IMOS
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Integrated **Marine Observing** System
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Wobbegongs have more complex social lives than we thought

IMOS Animal tracking observations have revealed that the spotted wobbegong sharks gather in social groups rather than randomly, reflecting far more complex social relationships exist than previously imagined. PAGE 7

A single portal to access marine data.
The new-look Australian Ocean Data Network (AODN) Portal was launched in June.

Slocum gliders track sub-surface warming in the Great Barrier Reef

Introducing ZOOM

Rob Harcourt, Macquarie University

director's corner

Welcome to Marine Matters Issue #24. We freshened up the look of Marine Matters in the previous issue, and feedback received has been positive. Please continue to let us know what you think about our communications.

All eyes are on the future as we plan for the next stage of IMOS as a national research infrastructure. The Australian Chief Scientist is leading the process to develop a National Research Infrastructure Roadmap which will guide Australian Government investment from July 2017. A discussion paper will be released in mid-July, followed by an exposure draft in mid-September with the final Roadmap being completed by mid-December. IMOS is engaging with four of the six capability areas being addressed – Environment and Natural Resources, National Interest and National Security, Underpinning Research Infrastructure, and Advanced Physics, Maths and Materials. It is intended that the Roadmap and related processes will result in allocation of multi-year funding under the National Collaborative Research Infrastructure Strategy (NCRIS).

The IMOS Office was pleased to host a recent visit by the Australian Chief Scientist and all of his State and Territory colleagues. To implement an effective, national marine observing system, it is imperative that we are able to work collaboratively with Federal, State and Territory Governments. IMOS enjoys excellent support from all jurisdictions and we see increasing recognition of the value that can be added through a national, collaborative approach to marine observing and information infrastructure.

A significant milestone was achieved on 1 June with the launch of a single Australian Ocean Data Network (AODN) Portal. It brings together the strengths of the IMOS marine information infrastructure with the metadata and data holdings of many other university, government and industry partners. Improving access and use of Australia's marine data assets is seen to be core business for IMOS into the future.

In closing, it is important to acknowledge the passing of Dr Gary Meyers, the foundation Director of IMOS. Gary was an eminent oceanographer at CSIRO in Hobart for many years before taking up the role of IMOS Director at the University of Tasmania in 2007. He led the program through its formative stage, putting IMOS on a stable base that continues to serve a large science community to this day. Our thoughts are with his wife and family.

Tim Moltmann

NEWS A single portal to access marine data

The new-look Australian Ocean Data Network (AODN) Portal was launched on June 1, along with the official merger of the IMOS eMarine Information Infrastructure (eMII) Facility and the Australian Ocean Data Network (AODN) into a single entity. The marine information Facility of IMOS is now the AODN.

Enabling open access to marine data is core business for IMOS. The IMOS data will continue to be discoverable alongside a wider collection of Australian marine and climate data via the new-look AODN Portal.

IMOS is a multi-institutional collaboration with a focus on open data access. It is ideally placed to manage the AODN on behalf of the Australian marine and climate community.

"We've had responsibility for AODN for some years, but for historical reasons there were two portals," says IMOS Director, Tim Moltmann.

"Recent improvements to the IMOS information infrastructure mean it's now time to consolidate.

"We want to grow the AODN data holdings in collaboration with current partners, and with new partners," he said.

Visit the AODN Portal at http://portal.aodn.org.au.

Marine ecosystems benefit from collaboration between IMOS and data processing software developers

The IMOS Bio-Acoustic sub-facility is part of an international effort to observe how mid-water prey species such as small fish, squid, krill and jellyfish are distributed.

Working closely with data processing software developers, Australian marine scientists are boosting their contribution to the global project.

Bio-acoustic data provide an indicator of abundance, distribution and behaviour of mid-trophic level organisms (macro-zooplankton and micronekton communities between 2 cm and 20 cm in length) needed for ecosystem-based fisheries management, marine planning and monitoring impacts of climate change and variability.

These species are a key link between the phytoplankton and smaller zooplankton and higher predators in marine food webs. They transfer energy from primary producers at the ocean surface to top predators such as tunas, billfish, sharks, seals and seabirds, thereby actively transporting carbon from surface waters to the deep-ocean.

Since July 2010, the IMOS Bio-Acoustic program has operated as a Ships of Opportunity (SOOP) sub-facility, collecting data from vessels traversing the Indian Ocean and waters south and east of Australia and across to New Zealand. Between 2010 and 2015 161,793 km of data were collected and processed.

A number of vessels are participating in the bio-acoustics program depending on location and availability (5-10). Some of the vessels are commercial fishing vessels that have agreed to record data during transits to and from fishing grounds, while others are scientific research vessels.

The IMOS Bio-Acoustic sub-facility uses **Echoview** software to process the acoustic data gathered. Processed data is then made publicly available through the Australian Ocean Data Network (AODN) portal.

Leader of the IMOS Bio-Acoustic sub-facility, Dr Rudy Kloser, believes the Echoview software and ongoing interaction with developers at the company, have been important factors in being able to deliver quality data to users.

"We've had a long and successful association with Echoview, and our team talks to the Echoview people regularly to discuss our needs.

"We are constantly striving to obtain better software tools to improve data quality and reduce data processing time," said Dr Kloser.

Echoview Fisheries Scientist, Dr Francisco Neira, appreciates the opportunity to work with the IMOS Bio-Acoustics team.

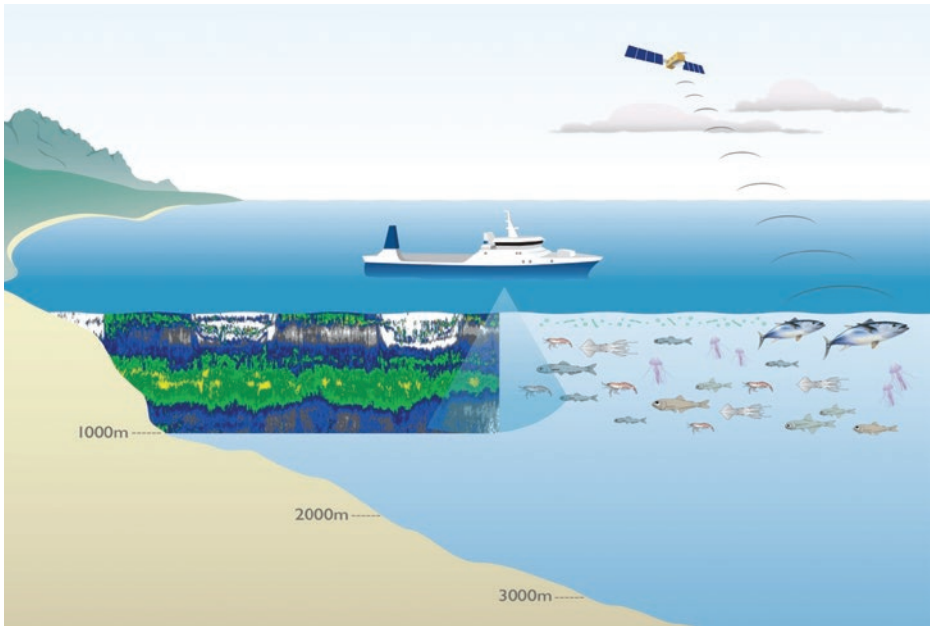
"Being able to work directly with Dr Kloser and his colleague Tim Ryan is very valuable as it enables us to continually improve Echoview to meet the specialised needs of our clients, and allow us to keep up with the latest developments in the bio-acoustic space in terms of mid-water ecology and fisheries research in the marine ecosystem," says Dr Neira.

The mass and distribution of micronekton reflects broad-scale patterns in the structure and function of the ocean, as well as the dynamics of marine ecosystems. Bio-Acoustic data, combined with information from other established observing systems greatly enhance the capacity of marine scientists to monitor these species. Monitoring shifts in food availability over time, assists in understanding the behaviour of top predators and provides inputs to ecosystem models, fisheries and climate change and variation indicators.

The goal of the IMOS Bio-Acoustic sub-facility is to improve knowledge and to develop a reliable predictive capacity combining observation and modelling for single species and ecosystem dynamics at short, medium and long term scales.

As the number of vessels, acoustic frequencies (including broadband) and hence data volumes grow, Dr Kloser's team relies on software that is evolving to meet these needs.

The IMOS Bio-Acoustics team looks forward to working with Echoview to continue developing and improving the data processing software in order to provide researchers with the highest quality data.

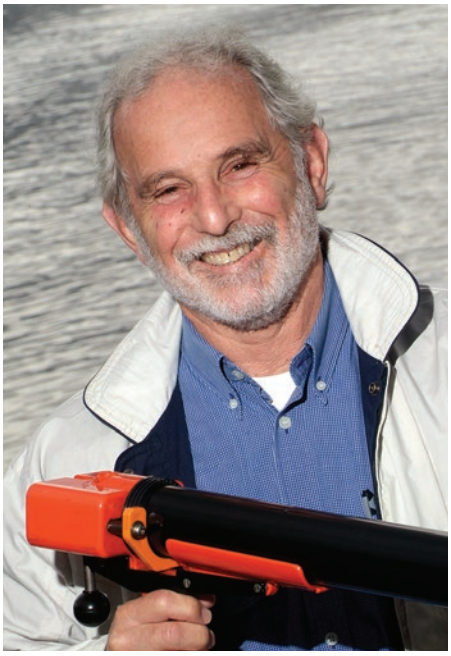


CSIRO

This figure demonstrates how bioacoustics data is collected by transmitting a pulse of sound in the water that reflects off the species to produce an echogram.

Vale Gary Meyers

The IMOS community is mourning the passing of its foundation Director, Dr Gary Meyers.



Dr Gary Meyers was an eminent oceanographer at CSIRO in Hobart for many years before taking up the role of IMOS Director at the University of Tasmania in 2007. He led the program through its formative stage, putting IMOS on a stable base that continues to serve a large science community to this day. Gary retired in 2009 having been instrumental in securing an additional $52M investment through the Education Investment Fund.

Current IMOS Director, Tim Moltmann, holds Dr Meyers in high regard and speaks of his important contribution to marine science in Australia.

"Gary was the ideal person to lead IMOS in its establishment phase. He was well known and respected in the global ocean observing community, and brought an incredible wisdom and depth of experience to the job."

"He had the courage, intellect and passion required to turn a great concept into a fully functional, national ocean observing system.

"That's quite an achievement," said Mr Moltmann.

Dr Meyers completed his PhD in 1978 under supervision of Prof Klaus Wyrtki. Gary and his family came to Australia in 1983 to join the CSIRO Division of Oceanography in Hobart. This was the beginning of a golden era in Australian oceanography, with the building of CSIRO's Marine Laboratories in Hobart and commissioning of Australia's first marine National Facility, RV Franklin. Dr Meyers was one of a small group of scientists carefully selected to lead this national endeavour.

"We mourn Gary's passing but at the same time we celebrate his legacy. "Throughout his life and career as a physical oceanographer, Gary Meyers strove to make a difference. And he succeeded."

"The IMOS community will work hard to ensure this legacy is honoured through great ocean science underpinned by high quality ocean observations, which is what Gary would expect," said Mr Moltmann.

Dr Gary Meyers passed away peacefully on Tuesday 19th April. Our thoughts are with his wife Linda, their daughters Rachel and Rebecca, and their families.

"Throughout his life and career as a physical oceanographer, Gary Meyers strove to make a difference. And he succeeded."

Blue economy on the global agenda

IMOS Director, Tim Moltmann, has recently attended two international ocean science and technology conferences at which the blue economy has been a headline issue. The 2016 Ocean Sciences Meeting in New Orleans and Oceanology International in London both clearly demonstrated that the Blue economy is a global agenda.

The 2016 Ocean Sciences Meeting was held in New Orleans during February, with over 4,000 ocean scientists in attendance. Dr Rick Spinrad, Chief Scientist of the National Oceanic and Atmospheric Administration (NOAA) gave a nice 'over the horizon' talk in which he suggested that there are three dimensions to the blue economy.

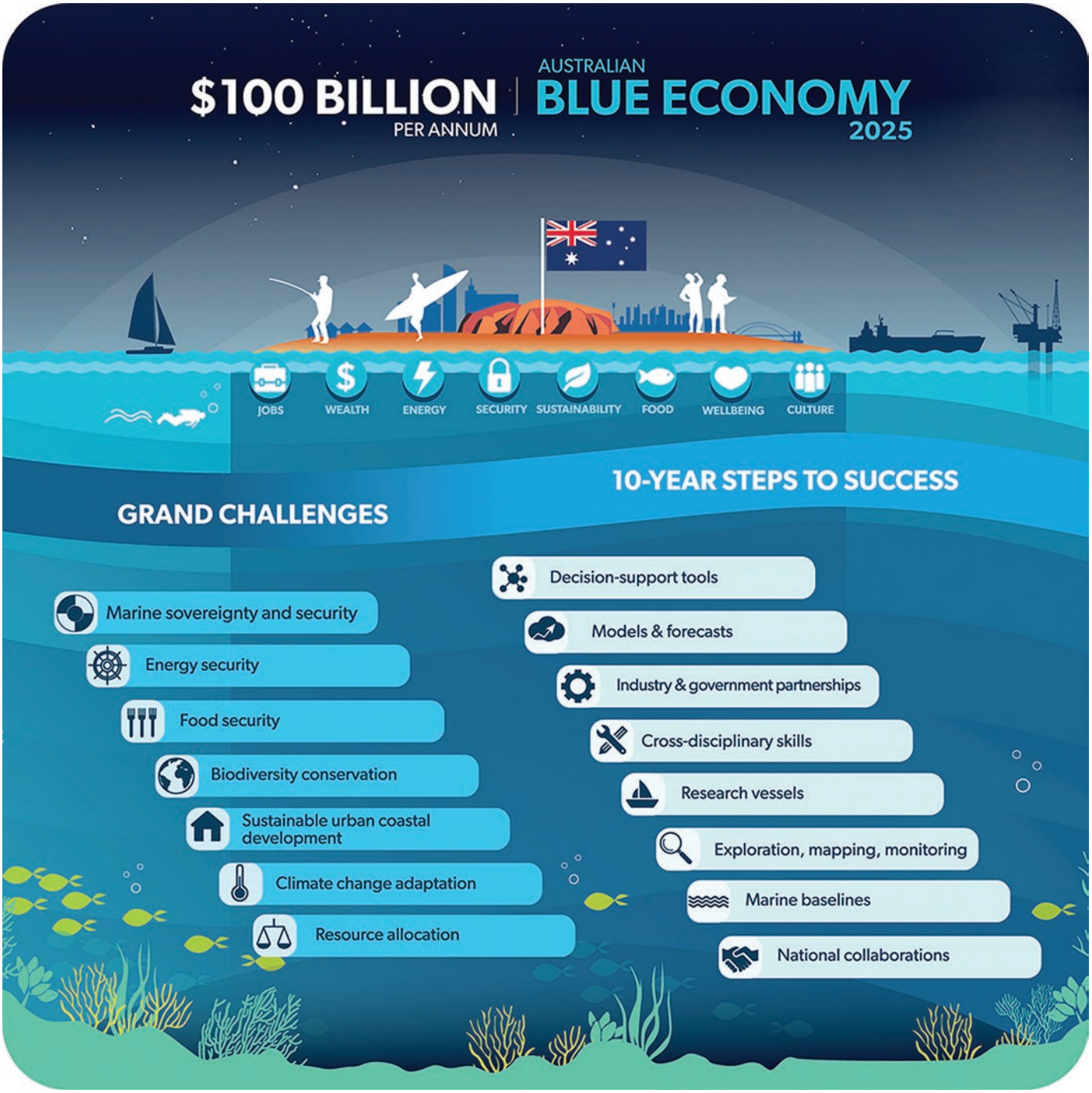
There is the 'traditional' blue economy which includes fisheries and aquaculture, offshore oil and gas, ports and shipping, marine tourism and so on. In Australia we have valued the 'traditional' blue economy at $47.2 billion per annum and growing.

Then there is 'hidden' blue economy which picks up engineering firms, consulting firms and the like. Businesses that have diversified client bases but with a strong footprint in the marine sector.

And then there is 'emerging' blue economy. This will be "service based, information dependent, and prediction critical" said Dr Spinrad. Much as we've seen a 'weather enterprise' emerge over the last decade, the 'ocean enterprise' is coming.

Coinciding with Ocean Sciences 2016, U.S. IOOS® along with NOAA released the Ocean Enterprise Study – A Study of US Business Activity in Ocean Measurement, Observation & Forecasting.

Zdenka Willis, Director of the U.S. IOOS® Program Office at NOAA, noted in her Foreword to the Study Report that "As the Blue Economy – the use of the oceans – expands in the coming decade so too will the need for ocean data and information. As a part of the wider 'Blue Tech' industry, the Ocean Enterprise is set to be a growing sector, delivering increasing benefits to the U.S. economy and U.S. employment."



Australian Blue economy infographic from National Marine Science Plan 2015–2025.

The Ocean Enterprise Study identified:

- More than 400 firms in the United States as operating in the sphere of Ocean Enterprise.
- The Ocean Enterprise generated $7B (USD) in revenue annually.
- 86% of businesses have been operating 5 or more years in the Ocean Enterprise.
- More than 54% of them expect growth in their Ocean Enterprise business in the next year.

Oceanology International (OI) is billed as "the world's premier event for marine science and ocean technology". OI 2016 was held in London during March.

Tim Moltmann delivered the keynote in a session entitled "Marine Technology and Services Sector Role in the Blue Economy". His talk, "From Observation to Impact – An Australian Perspective on Development of the Blue Economy", drew heavily on recent experiences in creating the National Marine Science Plan and establishing the Forum for Operational Oceanography (FOO). Feedback from the international audience in attendance was that Australia is very much 'on the right track' with these initiatives.

Constructive discussions were held with counterparts leading the UK's efforts in operational oceanography. The Institute of Marine Engineering, Science & Technology (IMAREST) has established an Operational Oceanography Special Interest Group (OOSIG) and they are keen to collaborate with Australia's FOO.

Australia's Chief Scientists visit IMOS in Hobart

IMOS Director, Tim Moltmann, recently met with Australia's Chief Scientist, Dr Alan Finkel and the Chief Scientists of Australian states.

The Forum of Australian Chief Scientists is a gathering of science leaders advising State and Commonwealth governments on the opportunities the future holds, chaired by Australia's Chief Scientist Dr Alan Finkel.

The event was hosted by the Tasmanian Department of State Growth. Professor Denzil Miller led the group of Chief Scientists on a tour of major scientific facilities in Hobart to demonstrate the critical role of science and innovation to Tasmania's future.

Following their tour of the University of Tasmania's waterfront campus, which houses the Institute for Marine and Antarctic Studies, the Antarctic Climate and Ecosystems CRC and IMOS, the group gathered for a presentation and Q&A with Tim Moltmann.

Mr Moltmann gave an overview of the role of IMOS as a national, multi-institutional marine observation infrastructure and outlined major activities with IMOS operating partners state-by-state.

"IMOS works with all of Australia's coastal states and territories and this was a rare opportunity to be able to meet with the Forum of Australian Chief Scientists to discuss the benefits of national collaborative research infrastructure in the marine domain," said Mr Moltmann.

It was Dr Finkel's first forum and his first visit to Tasmania since commencing as Chief Scientist in January.

"Tasmania is a scientific hub built on a foundation of world class work," said Dr Finkel.

"There is a growing critical mass of scientific excellence in Tasmania. The state is playing an increasingly important role in climate science and is a clear leader in demonstrating how to deliver a low emissions energy mix," he said.

Warrick Glynn, IMOS

The Forum of Australian Chief Scientists was held in Hobart on 12 May, 2016. IMOS Director, Tim Moltmann, met with the group.

"Tasmania is a scientific hub built on a foundation of world class work"

Rob Harcourt, Macquarie University

Wobbegongs have more complex social lives than we thought

IMOS Animal tracking observations have revealed that the spotted wobbegong sharks gather in social groups rather than randomly, reflecting far more complex social relationships exist than previously imagined.

Researchers studying spotted wobbegongs in Sydney have found that these sharks gather in social groups rather than associating randomly or according to the amount of food available.

The study, led by researchers at Macquarie University, reveals the potentially damaging consequences of fishing on shark populations – as, instead of randomly catching individuals, important members of social networks could be removed.

"If these aggregations are not random but in fact reflect more complex social relationships, then the impacts from historical fishing may not be random, but may have continuing consequences," said Nicolette Armansin, an animal behaviour expert who led the research.

"Wobbegongs are a large bottom-dwelling ambush predator often found in large groups close to shore where they have been heavily exploited – the last place most people would have encountered one was at their local fish and chip shop," she said.

IMOS data

Data was collected from the IMOS Animal tracking network of acoustic receivers, to track the movements and associations of individual sharks in Cabbage Tree Bay Aquatic Reserve in Manly on the northern beaches of Sydney, New South Wales.

They found that groupings were not sex- or age-related, meaning younger animals may not be sticking together for safety.

With the stability of these aggregations not yet known, removing individuals from a group could have a significant impact.

Higher-order thinking

The study, which has been ongoing for over a decade, found that sharks grouped together with preferred partners, even in different areas across the reserve, while others never associated.

"What we found was a complex network of associations," said Professor Robert Harcourt, leader of the IMOS Animal tracking facility and co-author of the paper.

The findings were published this month in the journal Animal Behaviour, and suggest that even lone predators such as as the wobbegong could demonstrate complex social relationships.

"Social behaviour might be expected in sharks that feed together on large schools of fish, but the existence of these associations in even bottom-dwelling predators that individually ambush their prey points to a much higher level of social complexity than previously imagined, and to possible common evolutionary mechanisms across multiple animal groups," said Harcourt, who added that sharks are a far more complex species than we understand.

"Like mammals, birds and reptiles, it appears that sharks inhabit a far richer social world than we would have imagined, or deemed necessary," he said.

These same wobbegongs, when not at Cabbage Tree Bay Aquatic Reserve in Manly, have been recorded moving up and down the coast on IMOS Animal Tracking acoustic lines. They have been recorded out to the edge of the continental slope in waters 200m deep at the very end of the IMOS Animal Tracking Acoustic Bondi line.

This news item has been adapted from **an article by George Meredith in 'Australian Geographic'**, 4 May 2016.

The full paper is available: Armansin NC, Lee KA, Huveneers C, Harcourt RG. 2016 Integrating social network analysis and fine-scale positioning to characterize the associations of a benthic shark. *Animal Behaviour*, 115, 245-258. **doi:10.1016/j.anbehav.2016.02.014**

> *"Like mammals, birds and reptiles, it appears that sharks inhabit a far richer social world than we would have imagined, or deemed necessary"*

VIDEO

IMOS in MOcean

– What is currently happening in Australia's oceans?

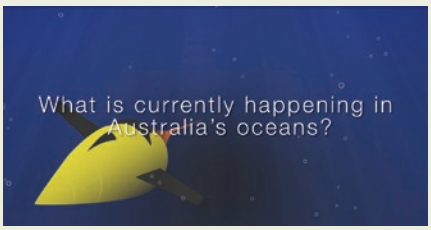
The latest video in the 'IMOS in MOcean' series shows how IMOS *OceanCurrent* produces visual representations of water movement, sea surface temperature, ocean colour and sea surface height.

This information is made publicly available via the IMOS *OceanCurrent* website (**http: //oceancurrent.imos.org.au**) and has practical applications including commercial shipping, fishing, search and rescue efforts and recreational activities like boating and even ocean swimming.

IMOS *OceanCurrent* maps inform research into areas such as the interaction between currents, sea-level and climate and the movement of nutrients, sediment and species.

Keep an eye out for future episodes and do let us know if you have an idea for a new video.

Visit the *IMOS in MOcean* collection



Introducing the Zooplankton Ocean Observing and Modelling (ZOOM) Task Team

Written by Jason D. Everett[1,2]*, Anthony J. Richardson[3,4] and Mark E. Baird[5]

Relative to our knowledge of the oceans' phytoplankton and fisheries, we have little understanding of the zooplankton that link them. This is a major knowledge gap, as it is the zooplankton that graze the ocean phytoplankton, drive fisheries production, and play a key role in global carbon export. This knowledge gap hampers management of marine systems and needs to be resolved through advances and collaborative efforts in both observational and modelling research. The IMOS-ZOOM Task Team has begun to address this gap by bringing modellers and observers together in order to maximise the collaborative research efforts being undertaken from the continuous IMOS and intermittent non-IMOS zooplankton observations.

The physical ocean state (temperature, salinity, height, waves) and phytoplankton biomass can be assessed from satellite observations, and fisheries biomass can be derived from fishery catch reporting, but no such high frequency synoptic sampling method exists for zooplankton. Zooplankton are difficult to collect and analyse because of their enormous diversity (almost every phylum on Earth) and they are distributed throughout the vast expanse of the pelagic environment. Zooplankton observations are thus collected using a variety of platforms and methods, each with their own characteristic spatial and temporal scales. Ultimately this has meant that available zooplankton observations are sparse in time and space, and come from a range of different observing methods, platforms and data types (biomass, abundance, carbon, size). This makes comparison of data among different sampling devices and challenges its use and uptake in biogeochemical and

1 Evolution and Ecology Research Centre, University of New South Wales (UNSW), Sydney NSW, Australia
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The copepod *Corycaeus speciosus*.
©Anita Slotwinski

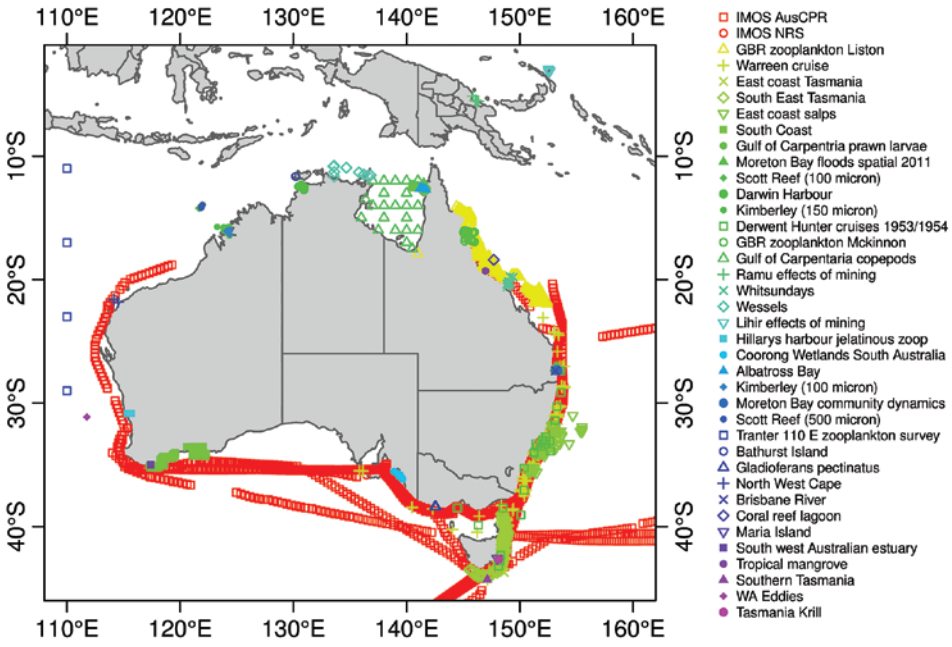
ecosystem models. Within numerical models, zooplankton parameters are nearly always poorly constrained due to the limited data available to modellers.

Zooplankton observations being undertaken within IMOS (and by IMOS scientists outside of the program) provide a unique opportunity to bring together discrete yet complementary observations at multiple scales to address these sources of significant uncertainty in ecosystem models. Because of the diverse types and nature of these zooplankton observations, the challenge of using these observations in models, and the different languages and backgrounds of the observing and modelling research communities, there has been relatively little uptake of these IMOS observations into biogeochemical and ecosystem models. This Task Team will begin the process of systematically integrating these observations into ecosystems models.

The IMOS-ZOOM Task Team is co-convened by Jason Everett (UNSW), Anthony Richardson (UQ/CSIRO) and Mark Baird (CSIRO) and currently comprises more than 20 scientists from universities and government research organizations. Following some teleconferences, we met for the first time in Hobart in February 2016. Tim Moltmann opened the meeting and we began by getting everyone on the same page with overviews of zooplankton modelling and zooplankton sampling. This was followed by some interesting and robust discussions about how to bring these fields together.

We examined in detail the 'currency' of zooplankton observations collected (i.e. species abundance, biomass [mg wet weight], size) compared to what is generally used in models (i.e. community biomass mol. N m^{-3}) and how we can better link these. We also discussed strengths and weaknesses of different zooplankton sampling (e.g. nets, Continuous Plankton Recorders, bioacoustics, Laser Optical Plankton Counters, genetics), and the new opportunities presented by those that collect high resolution observations. This led to a detailed discussion about ways that observations can be used in models – from simple simulation (e.g. a net tow in the model to match that from observations) to more complex observing models (e.g. that could simulate the acoustic backscatter, size spectrum or isotopic signature of zooplankton).

These discussions form the basis for a manuscript that will be submitted to the Frontiers in Marine Science Special Issue: "Modelling the plankton – enhancing the integration of biological knowledge and mechanistic understanding". This manuscript has started the scientific discussion and innovation that needs to underpin uptake of zooplankton data into models. We also had detailed discussion about several simple case studies where we can start the process of using IMOS zooplankton data in models – particularly e-Reefs, Ecopath, and Atlantis. We hope that this work will be a major focus of our 2nd ZOOM meeting later in the year. If you would like to participate in the Task Team, please contact us. We would like to thank IMOS for supporting ZOOM and look forward to continuing our progress in 2016.



The Australian Zooplankton Database contains data on the abundance of marine zooplankton in Australian waters. It includes data from IMOS (National Reference Stations and Australian Continuous Plankton Recorders), papers, reports, unpublished data and theses. The compiled dataset has 98,676 records from 38 projects and includes >1000 taxa. The challenge for ZOOM will be to turn products such as this into model-ready datasets for the community to use.

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Sampling zooplankton off North Stradbroke Island National Reference Station.

Slocum gliders track sub-surface warming in the Great Barrier Reef

In recent months, widespread coral bleaching has been reported from the Northern to the Central Great Barrier Reef (GBR).

Bleached coral. AIMS

The main cause of coral bleaching is persistently high sea temperatures. This bleaching event has coincided with a marine heat wave on the GBR where the monthly average sea surface temperature (SST) anomaly for March was greater than 1°C for much of the Central GBR, and reaching 2°C for much of the Northern GBR (see top figure).

Since October 2015, IMOS & CSIRO Slocum gliders have traversed this region, tracking the seasonal evolution of coastal waters. The intensive missions* were principally planned to help validate the eReefs model but have also provided unprecedented observations of the formation, persistence and now waning of the thermal stress of the GBR waters.

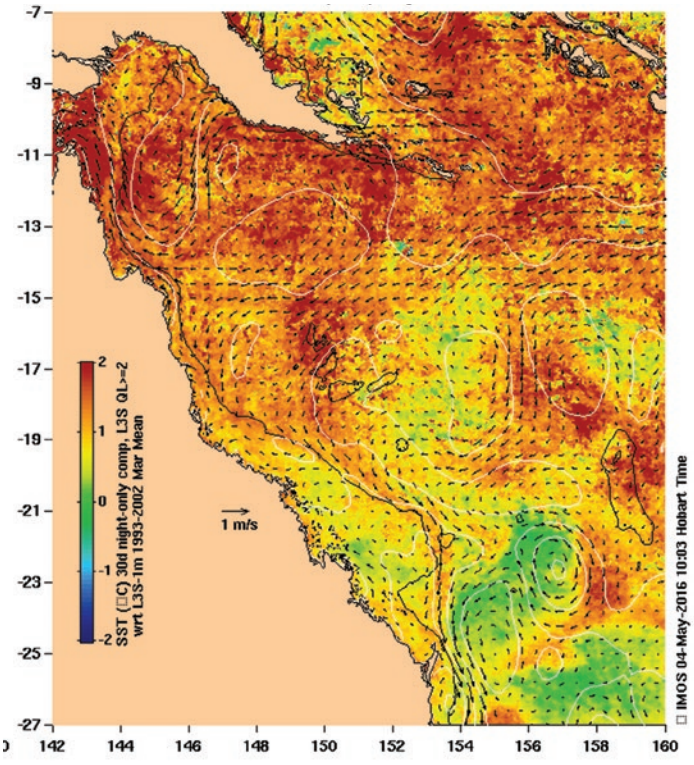
Glider pilots remotely navigate the gliders through complex pathways between reefs, which can be challenging with strong currents and tides. Gliders are capable of making observations in places difficult for ships and can stay at sea for several weeks. By sampling the water in see-saw manner, the gliders can reveal how deep the warming extends. By April 2016, **glider observations** indicated water throughout the water column on the inner shelf was still warmer than **historical observations**.

While revealing where the warming occurs, the gliders can also show where cooling occurs. A glider transect in Palm Passage, on the outer Central GBR, **detected upwelling**, in which cooler water lifts up onto the shelf from offshore. This cool water may provide relief to marine ecosystems sensitive to the marine heatwave. SST from 27 March (bottom figure) indicate the outer reef of the Northern GBR, 2-3 degrees cooler, than the inner reef, may be buffered by a combination of upwelling and tidal mixing.

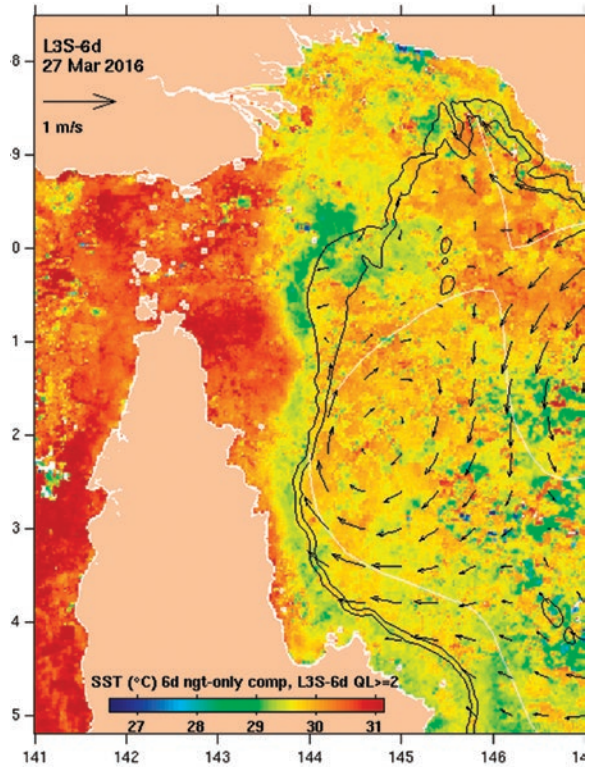
In May 2016 two gliders identified the existence of dense shelf water cascades for the first time in the central and northern GBR. These cascades can occur when heat loss during autumn causes waters to cool and become more dense near the coast. Both cascades occurred nearly at the same time off **Port Douglas** and the other off **Mission Beach** south of Cairns. These cascades flow offshore and can cool the communities living near the sea bed. Ongoing glider deployments into winter will inform how long the warming lasts.

*Funding for the glider missions was provided from a collaboration by the Great Barrier Reef Foundation (**GBRF**), IMOS, **CSIRO** and the Australian Institute of Marine Science (**AIMS**).

This news item was originally published on the ***IMOS OceanCurrent*** website and was written by Jessica Benthuysen and Madeleine Cahill.



Monthly average SST anomaly for March 2016.
Image from IMOS OceanCurrent



SST from 27 March 2016.
Image from IMOS OceanCurrent

Deep Water Moorings: The EAC Array – Revealing the Boundary Current

Data from the IMOS East Australian Current (EAC) array of moorings provides a significant advance in our understanding of the system and begins to expose its complexity.

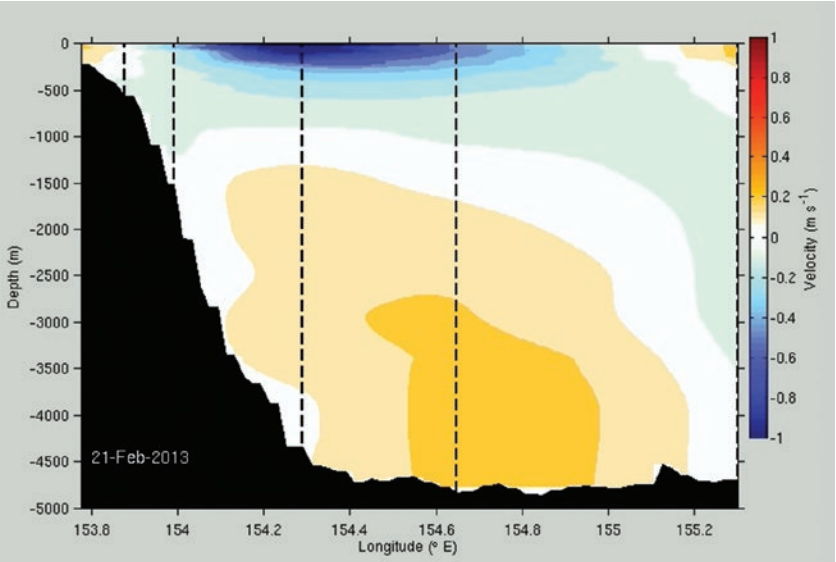
Ocean western boundary currents redistribute heat around the world and have a profound effect on the world's climate. The EAC is the major pole-ward flowing current of the South Pacific. It provides the dominant mechanism for transporting heat from the equatorial Pacific to the cooler mid-latitudes. Satellite observations show the spatial extent and variability at the surface but the subsurface velocities and properties can extend to depths of thousands of metres and remain largely unknown.

Data from the first IMOS deployment, April 2012–August 2013, reveal the complexity and dynamic nature of the EAC, including the offshore return flow and the episodic nature of the deep northward undercurrent. The EAC array was designed to capture the entire breadth and depth of the flow. For this reason it was placed off Brisbane where the current is almost at full strength and still in jet form rather than as a complex eddy field found further south. Even so, there are a few days in June 2012 when a rarely occurring eddy pushes the main stream of the EAC further offshore than the 150km extent of the array.

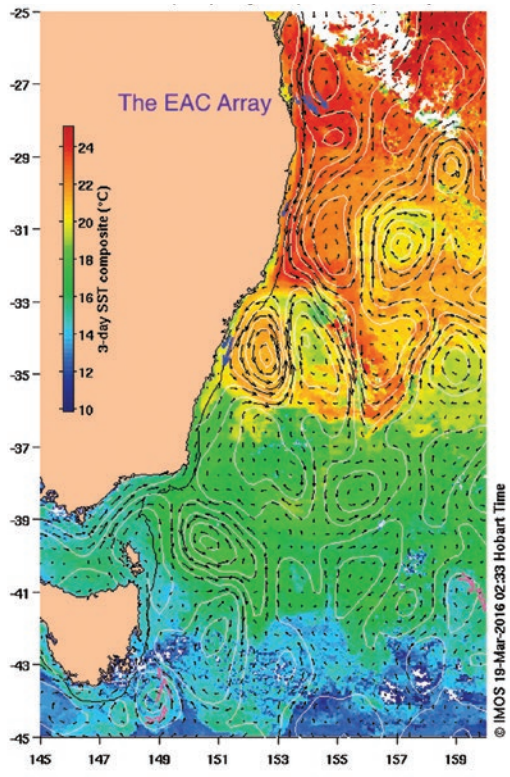
Data from the initial 18-month deployment has been calibrated and extensively quality controlled. Tidal signals have been filtered out and for ease of interpretation the data have been interpolated onto a regular grid (10m vertical, 2km horizontal resolution).

The original dataset is available for download from the **Australian Ocean Data Network (AODN) Portal**.

Further details of the deployment, initial results and data preparation are presented in **Sloyan *et al*, 2016**.



Velocity throughout the water column as observed by the EAC Array for 21 Feb 2013, showing the array has captured the entire southward flow (in blue) of the EAC (in the upper 250m) and also a weak northward flow which extends for 2,000m at the bottom of the water column.



Sea Surface Temperature (SST) for 25 May 2012 with EAC Array observed surface velocity at 27°S.

Warrick Glynn, IMOS

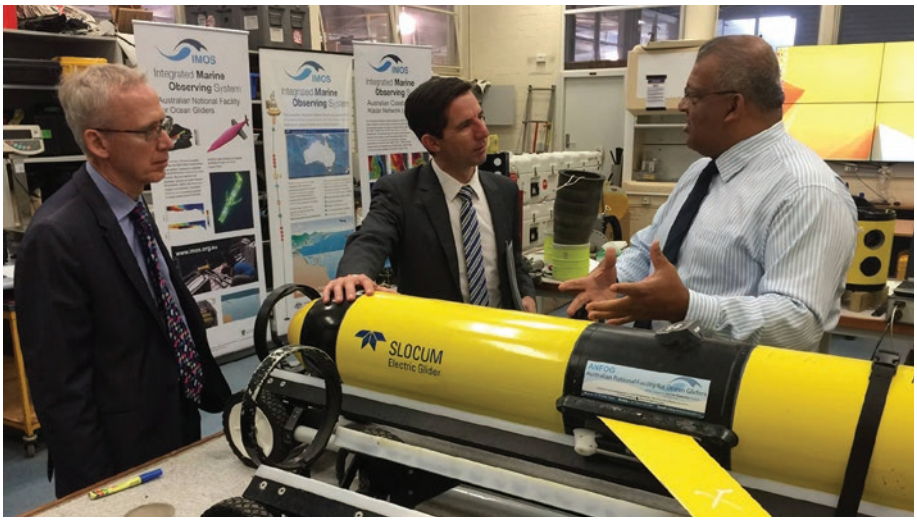
Ocean Gliders: Minister for Education and Training Simon Birmingham visits the IMOS ocean glider facility

The Minister took time during a visit to the Indian Ocean Marine Research Centre (IOMRC) in April to check out NCRIS-funded IMOS infrastructure.

Minister Birmingham toured the building site of the Indian Ocean Marine Research Centre (IOMRC), a new $62 million world-class marine research facility. The IOMRC will bring together the collective strengths of the University of Western Australia, the Australian Institute of Marine Science and CSIRO. These three organisations are all major partners in the National Collaborative Research Infrastructure Strategy (NCRIS)-funded Integrated Marine Observing System.

The IOMRC will house two IMOS National Facilities – the state-of-the-art Ocean Glider Facility, and the expanding Ocean Radar Facility that are both led by the University of Western Australia.

IMOS Director, Tim Moltmann says "The IOMRC is an exciting development that will help to drive development of Australia's blue economy, guided by WA's excellent Blueprint for Marine Science 2050 and the National Marine Science Plan."



Simon Birmingham's Facebook Page

UWA Vice-Chancellor Prof Paul Johnson, Minister Simon Birmingham and Ocean Glider Facility Leader Prof Chari Pattiaratchi.

UWA Professor and IMOS Ocean glider Facility leader, Chari Pattiaratchi demonstrated how ocean gliders work to Minister Birmingham, and displayed some of the real time data collected by gliders currently deployed in the northern Great Barrier Reef and in the Great Australian Bight (GAB).

Minister Birmingham noted that data from the IMOS glider in the GAB is being used by researchers in his home state of South Australia in the Great Australian Bight Research Program.

The Great Australian Bight Research Program is a collaboration between BP, CSIRO, the South Australian Research and Development Institute (SARDI), the University of Adelaide, and Flinders University and is an excellent example of the expanding use and value of IMOS to Australian science and industry.

Prof Chari Pattiaratchi said, "The Minister was very interested in the operations of both ocean gliders and HF Radars. He inquired whether we have a roster to monitor gliders on a 24 hour basis and was fascinated by the shark attacks on the gliders."

Minister Birmingham was presented with a small memento of his visit to the IMOS Glider Facility, a model lego glider.

Autonomous Underwater Vehicles (AUV): **Welcomes new Technical Officer**

We are pleased to welcome Jorja Martin as a new technical officer working with the IMOS AUV Facility. Jorja joins us from another industry partnership that grew out of the Australian Centre for Field Robotics (ACFR), the AutoStrad project, and with a sailing background she is excited by the opportunity for hands on, marine fieldwork with the AUV and IMOS teams.

For the last few years since completing her bachelors degree (Mechatronic Engineering and Computer Science) at The University of Sydney, she has worked with Patrick and then Kalmar developing the AutoStrad autonomous port equipment. Prior to this degree she worked in graphic design and computer network support, primarily in the arts, community development and not-for-profit sectors. Jorja will take over from Andrew Durrant who has left us to return to the UK. Although Andrew's enthusiasm and dedication to getting the job done will be missed we are sure that Jorja will ably fill his large, steel-capped boots.

National Mooring Network: Ocean acidification impact on shellfish production

The importance of measuring water chemistry in Australia's shellfish growing regions was raised at the 4th International Oceans in a High CO_2 World symposium in Hobart in May.

IMOS Acidification moorings sub-facility leader and CSIRO researcher Dr Bronte Tilbrook said the measurements are crucial for alerting scientists and managers to rising ocean acidification which impacts shellfish production.

Dr Tilbrook said there are numerous studies demonstrating how shellfish are effected by raising carbon dioxide levels in coastal waters.

"In Australia our monitoring through the Integrated Marine Observing System is centered on two coastal sites in Tasmania and South Australia."

"The IMOS sites are equipped with high tech CO_2 moorings that deliver data each day and provide information on conditions in the waters that flow from offshore and into two of Australia's major shellfish producing regions."

Recent research indicates that the threats posed by ocean acidification progression will be further compounded by other dimensions of global climate change, such as the intensification and expansion of low dissolved oxygen – or hypoxic – zones.

It is predicted that in the coming decades, the impacts of ocean acidification and hypoxia, which are already being felt across US West Coast systems, are projected to grow rapidly in intensity and extent.

"Scientists initially observed the impacts of ocean acidification on calcifying marine organisms that were having difficulty forming their shells, but additional evidence now indicates that growth, survival and behavioral effects linked to acidification extend throughout food webs, threatening coastal ecosystems, and marine-dependent industries and human communities."

"Understanding how water chemistry conditions have changed has helped develop some methods to offset the problem."

"However, even if atmospheric CO_2 emissions are stabilized today, many of the ongoing chemical changes to the ocean are already "locked in" and will continue to occur for the next several decades. Given these challenges, decision-makers must act decisively and in concert now," says Dr Tilbrook.

IMOS has a key role to play in observing ocean acidification, providing vital information in the oceans surrounding Australia. In addition to the the CO_2 moorings in South Australia and Tasmania, IMOS has new measurement platforms at the Southern Ocean Time Series Deep Water moorings site. The Ships of Opportunity Biogeochemical Sensors Sub-facility also collects high-quality underway CO_2 observations in Australian waters that would otherwise not be covered. These underway observations provide spatial coverage around Australia and in the Southern Ocean.

Tim Fountain, CSIRO

An IMOS acidification mooring is recovered from Kangaroo Island.

Satellite Remote Sensing: **Satellite Oceanography Users Workshop 2015 videos now available**

The videos are available via the Committee on Earth Observation Satellites (CEOS) web page at **http://ceos.org/home-2/satellite-oceanography-user-workshop-videos-available/** which provides easy links for satellite ocean product users to access each of the videos from the Satellite Oceanography Users Workshop 2015.

This three-day workshop provided an opportunity for users of satellite-derived products of key oceanographic variables to meet with and provide feedback to data providers. The presentations were recorded, and the CEOS Working Group on Capacity Building and Data Democracy worked with the workshop organizers (including the SST- Virtual Constellation and Australian Bureau of Meteorology) to obtain, and then edit and produce the videos, in order to make them available as a user-friendly resource for those users who were unable to attend.

SAIMOS:

Prawn and crab harvest optimisation: a biophysical management tool

WRITTEN BY PAUL VAN RUTH

Fisheries Scientists and Oceanographers at SARDI Aquatic Sciences, with the support of the Fisheries Research and Development Corporation, the Spencer Gulf and West Coast Prawn Fishermen's Association, and the South Australian Blue Crab Pot Fishers Association, have recently completed research into the links between physical ocean processes and the reproductive and larval biology of western king prawns and blue swimmer crabs in Spencer Gulf, South Australia. These species are key targets of South Australian commercial fisheries.

The Spencer Gulf Prawn Fishery is a demersal trawl fishery that targets prawns over 50-60 nights a year at a value of ~$27 million per annum. The Blue Crab Fishery in Spencer Gulf targets blue swimmer crabs with pots and drop nets at a value of ~$4.9 million per annum.

Western King Prawn life cycle.

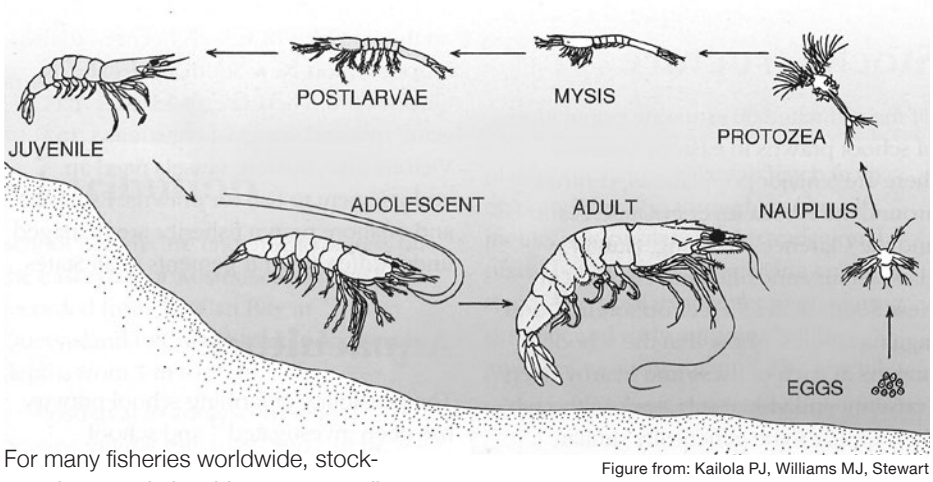
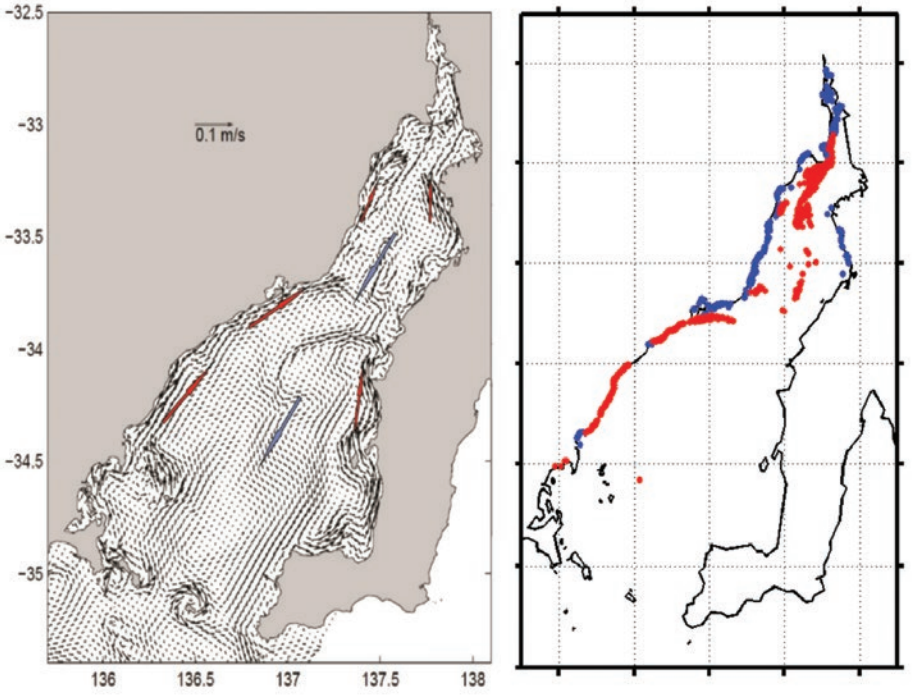


Figure from: Kailola PJ, Williams MJ, Stewart PC, Reichelt RE, McNee A and Grieve C. 1993 Australian Fisheries Resources. Bureau of Resource Sciences and Fisheries Research Development Corporation. Canberra, Australia. 422 pp.

For many fisheries worldwide, stock-recruitment relationships are not well understood due to the length of time between spawning and recruitment to the fishery and oceanographic processes acting on larvae during this time. Research for this project combined data from IMOS climate and ocean sensors, with data from SARDI fisheries stock assessment surveys, and published research to develop a biophysical model to mimic the transport of prawn and crab larvae between spawning grounds ('source') and nursery areas ('sink').

Using western king prawns as a test case, outputs of the model identified potential harvest strategies to optimise both fishing harvests and future prawn recruitment by targeting prawns in specific areas of the fishery. The effects of increased temperatures in Spencer Gulf on larval development, dispersal and settlement were also assessed to examine the potential threat to these fisheries posed by global warming.

This research has now been published in a **final report to FRDC** and in **Fisheries Oceanography**. The research has helped identify the links between ocean processes and fisheries production in Spencer Gulf, and will promote sustainable management of these valuable fisheries. It also highlights some of the potential impacts to fisheries posed by global climate change.



(Left) Depth-averaged residual currents from the hydrodynamic model time-averaged over a 47 day simulation period. Red and blue arrows show the direction of flow associated with the major coastal and outflow current pathways. (Right) Final distribution of settled (blue) and non-settled (red) larvae simulated for one of the five scenarios tested using a larval transport model coupled with the hydrodynamic model.
Mark Doubell, SARDI Oceanography.

SARDI Aquatic Sciences

Adult Western King Prawn
(*Penaeus (Melicertus) latisulcatus*)

Paul Malthouse, SARDI Oceanography

Oceanographic mooring being deployed at the SA-IMOS Kangaroo Island National Reference station. Observations provided by IMOS are essential to the development of the hydrodynamic model used to simulate larval transport and settlement.

Postgraduate Student | **Mohammad Hadi Bahmanpour**

PROJECT TITLE:

Annual and inter-annual variability of a boundary flow along the North West shelf of Australia

School of Civil, Environmental and Mining Engineering & UWA Oceans Institute, The University of Western Australia

The North West Shelf (NWS) region of Australia has been the subject to a number of oceanographic studies in the past. However, there are still many unanswered questions regarding mean flow pattern and volume transport, and its annual and inter-annual variability. Various theories have been proposed to describe the mechanisms that can account for the observed seasonality of circulation in that region, and yet no single theory exists that can thoroughly define the flow pattern in that region because of the complexities involved and lack of observational data. Past data sets were inadequate to characterise the variability of the along shelf flow on the North West Shelf.

In early 2012 IMOS deployed two mooring arrays off the Kimberley and Pilbara continental shelf regions. The arrays provided observations of physical variables (temperature, salinity, sea level and currents) and water quality (turbidity and chlorophyll) measurements. The Kimberley and Pilbara mooring arrays were funded through Western Australian Government co-investment with IMOS.

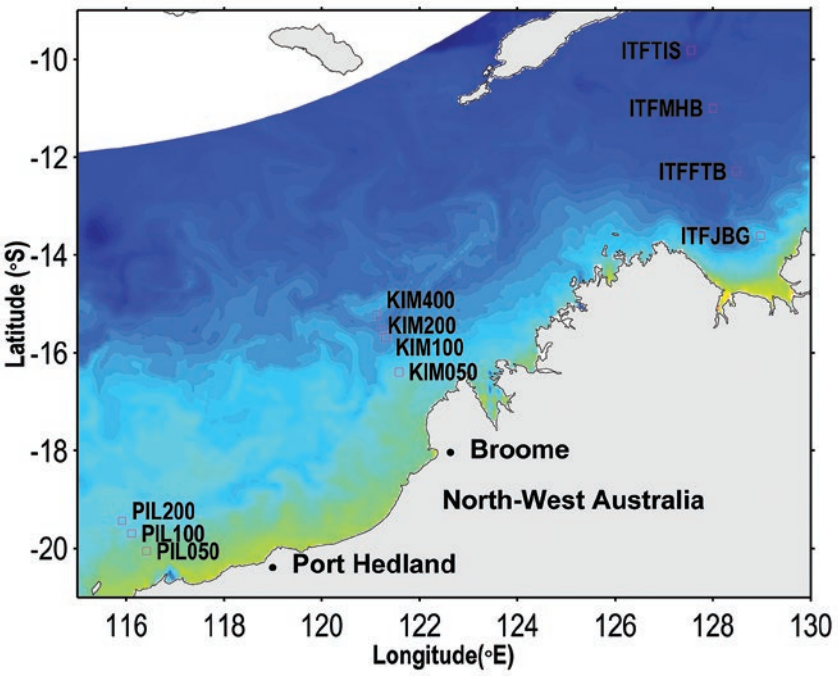
These IMOS moorings offered a new opportunity to increase the knowledge of volume transport characteristics and other oceanographic features in the region, as they delivered almost three years of high temporal resolution measurements.

University of Western Australia Oceans Institute PhD student, Mohammad Hadi Bahmanpour, was awarded the student 'Best Poster' at the International Coastal Symposium held in Sydney in March this year. His paper presented research on the Holloway Current along north-west Australia which was based entirely on IMOS data collected from the moorings. The poster (and the associated paper) highlights work from Hadi's PhD research and is based on mooring data from the Pilbara transect.

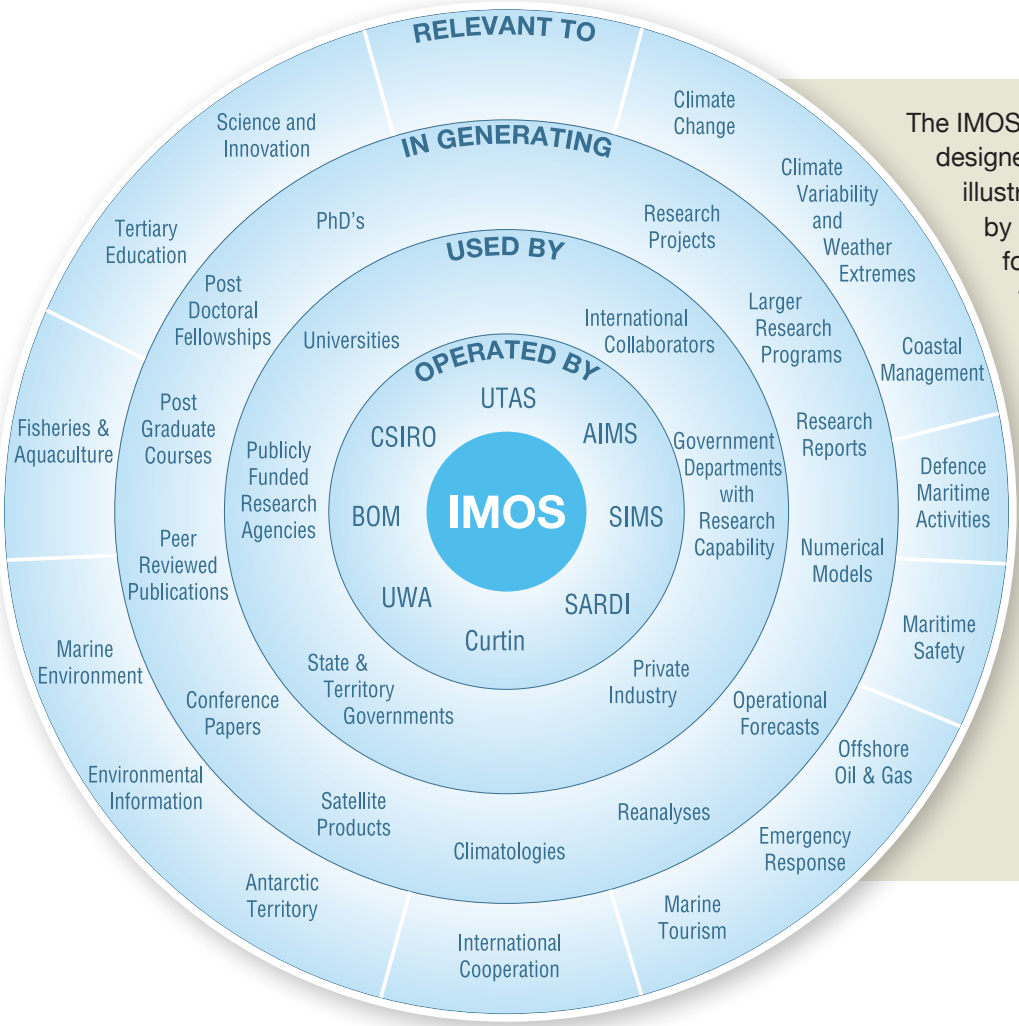
Hadi analysed multi-year current meter data across the North West shelf of Australia and identified various aspects of the mean flow in a macro-tidal environment. The main features of the flow appear to be a continuous alongshore south-westward flow, i.e., The Holloway current located along the continental shelf edge in depths 70-150 m.

Annually, the current transports ~ 1 Sv of lower salinity, higher temperature water from the tropical regions to North West Cape and it is at its maximum intensity during autumn/winter (Apr-Jul) when the winds are either weak or the region is dominated by south-east trade winds. The Autumn intensification of the Holloway Current is at phase with the annual passage of a south-westward propagating sea level anomaly originating in the Gulf of Carpentaria, some several hundred kilometres northward of where Holloway Current becomes well established.

Further insights into the origin of Holloway Current came from the use of a three-dimensional ocean circulation model, which was able to capture the autumn intensification of the Holloway Current and its seasonal variation.



Location of long-term moorings. Background colour coding shows surface salinity field from numerical modelling. Low salinity waters off NWS represent Holloway Current.



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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