

IMOS News

GBROOS launched by Senator Kim Carr

One of the five IMOS Science Nodes, GBROOS was officially launched by Senator Kim Carr, the Minister for Innovation, Industry, Science and Research on May 9th.

The Great Barrier Reef Ocean Observing System, GBROOS, is a regional ocean observation network covering the eastern Coral Sea and the Great Barrier Reef, and includes the world's first large scale reef-based Internet Protocol (IP) sensor-network.

The IP network, or "digital skin" of sensors will monitor the Great Barrier Reef (GBR), picking up real-time bio-physical measurements, enabling researchers to observe any changes to the reef. Seven reef-based sensor networks will be installed over the next 18 months.

GBROOS have installed 10 moorings on the GBR-four pairs of shelf-slope moorings at Lizard Island, Myrmidon

Reef, Swains Reef and Heron Island, a National Reference Station near Yongala Wreck, and a mooring at Heron Island to develop methods to monitor CO₂. The shelf-slope moorings involve one in shallow water on the reef and one at about 200m on the edge of the East Australian and Hiri western boundary currents. The mooring array will monitor impacts on the reef by change in the boundary currents. A full report on the GBROOS moorings will be in the next issue of Marine Matters.

GBROOS also includes a coastal radar system, installed at Tannum Sands near Heron Island. With its ability to track and describe current movements, coastal radar has the potential to aid reef restoration and protection efforts.

In addition, AIMS' major research vessels, RV Cape Ferguson and RV Solander, are being fitted with monitoring devices to measure water quality and ocean nutrient data throughout their voyages.

GBROOS has also upgraded the Townsville satellite receiving facility, located at AIMS' headquarters, to gather remotely sensed data on sea surface temperature and ocean colour.



Senator Kim Carr, the Minister for Innovation, Industry, Science and Research launching GBROOS. Photo courtesy of Tim Simmonds, AIMS

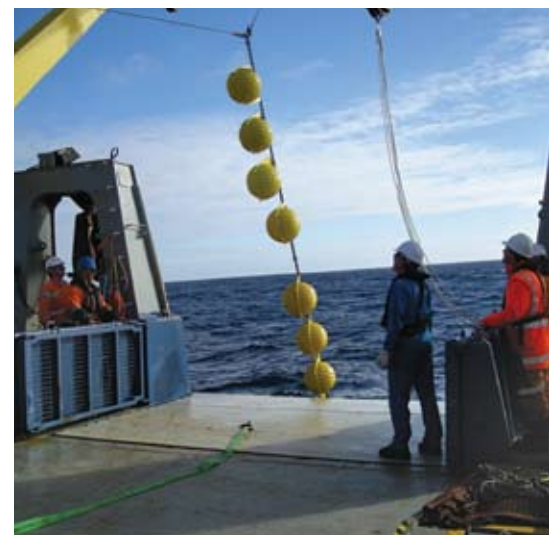
SOTS retrieve test PULSE mooring

The development process continues for one of the more technically challenging aspects of IMOS. On Sunday April 6 2008 the PULSE mooring was recovered less the surface float, rubber element and some chain. It was deployed in January 2008 in ~3500m of water. Sadly, two weeks before the recovery cruise the mooring stopped transmitting its position. The final engineering analysis is not complete but it is thought that the surface float flooded and then some of the plastic subsurface floats imploded. The mooring parted on a threaded rod that held the plastic floats. As it was a test mooring the only instruments lost were a GPS transmitter and an accelerometer. A special thanks to the master and

crew of the Southern Surveyor for all their cooperation and hard work.

It is believed most of the mooring design is sound despite the extremely challenging conditions. This winter tests will be performed on some new surface float configurations so that we can have more experience and understanding before a fully instrumented mooring is deployed this spring/summer.

The SOTS mooring activity was always going to push the boundaries of ocean observations. Deploying cutting edge instrumentation in some of the roughest conditions in the world ocean is a considerable challenge. A period of testing and development is to be expected.



Retrieving the SOTS pulse mooring in the Southern Ocean

AATAMS survives Cyclone Nicholas

In late 2007 and early 2008, AATAMS (for more information about AATAMS see Marine Matters issue 3), in collaboration with CSIRO and AIMS, deployed nearly one hundred acoustic receivers off Ningaloo Reef in Western Australia. The receivers were deployed as three curtains from the coast to the 100 and 200 m isobath off northern, southern and mid Ningaloo Reef. These curtains detect all tagged fish migrating along the Ningaloo Reef coast. Three grid arrays of receivers were also deployed to investigate habitat use, movements, and residence time of coral reef fishes, sharks, and rays.



Dr Charlie Huveneers, the AATAMS Technical Officer, deploying an acoustic receiver at Ningaloo Reef, WA. Photo courtesy of Frazer McGregor.

However, within days of the last deployments, Cyclone Nicholas travelled down the Ningaloo Reef coast over the top of the curtains and arrays. Luckily, AATAMS Technical Officer Charlie Huveneers had the opportunity to check on the majority of the moorings and receivers after the cyclone had passed and all of the checked moorings were still present at the deployed locations. No damage could be seen.

This is great news for AATAMS confirming that the mooring design is strong enough to withstand cyclonic winds. We are looking forward to recovering and downloading data from the receivers in July.

Maria Island reference station is deployed

Drs Tim Lynch and Lindsay Pender, ably assisted by the deck crew of the RV *Southern Surveyor*, successfully deployed moored infrastructure for the National Reference Stations (NRS) on the 10 April 2008. Operating at night, the sub surface component of the Maria Island NRS was placed onto the seafloor at 42 35 .80S, 148 14.00E, which is the same location where data has been collected from small boats since 1944.

Built by Danny McLaughlan and David Cherry from the Ocean Sensor Deployment Group (OSDG) at CMAR, the NRS mooring carried a sensor payload of two Wetlabs Water Quality Monitors (WQM), one located near the bottom at 90 metres and another in the euphotic zone at 20 metres. David Hughes, also from OSDG, programmed the initial deployment of this new combination sensor (conductivity, temperature, pressure, salinity, oxygen, chlorophyll and turbidity) to test two different rates of battery use. The mooring is set to be recovered for data downloading

and analysis after two months. This will provide valuable information on the rate of bio-fouling of the equipment, the integrity of the data stream and the actual, as opposed to modelled, use of battery power. The next stage of the project is to deploy a surface float to commence development of a telemetry stream from the WQMs. Team members from the OSDG are currently finalising designs for a water proof telemetry canister which will become the generic module for both future NRS deployments and other programs.

eMII MEST workshops

The eMarine Information Infrastructure (eMII) Facility have run Metadata Entry and Search Tool (MEST) workshops in May, hosted at the Bureau of Meteorology and the University of Tasmania.

The goal of the workshops was to lead the data facilitators from each facility through the steps required to upload metadata and observational data to eMII, and to provide an overview of user's access to IMOS data over the internet using the MEST, Presentations and hands-on experience at the workshop demonstrated:

- Navigating around the MEST;
- Searching the MEST;
- Permissions and MEST behaviour;
- How to clone a "sample record" and amend the content to describe a specific instance of an IMOS dataset;
- How to edit and delete data files;
- How to save and manage permissions over a record;
- How to upload and download observational data files;
- How to link related records.

SST data to flow with new file servers

The Satellite Remote Sensing (SRS) Facility had two Sun X4500 40 terabyte file servers delivered in Melbourne and Canberra recently. Each system weighs 98 kilograms and has 48, one terabyte disk drives. It took four people to get the unit out of the box and into the rack. Once the systems are configured, Sea Surface Temperature (SST) data will start flowing to the Melbourne system from the Bureau of

Meteorology. Work towards population data arrays in Perth is underway and SRS should have MODIS data online in a few weeks. SRS will initially use the Canberra system to test AO-DAAC software components with some test data before full deployment. SRS are progressing with the software and the installation of the OPeNDAP server software which should follow quickly once the systems are up and running.

Annual Planning Meeting

The 2nd IMOS Annual Planning Meeting was held on 18-20 February at Glenelg, South Australia. There were 34 participants including five Board members, node, facility and sub-facility leaders, Operator contacts, IMOS Office and an invited speaker. The invited speaker, Anne Fitzgerald from QUT Law Faculty, discussed legal issues that arise in a free and open data environment. Nick D'Adamo presented an overview of international ocean-observing activities, particularly in the Intergovernmental Oceanographic Commission, as they relate to IMOS.

The major part of the meeting concerned reports on the current status and plans out to June 2009 from the 11 facilities. It was encouraging to see how much progress has been achieved.



Annual Planning Meeting attendees (left to right): Standing: Dr Stefan Williams, Mr Craig Steinberg, Dr Moninya Roughan, Dr Nick D'Adamo, Prof Mal Heron, Prof Iain Suthers, Dr John Gould, Dr Peter Turner, Dr Peter Doherty, Prof Chari Pattiaratchi, Mr Simon Allen, Dr Marian McGowen, Mrs Jo Neilson, Dr Susan Wijffels, Mr Scott Bainbridge, Dr Rob Harcourt, Prof Craig Johnson. Sitting: Prof Richard Coleman, Mr Ken Ridgway, Dr Eric Schulz, Prof Gary Meyers, Prof Jo Laybourn-Parry and Dr Trevor Powell.

Progress-highlight for each facility

Bluewater and climate facilities

Argo: The planned global coverage of 3000 floats was achieved and float-deployment in the IMOS region is nearing completion

SOOP: First steps to change from a primarily physical oceanographic network to a multidisciplinary network to support research on the physical environment and ecosystems. Victoria state government is supporting instruments on the Bass Strait Ferries.

SOTS: A trial deployment of the biogeochemical mooring will be subjected to engineering analysis after recovery

Coastal currents and water property facilities

ANMN: 15 moorings in the water by June 2008

ACORN: A radar system operating off southern Qld and sites selected in WA and SA

ANFOG: 5 gliders delivered and full stable of 8 (5 Sea-gliders and 3 Slocums) expected by June 2008.

Coastal ecosystem facilities

FAIMMS: First test deployments are now live and data is coming from these via a simplistic data management system; June 2008 sees the first major deployment at Heron and One-Tree Islands with Rib Reef soon after;

AATAMS: Ningaloo acoustic screens installed in February and no lost instruments after tropical cyclone Nicholas went over.

AUV: Completed deployments at Jervis Bay, biodiversity assessment at Ningaloo (supported by AIMS), drowned reefs on GBR (Southern Surveyor)

Data management facilities

SRS: High resolution (1-5km), real-time and re-processed SST maps are available in the IMOS region

eMII: MEST is ready for IMOS data.

In closing the meeting, Dr Trevor Powell, the chair of the IMOS Advisory Board, noted the progress, and how quickly it was achieved, given that subcontracts were completed much less than a year ago. He noted that the emphasis is changing now from the logistics of getting started, to implementation and engagement with the user community. Dr John Gould, the international member of the Advisory Board, commented that IMOS is an ambitious and wide ranging national effort, in many ways trail-blazing for the international community.

Annual Business Plan 2008/09 to DIISR

Following on from the IMOS Annual Planning Meeting in February, the IMOS office with the Facility and Sub-facility leaders, prepared their plans for the 2008/09 financial year. The Annual Business Plan (ABP) was approved by the IMOS Advisory Board and submitted to the Department of Innovation, Industry, Science and Research (DIISR) on 27th March 2008. We are currently awaiting advice from DIISR that the ABP has been accepted.

If you would like a copy of the 2nd Annual Business Plan, please contact the IMOS office.



Dr Gary Meyers

Two ongoing major reviews initiated by the new Labour Government are highly relevant to IMOS – the Review of the National Innovation System and the Review of the NCRIS Roadmap. This newsletter is an opportunity to publically air some of the ideas expressed in the IMOS submissions.

Firstly, the national, strategic approach to infrastructure-development, as implemented by NCRIS, was highly effective for the marine community. We were ready for a national, community-driven approach because many had worked hard for almost two decades to establish small parts of the observing system, always knowing that more is required to support research on the role of the ocean in the climate system, human (including climate) impacts on marine ecosystems and conservation of marine biodiversity. The strategy for the observing system was embodied in Australia's Oceans Policy (1998) and the associated Marine Science and Technology (MS&T) Plan (1999). The documents clearly articulated the strategic approach. After these efforts, many in the marine community were ready to take advantage of NCRIS facilitated process, and ready to make the compromises required for a community plan. A long time has passed since the MS&T Plan was published. For the researchers who contributed to writing it, it is worthwhile now to go back and have a read.

As a community, we strongly recommend that the national, strategic

approach to infrastructure development be maintained. It has been more effective for developing the marine observing system than the previous competitive grant schemes, and this is likely to be true for all aspects of environmental monitoring.

Another point is that the marine observing system has to be largely a public service supported by public funding, like the weather service. This is because there are many activities and businesses in addition to research that benefit from the same observations – e.g. fishing, tourism, search and rescue, shipping, port-management, offshore industries, etc – and the total investment is justified by adding all of the relatively small benefits together. The onus then is placed back on the marine community to develop the capability for innovative, public services that will justify public funding. Of course, we have already been innovative: IMOS data is already flowing into *BLUElink* (a hugely successful service jointly developed by CSIRO, BoM and RAN during the past seven years, and running operationally now at BoM). However, much remains to be done to prove the value of sustained marine observations to all of the potential users. I suggested in the submissions that we follow the lead of Europe's Global Monitoring for Environment and Security, a new multinational organisation whose primary purpose is to develop highly innovative applications of earth observations. This is not the place to describe GMES in detail, but if you Google it you'll see that it is a potentially useful strategic approach.

Finally, there is a need to sustain IMOS beyond the current investment, to maintain the long-term monitoring capability required to support marine and climate research and applications. The long term development needs to be based on staged increments, where the observing system at each stage is re-assessed against priorities that are broadly accepted by the developers and the users. But re-assessment should not preclude a long term commitment to investment in marine observations by the Government.



A sample mosaic from the Autonomous Underwater Vehicle (AUV) taken at Ningaloo marine park, Western Australia showing sponge beds in 80m of water. The AUV was maintaining an altitude of 2m, giving a 1.5m swath, and traveling at 0.5m/s. The mosaic is composed of 40 images captured at 2Hz and represents a 10m transect.

Ships of Opportunity – Mr Ken Ridgeway

The measurement of ocean temperature has a long dependence on volunteer observing ships, with original instrumentation consisting of a bucket and thermometer. Sampling techniques have progressed with advances in technology in the latter half of the 20th century, enabling the collection of data from participating merchant vessels and cruise liners (Ships of Opportunity, SOOP). Until recently, researchers have collected only sea temperature and physical data; however, IMOS is currently upgrading the SOOP program in Australia to enable a broader, multidisciplinary suite of data collection.

A Brief history

One of the first oceanographic variables measured was sea surface temperature (SST). In an effort to understand the Gulf Stream, Benjamin Franklin measured SST over 200 years ago using a simple mercury-in-glass thermometer suspended over the side of his ship during the voyage between the US and Europe. Although improvements to thermometers subsequently increased precision, measurements were still constrained to individual water depths. With the invention of the mechanical bathythermograph (a torpedo-like device about the size of a water bottle, attached to a line and thrown over the side of a ship) by Athelstan Spilhaus in 1937, it became possible to make a continuous record of temperature versus depth. The development of thermistors, electronic devices to measure temperature, led to the expendable bathythermograph (XBT) in the 1960's, originally designed for use in submarine warfare. Oceanographer Ray Montgomery recognised the potential for XBTs in ocean research and initiated what was to become the modern SOOP program, installing XBTs on the cruise liner that operated between Honolulu, Tahiti and Samoa to monitor the equatorial current system of the Central Pacific.

When researchers Jean-René Donguy and Gary Meyers began studying the El Niño – Southern Oscillation phenomenon in the 1970's, they realised that XBT transects were



XBT

needed in the east central and west Pacific, as well as in the middle of the ocean. The XBT network was extended across the Indian Ocean in the mid 1980s with Gary Meyers' move to CSIRO in Australia, where he helped to establish a consistent data stream from merchant ships around Australia. The data generated by these XBT lines is currently sent in near real-time to climate analysis centres around the world where it is routinely used in models for seasonal climate prediction. This data set is invaluable for examining climate variability and change in the ocean as some records now go back over 25 years. At least 44 publications in refereed scientific journals have used the Australian XBT data, not to mention many more using the global SOOP data.

Enhanced Measurements from Ships of Opportunity (SOOP)

Ken Ridgway, a researcher at CSIRO Marine and Atmospheric Research and the SOOP Facility Leader, is currently upgrading SOOP within IMOS. This evolution will lead to a multidisciplinary set of integrated, repeat underway observing systems on volunteer ships in Australian regional seas, linking physical, chemical and biological oceanography. The observations will span spatial scales from eddies to basin width, and timescales from seasonal to decadal. The enhanced SOOP facility will generate time-series data in areas that have only sparse, discontinuous biological data in the past. Target regions include the boundary current systems off Eastern and Western Australia, the Southern

Ocean, the shelf seas across northern Australia, and the Great Barrier Reef. A number of organisations have made significant co-investments into the SOOP facility, including the Australian Climate Change Science Program, Antarctic Climate and Ecosystems CRC, Australian Government Antarctic Division, Australian Institute of Marine Science, Bureau of Meteorology, CSIRO, Marine National Facility, Royal Australian Navy and Scripps Institute of Oceanography. Although the framework of SOOP has been established by IMOS new participating agencies can add observations tailored to their needs. For example, the Environment Protection Authority Victoria has recently funded the installation of an autonomous marine sensor package onto the ferry, Spirit of Tasmania 2, on its Bass Strait route. Through joining IMOS they have been incorporated into the national SOOP network.

Enhanced SOOP is coordinated with the merchant ship programs in other countries through the intergovernmental Joint Committee on Oceanography and Marine Meteorology (<http://www.jcommops.org>). The international program provides global coverage of oceanic thermal structure. IMOS is one of the first to enhance the XBT ships with biogeochemical observations. Enhanced SOOP also participates in international research programs such as the Southwest Pacific Ocean Circulation and Climate Experiment (SPICE). SPICE aims to understand the role of the Southwest Pacific in the transmission of decadal climate signal to the equatorial and Tasman region.

The SOOP program within IMOS is divided into 4 sub-facilities

Multidisciplinary Underway Network

CSIRO Marine and Atmospheric Research (CMAR) will operate the network, using commercial shipping lines to add biogeochemical observations to the existing XBT lines. This will improve coverage, enabling researchers to monitor the transport of mass, heat and freshwater in Australia's major boundary currents and their relation to ecosystems. Biogeochemical sensors will be added to the National Marine Research Facility, RV Southern Surveyor to monitor the sensitivity of biogeochemical cycling to climate change, and to measure CO2 uptake in critical areas. Continuous Plankton Recorder (CPR) devices, capable of recording species-level data of phytoplankton and zooplankton, will be installed on two lines to establish links between planktonic ecosystem structure and large-scale physical variability. One line will run down the core of the East Australia Current and the second across the Southern Ocean to Antarctica. The State Government of Victoria recently

enhanced this sub-facility to include an autonomous marine monitoring system on the Spirit of Tasmania 2. The sensors will record temperature, salinity, chlorophyll-a and turbidity.

Sensors on Tropical Research Vessels

The Australian Institute of Marine Science (AIMS) will increase its monitoring of the Great Barrier Reef and the western Coral Sea. Research vessels Cape Ferguson and Solander will be upgraded to include thermosalinograph and chlorophyll sensors, with the total suite of sensors able to record temperature, salinity, fluorescence, light absorption and irradiance. These research vessels will undertake repeated transects in the target areas as well as individual cruise tracks.

Sea Surface Temperature (SST) Sensors for Australian Vessels

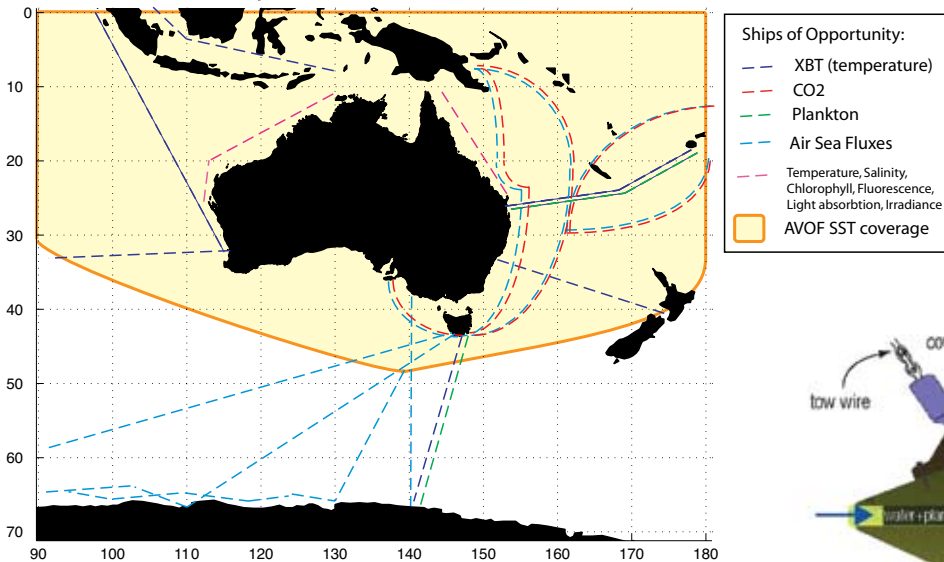
This sub-facility of SOOP, in collaboration with the Bureau of Meteorology (BoM), will improve validation of SST data gathered by satellite by equipping eight to ten Australian Volunteer Observing Ships with hull-mounted SST sensors

transmitting data by GPS Tracking System (GTS) every 1-3 hours. The data collected will be used to validate environmental satellite instruments and contribute to the routine mapping of SST. BoM (in partnership with AIMS and CMAR) will install a near real-time thermosalinograph system on the Gladstone to Heron Island Ferry.

Research Vessels Real-Time Air-Sea Fluxes

SOOP will install sensors on RV Southern Surveyor and RV Aurora Australis to produce high quality, real-time measurements of air sea fluxes (the transfer of heat and freshwater between the atmosphere and the sea). Improved knowledge and mapping of air-sea fluxes is one of the great challenges of climate research. This sub-facility will obtain data for study of the role of the ocean on climate variability, carbon levels, ecosystems and coastal environments.

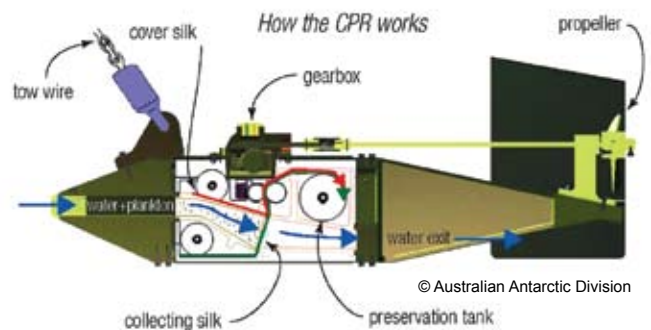
SOOP Observation plan out to June 2009.



The shipping routes that will provide the observational data streams for SOOP. Navy blue lines are XBT (temperature) transects; the red lines are CO2 transects to measure the CO2 uptake in critical areas; green lines are plankton transects and will collect abundance and species data with CPR's; aqua blue lines are air sea flux transects that will measure the transfer of heat and freshwater between the atmosphere and the ocean; and pink lines represent the routes of the upgraded Research vessels Cape Ferguson and Solander. The area covered by the Australian Volunteer Observing Ships (AVOF) for measuring Sea Surface Temperature (SST) is shaded yellow.



© Stevie Davenport, Australian Antarctic Division



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The Continuous Plankton Recorder (CPR) is a device that is trailed behind a vessel to record quantity and genera of plankton in the water in long transects. The microscopic plankton enters the device and is trapped on a silk that is continuously wound. The silk is then put under a microscope and the abundance of the different types of plankton is measured. CPR surveys allow researchers to observe changes in distribution, abundance and phenology.

Cooperation with shipping companies

The strength of the SOOP facility lies in the cooperative efforts of marine scientists and commercial shipping companies to collect data of increasing sophistication and breadth, thereby increasing our knowledge of ocean currents and climate, which ultimately returns benefits to both shipping companies and the wider community. The SOOP team has developed a rapport with volunteer observers from the commercial shipping companies ensuring they feel involved in the project. Marine scientists provide training on how to collect the data at sea, encourage interest in what the data will be used for, and provide feedback on the findings. Conversely, the volunteers welcome the distraction of collecting data whilst at sea, and are usually very interested in the research being done, becoming excellent

observers and providing high quality data for SOOP. The SOOP program, with their crew of volunteers on existing commercial shipping lines, provides a cost-effective means of obtaining reliable and accurate time-series data across the oceans.

The enhancements to SOOP, funded through IMOS, will provide long-term ocean observations that are vital to understanding the influences responsible for changes and variability in Australia's climate system, and could even help predict the effects of climate events such as the El Niño – Southern Oscillation phenomenon. Increasing our understanding of the ocean and climate is not only important for merchant shipping, fisheries, national defense, and the public, but has the potential to improve planning and management of significant sectors of the Australian economy, such as agriculture, energy and resources.



“The ships companies might benefit in the long term from the improved knowledge of ocean current and climate, but for the most part they undertake it as a community service,” says Mr Ken Ridgway.

For more information, please contact:

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Ocean Gliders – Professor Chari Pattiaratchi

Facility Feature Article #5

By Wilbur Longbottom & Marian McGowen

Oceanographers have traditionally used ships to observe the oceans, however, the high cost of ship time restricts the size of the area covered and makes repeated surveys over a particular area uneconomic. Underwater ocean gliders represent a technological revolution for oceanography. Autonomous ocean gliders can be built relatively cheaply, are controlled remotely and are reusable; allowing them to make repeated subsurface ocean observations at a fraction of the cost of conventional methods. The Australian National Facility for Ocean Gliders (ANFOG), with IMOS/NCRIS funding, will deploy a fleet of eight gliders this year. The data retrieved from the glider fleet will contribute to the study of the major boundary current systems surrounding Australia and their links to coastal ecosystems.

Realising a vision

Henry Stommel, a renowned physical oceanographer, published a visionary article in the journal *Oceanography* in 1989, written from the perspective of an oceanographer reminiscing in 2021. He described a world ocean observing system based on “a fleet of small neutrally buoyant floats called Slocums”. The floats would “migrate vertically through the ocean changing ballast...steered horizontally by gliding on wings...broaching the surface to

transmit via satellite their accumulated data and receive instructions telling them how to steer through the ocean”. Ocean gliders have undergone a steady development in the 20 years since Stommel's article, making the transition from fantasy to reality.

Ocean gliders propel themselves by changing buoyancy, they alternately reduce and expand their volume to dive and climb through the ocean, in the same way as Argo profiling floats (see *Marine Matters* issue two). However,

unlike Argo floats that drift in the ocean currents, gliders have wings and a rudder to allow them to move horizontally in a selected direction while profiling across strong currents. Essentially this means that the gliders' horizontal position is controllable, and allows researchers to decide where the glider goes. Global low-power satellite communication is a key enabling technology for gliders, making it possible for them to be remotely controlled world-wide and for the transfer of near real-time data.

Ocean glider Fact File

Slocum glider



Seaglider



Type	Coastal	Open ocean
Depth range	5-200m	Up to 1000m
Maximum Range	500km	4600km
Speed	40cm/s	25cm/s
Deployment time	30 days	6 months

ANFOG's glider fleet

The IMOS glider fleet will consist of two types; Slocum gliders and Seagliders. Slocum gliders (named for Joshua Slocum the first solo global circumnavigator) and manufactured by Webb Research Corp are optimised for shallow coastal waters (< 200m) where high manoeuvrability is needed. ANFOG will have three Slocum gliders to be deployed on the continental shelf. Seagliders, built at the University of Washington, are designed to operate most efficiently in the open ocean up to 1000m water depth. ANFOG will use their five Seagliders to monitor the boundary currents surrounding Australia. The Seagliders can be used to conduct repeated glider surveys across the boundary currents and continental shelves, which is valuable for gathering long-term environmental records of physical, chemical and biological data not widely measured to date. Whilst the Slocum gliders, due to their low cost and operational flexibility, will be of great use in intensive coastal monitoring, both types of glider weigh only 50kg enabling them to be launched from small boats. They will have the same suite of sensors, able to record temperature, salinity, dissolved oxygen, turbidity, dissolved organic matter and chlorophyll against position and depth.

The key feature that sets ocean gliders apart from other autonomous underwater vehicles is that they are slow. Slocum gliders cruise at a maximum speed of only 40cm/s, whilst Seagliders cruise at 24cm/s. This slow speed and consequent low drag permit long deployments of up to 6 months. Professor Chari Pattiaratchi, the leader of ANFOG, and the Coastal Oceanography Group at the University of Western Australia, notes that although the data collected by the gliders will not be unique, the low

cost and duration of their deployment will vastly improve the amount of data oceanographers are able to collect. Also gliders will collect data during periods of extreme weather conditions. "Usually we go on a ship to obtain data – this is very expensive and limited to when the weather is suitable and the availability of a ship – but gliders will collect data under any weather conditions at a fraction of the cost. Gliders will enable sustained ocean observations," he says.

Sustained ocean observations will allow researchers to document the natural variability of the ocean, and better understand the effect of climate change on coastal ecosystems. The IMOS gliders will focus particularly on the major boundary currents that run down the Australian coast, the Leeuwin in the west and the East Australian Current (EAC). The study of these currents is critical for understanding the north-south transport of freshwater, heat and biogeochemical properties. The currents exert a large influence on coastal ecosystems, shipping lanes and fisheries.

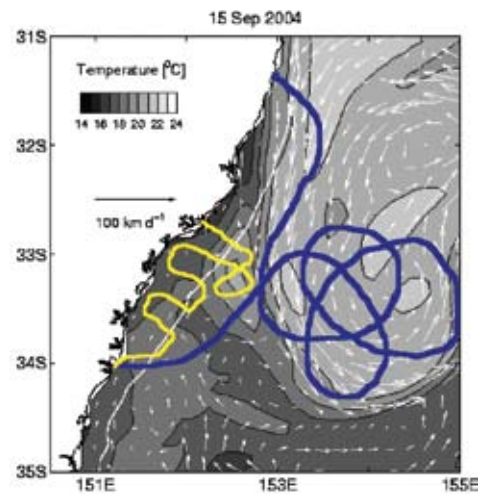
IMOS Glider projects

Following a public Call for Proposals in 2007 for the IMOS infrastructure the ocean gliders have been allocated to four projects which will be coordinated by research teams at four of the IMOS Science nodes; NSW-IMOS, Bluewater, SAIMOS and WAIMOS.

NSW-IMOS – Exploring hydrography and fluorescence in the EAC, its eddy field and in the Tasman Front

NSW-IMOS will deploy one Seaglider for 6 month deployments in the Tasman Sea, to obtain physical and biological properties in order to improve the understanding of the dynamics and variability of the EAC, the Tasman Front, and eddies shed by the EAC. They will

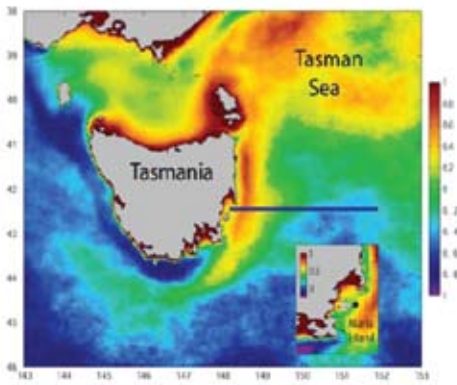
also use a Slocum glider to investigate the challenging environment of the continental shelf off Stockton Bight, Jervis Bay and Eden. The Slocum glider will sample recurrent features during 3 week deployments, such as tracking the maturation of phytoplankton after a cold core eddy brings nutrients into the photic zone. The inshore monitoring will also track the effects of estuarine discharge and southern extensions of the isotherms off Eden. These Slocum deployments will complement zooplankton sampling from the RV Southern Surveyor.



SeaGlider (blue) samples EAC and then warm core eddy. Slocum glider (yellow) has a similar track through a cold core eddy.

Bluewater and climate – Monitoring the Southward extension of the East Australian Current

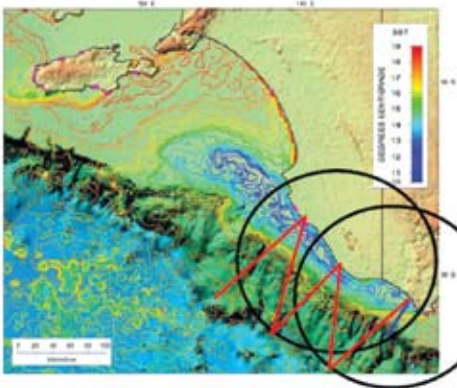
The Bluewater node will use a Seaglider to complete glider tracks to monitor the flow of the EAC off Tasmania. The glider transect will provide the first extended time-series of the absolute transport of the EAC. Climate modelling and sparse historical data suggest that the EAC is spreading southward over decades and affecting the temperate marine ecosystem. The Seaglider will begin monitoring this process in a systematic way. The data obtained from the Seaglider will compliment other data streams from Argo, XBT transects, satellite altimetry and Sea Surface Temperature, and further develop general ocean observing techniques and algorithms, assimilated into ocean models to provide a detailed description of the EAC flow.



The February Sea Surface temperature around Tasmania. The Seaglider track is shown in blue.

SAIMOS – Boundary and Shelf Currents: exchange with the shelves of SA and Victoria

SAIMOS will use a Seaglider to explore and map the deep boundary currents between the Eyre Peninsula and the western mouth of Bass Strait, at present largely unknown, and identify hot spots for deep ocean exchange with the shelf, between SA and Tasmania. A Slocum glider will also be used to investigate the shelf and shelf break exchange and currents of the SA upwelling zone and Bonney Coast and western mouth of Bass Strait.

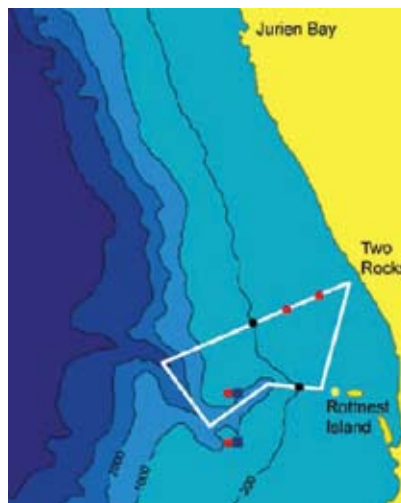


Upwelling off the Bonney Coast during March 1995 as illustrated by SST. The red line denotes a possible Seaglider path.

WAIMOS – Deployment of ocean gliders in Western Australia as part of the WAIMOS

WAIMOS will use two Seagliders and one Slocum glider to continue ongoing research efforts to understand the role of the Leeuwin current system in controlling not only the marine life but also the climate of south-western Australia. The Leeuwin current, in contrast to the highly

productive boundary currents off the west coasts of Africa and the Americas is nutrient depleted. Originating in the tropics, the Leeuwin current is a shallow, narrow band of warm, low salinity water, which flows poleward from Exmouth to Cape Leeuwin and into the Great Australian Bight. The Slocum glider will complete circuits from Two Rocks (north of Perth) to the edge of the Leeuwin Current and then return through the axis of the Perth Canyon. A Seaglider will be released off Dampier every 3 months and will traverse back and forth across the Leeuwin Current, completing its deployment in Freemantle.



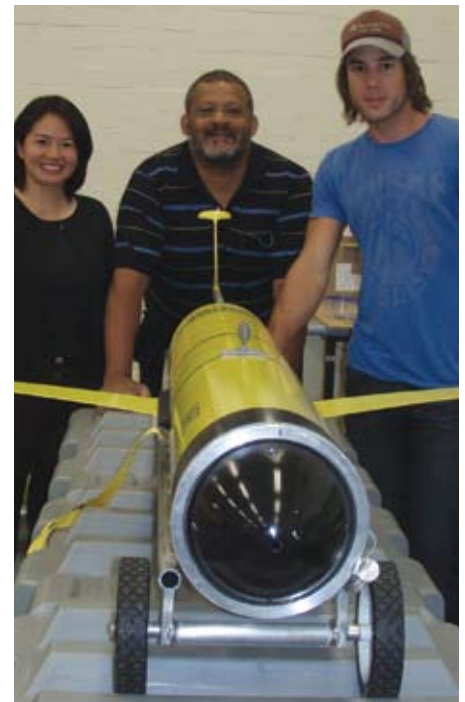
Proposed Slocum glider track along Two Rocks transect returning through the Perth Canyon.



Proposed Seaglider deployment off Western Australia. The glider will be released off Dampier and recovered at Freemantle.

Future of oceanography

Ocean gliders present new opportunities for studying the oceans surrounding Australia. With these glider projects, ANFOG will develop strategies and techniques to use gliders in sustained ocean observing to best advantage. These projects will also build technical capability in the IMOS nodes around the country, and transfer skills needed in the operation of ocean gliders. Ocean observing will always present a challenge to researchers, with the wide range of time and space scales that need to be resolved. Whilst ships and moorings will remain important for oceanography, Stommel's vision of a network of ocean gliders will provide the best way to obtain sustained spatial sampling of the sub-surface ocean.



The ANFOG team, Mun Woo, Chari Pattiaratchi and Ben Hollings, with a Slocum glider.

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IMOS PhD Student Profile

Students using IMOS data for their PhD research

Paul Durack

Quantitative Marine Science
(QMS) Program

CSIRO and University of Tasmania

Paul's PhD project is focused on looking at changes to observed ocean salinity through time. The available historical data covers the period from 1874 to 2005, however around 20% of more recent data is provided by Argo floats with good spatial coverage beginning around 2002 from this platform. Change in salinity is an indication of the global hydrological cycle, because ocean salinity is a consequence of the difference between rainfall and evaporation at the sea surface. The rate of global climate change – which is a very important scientific and political question – can be monitored by tracking salinity.

Paul started his scientific life back last century, completing his undergraduate studies in Western Australia, before heading to Melbourne to work at the CSIRO labs in Aspendale. He started his PhD in the CSIRO and U Tas QMS program in 2006, and is working under supervision from Susan Wijffels (leader of the IMOS Argo Facility), Nathan Bindoff, Helen Phillips and Richard Coleman – quite the dynamic team!

Project Title: *Oceanic influence on the global hydrological cycle: Quantifying the global salinity cycle - Ocean-atmosphere freshwater fluxes*

Paul's project is dependent on the new Argo data array, in fact, without this great new data resource, he'd be unable to look at global changes in the 4 key ocean basins due to the sparseness of historical ocean data both in time and space. This new data resource has enabled Paul and his colleagues to get a much better idea of what is happening in the global oceans, providing complete coverage throughout the seasonal and annual cycle. At last count 3110 active floats (and counting..) make up the array, with the original operational target being 3000, so it's at full capacity and giving oceanographers some incredible new insights to the workings of the global oceans.. Along with historical data from ships and moorings back to the 1950's, and the existing coverage of ocean surface and atmospheric flux data, Argo is providing answers to many ocean-related questions, including the sustained monitoring of ocean salinity.

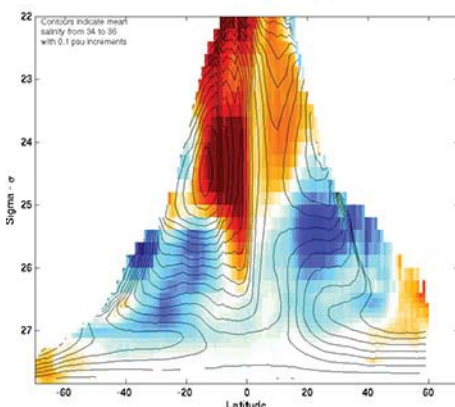


As part of Paul's PhD, he was invited to take part on the last voyage of the INSTANT program, during which he was involved in Argo deployment in Indonesia's Banda Sea.

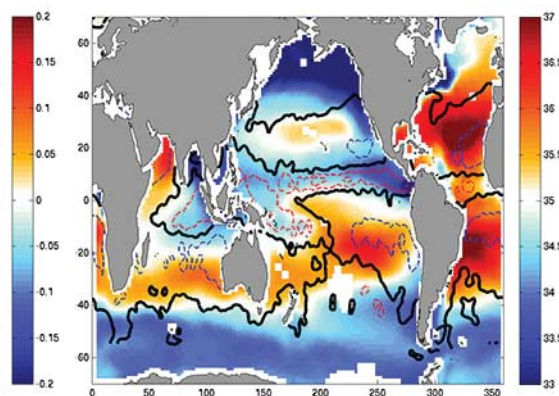
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a) Pacific Ocean basin salinity changes 1950-2005



b) Surface annual salinity climatology centred on 1975



This figure expresses (a) integrated changes to the Pacific Ocean basin salinity from 1950-2005 and (b) an annual surface ocean salinity climatology (right) centred on 1975; generated from a collection of varied data products; including over 330,000 Argo data profiles (Contours show regions of maximum evaporation (blue) and precipitation (red) with the transition zone indicated in black).

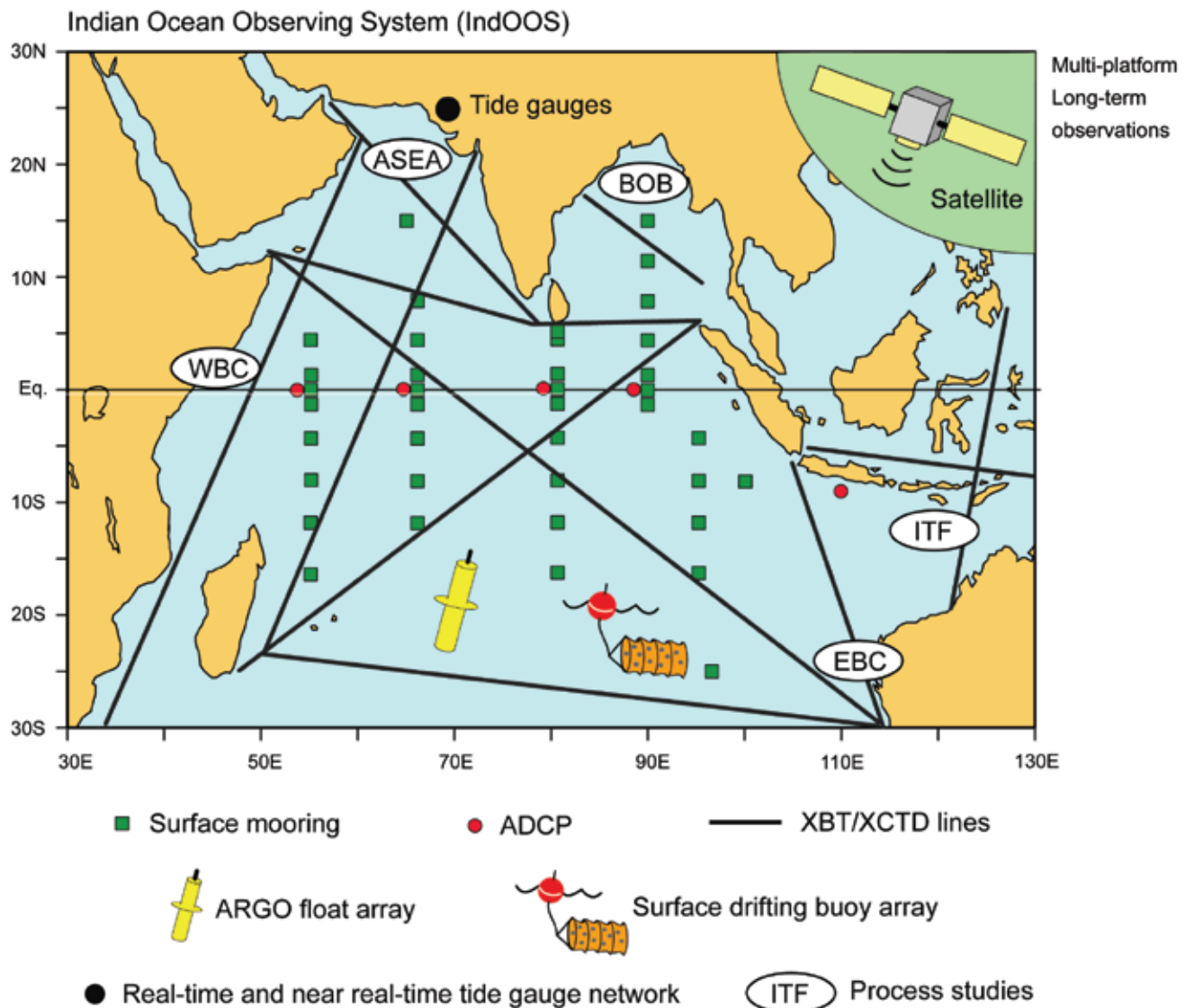
Indian Ocean Observing System (IndOOS)

The Indian Ocean is unique among the three tropical ocean basins in that its western boundary current is blocked at 25°N by the Asian land mass, and the Indonesian Throughflow is an additional source of heat. Seasonal heating of the land sets the stage for dramatic monsoon wind reversals, strong ocean-atmosphere interactions and intense seasonal rains over the Indian subcontinent, Southeast Asia, East Africa, and Australia.

Recurrence of these monsoon rains is critical to agricultural production that provides life-sustaining support for half the world's population. However, the annual cycle of the Indian Ocean is not sufficiently repeatable to avoid variations of climate from year to year. The Indian Ocean remotely influences the evolution of El Niño and the Southern Oscillation (ENSO), the North Atlantic Oscillation (NAO), North American weather, Atlantic hurricane formation, and most importantly for us, the seasonal climate of Australia. Despite the importance of the Indian Ocean in the regional and global climate system though, it is the most poorly observed and least well understood of the three tropical oceans.

The World Climate Research Programme (CLIVAR) www.clivar.org/organization/indian/IndOOS/timeseries.php and the Intergovernmental Oceanographic commission are working to design and implement an integrated observing system for the Indian Ocean, including a basin-wide mooring array, a 3°x3° array of Argo floats, a 5°x5° array of surface drifters, an enhanced XBT network as well as many other measurements (e.g., process studies, tide gauges and satellites).

Visit the above webpage to see what has already been implemented in the basin-scale Indian Ocean Observing System (IndOOS).



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

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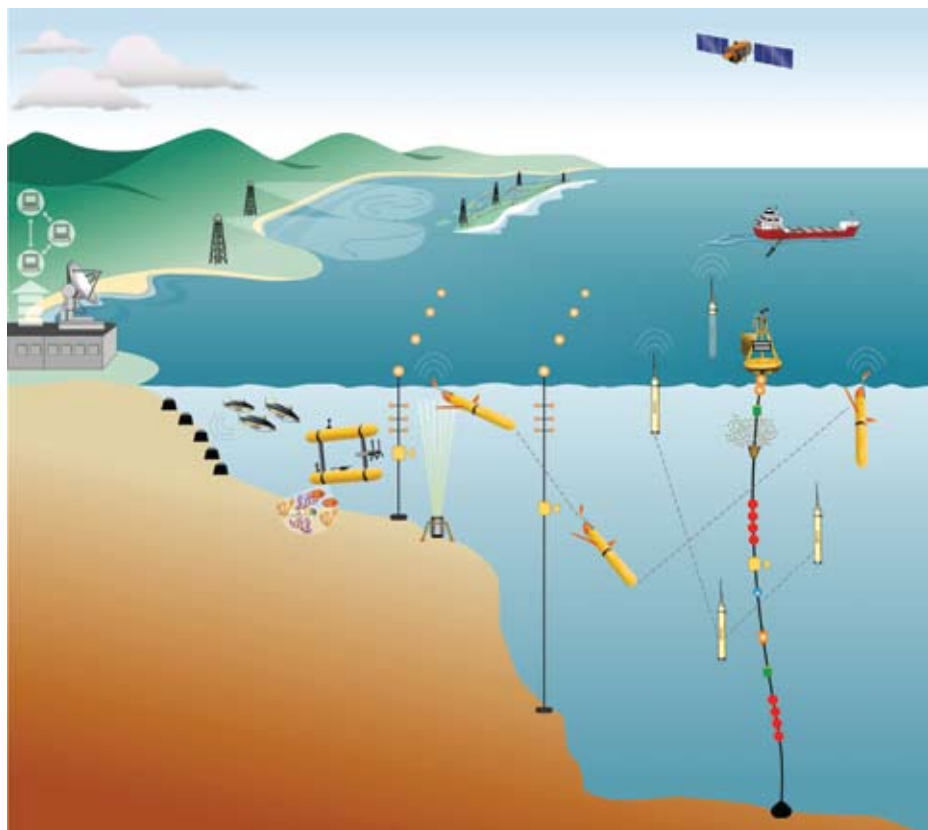


Diagram illustrating how the national IMOS program works. IMOS integrates several independent technologies and instruments, ranging from moored sensors and deep sea autonomous floats to acoustic tracking devices, radar imagery and remote satellites, among others, into research infrastructure covering a vast swath of Australia's large coastal and deep water marine territory. IMOS will generate critical data needed to support a diverse range of marine research projects.

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IMOS is an initiative of the Australian Government being conducted as part of the National Collaborative Research Infrastructure Strategy
www.ncris.dest.gov.au/capabilities/integrated_marine_observing_system.htm

This issue of marine matters has been compiled by Dr Marian McGowen.

