

The Australian Integrated Marine Observing System (IMOS)

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Background to IMOS

The Integrated Marine Observing System aims to observe the oceans around Australia to meet the national and international research needs. Australia has one of the largest marine jurisdictions of any nation on earth. At over 14 million km² Australia's Exclusive Economic Zone (EEZ) is nearly twice the surface area of the Australian continent. It extends from the tropics to high latitudes in Antarctic waters and much of it is unexplored.

The surrounding Pacific and Indian Oceans strongly affect the continental climate-system at all time scales, from seasons to decades. The major ocean currents on its eastern, western, northern and southern boundaries, best known of these being the East Australian Current (EAC) and the Leeuwin Current affect regional climatic conditions and help sustain the marine ecosystems. There is evidence that these currents are changing on decadal time scales and have already impacted marine ecosystems, but the data is sparse and neither the currents nor ecosystems have been monitored in a systematic way.

IMOS Funding

The Integrated Marine Observing System (IMOS) was established in 2006 as part of the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS) with \$A50M and \$44M in co-investments from Universities and government agencies over 5 years. An additional \$52 million of federal funds over 4 years were secured in 2009, as part of the Education Investment Fund (EIF) Super Science Initiative to enhance the existing observing system, and extend into Northern Australian and Southern Ocean waters. Such an investment is testament to the early success of IMOS and a proactive marine community that prepared by consensus a policy document entitled *A Marine Nation: A National Framework for Marine Research and Innovation*. The community consultation and planning for the enhancement and extension of IMOS is currently underway.

IMOS Goals

IMOS is a nationally managed and distributed set of equipment established and maintained at sea, providing streams of in situ oceanographic data and information services that collectively will contribute to meeting the

needs of marine research in both open oceans and coastal oceans around Australia. Combined with satellite data, it provides essential in situ data to understand and model the role of the oceans in climate change, and data to initialize seasonal climate prediction models. If sustained in the long term, it will permit identification and management of climate change in the coastal marine environment. It will provide an observational nexus to better understand and predict the fundamental connections between coastal biological processes and regional/oceanic phenomena that influence biodiversity. While as an NCRIS project IMOS was designed to support research, the data streams are also useful for many societal, environmental and economic applications, such as management of marine natural resources and their associated ecosystems, support and management of coastal and offshore industries, safety at sea, marine tourism and defense.

The IMOS strategic research-goal is to assemble and provide free, open and timely access to streams of data that support research on:

- The role of the oceans in the climate system, and
- The impact of major boundary currents on continental shelf environments, ecosystems and biodiversity.

The Value of IMOS

Given the extent and challenge of addressing the broad range of marine issues in the Australian EEZ, IMOS is considered only the beginning of the observing system that Australia needs. The cost of an adequate observing system will be high due to the great length of coastline and the relatively small population and economy. Never-the-less, staged enhancements are being planned. The return from investing in ocean observations around Australia was estimated through an economic analysis undertaken in 2006 by the Australian Academy of Technological Sciences and Engineering and the Western Australian Global Ocean Observing System Inc. (*Economics of Australia's sustained ocean observation system, benefits and rationale for public funding*). That study, based on only a limited set of benefiting industries concluded that the cost:benefit to the Australian economy of investing in ocean observations was better than 1:20.



Figure 1. The IMOS data facilities and their regional node implementation

IMOS Governance and implementation

Governance of IMOS is controlled by an Advisory Board with an independent Chair. The Board members are appointed for outstanding abilities to guide the program and are senior leaders able to take a broad, national perspective on IMOS development. The IMOS Office established at the University of Tasmania coordinates and manages all of the investments as a national system.

The scientific rationale for IMOS is set by five regional Nodes covering the Great Barrier Reef, New South Wales (southeastern Australia), Southern Australia, Western Australia and the Bluewater and Climate Node (Fig. 1). Each Node has 50 to 100 members. The Node Leaders and the Director of the IMOS Office are members of the IMOS Steering Committee. Nine national Facilities under direction of the IMOS Office make the observations specified by the Nodes using different components of infrastructure and instruments, for example there are separate facilities for Argo floats, ships of opportunity, coastal radar, etc. The observing facilities include three for *bluewater and climate observations* (Argo Australia, Enhanced Measurements

from Ships of Opportunity and Southern Ocean Time Series), three facilities for *coastal currents and water properties* (Moorings, Ocean Gliders and HF Radar) and three for *coastal ecosystems* (Acoustic Tagging and Tracking, Autonomous Underwater Vehicle and a biophysical sensor network on the Great Barrier Reef). The operators of the facilities are the major players in marine research in Australia. A satellite remote sensing facility assembles data for the region and the electronic Marine Information Infrastructure (eMII) provides access to all IMOS data, enhanced data products, and web services in a searchable and interoperable framework. Recognizing the importance of access to data in eResearch, the Director of eMII also is a member of the IMOS Steering Committee. The value from this infrastructure investment lies in the nationally coordinated deployment of a wide range of equipment aimed at deriving critical data sets within a region that serve multiple applications. Implementation of IMOS facilities began in 2007, and over 90% of the planned infrastructure has now been deployed. Free and open access to IMOS data streams in near real time is available through the IMOS Ocean Portal on IMOS website.

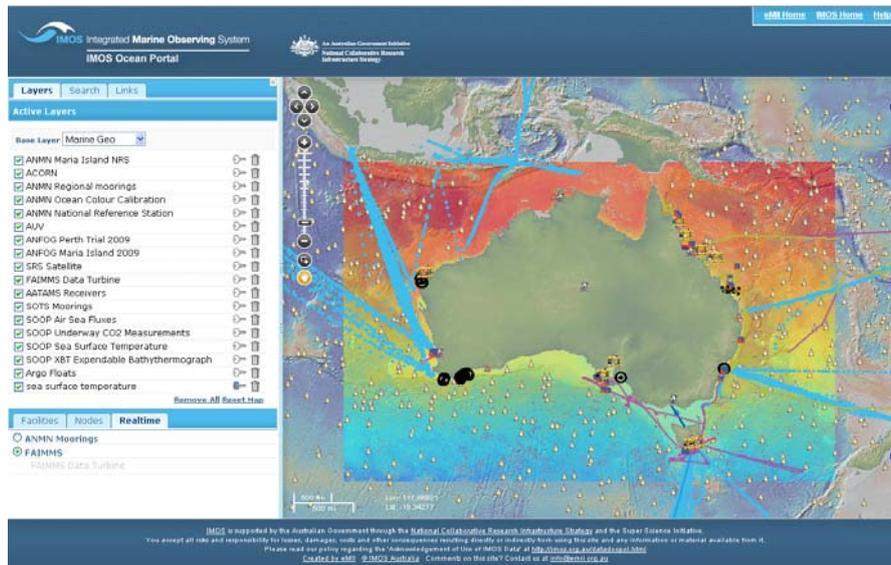


Fig. 2 The IMOS Ocean Portal; providing free and open access to all IMOS data through the IMOS website <http://www.imos.org.au>

IMOS 5 year strategy (2009-2013)

Moving forward, IMOS will focus its development on 10 strategic priorities;

1. *Ongoing development of a coherent, well-positioned Bluewater and Climate Node*

Sustained observing is crucial to improved understanding the oceans' role in the global climate system, how the system is changing, and the potential impacts of change. IMOS has two important responsibilities here. Firstly, through the Bluewater and Climate Node, to provide a mechanism for Australia to articulate its national, strategic approach to observing in the Southern, Indian and Pacific oceans. And secondly, to address critical gaps in the observation record through its Facilities. In response to the May 2009 Federal Budget decision, enhanced monitoring capability in the Southern Ocean, and extended coverage in northern Australian waters, will be priorities. Opportunities provided by a replacement blue-water research vessel capable of going to the ice edge should also be considered.

2. *Impact and delivery through improving model output (BLUElink, ACCESS, other)*

Australia is at the forefront of international developments in operational ocean forecasting and analysis (through BLUElink, and now GODAE Oceanview), and climate analysis (through Australian Community Climate and Earth System Simulator (ACCESS)). IMOS will engage with these modelling communities to ensure that its observing strategy is supporting the validation and development of national ocean modelling initiatives. Moving more data streams

to real time will be an important element, noting that reanalysis of delayed mode data is also valuable. The potential for these models to feed back into improved observing system design (e.g. through simulation experiments) will also be investigated. Engagement will be extended to the modelling communities developing shelf-scale models (e.g. of the GBR), which have the potential to encompass whole-of-boundary-current approaches under the 'ribbon model' concept under development at CSIRO. Consideration will also be given to whether IMOS observations can contribute to the development of ecosystem models, noting that national acceptance of these approaches is currently much less advanced than for the physics, and less advanced than for the biogeochemistry.

3. *Providing a national backbone for observing boundary currents*

A focus on the impact of major boundary currents on the continental shelf will be maintained. IMOS will need to ensure that there is a coherent national strategy for monitoring the major ocean currents on our eastern, western, northern and southern boundaries, the best known of these being the EAC and Leeuwin. Progress with developing a 'backbone' of national reference stations, satellite remote sensing data/products, and information infrastructure (through eMII) will be reviewed and strengthened as necessary. Opportunities provided by a replacement blue-water research vessel operating 300 days per annum around the coast of Australia should also be considered. The objective here will be to ensure that all marine and climate science communities around Australia are as well-supported as possible by the national-level investment

provided through IMOS. International developments will also be examined through engagement with Panel for Integrated Coastal Observations (PICO) and related initiatives such as US-IOOS and EuroGOOS.

4. *Ongoing development of Regional Nodes*

The four existing Regional Nodes will be further developed, and integration between these nodes will be based on the IMOS strategic goal for coherent monitoring of Australia's boundary currents.

- Engagement with all State and Territory Governments is essential in the ongoing development of Regional Nodes. So too is engagement with the Universities and National Agencies working in the Regions.
- New Regional Nodes will be developed if necessary, noting that Nodes require a clear science rationale, a formal structure and resources to sustain themselves.

5. *Continuing to build institutional strengths into national capability*

IMOS has been successful in pooling the institutional strengths of individual Operators to create national capability supporting all Australian marine and climate science. NCRIS/EIF funding provides both the incentive and the means for this to occur. Because the Operators of Facilities and Sub-Facilities are funded under the IMOS model, there has been some tendency in the early stages to focus on 'who's getting the money'. As IMOS matures the focus is now, quite correctly, shifting to 'who's using the data'. In making this necessary transition, it will be important to continue working closely with current and prospective Operators. If our forward plans are to be successfully implemented, IMOS must ensure that the future data requirements of Nodes are well-aligned with the future observing capabilities and interests of current and prospective Facility Operators. Careful consideration of capability requirements will be required as we finalise plans for investment of new funding during 2009, including the feasibility of growing particular capabilities in relatively short timeframes.

6. *Exploring the potential for whole-of-system approaches*

In addition to striking an appropriate balance across space and time scales, IMOS is challenged to make wise decisions about what variables to observe, and how. This is fairly well-defined for the physics, and maturing for the biogeochemistry, but it remains quite unclear for the biology. Nevertheless, a national-scale, integrated, marine observing system needs to strive to provide the data streams required to support the whole-of-system approaches we now know are required for

successful management in the marine domain. Potential in this area will be further explored through multiple pathways, including:

- Reviewing achievements of existing activities with an ecosystem focus.
- Exploring the potential of new methods and approaches.
- Monitoring international developments in integration across physics and biology.
- Engaging with national debates about development of indicators for marine systems (e.g. for Bioregional Planning and Management, Commonwealth/State interest emerging through Marine and Coastal Committee (MACC), and the proposed National Environment Information System (NEIS)).
- Greater engagement with other NCRIS Activities, the Atlas of Living Australia (ALA) and the Terrestrial Ecosystem Research Network (TERN), with a focus on the discoverability and interoperability of biological data streams.

A risk associated with the climate/coastal model adopted by IMOS is that pelagic ecosystems are not particularly well-catered for. Thinking this through from a strategic research perspective, as for the major boundary currents, may be productive.

7. *Driving down the cost per observation*

Demand from the marine and climate science community will always exceed our ability to provide observational data. The community-driven science planning provided by the IMOS Nodes is the primary mechanism for dealing with this issue. However IMOS will also have an explicit focus on driving down the cost per observation over time. New methods and approaches will be investigated, and new Facilities may be spawned. Existing Facilities working with new technologies will be actively matured, and multi-sensor platforms utilised as appropriate. Where necessary, inefficient approaches will be discontinued.

8. *Creating and developing the information infrastructure*

From its inception, IMOS has had a clear focus on the need for information infrastructure development, and has allocated significant resources to the task through the eMII Facility. This will continue to be a high priority, though there is likely to be more emphasis on integration and value-adding now that the data streams are flowing. eMII has a strong relationship with the 'Platforms for Collaboration' component of NCRIS, and growing relationships with related NCRIS priority areas (e.g. TERN, AuScope and ALA). The IMOS information infrastructure has also been designed to

provide the basis for an Australian Ocean Data Network (AODN) to serve all of Australia's ocean data needs.

9. Ensuring the data is actually used

For IMOS, the ultimate measure of success will be use of the data streams by the Australian marine and climate science community. Nodes have been the primary mechanism for facilitating uptake to date, but as more data becomes available for longer, other mechanisms will be developed. Data User Workshops have commenced, and engagement with University partners running marine and climate science programs looks to be fertile ground. IMOS is a research infrastructure program, and so the primary audience for IMOS data is the research community who then use this data to meet the needs of their stakeholders and clients. However every effort will be made to ensure that IMOS data streams are as useful as possible, and government and industry stakeholders will be engaged via the Nodes, and directly where appropriate.

10. Partnering for sustained ocean observing

Co-investment by partners (Operators, Collaborators, State Governments, Industries and other Commonwealth Government portfolios) is inherent in the IMOS model. The new EIF funding provides an opportunity for existing and prospective partners to co-invest in the enhancement and extension of IMOS to further their own interests within a national strategic approach. Investments required to create and develop the research infrastructure, and ultimately to establish an operational ocean observing system, will need to be considered. Both will be necessary if Australia, with the third largest ocean territory on Earth, is to play a meaningful role in achieving the global vision for ocean observing.