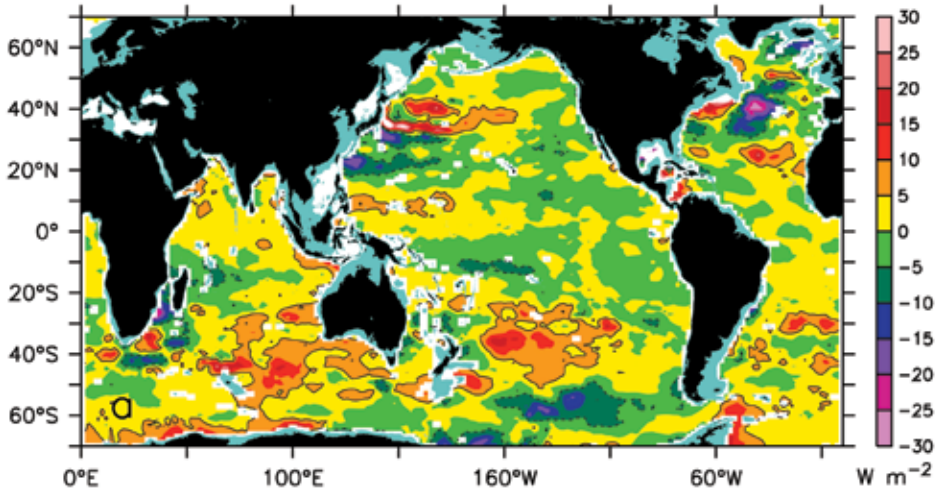
The researchers reported that they used three statistical analysis methods to estimate global ocean heat content and that all three largely agreed, pointing to the robustness of the Argo network's accuracy. Because nearly all of the excess heat in the climate system is retained in the oceans, the Argo network has provided scientists the most direct and accurate means of observing energy accumulation in the climate system.

The Argo dataset is freely available online, scientists hope that over the long term, Argo data will be used to enhance the understanding of ocean trends and cycles that play out over multiple decades.



The spatial distribution of the heat gain reveals a large build-up of heat in the mid-latitude South Indian and Pacific oceans, with weaker warming in the South Atlantic.

IMOS community meets for annual planning

One hundred people representing the IMOS community of researchers met in Melbourne in February for the 9th Annual Planning Meeting (APM).

IMOS Director, Tim Moltmann opened the meeting by inviting participants to consider the 'S' in IMOS. Mr Moltmann described IMOS as an end-to-end System, or loop, which involves deploying and recovering equipment and subsequently making data discoverable and accessible. He urged the gathering to use the meeting to think about how we could improve on the uptake and use of data and how we could ensure relevance and impact of science outputs.

With the theme set for the three-day event, a series of informative presentations and lively panel discussions followed. Breaks and meals provided opportunities for networking and catching up with colleagues and friends. It was apparent that although geographically dispersed, the community of marine scientists, meteorologists and other researchers are well connected and that marine observation is a truly cross-discipline endeavor.

It was great to hear from the invited speakers and this year we were lucky to have talks from Steve Piotrowicz (NOAA) on Deep Argo, Neville Smith on The Tropical Pacific Observing System 2020 project, Lev Bodrossy (CSIRO) on marine microbes and Adam Lewis (Geoscience Australia) on next generation ocean remote sensing. Adam Lewis had the room buzzing with news of a forthcoming launch of a new European Space Agency Satellite and the potential of Satellite Remote Sensing for coastal observations. His talk also sparked a discussion of Australia's contribution to and influence over Earth Observing Satellites.

Each node leader (or deputy leader) reported on activities, issues and opportunities related to their particular areas of interest. They drew upon data from a number of facilities as well as reporting on the progress of partnerships such as the Great Australian Bight Research Program, eReefs, Western Australian Marine Science Institution (WAMSI) and Sydney Harbour Research Project.

As well as hearing about the generation and application of IMOS data we learned how IMOS data is utilised in education programs. Martina Doblin and Tim Ingleton from NSW-IMOS told the group how the next generation of marine scientists were experiencing the value of IMOS data as part of their post-graduate studies through the Sydney Institute of Marine Science.

This year facility updates were circulated to participants prior to the meeting so that more time in Melbourne could be devoted to matters that cut across various facilities. Time was put aside in the program for people to ask specific questions about matters reported in these updates. Feedback from participants indicated that this format worked well, both informing everyone about the latest issues with each facility and allowing more time for group discussion of broad issues.

Following last year's trial of a panel discussion format, six panels were assembled for the 2015 meeting. Papers outlining the matters to be covered by panels were distributed prior to the meeting so that participants were able to come to each discussion with the relevant background. Panels were structured such that different perspectives could be brought to an issue by people with a particular interest in the subject. For example, in a discussion about new sensor technologies, people from different facilities were able to talk about how specific technologies could potentially improve their own set of observations.

At the conclusion of the meeting a list of issues arising from discussions was drawn up. Where appropriate issues will be assigned to task teams for further investigation and potentially project development. We'll be in a position to say more about that in future communications.

A special thanks to Donna Harris in the IMOS office for organising the logistics of the APM, including audio-visual presentation, enabling a smooth, enjoyable and productive meeting.

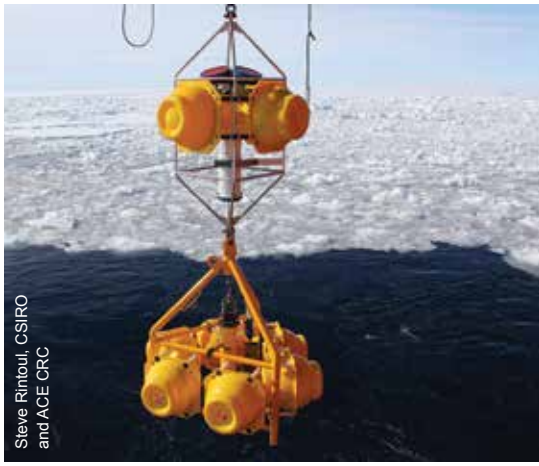
Presentations are available via the IMOS website at http://imos.org.au/apm2015.html

INVITED PRESENTATIONS:

- Steve Piotrowicz (NOAA), Deep Argo
- Neville Smith (TPOS), The Tropical Pacific Observing System 2020 Project
- Lev Bodrossy (CSIRO), Marine Microbes – The Australian Marine Microbial Biodiversity Initiative (AMMBI), and the Marine Microbial Data project with Bioplatforms Australia
- Adam Lewis (Geoscience Australia), Earth Observations for Space – national infrastructure for new mission satellite missions and ever bigger data

PANEL DISCUSSIONS:

- IMOS in the Southern Ocean
- The National Environmental Science Program (NESP)
- Revision of IMOS Science and Implementation Plans
- New sensor technologies for oxygen, pH, nutrients, bio-optics
- IMOS in Major Boundary Currents
- Ocean remote sensing in Australia



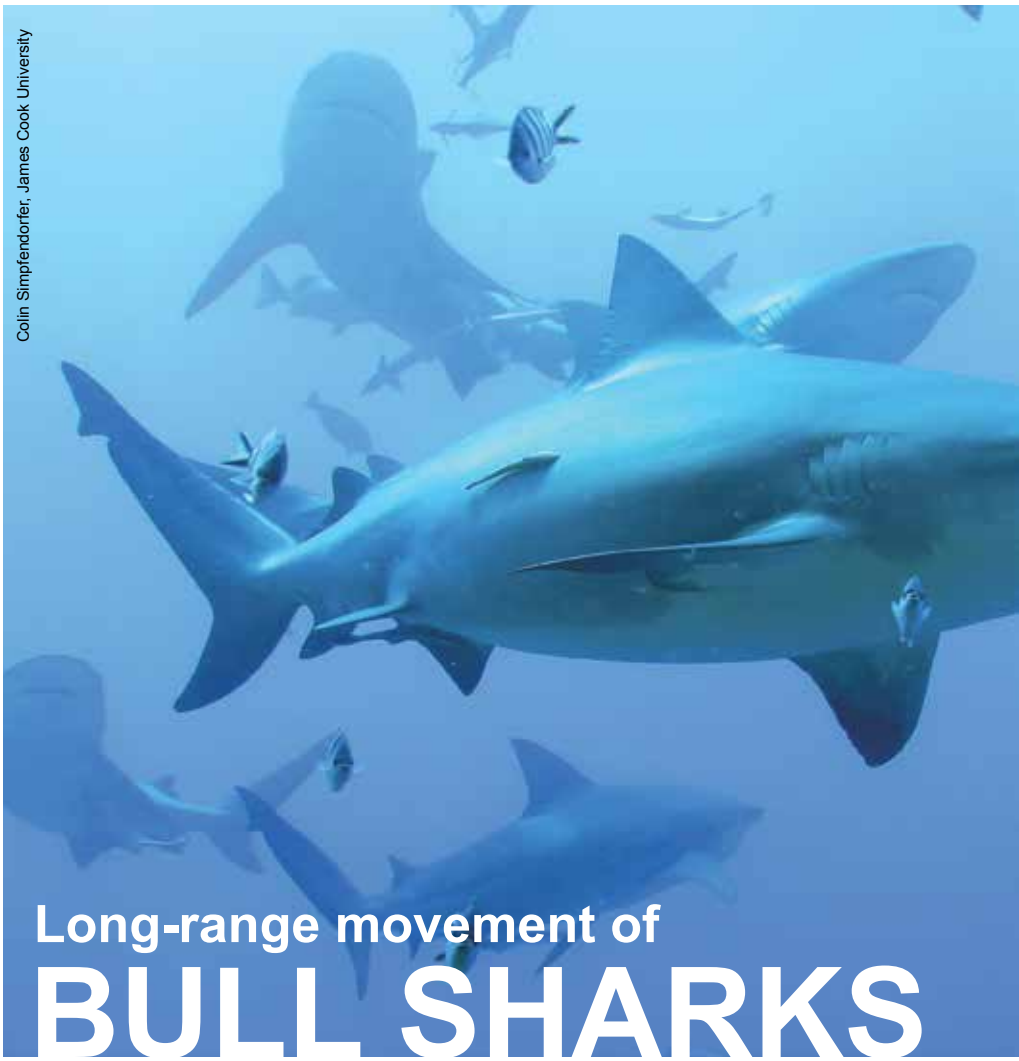
A deep water mooring at the Totten Glacier. Retrieval of the moorings was presented as a highlight for the Bluewater Node. For more information about the moorings see the news item on page 3.

Reef Integrated Monitoring and Reporting Program

The Reef Integrated Monitoring and Reporting Program (RIMRep) is a new collaborative partnership being coordinated and managed by the Great Barrier Reef Marine Park Authority. It aims to improve understanding of the condition and trend of the Reef's values together with the drivers, pressures and activities affecting them to inform adaptive management.

RIMRep will inform the evaluation of management actions against the objectives and targets of the Reef 2050 Long-Term Sustainability Plan. The Reef 2050 Long-Term Sustainability Plan is the overarching framework for protecting and managing the Great Barrier Reef from 2015 to 2050. The Plan is a key component of the Australian Government's response to the recommendations of the UNESCO World Heritage Committee.

RIMRep will rely on the collaboration between the research, modelling, and monitoring community, relevant industries and community based citizen science programs together with all levels of government. IMOS has been invited to be a partner in the program and Tim Moltmann (IMOS Director) has attended the first two meetings. Representatives from relevant IMOS Nodes and Facilities will be contributing to working groups that will focus on the program design and the data management. The working groups will meet in March to refine and prioritise tasks for program establishment.



Colin Simpfendorfer, James Cook University

Long-range movement of BULL SHARKS

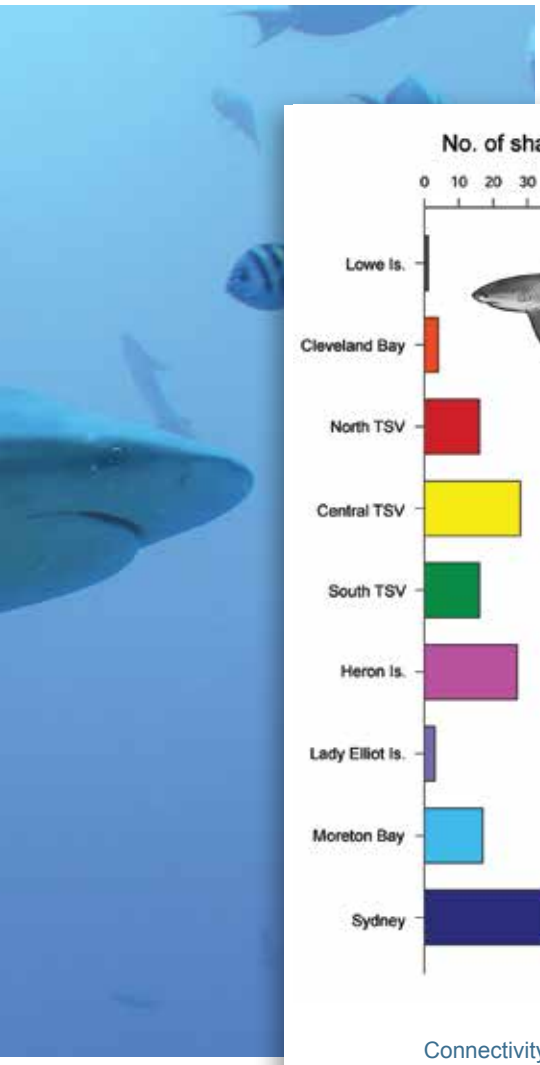
Written by Michelle Heupel

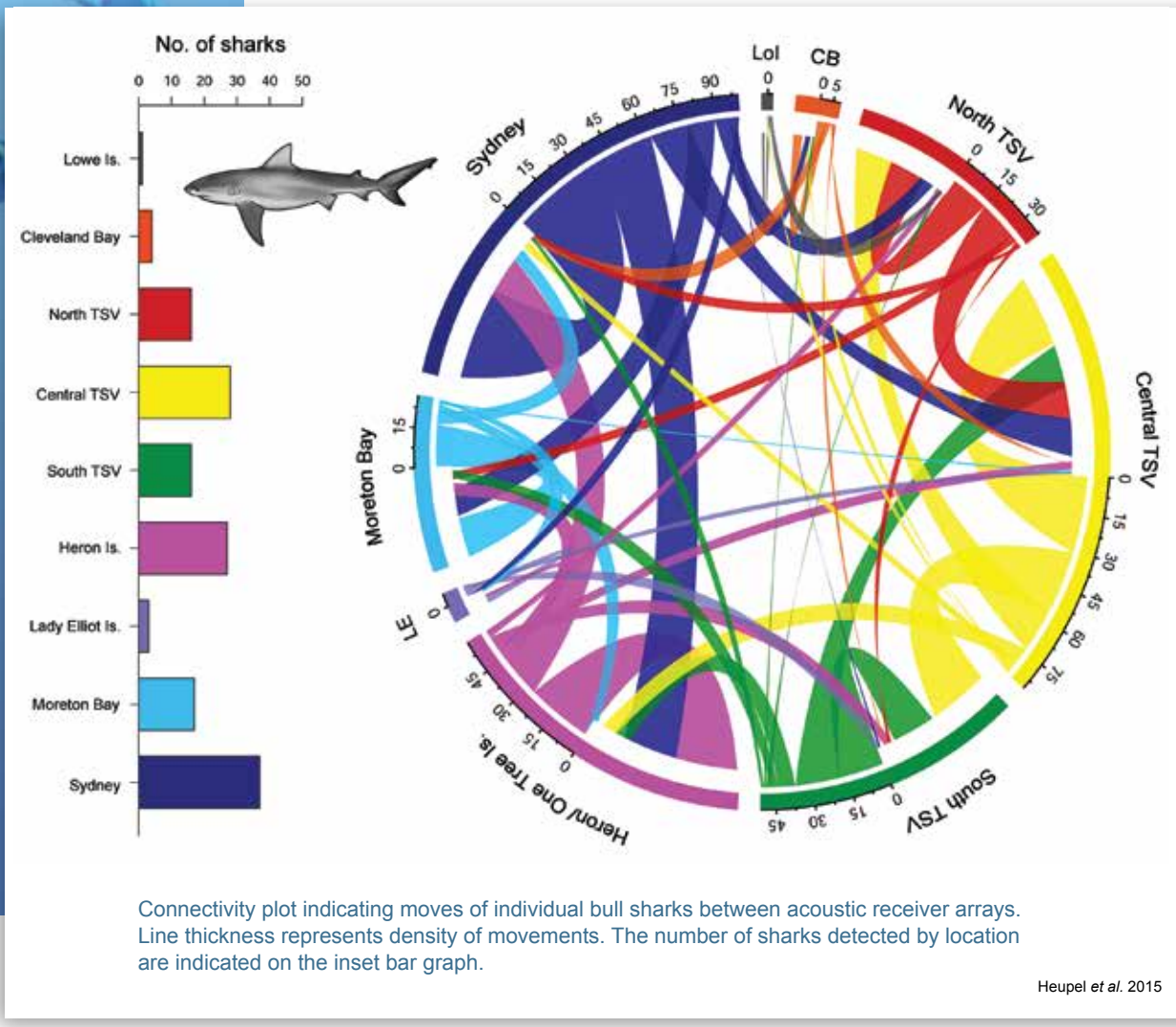
The long-range movements of species can be hard to capture. Technology is advancing to help solve these issues, but sometimes it is a matter of being in the right place at the right time.

A collaboration between the Australian Institute of Marine Science, James Cook University and NSW Department of Fisheries has revealed previously unknown linkages in coastal bull shark populations. This discovery was facilitated by use of data from the network of acoustic receivers around the coast of Australia deployed as part of the IMOS Animal Tagging and Monitoring Facility.

In two separate research projects 39 bull sharks were fitted with acoustic transmitters in the reefs offshore from Townsville and 75 individuals were similarly tagged in Sydney Harbour and the Clarence River. Approximately half of the individuals tagged in NSW were recorded on receivers in Qld, including the region offshore from Townsville.

Individuals were detected on various acoustic receiver arrays along the Qld coast and at installations offshore in regions such as the Capricorn Bunker Group. Shared detection data from individuals that made large moves has provided a unique opportunity to examine long range movements





Connectivity plot indicating moves of individual bull sharks between acoustic receiver arrays. Line thickness represents density of movements. The number of sharks detected by location are indicated on the inset bar graph.

Heupel *et al.* 2015

of bull sharks along the east coast. This would not have been possible without collaboration and connections within the IMOS community.

In contrast, sharks tagged in reef regions were less likely to move south. Only one individual released in Qld was detected on NSW arrays. Approximately 25% of reef tagged individuals, however, moved further north beyond the Townsville region suggested broader movements are also likely in this segment in the population, just not in a southerly direction.

Broad scale movement of large predators is directly relevant to both management and conservation efforts. Crossing of jurisdictional boundaries, both national and international, could have significant consequences for the status of populations. Further data is needed on key species to understand the dynamics of these movements and implications for management.

These findings indicates direct linkages between what may have been considered separate populations and suggests coral reef regions may play a key role in the ecology of bull sharks on the east coast of Australia. The results also clearly demonstrate the power of a coordinated continental scale acoustic network and the opportunities for discovery and exploration it can provide.

For more information about this research please see the recent publication in Frontiers in Marine Science:

Heupel M, Simpfendorfer C, Espinoza M, Smoothey A, Tobin A and Peddemors V (2015). Conservation challenges of sharks with continental scale migrations. Front. Mar. Sci. 2:12. doi: 10.3389/fmars.2015.00012

Postdoctoral project profile

Researchers working with IMOS data for their postdoctoral research

Dr Colette Kerry | University of New South Wales

Dr Colette Kerry is working as a postdoc on the ARC Discovery project, Advancing Dynamical Understanding in the East Australian Current, led by Associate Professor Moninya Roughan (UNSW), Assistant Professor Brian Powell (University of Hawaii), and Dr Peter Oke (CSIRO). The project utilises IMOS data from a range of platforms; including temperature, salinity and velocity data from the EAC deep water moorings, and the shelf moorings in South East Queensland and NSW, temperature and salinity from ocean gliders off NSW, the surface radial vectors from the Coffs Harbour ocean radar, data from Argo profiling floats and XBT lines (PX30 and PX34).

The East Australian Current (EAC) is one of the most dynamic oceanic regions on the planet which makes its circulation very difficult to predict. In particular, predicting separation of the current from the coast and the formation and behaviour of mesoscale eddies in the Tasman Sea is a major challenge. The project uses a variety of observations to develop a reanalysis of the region and aims to provide new insight into the complex EAC dynamics and the value of specific oceanic observations for improved state-estimation and thus prediction.

The project uses the ROMS (Regional Ocean Modeling System) 4-Dimensional Variational assimilation tools to combine the available data streams with the model fields providing a reanalysis of the ocean state at 3-6km resolution over a 2-year period (Jan 2012- Dec 2013). In addition to the data listed above it makes use of satellite derived sea surface height (SSH) and sea surface temperature (SST). By combining a state-of-the-art modeling system, an array of traditional and newly available data streams and an advanced assimilation method, this reanalysis provides a dynamically-consistent "best estimate" of the ocean state along the east coast of Australia that is more useful that observations or model estimates alone.

The reanalysis allows us to study the dynamical variability, transport, and separation dynamics of the EAC and will be useful for a number of local studies involving nesting of higher resolution models. The next phase of the project will use the reanalysis to quantify how the observations contribute to our understanding of certain circulation metrics that describe key dynamics of the EAC and its separation from the coast. This allows us to assess the impact of particular data streams on our circulation estimates and provides information vital in assessing and improving the observing system design for Australia's western boundary current.

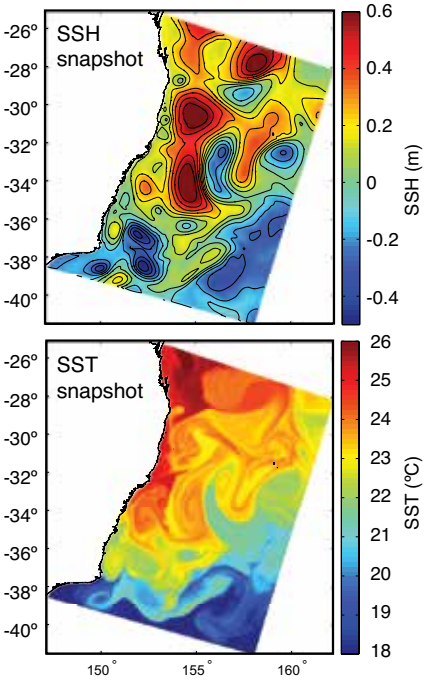


Figure 1: Model snapshots of SSH and SST over model domain. Note the resolution of small-scale features on the shelf upstream of the separation zone.

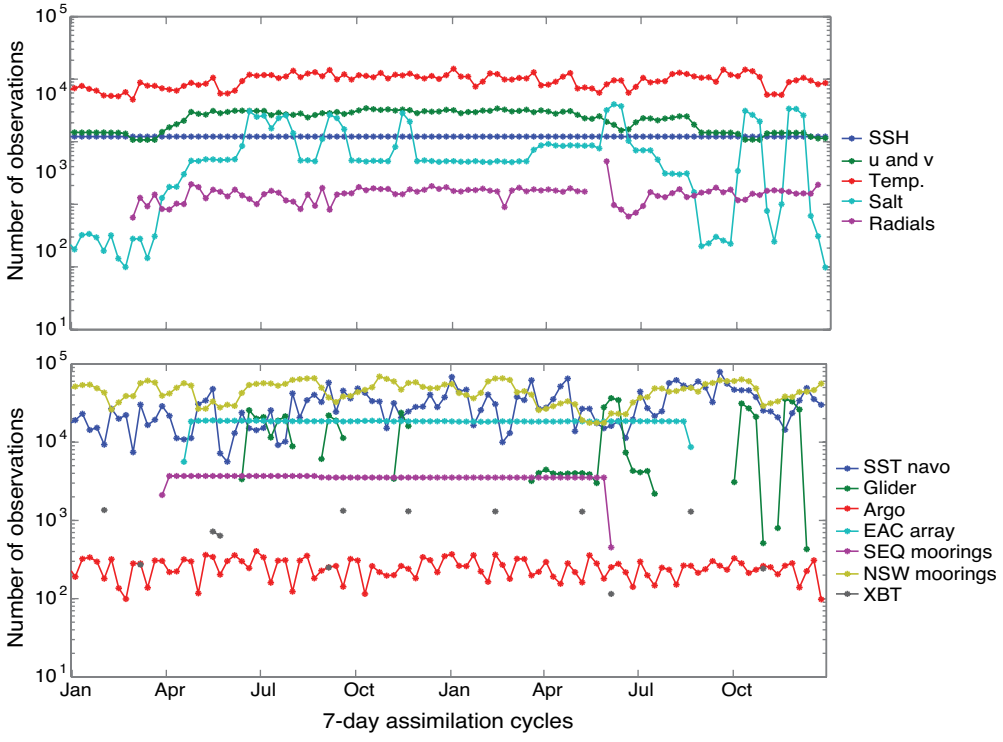


Figure 2: Number of observations assimilated for 2012-2013, by observation type (top panel) and temperature observations by data source (bottom panel).

IMOS has a new science node: South East Australia IMOS (SEA-IMOS)

The Tasmanian IMOS science node has recently been repositioned as South East Australian IMOS (SEA-IMOS). This development is intended to better engage the Victorian science community and stakeholders, and to better address research opportunities in the region. These include research relevant to fisheries and aquaculture, marine spatial planning, climate variability and change, offshore industries, and coastal planning and management.

The SEA-IMOS Node will employ an integrated 'whole of system' approach to sustained observing in the region that links oceanography and biogeochemistry with biology at a range of spatial scales. Ultimately, the node supports observations on the temporal dynamics of the global, national, regional and local oceanography that will contribute to our understanding of their impacts on climate, people and our ecosystems.

The new leadership team of the SEA-IMOS node consists of Node leader, Dr Mark Baird from the CSIRO, and two deputy Node Leaders, Dr Vanessa Lucieer from the Institute for Marine and Antarctic Studies and Dr Daniel Ierodiaconou from Deakin University. Our thanks go to the outgoing TasIMOS node leaders, Dr Peter Thompson and Dr Kerrie Swadling, who will remain involved in the science of the new node.

DR MARK BAIRD is an aquatic scientist who uses observations and numerical models to study estuarine and marine ecosystems. Mark has spent 20 years researching physical and biological processes in the ocean, working at the University of NSW, the University of Technology Sydney and at CSIRO. Mark presently leads the CSIRO Coastal Environmental Modelling Team, and is a principal developer of the CSIRO Environmental Modelling Suite. He has been to sea on 8 research cruises, and been involved in the deployment of autonomous gliders. With Ken Ridgway, Mark used glider transects off eastern Tasmania to discover a new pathway for Bass Strait water in the Tasman Sea.

DR VANESSA LUCIEER is a marine spatial analyst at the Institute for Marine and Antarctic Studies at the University of Tasmania. Vanessa has had 14 years of experience working with acoustic and video seafloor data. Seafloor mapping has led her to work on research projects in Tasmania, around Australia, New Zealand, Norway and Antarctica. In recent years Vanessa has been applying her expertise in marine habitat mapping to help develop monitoring techniques that can be used to map, characterise, understand and manage our oceans' biodiversity through the National Marine Biodiversity Hub.

DR DANIEL IERODIACONOU is a senior lecturer at Deakin University, Warrnambool, Victoria. He is a marine ecologist interested in multidisciplinary and multi-scalar approaches to habitat mapping integrating remotely sensed geophysical and biological datasets. He has an interest in understanding the physical and biological processes that influence biogeographic patterns in marine ecosystems at both ecological and geological timescales.

NSW-IMOS: EAC glider featured on Coast Australia

Research using an IMOS ocean glider was featured on an episode of Coast Australia on Foxtel's History Channel. Associate Professor Moninya Roughan, an oceanographer at The University of New South Wales, took the host Neil Oliver along to deploy an ocean glider at Yamba. The episode which aired on 26th January demonstrated how Moninya's research team use the glider data to understand the East Australian Current (EAC).

Moninya Roughan, UNSW

NSW-IMOS: IMOS ocean observations underpin unique post-graduate course in Sydney

The IMOS Ocean portal is a valuable resource for researchers and others with an interest in ocean measurements such as currents, temperature, salinity and animal movements. A post-graduate degree course based on this data and its applications is being taught in Sydney in a unique collaboration of universities.

For the past three years the Sydney Institute for Marine Science (SIMS), in partnership with Macquarie University, the University of NSW, the University of Sydney and the University of Technology Sydney, has been running a Master's degree course called Topics in Australian Marine Science (TAMS). This course is unique in that the core of the course is built around IMOS - understanding how different measurement platforms work and exploring the data that these platforms collect. Students combine attending seminars and lectures with hands on practicals and personal assignments, all built around access to IMOS data and the many tools available to visualise and analyse it.

Dr Roger Proctor, who leads the e-Marine Information Infrastructure (eMII) team that aggregates data from facilities all over Australia, said 'IMOS is collecting unprecedented volumes of multi-disciplinary oceanographic data in the ocean and on the continental shelf which is made freely available through the IMOS Ocean Portal. '

'Students and lecturers are able to integrate these 'real' observations into the classroom while learning how to use the various tools available to manipulate these data.'

Since its inception, the popularity of the course has increased with 38 students undertaking the subject in 2014. Dr Jason Everett, the TAMS coordinator, speaks enthusiastically about the course and how it benefits the students.

'The course attracts a diverse cohort, including mature-age students, international students and recent graduates who are looking to increase their skill base prior to entering the workforce,' he said.

'Our students are interested in a range of career options from research to management. They find that the IMOS Ocean Portal and the other visualisation tools we make available to them, enable them to study the marine environment without the need for high level computational skills.'

Ms Katherine Tattersall and Dr Xavier Hoenner of eMII in Hobart travelled to Sydney for the first week of the course to deliver the 'Introduction to the IMOS Ocean Portal' component. They found the students were eager to learn how to access the wealth of ocean data and make use of it.

'This is a fantastic opportunity for these students to learn about IMOS and the wealth of data available to them. It was great to see them quickly pick up on how to interact with the IMOS Ocean Portal and download publicly-available data,' said Ms Tattersall. 'I'm excited to know that they will go forward and apply their knowledge to real problems.'

Students from the course can go on to a variety of careers where ocean data is used. These include research positions as well as jobs in private industry where ocean data form important foundations for decisions in shipping, fishing and other marine-based industries.

Katherine Tattersall, IMOS

Students attend the Master's degree course 'Topics in Australian Marine Science' (TAMS).

Facility 2: Ships of Opportunity

Industry support for the IMOS BA-SOOP project grows

Written by Ryan Downie

Petroleum Geo-Services (PGS) have teamed up with scientists at CSIRO to provide valuable data to the IMOS Bio-Acoustic Ships of Opportunity Program (BA-SOOP). PGS's Ramform Sovereign equipped with multi-frequency echosounders are committed to logging water column acoustic data to deliver to Australia's science community (Fig. 1). The vessel logged acoustic data while on transit from Norway to Western Australia and are actively logging during their survey in the Great Australian Bight (GAB).

This data is novel to the IMOS BA-SOOP program in that once calibrated, it will provide information on daily and seasonal dynamics of mesopelagic fish and invertebrate communities within the central GAB marine ecosystem. This along with BA-SOOP data delivered from research and fishing vessels (including Sealord NZ and Austral Fisheries) is providing a means to quantify mid-trophic organisms at ocean basin scales (Fig. 2). Uptake of this data into regional and global ecosystem models is progressing with a recent scientific article published by Lehodey et al. (2015).

Optimization of a micronekton model with acoustic data. Patrick Lehodey; Anna Conchon; Inna Senina; Reka Domokos; Beatriz Calmettes; Julien Jouanno; Olga Hernandez; Rudy Kloser. 2015; doi: 10.1093/icesjms/fsu233.

Petroleum Geo-services

Figure 1: PGS' Ramform Sovereign joins the fleet.

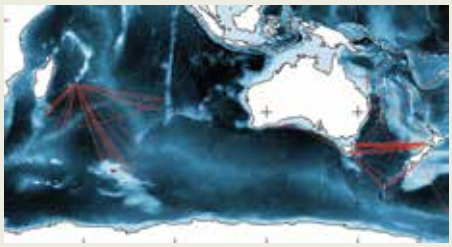


Figure 2: IMOS SOOP-BA data available on the portal.

Facility 4: Ocean gliders – IMOS hits the highway

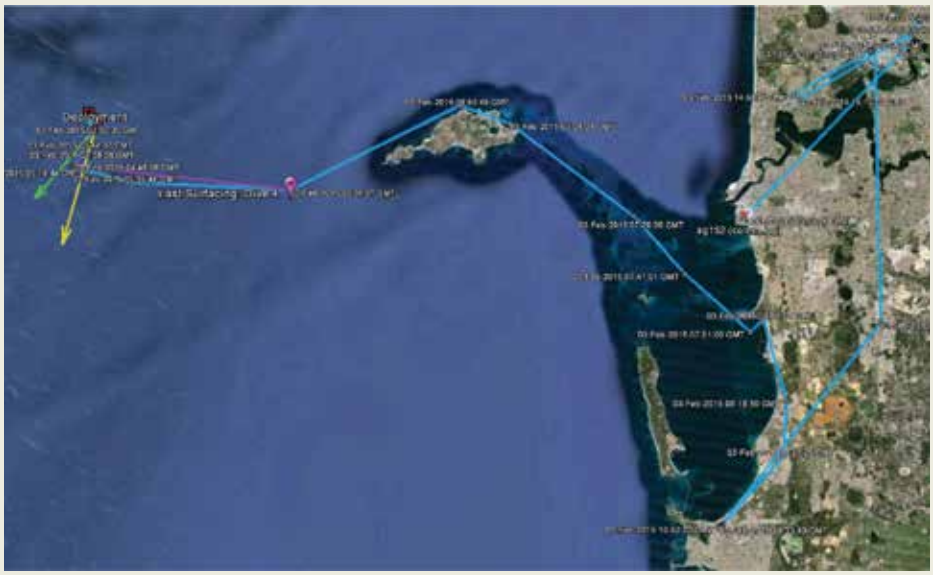
Recently one of the IMOS ocean gliders took an unexpected trip on dry land.

The Glider laboratory team was deploying gliders in sea trials in the ocean near the Perth Canyon in early February when one of their gliders headed unexpectedly straight to Rottnest Island. The team quickly realised that somebody had picked up the glider and had it on their boat, but with so many boats out on the water finding which one had the glider was going to prove difficult.

They were able to follow the GPS signals from the glider and once the glider team got back to land they followed the glider to a shopping centre in Rockingham, a 30km drive south from Freemantle. Unfortunately when they arrived it had already moved on. By now the glider was transmitting erratically and the Glider team suspected that the antenna had been damaged when it was recovered by a non-expert. So it was imperative that they tracked the glider before it was stored indoors, which would prevent a signal and obviously stop it from being located.

As there was no satellite information the final location was obtained through the backup animal tag installed on the glider rather than through the glider antennae. The team figured out the approximate location and narrowed it down to about five-six houses. It was around 7pm by now and just getting dark, so the team went door knocking.

Eventually they found the person who sheepishly admitted having the glider in his garage and handed it over without any problem. He thought it was lost and even rang the phone number on the glider, but of course with the team out there searching nobody was back at the glider lab to take his call! After some minor repairs the glider will be tested, and then shipped to South Australia for a deployment in the Great Australian Bight.



An odd use of a Slocum glider

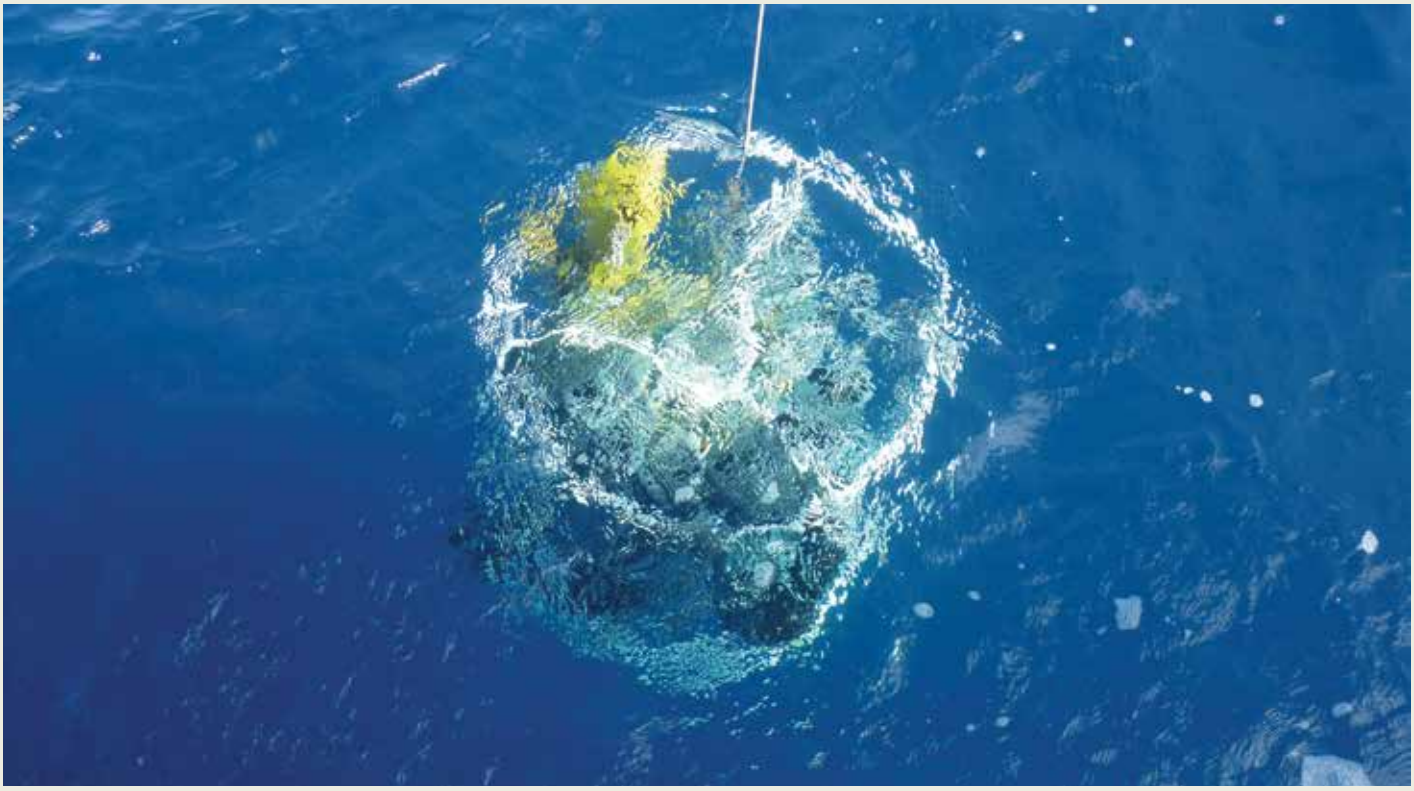
Written by Paul Thomson

The IMOS ocean glider Facility put a Slocum glider in an odd position on a cruise on the AIMS research vessel RV *Solander* between Exmouth and Darwin in mid-January this year. Dr Paul Thomson and University of Western Australia student Sara Hajbane, with the helpful RV *Solander* crew, nervously attached a Slocum glider vertically within the ships conductivity, temperature, and depth (CTD) rosette and then undertook 19 CTD casts along the north-west shelf off the Pilbara and Kimberly coastlines. During the casts seawater was collected from the surface and the chlorophyll maximum while continuously taking bio-optical (fluorescence, backscatter and coloured dissolved organic matter -CDOM) measurements using the glider's Ecopuck and a separately attached Ecotriplet. The purpose of this exercise is to: (1) study the microbial communities (viruses, bacteria and phytoplankton) of the productive tidal fronts of the North West Shelf; and, (2) validate bio-optical signals against pigment and particle concentrations and to evaluate if bio-optical measurements can be used to discriminate species or groups of phytoplankton based on their backscatter and fluorescence signatures. To do this, bio-optical signatures will be matched to phytoplankton community composition determined later by photosynthetic pigment composition, microscopy and flow cytometry.

During the cruise the team sampled across a high chlorophyll area of a tidal front offshore Karratha and within an eddy offshore the Kimberly coast, identified using IMOS OceanCurrent. At one site, the ships fluorometer recorded up to 6 µg/l fluorescence at the chlorophyll maximum but most sites were <2 µg/l. While the results are preliminary, bio-optical data shows samples with high, moderate and little correlation between fluorescence and backscatter signals, indicating that at least some of the phytoplankton populations may have specific bio-optical signatures.

Many thanks to AIMS for ship time and the extremely helpful and professional crew of the RV *Solander*.

Paul Thomson, UWA



Paul Thomson, UWA

Facility 5: Autonomous Underwater Vehicle

AUV deployed to examine the benefits of a no-take marine reserve off Tasmania's wild southwest coast

Scientists have been evaluating the benefits of no-take protection (i.e. no fishing) on deep reef systems of Tasmania's wild southwest coast.

This research is comparing the marine life and seafloor habitat in fished environments with those found within the Tasman Fracture Commonwealth Marine Reserve (CMR) southeast of Tasmania. A section of this reserve has been no-take protected for over seven years, and evaluating the effects of such protection is an important part of managing the CMR network in Australian waters.

The $300,000 assessment involved an initial phase of habitat mapping on the continental shelf component of the 42,501 sq km Reserve south of Maatsuyker Island.

A second phase concentrated on examining the extent that rock lobsters had been protected by this reserve, and the third phase of the study is now examining the actual habitat that supports rock lobsters and associated fish communities, the species that constitute the ecosystem, and the overall system health.

Research results will be used not only to inform management of changes over the past seven years in response to protection, but also to establish early knowledge of this remote environment from which to compare future changes and identify potential management issues.

Working from the Australian Maritime College training vessel Bluefin, the team of scientists and support staff relied on an autonomous underwater vehicle (AUV) to supply highly detailed imagery of the rocky reefs and sediments, together with an assessment of the marine animals that live in on the seafloor in these deep offshore systems.

The AUV, operated by the Australian Centre for Field Robotics at the University of Sydney, is a key national research facility of Australia's Integrated Marine Observing System. All imagery from the voyage will be made available through the IMOS Ocean Portal https://imos.aodn.org.au

Project leader Dr Neville Barrett, from the Institute for Marine and Antarctic Studies, said scientists were excited by the opportunity to visit the region and collect data. The knowledge gained will be used to inform management of Commonwealth Marine Reserves, including building an increased understanding of deep reef and other habitats within the Tasman Fracture CMR that support important invertebrate communities and species such as stripey trumpeter and rock lobster.

"The AUV has supplied us with highly-detailed imagery of the rocky reefs and sediments, together with an assessment of the benthic marine animals that live in these deep offshore systems."

"This provides our first detailed look at the shelf fauna of the Marine Reserve and cool temperate region, as well as the habitat and biological assemblages that support our important coastal fisheries, such as rock lobster."

"We'll be analysing the new data over the next few months, but first indications are that the deep reef systems extending south of Maatsuyker Island into the CMR are particularly rich in invertebrate diversity, and are unusually dominated by soft corals and brittlestars," Dr Barrett said.

The research is being undertaken through the Australian Government funded National Environmental Research Program (NERP) Marine Biodiversity Hub and supported by Parks Australia Division of the Department of the Environment.

Craig Macaulay, IMAS

Dr Neville Barrett (right), from the Institute for Marine and Antarctic Studies, with Jacquomo Monk (left), and Justin Hulls, dismantling the IMOS Autonomous Underwater Vehicle on the AMC vessel, *Bluefin*, at completion of the voyage.

Facility 8: Animal Tagging and Monitoring

Written by James van den Broek

The IMOS Australian Animal Tracking and Monitoring System (AATAMS) team have been kept busy in the New Year with a successful service of the Narooma line which included the deployment of six new VEMCO VR2-AR receivers. The Narooma line detects tagged marine animals travelling past the South coast of NSW and is a vital component of the network of receivers located around Australia.

The new receivers are an exciting development in the field of acoustically tracking tagged marine animals, combining a transceiver with an acoustic release, allowing researchers to remotely retrieve deployed receivers from the surface. Before, it was necessary to retrieve deployed receivers either manually, by a researcher entering the water, or by combining the receiver with a separate acoustic release unit.

Another useful development of the VR2-AR units is the ability for researchers to communicate with deployed receivers from the surface and interrogate them to determine the number of tag detections, tilt angle of the receiver, water temperature, battery life and memory remaining.

Phil McDowall, James van den Broek and Andre Steckenreuter from AATAMS deployed the receivers in February and will check the units at the next scheduled service period to evaluate their performance.

James van den Broek (SIMS)

Andre Steckenreuter with a new VR2-AR receiver ready for deployment.

Postgraduate student profile

Students working with IMOS data for their postgraduate research

Penny Pascoe | Institute for Marine and Antarctic Studies (IMAS)

Project: Comparison of two and three dimensional foraging metrics for predicting important southern elephant seal foraging habitats.

The identification of important population level foraging habitats is often achieved by developing models relating the foraging behaviour of a subset of individuals to local environmental conditions. These models can then be used to predict likely foraging activity across a populations range based on local environmental conditions. Developing models with high predictive capacities can be challenging, and despite their common use the predictive capacities of many previous habitat models has been poor. One model component that may improve model performance is the metric used to infer foraging behaviour.

Foraging behaviour is often inferred from movement data, as direct observation of foraging in marine predators is generally impossible. Traditional methods only considered movement in the horizontal plane when inferring foraging behaviour, however three-dimensional metrics have recently been developed that also take dive behaviour into consideration. The effect of employing these three-dimensional metrics on model predictive capacity has not yet been extensively considered.

Penny deploying a satellite-relay data logger on a southern elephant seal on Campbell Island.

For her honours project Penny assessed this by deriving both two and three-dimensional foraging metrics from movement and dive data collected from a major Southern Ocean consumer, the southern elephant seal. IMOS satellite-relay data loggers were deployed on 38 seals between 2004 and 2012 on southern pacific sub-Antarctic Macquarie and Campbell Islands. Using a suite of environmental co-variates, she developed environmental models based on the two and three-dimensional foraging metrics, predicting foraging effort for the seals in the two broad habitat types they visited; shelf (≤1500m) and open ocean (>1500m).

By comparing the predictive capacity of the two and three-dimensional models in each habitat type, she was able to determine that while a two-dimensional metric was adequate for modelling foraging activity in the open ocean, in more complex shelf habitats the use of a three-dimensional foraging metric improved model performance. Using these models she was then able to estimate important foraging regions for southern elephant seals in the southern pacific sector of the Southern Ocean. Key foraging habitats were identified over the Campbell Plateau and north of the Ross Sea (Fig. 1).

These results show that foraging metric choice can impact the results of analysis and a consideration of foraging metric choice is key to being able to develop models with high predictive capacities, essential for making population level inferences of key foraging habitats.

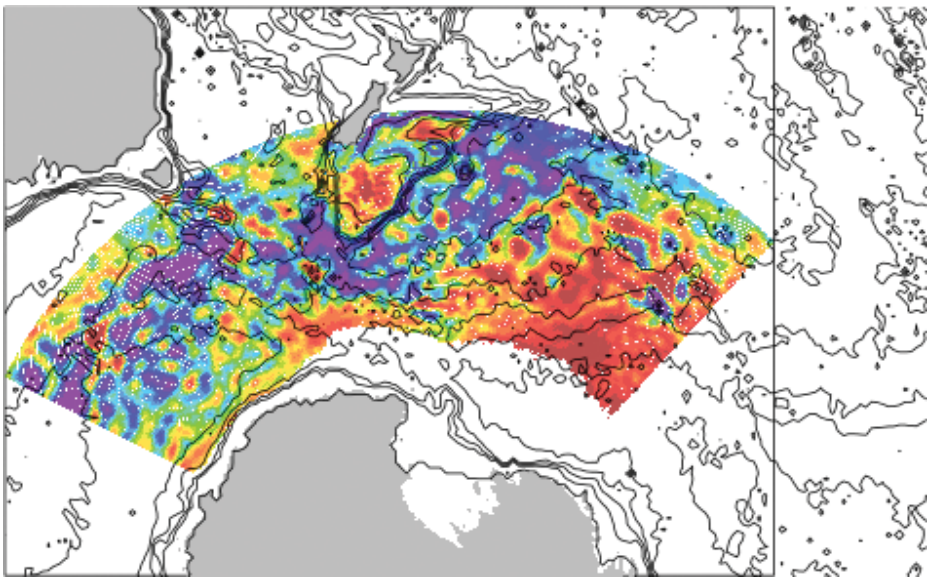


Figure 1: Estimated regions of elevated foraging behaviour across the domain of individuals in this study by the top shelf (*bottom-time* ~ SST + current speed + SSHa) and ocean open (*passage-time* ~ SSHa) models in sea ice free regions of the Southern Ocean.

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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