marinematters

IMOS

issue two July 2007 Integrated **Marine Observing** System

welcome

Welcome to the second issue of the newsletter for the Integrated Marine Observing System (IMOS) – now officially titled Marine Matters! The goal of this newsletter is to help keep the researchers, institutions, agencies and government bodies involved with IMOS – as well as the larger marine research community and outside groups interested in marine science – informed on the progress, happenings, and significant updates of the IMOS project.

Because the content will be driven by IMOS developments, the newsletter won't be published on a set schedule, but will come out instead when there are significant or newsworthy updates to report. As IMOS is just getting off the ground, however, there will be much to report over the next several months!

In the next few issues, we'll be featuring stories on each of the 11 national IMOS facilities, profiling the people and cadre of ocean observing instruments which form the core of the observing network, exploring the history of ocean observing in Australia, and examining some issues of related significance to Australian marine research.

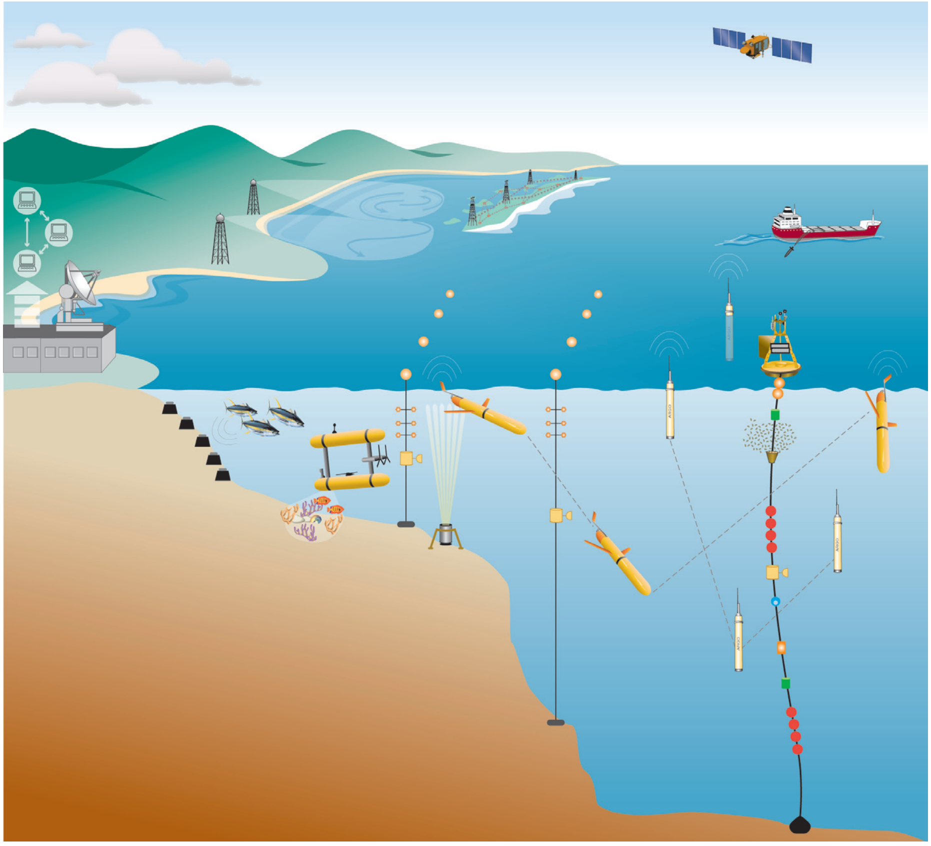


Diagram illustrating how the national IMOS program works. IMOS links several independent ocean observation projects involving technologies and observing instruments, ranging from moored observing instruments and deep sea autonomous floats to acoustic tracking devices and remote satellites, among others, into a more collaborative 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.

IMOS Funding Agreement signed

On 22 May 2007 IMOS became the first of the NCRIS grants to enter into a formal agreement with the Government. In early June the first instalment of the $50 million funding, being $15.682 million was received. The IMOS Office celebrated this major step by hosting thank-you drinks in Hobart for those research, legal, human resources and finance staff based at CSIRO and the University of Tasmania who assisted in finalising the contract. Thank you to all the other people involved in IMOS across the country who have assisted us in reaching this stage. A major research venture such as this involves a large number of people and organisations who are prepared to contribute their time in anticipation of the benefits which will accrue if the grant is successful, and the contributions of all are very much appreciated. A special thank-you to the Department of Education, Science and Training Staff who assisted us – especially Kathy Schmutter and Greg Piko, who were always very helpful and patient in answering our many questions in the contract finalisation process. While thanking people we also acknowledge the many hours put in by David Lyons, University of Tasmania Faculty Research Officer, who oversaw all the implementation issues until the IMOS staff were appointed. Better stop there, but again, thanks to everyone.

What is IMOS?

For those unfamiliar with it, IMOS is a $92 million project that represents an innovative and much-needed new infrastructure for studying Australia's oceans – both its coastal oceans and its deep 'bluewater' ocean realms. What makes it new? In brief, integration and a focus on community needs. Several regional marine research centers around Australia have been linked to create a nationally integrated marine observing system that aims to better coordinate use of ocean observing equipment and provide open access to high-quality marine data, often in real-time.

In late November 2006, the Australian Government announced a contribution of $50 million to help establish a nation-wide ocean observing system through the National Collaborative Research Infrastructure Strategy (NCRIS), an initiative of the federal Department of Education, Science and Training (DEST). Out of hundreds of proposals submitted for NCRIS funding in 2006, IMOS was one of nine selected – a strong indication that better understanding of Australia's oceans is being recognised as essential for national health on every front, from political to economic to environmental. The remaining $42 million has come from cash and in-kind co-investments from participating institutions.

The 4-year IMOS project has several goals – though enhancing collection and distribution of marine data is its main objective. In addition, IMOS aims to:

1. Coordinate the deployment of key ocean observing instruments and technologies that will serve as the foundation of data collection efforts and allow scientists to better complement each other's research;

2. Thoroughly describe Australia's oceans by supporting research on their chemistry, ecology, marine life, and hydrology;

3. Establish a system for long-term data collection that will be sustained after IMOS so climate effects and variation can be placed in context;

4. Provide near real-time data streams that will be easily accessed by users with a wide range of marine data needs;

5. Promote sustainable development of marine resources by equipping policy-makers and industry with the data necessary to make informed decisions;

6. Support marine research and national strategic policy by improving the quantity and quality of marine data available to researchers, industry and government.

How does IMOS work?

One of the main strengths of IMOS stems from its organisational structure. Ocean observation is a challenging science, and a great deal of oceanographic research relies on the use of special equipment and technologies that can canvass the vast territory and hard-to-access regions of the oceans.

In Australia, many universities, agencies, and marine scientists are already conducting research on a wide range of marine issues using these technologies, but typically the research has been regionally isolated or driven by individual researcher proposals. Although marine scientists have been targeting many important pieces of Australia's ocean puzzle, this type of research system has resulted in a fragmented portrait of the ocean environment.

Through IMOS, these organizations are linked in a more structured partnership that enhances their ability to synergise with each other and draw on potential areas of overlap. A central office – the University of Tasmania – has been appointed to manage, coordinate, and oversee the national system, including better coordination of ocean observing equipment.

IMOS has also created a two-tier structure to help organise research infrastructure initiatives based on their focus by designating principal facilities and regional nodes.

Principal facilities comprise the first level. These are the 11 national ocean observing research programs based at universities, government, or research agencies around Australia that together form the IMOS ocean observing network. Most IMOS facilities are centered on the use of a specific ocean observing technology, such as the ocean gliders, marine meteorology buoys, or robotic Argo floats to name a few.

Regional nodes comprise the second broader, meta-level. At this level, the national facilities and IMOS participating institutions are grouped according to the region, unique characteristics of specific ocean zones, or ecosystems being studied. The nodes will serve as focal points for the marine research community, helping scientists identify where to direct ocean observation efforts. There are five nodes in total. Some participants may be included in more than one node:

1. Blue Water and Climate Node – participants in this node focus on the physics and dynamics of the open ocean, including Antarctic and Southern Ocean research;

2. Great Barrier Reef Ocean Observing System (GBROOS) – a node focusing on the Great Barrier Reef and continental shelf zone of northeastern Queensland which seeks to understand the influence of the Coral Sea on continental shelf ecosystems in this region, as well as the impact of changing climate on the important marine transition zone between Australia's tropical and temperate marine species.

3. New South Wales IMOS (NSW IMOS) – a node focusing on the uniquely complex coastal and shelf processes driven by the East Australian Current (EAC), especially off NSW, where complex circulation patterns directly affect the entire trophic cascade off eastern Australia as well as the ocean dynamics of regional seas.

4. South Australian IMOS (SAIMOS) – a coastal node focusing on the nature and dynamics of two unique ecosystems – Kangaroo Island / Eyre Peninsula and the Bonney Coast – and the relationship in this region between ocean circulation, chemistry, sediments, and trophic dynamics, from lower (phyto/zooplankton) to upper levels (marine species foraging). This node will also help other nodes by providing observation information about key ocean current systems that connect the regions of W.A., the Southern Ocean, and N.S.W.

5. Western Australian IMOS (WAIMOS) – a node focusing on the unique Leeuwin Current System and its role in the pelagic and benthic ecosystems of Western Australian waters, which are warmer, lower in salinity, and more nutrient depleted than the highly productive oceans of Eastern Australia.

Who's involved with IMOS?

IMOS is truly collaborative, involving most of the universities, government, and research agencies in Australia with capacities in marine research, as well as some international agencies with an oceanographic focus. Over 30 participating institutions in Australia and abroad are involved, either directly or through financial or material support.

Importance of IMOS

The initiative has come at a particularly crucial time. Until now, ocean observation in Australia has been a fragmented and widely diffuse process, with regional hotspots of oceanographic activity and large gaps in between. Important research has been undertaken by individual researchers and organisations, but without a strong framework to promote collaboration or communication of data to the larger ocean observing community.

Part of the difficulty has been Australia's large size and the wide geographic spread of its comparatively small population. Attempting to study the nation's even larger marine territory is a challenge, but the relative isolation of regional work has weakened the inherent strengths of these individual efforts and their ability to provide a more holistic picture of what's happening in Australia's oceans.

As scientists begin to study climate change in earnest and to better understand the critical role of oceans as both an indicator of and contributor to climate change processes, the need for comprehensive marine data spanning all aspects of ocean science is essential.

This is where IMOS represents a critical cultural shift in ocean observing efforts. Under IMOS, the hindrance presented by widely dispersed oceanographic projects and isolated researcher-based proposals has been replaced by a community-wide approach bolstered by a national outlook, a more centralised structure, and better collaboration of regional marine research efforts. Equally important, IMOS will become another important link on the global stage.

Meetings with Regional Nodes and the IMOS Steering Committee

The IMOS Director Gary Meyers and Executive Officer Jo Neilson have recently attended a series of meetings around the country, visiting each of the IMOS regional Nodes as follows:

GBROOS Townsville 11 May 2007 – (leader) Peter Doherty

WAIMOS Perth 18 May 2007 – Chari Pattiaratchi

Bluewater Hobart 30 May 2007 – Ken Ridgway

NSWIMOS Sydney 4 June 2007 – Iain Suthers

SAIMOS Adelaide 12 June 2007 – John Middleton

Each of these meetings were well attended by researchers and government and industry representatives with interests in IMOS. Presentations were given by the scientists leading the facilities in each of the Nodes and all were well received by the research community. Thank you to all involved in organising and presenting at these meetings, which in total were attended by over 200 people!

Following these meetings, on 21 June the initial meeting of the IMOS Steering Committee was held via teleconference, and each of the Node leaders participated. The main items discussed were outcomes of each of the Node Meetings, Terms of Reference for the Nodes, the template for the annual report, subcontracts, progress with determining the moorings arrangements for each Node, plus a discussion on the preference for IMOS facilities to focus on sustained observations rather than process studies.

Charting Australia's Exclusive Economic Zone

In Australia, the need for marine data is even more imperative. At 16.1 million km2, Australia's ocean territory is one of the world's largest; yet its oceans are among the world's most poorly understood and least explored.

According to CSIRO, only about 5 percent of Australia's oceans have been mapped to show the physical undersea landscape, and only about 2 percent have been mapped to describe the various marine habitats. This is partly due to the fact that a significant part of Australia's ocean territory lies in the particularly hard-to-study Antarctic zone – where access is never simple, and research efforts are limited to the six months when the oceans are ice-free.

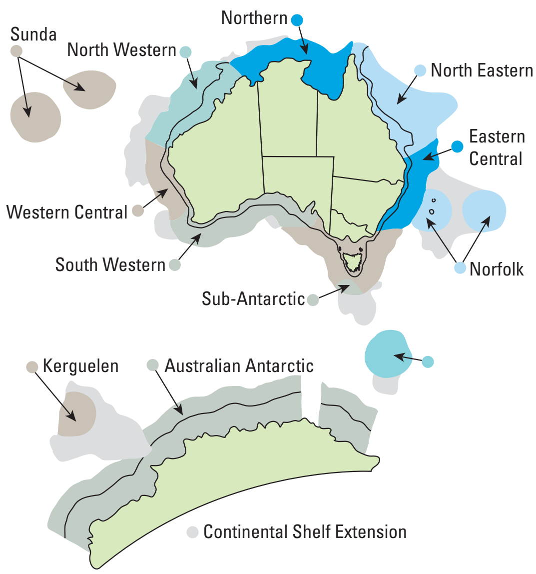
This has meant a critical knowledge gap in scientific understanding of both Australia's and the world's oceans. While some significant advances have been made in ocean exploration – in 2006, for instance, CSIRO's Wealth from Oceans Flagship and its partners created the first undersea map of all known mineral deposits in Australia's marine jurisdiction – many more mysteries still lurk beneath the deep, dark surface of Australia's seas. In the mid-1990's, for example, an extensive series of extinct underwater volcanoes known as the Seamounts was discovered off the southeastern coast of Tasmania. Now part of an undersea marine reserve, the Seamounts are saturated with unique flora and fauna, much of it unknown until recent exploration. Knowledge of Australia's marine biodiversity is also relatively limited. Over the past 20 years, more than 800 new species of fish have been found in Australia's marine territory – some located in major fisheries close to the country's most densely populated coastlines.

This lack of knowledge about its terrestrial seas has put Australia in the awkward position of potentially failing to comply with certain provisions of the 1982 United Nations Convention on the Law of the Sea – in particular, the rules pertaining to the Exclusive Economic Zone (EEZ) provision, a legal designation which gives a country rights to the sea zone extending 200 nautical miles from its coasts. Nations that sign the Convention gain special rights over the exploration and use of marine resources in their EEZ – but the law of the sea to which they are subsequently bound also imposes responsibilities to adequately conserve and manage those resources, both living and non-living, as well as to combat pollution and advance marine research.

Several of the Convention's articles deal with conservation and management of marine resources, but Articles 61 is a particularly crucial clause. It specifically addresses the "Conservation of the living resources" and spells out a country's obligations to ensure that the marine species it harvests are sustainably maintained or restored, and also not endangered by over-exploitation. According to S. Nandan of the UN's Food and Agriculture Organization, who wrote an essay explaining the Convention and its historical context, "in light of these management responsibilities, a coastal state which has claimed an exclusive economic zone cannot pursue a policy of inaction with respect to its living resources."

However, management efforts and wise use of the ocean's resources requires a reasonable knowledge of the marine environment. IMOS will help Australia better understand its EEZ by:

- boosting the amount of marine data available on Australia's ocean environments, species, and dynamics, which will aid researchers attempting to study and understand the country's hugely varied marine regions;
- centralising the coordination of diverse marine research initiatives around Australia – especially the deployment of essential ocean-observing instruments;
- facilitating communication among scientists and agencies studying the many disparate aspects of Australia's ocean characteristics and environment.
- helping Australia's marine industries and policymakers better understand Australia's marine resources so sustainable management practices can be developed; and
- targeting the Antarctic region by supporting the use of specific ocean observing instruments capable of operating in the challenging Antarctic marine environment, such as Argo floats – specially designed for deep ocean observation – that can collect data in Antarctic waters during ice-free months.



Map showing Australia's EEZ. The country's marine territory is twice as big as its landmass, and accounts for 4.4% of the world's oceans. (Map courtesy of the Australian Federal Police).

Additional Information

EEZ:
www.marine.csiro.au/LeafletsFolder/18aust/18.html

Minerals Map:
www.csiro.au/science/ps2es.html

ARGO Floats: automated divers of the deep

Dr Susan Wijffels

In oceans around Australia and the world, a growing armada of self-sustaining, autonomous floats is rapidly revolutionising the way oceans are studied. More like graceful sea turtles drifting with the deep sea currents than the pelagic birds who float above, these singular submersibles are taking the pulse of the oceans – measuring temperature and salinity necessary to detect changes in ocean chemistry – from inside the oceans themselves.

Known as Argo floats – a name inspired by the mythological tale of Jason and the Argonauts who sailed beyond the known world on a hero's quest – these novel profiling floats have indeed been charting new horizons of possibility in ocean observation and venturing where other ocean observing instruments have been unable to go before: into the upper portions of the open "bluewater" realm and into the remotest reaches of the world's ice-free oceans. Argo floats are also providing scientists with the first global measurements of ocean salinity – something previous technologies were unable to do.

Sporting long, slender satellite antennae on their tips, the floats vaguely resemble a curious cross between a small flourescent rocket and a marlin. But their mechanics are far less far-fetched. Based on simple neutrally buoyant float technology developed in the 1950s (with some additional modern retrofitting), the floats work by sinking to a depth of one to two kilometers and drifting underwater for 10 days, at which time they slowly ascend to the surface measuring temperature and salinity at regular intervals on the way up. At the surface, the floats linger for 12 to 18 hours transmitting their data to satellites, which is then sent in virutally real-time to weather and climate forecasting centers around the world.

The floats are allowing scientists to track everything from changes in ocean circulation and temperature patterns to interactions between ocean movements and large-scale weather and climate processes. The data being collected by these roaming robotic seafarers have been filling in critical gaps in world ocean measurements, and are already reshaping scientists' knowledge of how the oceans shape and are influenced by the Earth's complex climate system.

Dr Susan Wijffels (centre) stands with an Argo float next to John Gunn (left), Deputy Chief of CSIRO's Marine and Atmospheric Research Division, and Capt. Evan Solly (right), Master of the New Zealand research vessel Kaharoa, which has deployed more Argo floats than any other research vessel – more than 400 in the past three years in remote parts of the South Pacific and Indian oceans.

Annual Business Plan for 2007/08

A major job for the first year of IMOS was to inform DEST of our plans for the 2007/08 year. Information was provided by the facility leaders (and where applicable sub-facility leaders), and the director used this information to prepare the draft report to DEST. Following approval by the Advisory Board, the ABP was submitted to DEST on 31 May 2007. We are currently awaiting advice from DEST that the ABP has been accepted

Argo Meets IMOS

As one of the principal technologies in Australia's new Integrated Marine Observing System, the more established Argo program brings to the IMOS network nearly a decade's worth of technological development, operational experience in the oceans, and well-established international links. Argo also brings to IMOS the expertise of Dr Susan Wijffels, an oceanographer with CSIRO's Marine and Atmospheric Research Division, based in Hobart, Tasmania, who is heading the Argo program in Australia. Wijffels says that one key reason why Argo floats have been so important to ocean observation has to do with ocean demographics: the hard to study deep realm accounts for the majority of the world's ocean territory, in contrast to the smaller but more accessible shelf zone closer to shore.

"Most oceans are five or more kilometers deep, whereas the shelf is much wider than it is deep: about 100 to 150 kilometers wide and only about 50 to 100 meters deep," Wijffels says. "Thus, the physics and chemistry of the shelf are quite different to the deep ocean. The time scale and region are quite different, so we need a different observing system for the deep ocean."

Salinity and the Cold Seas

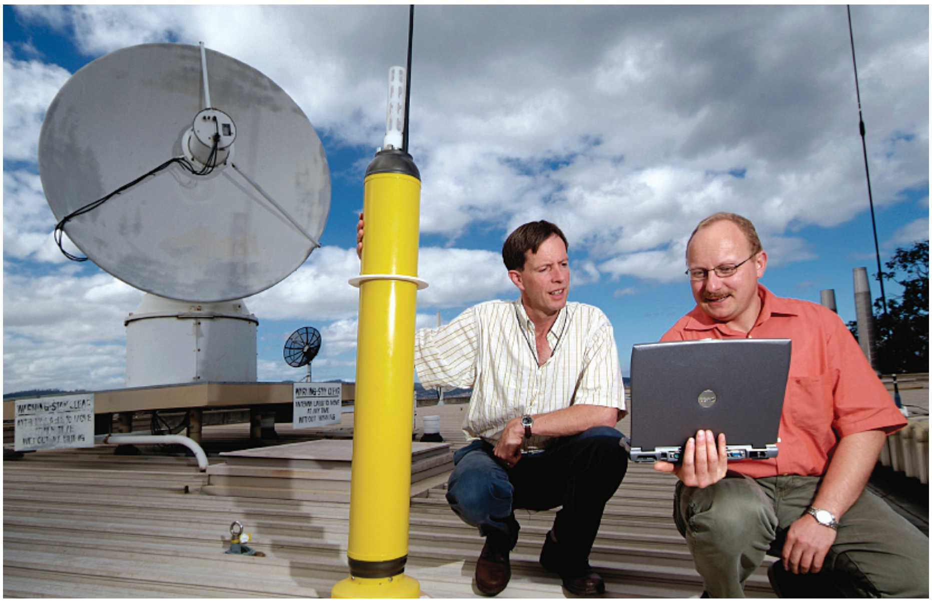
The ability of the Argo floats to capture salinity data has been especially important to study of changing ocean dynamics in the frigid Polar and Antarctic regions, where salinity plays a much bigger role in driving some of the large-scale deep ocean currents (which in turn affect the global climate system) than other factors like temperature, tides, or winds, which are more influential in warmer ocean basins. For instance, Wijffels says that the Global Overturning Circulation – sometimes called the "great ocean conveyor belt" and one of the pivotal ocean processes regulating climate, heat transport and carbon storage in the oceans, as well as the amount of nutrients and oxygen available to Antarctic ecosystems – is directly affected by salinity because of the Southern Ocean's unique role linking the polar currents with the world's major ocean basins.

Why is salinity so important? More broadly, salinity is a telling indicator of changing climate patterns. The earth's atmosphere doesn't process much moisture or heat, Wijffels explains. Instead, it cycles them through as rainfall or evaporation – which either dilutes or concentrates the salt minerals in water. With the increasingly dynamic weather happening because of climate change, more of this cycling is occurring.

"Thus, salinity reflects where there is a lot of evaporation and precipitation happening," Wijffels says. "Argo will allow us to directly track this for climate monitoring."

In the polar regions, because ocean water is colder, heavier, and denser, it tends to get trapped as "bottom water" under the lighter, less dense waters closer to the equator, limiting contact with the atmosphere and thus minimising the effects of those interactions. As a result, the influence of salinity is heightened in the colder seas.

"Many ocean currents are driven by a flow field and pressure gradient," Wijffels says. "Because these are weak at the poles, salinity is therefore much more significant, Thus, polar areas are very sensitive to salinity changes."



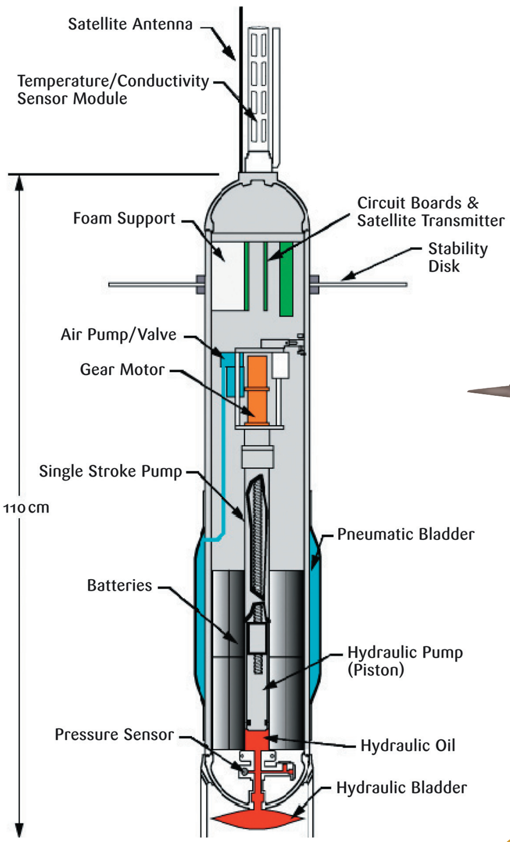
Argo is a system that bridges earth, space, and sea: real-time ocean data is sent to satellites, which is downloaded and analyzed by researches around the world. David Griffin and Andreas Schiller from CSIRO Marine and Atmospheric Research.

Argo Quick Stats

- Operating since 1998-'99 → involves 15 float-deploying countries and many more assisting
- Targeting: 3,000 total floats in the water worldwide → the global array is currently at 95% and should be completed this year
- Australia has 120 floats, but is targeting 240
- Worldwide, Argo floats take about 8,000 profiles per month
- Argo is providing scientists with the first global ocean salinity measurements.
- First Argo deployments made in the Indian Ocean by Australia in late 1999
- Sponsored by CLIVAR and GODAE

Because Argo floats operate independently and have a lifespan of four to five years, they can be deployed in these colder latitudes and left on their own to collect this critical salinity and temperature data, greatly reducing the amount of time and manual labor once required.

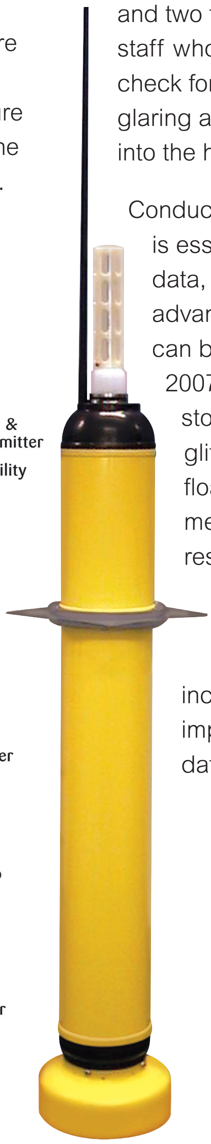
One major challenge still remains, however: sea ice. In the polar winters when sea ice spreads across the ocean surface, the floats become trapped and cannot yet transmit data through the ice to satellites. However, acoustically-tracked floats are providing an interim solution. An ice detection algorithm in the floats keeps them from attempting to surface when they're under ice. But scientists can still detect an acoustic signal emitted from the floats, allowing them to monitor where the floats drift while underneath. During this time, the floats store their temperature and salinity data until the spring when the ice melts and they are able to resurface.



How the Argo System Works

In essence, the Argo system is possible because of a dialogue between space and sea: ocean-bound floats communicating with satellites patrolling the perimeter of the planet. Four times per day, Argo centres around the world check for updated data, which comes in two forms: real-time data, typically used by weather forecasting centres; and time-delayed data put into a high-quality scientific format.

Wijffel's Argo crew is made up of a part-time operations officer, a couple of people doing technical work on engineering and deployment, and two full-time data quality staff who get the real-time data, check for inconsistencies or glaring anomalies, and put it into the high-quality format.



Conducting data quality checks is essential to ensure reliable data, because no matter how advanced, new technologies can be error-prone. In May 2007, *Nature* published a story about how a software glitch in a batch of Argo floats caused errors in profile measurements, leading some researchers to incorrectly declare that the oceans had actually cooled between 2003-05. The incident illustrates the critical importance of a rigorous data quality control process.

IMOS Advisory Board meeting

3 May 2007

The first meeting of the IMOS Board was held at the University of Tasmania on 3 May 2007. The Advisory Board Members are Dr. Trevor Powell (Chair), Dr. John Gould, Dr. Rob Lewis, Prof. Chris Marlin, Prof. Jason Middleton, Dr. John Parslow, Dr. Ian Poiner, Dr. Chris Simpson, and Dr. Neville Smith. Ex Officio members are Prof. Alan Canty, acting Pro Vice-Chancellor (Research), University of Tasmania and Prof. Gary Meyers, IMOS Director; Mrs Jo Neilson IMOS Executive Officer is secretary to the Advisory Board.

The meeting opened with an overview by Professor Canty of the bid process and thanking those involved. Board members were then given an opportunity to introduce themselves and provide detail on their background. The Chair then advised the meeting would focus on an overview of the totality of IMOS – where the issues are likely to be and how we will plan to manage these.

In particular, the role of the Advisory Board and gaining an understanding of the implementation were key outcomes from the initial meeting. The Advisory Board also reached in-principal agreement on the 2007/2008 Annual Business Plan, discussed the 2007 meeting schedule for IMOS, reporting, key performance indicators and arrangements for access to IMOS data.

The Path to Argo

Dr Wijffels became involved in Argo through her involvement with its predecessor, the WOCE (World Ocean Circulation Experiment) program – a 10-year project which at the time was the first and largest collaborative attempt to understand the workings of the oceans. WOCE also had a float program, an earlier and more simplified version of Argo, which originally sought to measure subsurface currents and their velocity.

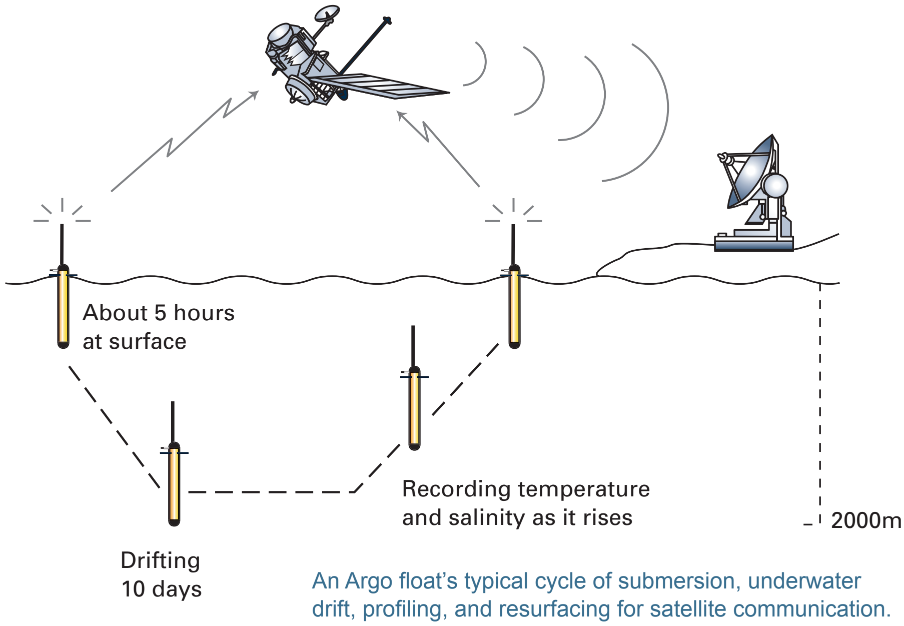
"This was very hard, because the waters were very turbulent," Wijffels says. "Also, the ocean is wide, and so we needed to invent a technology that could deal with the large span of the oceans."

Before Argo, the only way researchers were able to measure the interior workings of the oceans came from individual research vessel measurements and from temperature probes called XBT's dropped from commercial ships – a system that took years, depended on established merchant ship routes, and left huge gaps because of sparse cover and seasonal limitations. After eight years of laborious and expensive attempts to collect temperature and salinity data from aboard research vessels, researchers working with WOCE had the idea to try putting a thermister – an electronic temperature guage – on the end of the floats. Argo was but a short step away. Wijffels says that idea for Argo came into being at the end of WOCE, around 1998-'99 at international meetings.

"At the end of WOCE, we had a platform and were asking 'what next?' We thought we could build a really global ocean observation system, but we didn't know if the technology would permit it," she says. "There was the possibility of losing the global perspective at the end of WOCE. We were all getting really depressed . . . . Then the idea of Argo came about, and we thought: this is really important, it has to happen. We just can't go back to the bad old days studying regional climate variation."

Wijffels is hoping that over the four-year period of IMOS, the Argo program can be transitioned from private research funding, currently the primary source of money, to operational funding.

"The difference is that operational funding is sustained, whereas research funds are typically for a short-term, well-defined timeframe," she says. "A switch to operational funding would indicate the shift to a view that there is an ongoing need for this data."



An Argo float's typical cycle of submersion, underwater drift, profiling, and resurfacing for satellite communication.

Sub-contracts with research organisations now under negotiation

Subsequent to the initial funding being received (see "IMOS funding Agreement signed") the IMOS Office, in conjunction with the University of Tasmania Legal Officer Andrea McAuliffe has been focussing on preparing sub-contracts with the nine research organisations (CSIRO, Australian Institute of Marine Science, Sydney Institute of Marine Science, South Australian Research and Development Institute, Geoscience Australia, James Cook University, University of Western Australia, Bureau of Meteorology and Curtin University of Technology). The draft contracts were sent to these organisations on 22 June, and we are working to finalise these contracts to meet the requirement for transferring funding to those organisations who have been incurring costs on the anticipation of finalisation of the legal requirements. A big thank-you to Andrea for all her wise advice, and the time she spent on the IMOS contracts, during a time of major work-load for her due to the number of other recent grants the University has been successful with.

Facility feature: Coastal Ocean Radar

Dr Mal Heron

While Dr Wijffels uses Argo floats to plumb the depths of the remote deep oceans, Dr Mal Heron of James Cook University is focusing his efforts closer to shore, using new high-frequency coastal radar technology to deconstruct the complex inshore currents of Australia's coastal oceans.

Scott Heron stands next to a trench dug for a cable relaying power to one of the radar installations in the Coastal Ocean Radar network.

Unlike the itinerant ocean-dwelling floats, Heron can glean his insights into the geophysical dynamics of the coastal seas without ever leaving dry land.

As part of the IMOS project, Heron, a specialist in radio science and marine physics, is helping establish Australia's first national Coastal Ocean Radar network. Formally called the Australian Coastal Ocean Radar Network (ACORN), Heron is now the director of a system with exciting implications and widespread potential to help many aspects of coastal ocean research and management, from coral reef restoration and tsunami warning to pollution control and search-and-rescue efforts.

Mapping the Coastal Currents

Through a series of strategically placed radar poles installed along the back edge of beaches that send radio signals pulsing across the sea surface and receive the altered signal bits that scatter back, the radars can track the movements of coastal currents in a pie-shaped swath up to 150km out over the shore.

"We look at the Doppler shift, which is when you send out a radio wave to a moving target, and you get a different frequency returning back to you as it bounces off that moving target," Heron says.

He explains that when a radio wave is sent out across the ocean, it will scatter in all directions off the rough surface of the sea. Almost like a boomerang, however, some parts of the wave will bounce back toward shore and are detected by the radars.

"It's a very subtle change – maybe one-tenth of a Hertz," he says, adding for comparison that high-frequency radar waves are typically in the range of five to 30 mega-hertz. "If we look at a patch of water, and we average over all movements, that tells us the surface current. If we look at the individual bits, we get the surface wave structure."

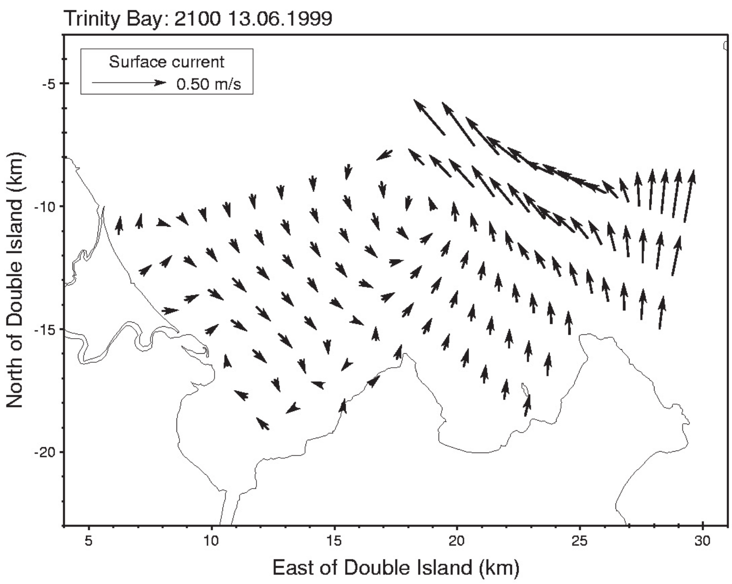
With the data, researchers can create maps of sea-surface currents, wave features, and ocean swells generated by the coastal ocean's intricate dynamics – factors which interact to affect everything from coral bleaching and fish migrations to pollution drift and deep ocean water movements. Describing and understanding these relatively undeciphered yet highly important shifting dynamics will help link study of deep ocean patterns with near-shore processes.

"We have the *BLUElink* model, and moorings," Heron says, in reference to a new national ocean forecasting program that recently came online, and other ocean observation tools. "What we don't have so well are the changes: upwellings from the deep ocean, or eddies – small-scale eddies that are difficult to model. We know large-scale currents around Australia, but we don't know the interactions and the small-scale details. . . . What we're doing is putting in a very important basic research layer,"

The idea behind ACORN is to provide a continuous, detailed map of the surface current which will be updated every hour.

"With ACORN, in a 150 km area, we'll have current measurements every 4 km by 4 km along the whole grid," Heron says.

The data, which is sent back to the university's lab every 10 minutes, will allow for highly detailed maps of the



An example of a current map generated by ACORN data.

currents from the shore out to the edge of the radars' range. Eventually, there are plans for a public website where surface current images would be freely available. The maps will potentially benefit many sectors of the community, from marine researchers to fishermen to tourist operators and the general public, who may simply want to know what's happening in local waters.

"We want to encourage community use," Heron says. "We want to be able to demonstrate at the end of IMOS that there is a community following."

Coastal Radar, Currents and Corals

The coastal radar network will eventually be unveiled at sites all around Australia, but the initial installations are taking place in areas within the Great Barrier Reef World Heritage Area where coral bleaching has been a concern.

In early April 2007, the first radar was installed on the beach at Tannum Sands, near Heron Island in the Capricorn Bunker reef group off the coast of central Queensland. A second set was installed in May a little further south in the reef at Lady Elliot Island.

With its ability to track and describe current movements, coastal radar has huge potential to aid reef restoration and protection efforts.

"If we know the current, we'll know the transport path of [coral] larvae from reef to reef," Heron explains. "So, if we completely lose the corals on one reef, we'll know that it will regenerate from

Aerial view of the radar set-up at Tannum Sands. The four transmitters are at the southern end and 12 receivers are sited along an arc to the north. Each antennae is connected by cable to the control station (the red square).

brood stock on another reef, and then we'll know which are the nursery reefs."

Heron says that knowing current movements can also help researchers determine which reefs are likely to be susceptible to coral bleaching.

"On the Great Barrier Reef, some parts . . . have typically high currents – they're high turbulent areas. These areas are unlikely to get coral bleaching because the surface layer of water never gets too warm," he says. "But, if there are no currents, the coral is susceptible to bleaching because the warm water just sits on top."

This information can help researchers target reef areas – especially nursery reefs – in need of extra protection. In Palau, for instance, current interactions enabled researchers with the National

Oceanographic and Atmospheric Administration to pinpoint the more dynamic, high-current areas in the lagoon likely to be the location of nursery reefs for the entire area.

"Now there's a plan to protect those reefs because they're more resilient," Heron says.

Corals are also vulnerable to various forms of pollution, often resulting from human actions. Knowledge of current movements can help researchers and regulators anticipate pollution drift and make more informed decisions about waste management or the siting of new coastal industries.

Site Selection Challenges

Although coastal radars operate from land, and thus avoid the deployment challenges other ocean observing instruments can present to researchers who have to reckon with the wily seas, ACORN technology presents unique set-up challenges of its own. Heron says that site selection for the radars is the single hardest and most important decision.

"In general, the areas chosen, well it's quite challenging, actually. The site has to have power, telephone and be without obstruction looking towards the beach. We have to decide which technology is best to use," Heron says, referring to the fact that coastal radars come in two varieties: those with short antenae, which take up more space because there are more of them, and those with higher antennae which occupy less space.

There are benefits and drawbacks to both varieties. The small footprint antenna radars, developed in the U.S., are more discreet on a beach, safer from damage by the elements, and less noticeable to potential vandals – all benefits which need to be considered for set-ups on metro beaches. However, these radars can't map wind and wave measurements. The bigger footprint radars can take those important measurements, but they need more space generally to set up. At each

Example of a coastal radar receive antenna installed on dunes at the back end of a beach. This one islocated on the Eastern U.S. coast. (Photo courtesy of Rutgers University Coastal Ocean Observation Lab, New Jersey, USA).

site, the radars are installed in pairs – one radar to transmit signal, one to receive – and the bigger radars require about 20m of space between them.

"The big one spans 200m of beach," Heron says. "Now, if you've got a coffee shop or café, you simply can't put lots of cables and poles in, so if you're at a metropolitan site, you have to go for the small one."

Heron says that Australia will have both varieties, depending on the location. Researching the ideal site can take time, however, and there is still a chance of unseen obstacles.

"Sometimes when you look on Google maps at a site, you may think it's okay, but it's not really when you get there. It's scrubby, you may have to minimise vandalism, so you have to look for evidence of graffiti," Heron says. "If it's on private land, it's normally safer. Also, landowners will have some interest in the work. But, if it's private land you also have to pay some fees."

Heron says that these seemingly nitty-gritty details are the most important decisions to ensure the system will work, and so far, he has been doing most of that grunt work himself.

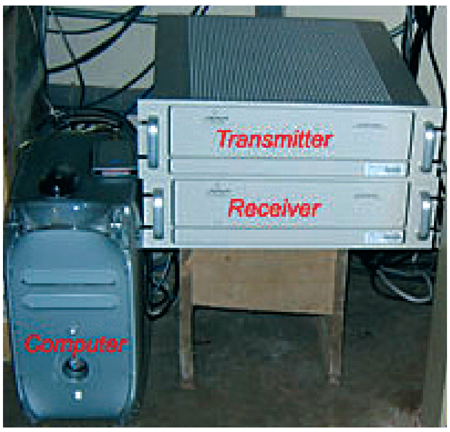
"Because if you choose the wrong site, the technology may not work properly – for instance, a fence pole happens to be in the wrong place," he says.

To emphasise his point, Heron recounts an incident in the U.S. where researchers installing a coastal radar set-up, who thought they had been scrupulous in their site selection, were repeatedly unsucessful getting the system to work.

"Old railway lines were buried in the ground," Heron says. "The researchers tried everything to get the system to work, but didn't realise there was metal interfering. This is important, because radio waves are affected by metal."

In addition to the time-consuming process of selecting a site, the actual set-up and installation can be fairly gruelling as well. Obstructions have to be cleared, if there are any, so the radars have a clear, unfettered view out to sea; trenches to bury the cable lines must be dug by hand; and electronic components must be properly wired.

"Setting up and installation is a fairly big deal," Heron says. "For the first one at Tannum Sands, we had to hand-dig trenches, about 1 km of trench for the cable. It took a week to do the install, and it was full-on that week."



The technological side of a coastal radar set-up: the transmitter sends radio signals out to sea; the receiver records the frequencies that have bounced back. A computer is necessary to communicate with the James Cook University labs.

Coastal Radar Plan for IMOS

Over the next four years, coastal radars will be installed at sites across Australia with the $5.46 million in funding allocated through IMOS. After Lady Elliot Island, the next radars slated for installation will be in South Australia, around Eyre Peninsula and Kangaroo Island, followed by set-ups in Western Australia from Perth to Jurien Bay.

"We're interested in the exchange between the Southern Ocean and the continental shelf," Heron says. "This is one of the main tuna fishing areas. It's a multi-million dollar industry, which is one reason for the S.A. research."

He hopes the S.A. and W.A. sites will be ready for installation by the beginning of next year, and running smoothly by the mid-year. Other plans for coastal radars in Queensland, Tasmania, New South Wales, and additional sites in South Australia, are subject to approval by IMOS.

The initial coastal radar proposals selected for funding – in the Great Barrier Reef, S.A., and W.A. – were "the most mature proposals with good science." These already had some of their own funding, and had also already passed through the usually time-consuming peer review process.

Right from the beginning of Heron's musings on bringing coastal radar to Australia, he says he had Heron Island in mind. When he learned about IMOS from CSIRO's Wealth from Oceans National Research Flagship, he decided to make a proposal for ACORN.

"I found out that a few people around Australia were interested in having HF radar," he says. "I decided to make a proposal to integrate the activities. IMOS rather liked the concept, and away we went from there."

11 National IMOS facilities:

1. Argo Australia: a fleet of ~200 profiling floats observing ocean physics to 2000m, part of a larger global program (argo.jcommops.org)

2. Enhancement of Measurements on Ships of Opportunity: a set of underway observing systems for physical, chemical and biological oceanography on volunteer observing ships.

3. Southern Ocean Automated Time Series Observations: a set of moored biogeochemical and ocean weather instruments in the Sub Antarctic Zone.

4. Australian National Facility for Gliders: a multisensor system similar to an Argo float, which can traverse as well as profile, and is operated from a land base.

5. Australian National Autonomous Underwater Vehicle (AUV) Facility: used for high resolution surveys of benthic habitats.

6. Australian National Mooring Network: a network of national reference stations, plus regional moorings on shelves and slopes.

7. Australian Coastal Ocean Radar Network: for high resolution mapping of coastal currents.

8. Australian Acoustic Tagging and Monitoring System: curtains of receivers to monitor movements of tagged marine animals.

9. Facility for Automated Intelligent Monitoring of Marine Systems: a communications system on the barrier reef, facilitating the delivery of data from sensors to the scientists in real time.

10. eMarine Information Infrastructure (eMII): responsible for hosting, managing, distributing and archiving IMOS data.

11. Enhancing Access to Australian Ocean Remote Sensing Data: to make satellite products to support research in Australia's regional waters.

For a more detailed overview of the national facilities and their operators, visit the IMOS website: **www.imos.org.au**

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 Ms Tamsyn Jones. Tamsyn is a journalism student at the University of Tasmania and is visiting on an international Rotary exchange program.