marinematters

IMOS

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Integrated **Marine Observing** System

IMOS News

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

Coffs Radar installation completes the IMOS ocean radar facility

The last radar system for the IMOS facility was installed in late February at Coffs Harbour in New South Wales.

The IMOS ocean radar facility already has five established sites across Australia – two each in Western Australia and South Australia and one in Queensland.

The Director of the IMOS ocean radar facility, which is based at James Cook University's School of Earth and Environmental Sciences, Professor Lucy Wyatt, said that the High Frequency (HF) radar systems made it possible to map real-time dynamics of sea-surface currents across substantial areas of inshore waters.

"The equipment provides information similar to that available through Bureau of Meteorology for the weather and will be used to monitor marine spills, sewage outfall release, shipping and boating activity and marine rescue operations," she said.

Dr Moninya Roughan, from the University of NSW's School of Mathematics and Statistics and the Sydney Institute of Marine Science leads the NSW Science Node of IMOS and is part of the team of scientists who will be using the infrastructure to conduct research.

"We have chosen the Coffs Harbour region as it is a significant marine ecosystem recognised by the zoning of both a state and federal marine park," Dr Roughan said. "Oceanographically, it is also important as it is typically upstream of the region where the warm East Australian Current separates from the coast.

"The radar will give us near real-time maps of the surface currents, which will let us investigate the circulation, the interaction of the East Australian Current with the coastal region, flow topography interactions around the islands in the Solitary Islands Marine Park and also wave dynamics and processes.

"We have been working towards this since 2008 and we believe that the local community will find the surface current information really useful," Dr Roughan said.

Professor Wyatt said that coastal currents communicate a wealth of information about properties such as heat and nutrient transport. In addition, they provide a mechanism for larval dispersal, pollution transport, and sediment redistribution.

"Until recently, spatial data was very difficult to find, as direct measurements are usually at a single point from moorings," she said. "With 85% of Australians living within 50km of the coast, sea level rise and coastal erosion are risks that affect the majority of the population.

"The new technology being used in the creation of the network provides maps of ocean currents and in some locations waves and winds within 200km of the coast," Professor Wyatt said.

This deployment complements the array of sub surface oceanographic moorings off Coffs Harbour that measure currents and temperatures below the ocean surface. In addition there is an array of sub-sea acoustic receivers which track the movement of tagged animals such as fish and sharks.

Dan Atwater, James Cook University.

director's corner

Tim Moltmann

This edition of Marine Matter highlights a number of significant milestones in the implementation and growth of Australia's Integrated Marine Observing System.

The featured East Australian Current moorings and Coffs Harbour ocean radar represent the last new deployments committed under existing funding arrangements. This means that IMOS is now at full strength. We have celebrated many achievements along the way, and reflected on a few setbacks. But it is timely to pause and say 'thanks' to the scientists, technicians, engineers and support staff in our Operating and Partner Institutions who have collectively built this system. Well done to you all.

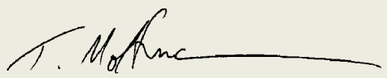
The scientific potential of IMOS is also on display, with features on some top flight research about changing ocean salinity and eddy transport, as well as two exciting PhD projects.

As IMOS beds down and matures, we are seeing an increasing number of opportunities to create new partnerships that enable us to grow the system and close key gaps. The decision by Western Australian Government to co-invest $6M in order to extend IMOS into the Kimberley and Pilbara regions is a great example. The recent launch with Minister Day in Perth highlights the work done to get new moorings, acoustic receivers and gliders into the water in these remote regions. It provides a clear demonstration of the enhanced marine observing capacity that Australia has created through the IMOS program.

An item on the new IMOS Portal and a featured story from the OceanCurrent website give focus to significant progress in our information systems, and opportunities to add value to data streams that are readily discoverable and accessible.

I hope you enjoy reading these and other stories about the great work being done within the program, and about the possibilities created by having a national collaborative research infrastructure in place.

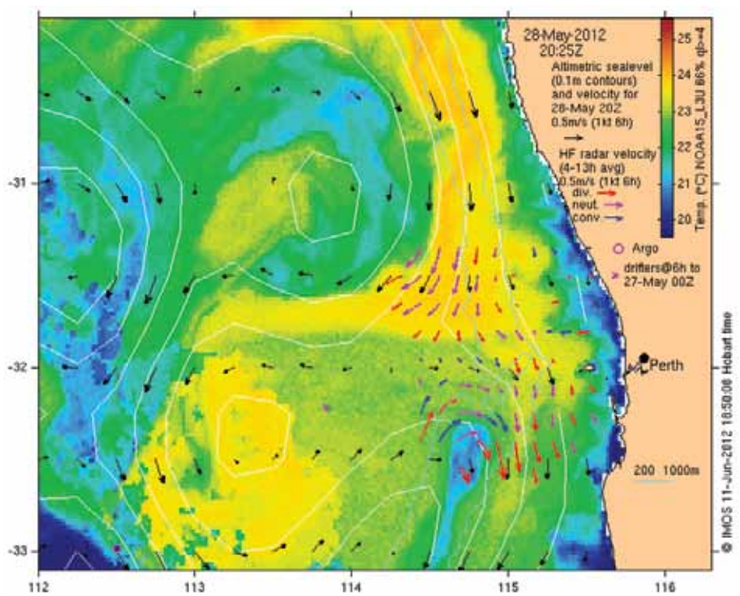
As many of you are aware, current funding for IMOS is committed to June 2013 and there was no new forward commitment in the May 2012 Federal Budget. IMOS was established as a sustained marine observing system, and the fact that it requires ongoing investment in order to create long time series of essential ocean variables has been clear from the outset. It is also now clear that, by all objective measures, IMOS has been successful in achieving what it set out to do. The IMOS Office and Advisory Board are working hard to ensure that the benefits of ongoing investment in IMOS, as planned, are evidenced and communicated to Australian Government. The high level of support received from the marine and climate science and stakeholder community is greatly appreciated, and I look forward to continuing to work with all of you in realising an increasing level of future benefits from our impressive, national system.



Tim Moltmann

IMOS *OceanCurrent:* surface current data from coastal radar is now available

Surface current data is now being included in the daily maps delivered via IMOS *OceanCurrent* (http://oceancurrent.imos.org.au). The map shown is from 9th June shows an intense cold core eddy of Perth, Western Australia. It is striking to note how the tight radius of the eddy is well-resolved by the radar, and the correspondence of the radar data with the SST imagery. This is a nice example of the power we are beginning to realise by bringing multiple data streams together in near real time.



New EAC mooring array completes the IMOS bluewater observing system

This final mooring deployment means IMOS is now observing Australia's deep oceans from the tropics to Antarctica. The deep water mooring array was deployed in April this year from the MNF Southern Surveyor to measure the East Australian Current (EAC).

This latest deep water mooring array will complement existing IMOS observations being taken off the Great Barrier Reef, the New South Wales coast, and the east coast of Tasmania. With this final piece of the jigsaw in place, Australian scientists will for the first time in history have the ability to accurately measure transport of mass, heat and salt from the tropics to the Southern Ocean, to see how it is changing over time, and to understand what these changes might mean for marine ecosystems and coastal populations along the eastern seaboard.

Lined with sensors recording temperature, salinity, nutrients and velocity of the current, five sets of moorings were deployed across the current, extending 240 kilometres east of Brisbane. The largest of the East Australian Current moorings will be located at a depth of nearly five kilometres below the surface.

Hobart-based scientists, Ken Ridgway and Dr Bernadette Sloyan, specialists in coastal currents in the Australian region led the voyage that deployed the moorings. Mr Ridgway said the East Australian Current is a significant natural resource for Australia and understanding its physical and chemical characteristics as recorded through the mooring network will be important for future natural resource management.

Mr Ridgway said scientists have been studying the East Australian Current for perhaps 100 years, although for the first 60-70 years the focus was on the biology and how it may be influenced by the current.

"In the last 25 years real advances have been made in understanding the chemical make-up of the East Australian Current, its physical structure and seasonal changes, and more recently its influence on the biodiversity of the east coast.

Top: Ken Ridgway and Bernadette Sloyan with part of the EAC moorings. Image: Sarah Schofield, CSIRO.

Above: Loading the moorings onto the MNF *Southern Surveyor.* Image: Craig Macaulay, CSIRO.

"What we have also seen in that time is a strengthening of the winds in the Pacific that have intensified ocean circulation and are pushing the current around 350 kilometres further south in the Tasman Sea".

IMOS welcomes Commander Robyn Phillips to the IMOS Advisory Board

Commander Robyn Phillips has recently joined the IMOS Advisory Board. Robyn is responsible for meteorology and oceanography policy and plans for the Royal Australian Navy.

Commander Robyn Phillips

Her roles include providing professional oversight for this specialised category within Navy, capability development and representing the Navy's meteorology and oceanography interests both within the Australian Defence Force and with external organisations, such as the Oceans Policy Science Advisory Group and the Australian Ocean Data Centre Joint Facility Board.

Robyn graduated from the Australian Defence Force Academy in 1992. During her time in the Navy, she has had a varied and exciting career. Robyn's first job was as an officer of the watch on a warship where she was responsible for the control and safety of the warship at sea and when alongside in port. She went on to specialise in meteorology and oceanography and has spent several years preparing maritime and aviation forecasts for the Navy that not only predict the environment but also explains the potential impact upon the military activities. During this time Robyn has also been responsible for providing advice on meteorological and oceanographic aspects of Navy capability and has been involved in the BLUElink ocean modelling project at different levels since 2003.

One of the highlights of Robyn's career so far was a secondment to the Department of the Prime Minister and Cabinet as a Defence Adviser where she was exposed to the internal workings of Federal Government. In this position, she was responsible for preparing advice for Government about all non-operational Defence matters, including the budget process.

Outside of the Navy, Robyn is a keen musician. Her clarinet can often be heard with the Wollongong community ensemble, The Con Artists, which recently played at the National Folk Festival. Her favourite music to play at the moment includes klezmer and wild gypsy tunes.

We welcome Robyn to the IMOS Advisory Board and the wider IMOS community.

Sharing ocean research and data across the Tasman

The New Zealand-Australia Symposium in Ocean Observing and Data Management, was held in early December 2011 at the University of Tasmania, aimed to develop collaborative research opportunities for possible inclusion in a bilateral work program, which will benefit both countries and their regional partners.

It was organised by IMOS and the New Zealand's National Institute of Water and Atmospheric Research (NIWA).

IMOS Director, Tim Moltmann, said Australia is now taking a much more national, collaborative approach to marine observing and data management.

"This is paying big dividends for marine and climate science in our own country, and it just makes good sense to reach out to our near neighbours," Mr Moltmann said.

"We're absolutely delighted that a very senior group of science leaders from New Zealand have been willing to travel to Hobart with the aim of figuring out how we can do this together, on a bigger, regional scale.

"So many of the problems we are studying are common across countries, and in the ocean, we're all connected."

The background to the symposium dates back to a meeting between the Australian and New Zealand Governments in February 2010. Among the issues discussed was the possibility of greater country to country cooperation on marine research and observation. The symposium is a major step toward achieving that goal.

Ms Charlotte Severne, Chief Scientist from NIWA, said that a trans-Tasman arrangement on marine observation will greatly enhance the ability of New Zealand to make marine observations, manage databases and undertake economic, environmental, and climate change research.

"This strategic initiative will provide us with a working platform for our common areas of interest, such as the Tasman Sea, Pacific Ocean and the Southern Ocean," she said.

"Additionally, it will assist our Countries to better understand and monitor natural variability and changes in the marine environment in the Asia-Pacific region."

New IMOS Ocean Portal launched in April

The portal is the primary access point for search, discovery, access and download of data collected by IMOS.

The portal provides two ways of discovering IMOS data, either through a map interface, or by searching the metadata catalogue. The eMarine Information Infrastructure Facility has been working hard on a new improved portal which it launched in April this year.

New features of the portal includes:

- Improved search, including the ability to search on spatial extent, temporal extent, keyword, parameter and organisation.
- View search results on the map.
- Easier access to data including a shopping cart feature.
- A forum to get help and to influence future portal development.

More new features and enhancements will appear regularly.

We encourage you to visit the new portal at the same url http://imos.aodn.org.au/webportal/

Following the symposium in December, IMOS and NIWA agreed to establish a New Zealand ocean data node compatible with the Australian Ocean Data Network (AODN). This will enable New Zealand to serve large amounts of ocean data into the international community using open standards. Peter Blain and Sebastien Mancini of the eMarine Information Infrastructure Facility visited NIWA in late June in order to align the two information infrastructure systems. Over the next few months cruise data, conductivity, temperature and depth (CTD) data, current meters and acoustic doppler current profiler (ADCP) data will all be served through the AODN (http://portal.aodn.org.au).

Senator the Hon. Chris Evans opens the new SIMS Research Facilities

International and Australian scientists can now access first class marine research facilities right on the edge of Sydney Harbour, after the $20 million Sydney Institute of Marine Science (SIMS) was officially opened in May by Minister for Tertiary Education, Skills, Science and Research, Senator Chris Evans.

The Federal Government contributed $19.5 million to the new SIMS facilities at Chowder Bay in Mosman, to upgrade and construct laboratories, expand seawater research aquarium facilities and purchase and install a range of marine research equipment.

Officially opening the facility, Senator Evans said there was nothing more important to Australia than its marine science.

''We have to be a smart country. We're an island continent and we need to understand our marine environment,'' he said.

SIMS operates a number of the IMOS infrastructure Facilities (including NSW moorings, the Autonomous Underwater Vehicle and Animal Tagging and Monitoring), and also hosts the NSW-IMOS Science Node.

Senator the Hon. Chris Evans speaking at the opening of the new SIMS research facilities. Image: SIMS.

Warming is altering ocean salinity and water cycle

A clear change in salinity has been detected in the world's oceans, signalling shifts and an acceleration in the global rainfall and evaporation cycle.

In a paper published in the journal Science, Australian scientists from CSIRO and the Lawrence Livermore National Laboratory, California, reported changing patterns of salinity in the global ocean during the past 50 years, marking a clear fingerprint of climate change.

Lead author, Dr Paul Durack, said that by looking at observed ocean salinity changes and the relationship between salinity, rainfall and evaporation in climate models, they determined the water cycle has strengthened by four percent from 1950-2000. This is twice the response projected by current generation global climate models.

"Salinity shifts in the ocean confirm climate and the global water cycle have changed.These changes suggest that arid regions have become drier and high rainfall regions have become wetter in response to observed global warming," said Dr Durack.

With a projected temperature rise of 3º C by the end of the century, the researchers estimate a 24 per cent acceleration of the water cycle is possible.

Scientists have struggled to determine coherent estimates of water cycle changes from land-based data because surface observations of rainfall and evaporation are sparse. However, according to the team, the global oceans provide a much clearer picture.

The ocean matters to climate – it stores 97 per cent of the world's water; receives 80 per cent of the all surface rainfall and; it has absorbed 90 per cent of the Earth's energy increase associated with past atmospheric warming.

In the study, the scientists combined 50-year observed global surface salinity changes with changes from global climate models and found "robust evidence of an intensified global water cycle at a rate of about eight percent per degree of surface warming."

Dr Durack said the patterns are not uniform, with regional variations agreeing with the 'rich get richer' mechanism, where wet regions get wetter and dry regions drier. He said a change in freshwater availability in response to climate change poses a more significant risk to human societies and ecosystems than warming alone.

"Changes to the global water cycle and the corresponding redistribution of rainfall will affect food availability, stability, access and utilization," Dr Durack said.

Dr Susan Wijffels, co-Chair of the global Argo project, leader of the Argo Facility in IMOS, and a co-author on the study, said maintenance of the present global fleet of around 3,500 Argo profilers is critical to observing continuing changes to salinity in the upper oceans.

Bass Strait's meandering currents revealed by ocean gliders

Deep-diving ocean "gliders" have revealed the journey of Bass Strait water from the Tasman Sea to the Indian Ocean. Deployed in 2010 and 2011, the gliders have also profiled a 200-metre tall wall of water at the core of long-lived ocean eddies formed from the East Australian Current.

The study, by University of Technology Sydney (UTS) and CSIRO oceanographers, revealed the value of new sensors being deployed by Australia's Integrated Marine Observing System.

"We're getting a terrific amount of data that is opening up a very big window on Australia's oceans," UTS scientist and lead author of the study Dr Mark Baird said.

"In this case, we have seen for the first time a 200-metre tall, 40 kilometre wide disc formed from water that originated in Bass Strait that amazingly remains undiluted as it travels hundreds of kilometres," he said.

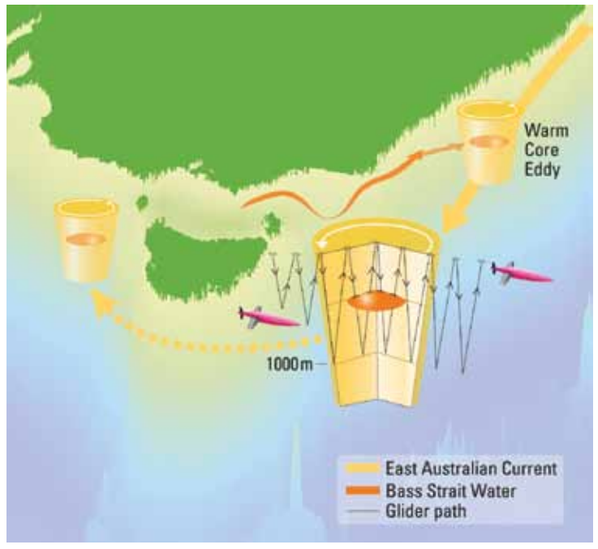
"This new discovery is a clear example of the benefits arising from a significantly enhanced technical ability to explore our oceans and identify features relevant to marine ecosystems and climate."

Scientists have known that salty Bass Strait water, with its unique chemical signature, flows into the Tasman Sea north-east of Flinders Island, sinking to a depth of 400-800 metres in a feature referred to as the Bass Strait Cascade.

However, the porpoising action of the ocean gliders has given scientists data to a depth of 1000 metres and a detailed insight into anti-clockwise rotating warm-core eddies that regulate ocean conditions and influence the ocean food chain.

Co-author CSIRO Wealth from Oceans scientist Ken Ridgway, said the gliders were programmed to sample across the East Australian Current and through long-lived ocean eddies up to 200 kilometres across that form off New South Wales.

"Further measurements show that at least some of this Bass Strait water makes the journey past southern Tasmania and possibly thousands of kilometres into the Indian Ocean," Ken Ridgway said.



The 200-metre tall, 40 kilometre wide disc formed from water that originated in Bass Strait and remains undiluted as it travels hundreds of kilometres.

Illustration: Louise Bell, CSIRO Creative Services

New eyes on northern waters

In the ocean off the Pilbara and Kimberley coasts, a new array of moored buoys, ocean gliders and acoustic listening stations are busy gathering data for use by scientists, managers and decision makers. Part of the Western Australian Integrated Marine Observing System (WAIMOS), these new measurements have come about through State Government investment of $6M over three years.

The state-of-the-art equipment is being operated by the University of Western Australia, Curtin University, the Australian Institute of Marine Science and the Sydney Institute of Marine Science.

Western Australian Science and Innovation Minister John Day welcomed the marine research being undertaken using the WAIMOS with $6million in assistance over three years, when he visited the ocean glider laboratory at the University of Western Australia in July.

Minister Day said access to better information about our oceans would ensure the sustainable management of the waters off the coast of WA for future generations.

"The ocean off WA influences our climate and weather on a daily basis. It also contains valuable fisheries, oil and gas reserves and unique marine biodiversity that attract tourists from across the world," Mr Day said.

"The State Government's $6million investment will go a long way to provide research infrastructure that will enable the State's world-class marine and ocean scientists to generate new insights and understanding.

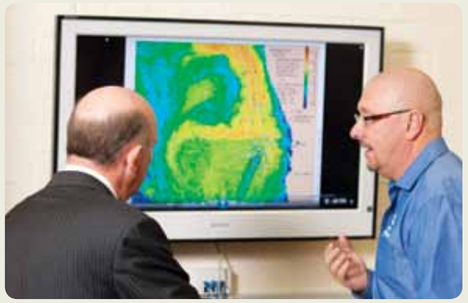
"This investment by the Western Australian Government is a fantastic development" says Mr Tim Moltmann, Director of IMOS. "The system has been operating in the west for some time, but funding limitations have restricted us to an area from about Perth to Ningaloo Reef. So this new infrastructure closes a big and very important gap."

Working off its Research Vessel Solander, the Australian Institute of Marine Science is operating moored buoys at four sites near Broome on the Kimberley coast, in water depths from 50 to 400 metres. The buoys have sensors measuring ocean temperature, salinity, currents and water quality. Another three mooring sites are being operated near Dampier on the Pilbara coast, at depths of 50 to 200 metres. The Kimberley moorings lie along the path of an orbiting satellite which measures the height of the ocean surface, adding further power to the observing system. Data obtained from all of the moorings will be used to improve numerical models of the ocean, used by scientists and managers in Government and industry.

The University of Western Australia is operating ocean gliders along the Kimberley and Pilbara mooring lines. These ocean 'robots' are piloted from the offices of the Australian National Facility for Ocean Gliders on the University's Crawley Campus. Gliders descend to the ocean floor then come back to the surface, beam the data home via satellite, then continue on their mission for up to a month at a time. They provide an unprecedented level of information about the three dimensional structure on the ocean below the surface, and have the potential to revolutionise understanding of ocean processes.

The Sydney Institute of Marine Science has deployed acoustic receiver lines at Rowley Shoals and Scott Reef region, and tagged 48 sharks (including grey reef, white tip and silver tip reef sharks).

Later this year, Curtin University will deploy acoustic listening stations to provide new information on a range of ocean phenomena, including movements of whales and fish.



Top: WA Science and Innovation Minister John Day and IMOS Director Tim Moltmann discuss the IMOS *OceanCurrent* website. Image: Department of Commerce.

Above: WA Science and Innovation Minister John Day and Professor Chari Pattiaratchi, leader of the IMOS ocean glider Facility, discuss the use of gliders in ocean observing. Image: Department of Commerce.

Australia leads on Southern Ocean carbon dioxide monitoring

Australia's Marine National Facility research vessel, Southern Surveyor, returned to the Southern Ocean in July to deploy three IMOS deep water moorings anchored at a depth of nearly five kilometres, about 580km south-west of Tasmania.

The moorings are an important part of the IMOS system and provide enhanced monitoring of the Southern Ocean. The moorings include the Air-Sea Flux Station, the Pulse biogeochemical sensor mooring and a deep sea sinking particle flux mooring. With the Education Investment Funding IMOS received in 2009, IMOS was able to invest in a second Air-Sea Flux Station mooring to allow the moorings to be hot-swapped. Prior to this the single mooring would have been deployed for a year at a time, then retrieved and taken back to land for servicing and then deployed several months later, creating gaps in the time series. This voyage deployed the new Air-Sea Flux station for the first time, enabling IMOS to provide a continuous time series of meteorological information in the Southern Ocean.

The leader of the Deep Water Mooring IMOS Facility, Professor Tom Trull, said the project was the only one of its type in the Southern Ocean.

"While the Southern Ocean plays a significant role in the global climate system, there is a paucity of sustained observations in this harsh and remote region. These high quality observations are a valuable contribution to understanding ocean processes that contribute to climate variability.

"The ability of the ocean to soak up carbon dioxide from the atmosphere and remove it to ocean depths is a natural process but the rate of that exchange and its influence on other chemical and biological properties in the ocean is now a central climate science question.

"We know the sub-Antarctic ocean is a hotspot for uptake of carbon dioxide and deployment of these mooring systems over the next 18 months will give us an insight into changes occurring from day-to-day and season-to-season in the upper ocean and at the sea surface.

"The results we obtain will be of interest around the world to climate and carbon cycle scientists," Professor Trull said.

Dr Eric Schulz and Professor Tom Trull, leaders of the Deep Water Mooring Facility, with the new Air-Sea Flux station. Image: Craig Macaulay, CSIRO.

IMOS at the Annual AMSA conference

IMOS had a booth at the Australian Marine Sciences Association (AMSA) Annual Conference in July 2012, Hobart, Tasmania. With two IMOS Ocean Portal displayed it was great way to catch up again with so many of our collaborators and to meet new people interested in using IMOS data.

It was also pleasing to see a large number of presentations and posters at the AMSA Conference referring to use of IMOS data. AMSA conferences provide a useful annual benchmark, and penetration in 2012 was demonstrably better than 2011.

"Whilst the IMOS office used to attend AMSA to promote IMOS, it is pleasing to see the promotion of IMOS data is community driven now," says IMOS Director, Tim Moltmann, who attended the conference.

The IMOS community would also like to extend our congratulations to Dr David Griffin, who received the 2012 AMSA Jubilee Award and presented the opening keynote address on extreme oceanic events. Dr Griffin has developed tools to assist in translating ocean science for society in his role as a physical oceanographer.

"David's contributions to physical oceanography have flowed to scientists, students, teachers, marine safety specialists, industry, marine archaeologists, recreational users of the marine environment and the Royal Australian Navy.

"His work has covered the potential future of Australia's ocean renewable energy, leading CSIRO's Wealth from Oceans remote sensing team, assisting with the search for HMAS Sydney and the hospital ship Centaur and developing the IMOS OceanCurrent website," says AMSA President Professor Lynnath Beckley.

In his opening keynote presentation to AMSA Dr Griffin said there is economic and environmental value in knowing how robust ecosystems are following extreme events.

"I would argue that 'extreme oceanic events' have received much less attention than they deserve from the science community.

"Indeed, science doesn't yet have a developed vocabulary for the many different types of extreme oceanic events," he said.

Dr Griffin said marine scientists are now catching up with meteorologists in terms of tools and data to monitor variability of environmental conditions. They now have two decades of sea surface height measurements, a decade of the autonomous Argo ocean sampling program, and the emergence of coastal and deep ocean gliders, backing up the traditional ocean mooring arrays and shipboard observations.

A significant contributor in the past five years has been Australia's Integrated Marine Observing System.

"Marine scientists are moving from a world of sparse observations to one that is becoming much more data-rich. Sensors on satellites complement observations by drifting and diving instruments.

"Agencies around the world have spent hundreds of millions of dollars on ocean observing systems. But that is nothing compared to the economic impacts of climate variability, some of which could be prevented by better understanding of the environment.

"The research opportunities are there," Dr Griffin said.

The Continuous Plankton Recorder goes Global

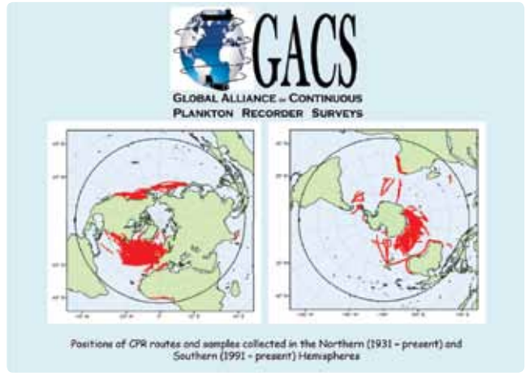
In January 2011, the Scientific Committee on Antarctic Research (SCAR) Southern Ocean Continuous Plankton Recorder (SO-CPR) Survey celebrated 20 years of plankton monitoring in the Southern Ocean.

Later in September 2011, several members of the SO-CPR international consortium, plus members of the IMOS AusCPR team joined other plankton researchers at the Plankton 2011 Symposium Plymouth UK, to celebrate the 80th anniversary of the North Sea CPR Survey, the longest running marine biological survey. The Sir Alister Hardy Foundation for Ocean Science, which runs the North Sea, Atlantic and North Pacific CPR Surveys, has long had a vision of creating a global network of CPR surveys to monitor changes in plankton biodiversity as an indication of the health of marine ecosystems.

The Symposium proved the opportune time for the heads of the nine regional CPR surveys to meet and establish the Global Alliance of CPR Surveys (GACS). A Memorandum of Understanding was signed by the partners and witnessed by representatives from Intergovernmental Oceanographic Commission/Global Ocean Observing System (IOC/GOOS), the Partnership for Observation of the Global Oceans (POGO) and North Pacific Marine Science Organization (PICES).

The general goal of GACS is to understand changes in plankton biodiversity at ocean basin scales through a global alliance of CPR surveys. By 'understand' we mean characterise, analyse and interpret. GACS has a number of specific aims which include:

- development of a global CPR database
- production of a regular Ecological Status Report for global plankton biodiversity
- ensuring common standards and methodologies are maintained
- providing an interface for plankton biodiversity with other global ocean observation programmes
- to set up and maintain a website for publicity and data access
- to facilitate new surveys and develop capacity building procedures
- to facilitate secondments of CPR scientists between GACS institutions



Positions of CPR routes and samples collected in the Northern (1931 – present) and Southern (1991 – present) Hemispheres

GACS brings together the expertise of approximately 50 plankton specialists, scientists, and technicians from 12 laboratories around the world, towing CPRs from about 50 vessels. Working together, pooling our data and resources, was considered essential in order to understand the effects of environmental changes on plankton biodiversity at a global level. It will also allow us to assess changes and events at a local or regional level in a world-wide context. The heart of GACS is the development of the global database of CPR data that will allow us to make such assessments.

GACS has a board of governance comprising members from all regional CPR surveys – Australia, UK, Canada, USA, Japan, New Zealand, South Africa, Brazil and China. GACS is supported by working groups developing the joint database and maintaining standards and methodologies.

Further details are available at http://www.globalcpr.org

Written by:
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Chair, Board of Governance - Global Alliance of CPR Surveys
Director, SCAR Southern Ocean CPR Survey
Co-Director, IMOS AusCPR

Stevie Davenport

Launch of the Australian-Canadian ocean tracking collaboration

The collaboration between IMOS and the Canadian Ocean Tracking Network (OTN) was launched at the High Commission of Canada in Canberra in early August.

A global network of marine scientists is pooling research efforts to learn more about the mysterious lives of underwater creatures. The OTN will electronically tag and track thousands of marine animals with the aim of demystifying their migration patterns and providing answers to global problems such as disappearing fish stocks and climate change.

The OTN project is a Canadian initiative based at Dalhousie University in Halifax and involves scientists working in all five of the world's oceans. This $168-million conservation mega-project is funded by the Canada Foundation for Innovation-International Joint Ventures Fund, the Natural Sciences and Engineering Research Council of Canada and the Social Sciences and Humanities Research Council of Canada.

The OTN has partnered with Australia's Integrated Marine Observing System (IMOS) to implement the global network in this region. IMOS is responsible for deploying and servicing the OTN receivers and providing administrative and data management services.

"Canada has a leadership position in this kind of marine science," says Tim Moltmann, Director of IMOS, the Australian partner in the project. "Canada traditionally has had a strong focus on marine technology, and the receiver technology for tracking tagged animals was developed there."

Australian researchers have already benefited from the collaboration. In 2009, OTN funded its first acoustic sensing line outside of Canadian waters, a "listening curtain" running 60 km from Perth's shoreline to the western edge of Australia's continental shelf, and the first line to fully capture animal movements along the shelf.

A second 50-km line running from Tasmania's east coast to the eastern edge of the continental shelf was installed earlier this year, and a third curtain, running 50 km east from Flinders Island in Bass Strait, will soon complete the OTN installations in Australia.

Top right: IMOS acoustic receiver locations around Australia. Above: deployment of OTN equipment. Right: tiger sharks.

Images: Rob Harcourt

Prof Harcourt says the OTN lines "are placed at critical junctures for animal movement, at places where the mixing of water masses can act like barriers to animals."

The IMOS Animal Tagging and Monitoring facility, which Prof Harcourt leads, is a collaborative network across many Australian institutions. The network has an array that detects tags from hundreds of marine animals in Australian waters each year and monitors their movements.

"The Perth line is detecting a lot of white sharks, which is one reason the line was placed where it is," Prof Harcourt says.

"Sharks tagged in Victoria and Tasmania have been detected on the Perth line, while white sharks tagged in New Zealand have been picked up along Australia's east coast".

But tagging and tracking sharks is just one of many projects benefitting from the new collaboration. The grey nurse shark and the southern bluefin tuna have also been tagged as both species are listed as vulnerable, the latter being commercially harvested by Australia and Japan.

Many fish species have been tagged including snapper, blue groper and the harlequin fish as well as marine invertebrates. Giant cuttlefish and crayfish or rock lobsters are being tagged, and the data shows they migrate long distances.

IMOS's lines pick up details about animal movements—things like the directions animals are swimming, how deep they are in the water, and the timing of their migrations. The OTN curtains are a critical component of this network and have been strategically placed to improve our understanding of animal movements around Australia's shores.

"Oceans in the southern hemisphere are generally poorly observed compared to those in the northern hemisphere. As Australia is quite advanced in animal tracking technologies, the collaboration will benefit both IMOS and OTN through major research programs, the sharing of data, and high-level publications," says Mr Moltmann.

Monitoring **ecosystem responses**

The key components of the Australian marine ecosystem and the approach IMOS is using to target observations at each trophic level.

1 Southern Ocean Time Series (SOTS) moorings

The SOTS site is comprised of a number of moorings, each of which is designed to measure specific physical, chemical and biogeochemical parameters to quantify the uptake of carbon by the ocean and its fate within the ocean system. A deep ocean sediment trap mooring collects samples of sinking particles to quantify the transport of carbon to the deep ocean in sinking particles.

2 National Reference Station (NRS): a network of nine mooring sites

A network of nine NRS mooring sites on the continental shelf around Australia are designed to provide baseline information on the physical and biogeochemical properties of the coastal ocean. Monthly water sampling occurs at the NRS sites for chemical, phytoplankton and zooplankton analysis. Acidification moorings are co-located at three sites providing partial pressure of CO_2 data, along with the total CO_2 and alkalinity data from the NRS, allowing for a complete determination of the carbonate system and pH.

3 Continuous Plankton Recorder (CPR)

Plankton assemblage data is collected using a CPR on Ships of Opportunity. This data compliments the point data collected in the monthly water sampling at the NRS sites. This data is used to understand changes and variability in the range of species.

4 Bio-acoustic observation

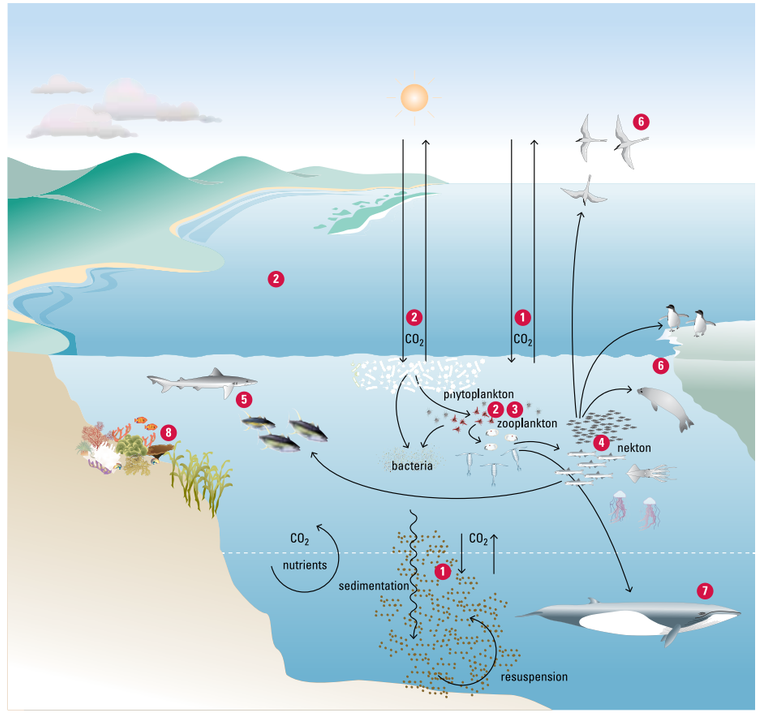
Bio-acoustic data is collected from Ships of Opportunity using tuned echo-sounders, from which the biomass of nekton can be estimated. Nekton connect the plankton at the base of the food web to the top predators.

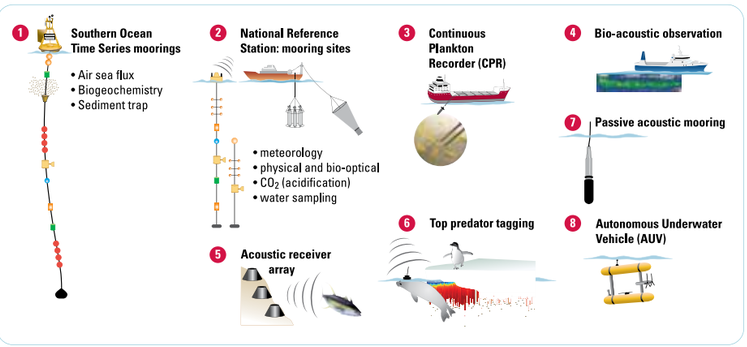
5 Acoustic receiver array

Acoustic receiver moorings have been deployed in curtains and arrays in the oceans surrounding Australia. When a tagged fish or animal swims by the acoustic receiver the tag number is identified and any sensor information logged, to determine the movement of key pelagic species around the coast.

6 Top predator tagging

Top predators are also tagged in the Southern Ocean. Tagged species include elephant seals, Weddell seals, sea lions, penguins, terns and petrels. The data allows researchers to identify areas of ecological significance where multiple species aggregate. Tagged elephant seals also collect temperature and salinity data. This data not only provides valuable physical data from remote parts of the ocean, but allows researchers to understand how the seals interact with physical features such as frontal zones.





7 Passive acoustic mooring

The passive acoustic sea noise moorings record sound emitted by natural processes in the ocean and the unique acoustic signatures of marine mammals, crustaceans and fish. Through an analysis of these signals, it is possible to discriminate and identify different species and to assess the relative abundance of animals present within the range of acoustic observation.

8 Autonomous underwater vehicle (AUV)

An AUV is used to collect geo-referenced, stereo imagery at key reference sites around Australia. These ongoing surveys will allow researchers to monitor changes to benthic ecosystems.

IMOS Postgraduate **Student Profile**

Students using IMOS data for their postgraduate research

Charlotte Robinson

University of Technology, Sydney

Port Hacking National Reference Station monthly time-series data within the Australian National Moorings Network, including vertical profiles of conductivity, temperature, salinity (CTD).

Project: *Correcting oceanographic estimates of chlorophyll distribution: Why do coastal phytoplankton form sub-surface chlorophyll maximas?*

Charlotte measuring the photosynthetic health of phytoplankton sampled at PH100 using the Fast Repetition Rate fluorometer (courtesy of SIMS). The fluorometer can provide information on the light harvesting efficiency and quantum yield of photosystem II.

This study aimed to determine why a coastal subsurface chlorophyll maximum (SCM) forms in temperate NSW waters.

Four major hypotheses regarding the mechanism of formation include: (1) a passive accumulation of senescent phytoplankton cells at the pycnocline; (2) zooplankton grazers exerting top-down control on vertical phytoplankton distribution; (3) an increase in cellular chlorophyll in response to low light (rather than a true increase in biomass); and (4) phytoplankton cells utilizing nutrients and light more efficiently, growing faster than phytoplankton found near the surface.

I investigated three of the four (1, 3 and 4) hypotheses during my honours. The SCM at the Port Hacking 100m station, off the coast of Sydney was observed each month from February to September, 2011. Water samples of phytoplankton from the surface and SCM (identified by vertical fluorescence profiles) were manipulated experimentally to determine if the SCM cells were physiologically active, if the SCM cells were more efficient at utilizing available nutrients, and if the cells were chromatically adapted to lower intensity light within a narrow spectral range found at the SCM.

Formation of an SCM at the Port Hacking 100m station occurred during more stratified conditions, and involved active accumulation of physiologically functional cells below the mixed layer depth. Manipulative laboratory experiments confirmed the availability and utilization of macronutrients at the SCM was not important for the formation of the SCM, nor was avoidance of the super-saturating light intensities present at the surface. Based on chromatic adaptation experiments, the SCM was likely formed by an accumulation of phytoplankton better adapted to the low intensity blue-centered spectral quality of light available at the SCM. This allowed phytoplankton within the SCM to maintain high levels of photosynthesis and carbon fixation compared to surface populations.

The project used a range of bio-optical equipment including a Fast Repetition Rate fluorometer to monitor photosynthetic performance of phytoplankton cells, an in situ hyperspectral radiometer, a lab based spectrophotometer and a flow cytometer to enumerate picoplankton.

Techniques employed included high performance liquid chromatography to identify photopigments of phytoplankton and radiocarbon productivity assays to estimate rates of carbon fixation.

IMOS Postgraduate **Student Profile**

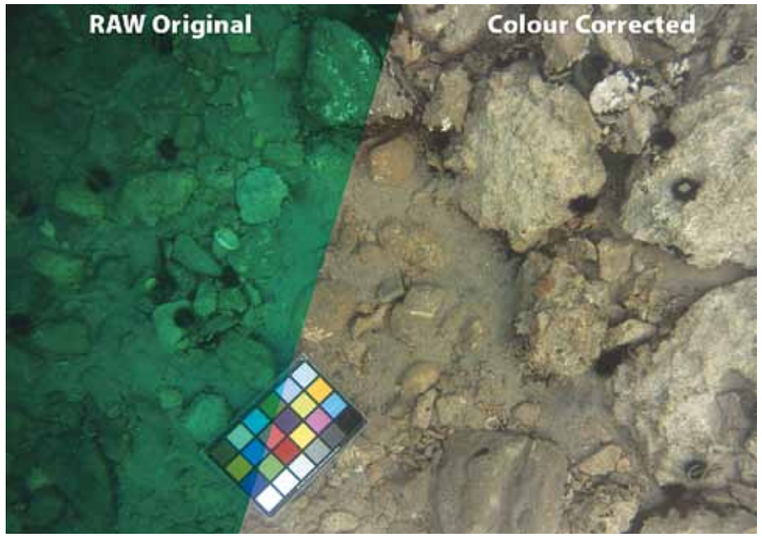
Students using IMOS data for their postgraduate research

Daniel Bongiorno

Australian Centre for Field Robotics (ACFR), University of Sydney

I will use data from the Autonomous Underwater Vehicle (AUV) Sirius, and possibly the Lucinda Jetty Coastal Observatory for validation of some modelling parameters.

Project: *Hyperspectral Underwater Radiometric Modelling*



The underwater environment presents formidable barriers towards its exploration, one of which is the limited passage of light. Optical sensing is an attractive means of underwater imaging over sonar based imaging due to its affordability, high resolution (both spatially and chromatically) and ease of interpretation by an operator. The major inhibitor of light transmission within the water column is the presence of suspended particles and absorption by water molecules. This results in both absorption and scattering of the photons.

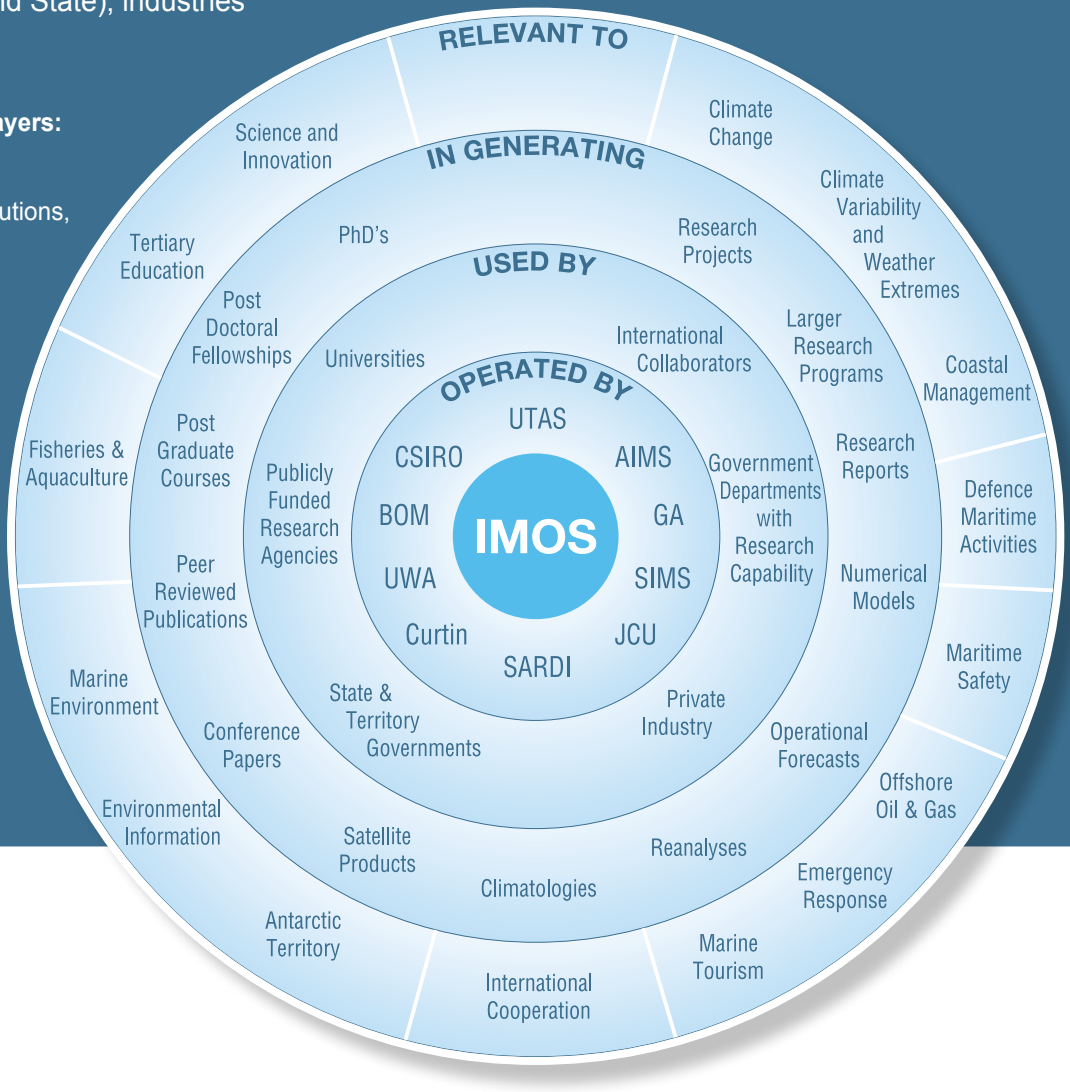
The absorption of light in water is not uniform across the visible spectrum with red being attenuated much more than blue or green. Resulting in a blue/green colour cast to the imagery acquired. The problem with the colour cast is it hinders accurate classification due to its chromatic basis and inconsistency. The colours will vary for different imaging distances, changing lighting conditions and changing water constituents.

ACFR's current benthic mapping work has primarily been under taken through the use of stereo cameras onboard the AUV Sirius. My project will focus on modelling of the underwater light field. It is based on a geometric framework built up by the 3D structure obtained from the stereo cameras onboard the AUV Sirius. The plan is to obtain the Inherent Optical Properties (IOPs) of the water through the use of hyperspectral sensors onboard Sirius. Knowledge of the IOPs and the structure of the scene will allow for the removal of the influence of the water column on the imagery. To an observer this will give the impression that the scene was imaged out of water, but more importantly each image regardless of location will have accurate colour representation. This colour accuracy should improve classification performance.

IMOS has developed a 'circle diagram' to capture the complexity of engagement for IMOS as a broadly based research infrastructure program delivering to a national community, undertaking research of relevance across government portfolios (Federal and State), industries and communities.

The diagram has five layers:

1. IMOS at the core,
2. the ten 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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