IMOS Integrated Marine Observing System

'Building on our strengths'

IMOS
Five Year Strategy
2009-13

Australian Government
Department of Innovation Industry, Science and Research

IMOS is supported by the Australian Government through the National Collaborative Research Infrastructure Strategy and the Super Science Initiative

IMOS is a national, collaborative project, led by the University of Tasmania on behalf of the Australian marine & climate science community

UTAS

Executive Summary

This Five Year Strategy is intended to consolidate the strengths of IMOS established during its initial phase, and to provide a clear framework for making decisions about enhancing and extending Australia's integrated, marine observing system out to June 2013, and well beyond.

The Strategy reflects on the background of IMOS, from mid-2005 to mid-2009, in order to ensure that fundamental design principles are not under-played or forgotten as we work through the important but complex task of deciding just what to observe, how, where and when. These design principles are:

1. The need for linked global and coastal components,
2. The need for strong international engagement in the global (ocean basin/climate) component,
3. The need for a coastal component integrated via a national backbone & regional nodes, and
4. The need for national consensus on data delivery and ongoing feedback into design, so as to ensure uptake and use.

It reaffirms the goals of IMOS, established during 2006-7. While much detail has changed since that time, the goals remain the same. The IMOS goals are:

1. To provide sustained ocean observations that meet the broad needs of the Australian marine and climate research communities,
2. To provide the marine and climate research community with free and timely access to quality assured observational data, and
3. To involve the marine and climate research community in defining future needs and to strengthen the technical and operational capability of the marine and climate community and hence sustain the ocean observing paradigm into the longer term.

The initial IMOS Plan (2007-11) is revisited, and it is argued that by all objective measures, the establishment of IMOS using Nodes and Facilities has been a success. This Five Year Strategy is built on the continuation of a Node and Facility structure, where Nodes will provide the scientific rationale and Facilities will enable the development of national capability in sustained ocean observing.

Investment parameters are outlined, covering initial funding, co-investment and new funding. While the quantum of new funding is impressively large, attention is given to the trade-off between the cost of taking on new observations and data streams, and the cost of sustaining the current suite of observations and moving towards real time. The importance of co-investment is emphasised.

Key lessons learned are noted. Major changes in the operating environment and significant, recent developments (nationally, regionally and globally) are identified.

Based on the background and goals, ongoing commitment to a Node and Facility structure, the investment parameters, lessons learned, changes and developments, ten strategic priorities have been identified for IMOS.

In summary, the IMOS Strategy will be to drive a national, collaborative approach to sustained ocean observing, designed to answer big science questions posed through the Nodes. Integration across time, space and depth scales, across physics, chemistry and biology, and between observing and modelling, will be further developed. The aim will be to enable open and timely use of data streams via an Australian (ocean) research data commons. Strong, mutually-beneficial partnerships between the institutions that make up the marine and climate component of the National Innovation System will be fundamental. The ten strategic priorities are:

1. Ongoing development of a coherent, well-positioned Bluewater and Climate Node
2. Impact and delivery through improving model output
3. Providing a national backbone for observing boundary currents
4. Ongoing development of Regional Nodes
5. Continuing to build institutional strengths into national capability
6. Exploring the potential for whole-of-system approaches
7. Driving down the cost per observation
8. Creating and developing the information infrastructure
9. Ensuring the data is used
10. Partnering for sustained ocean observing

Decisions already made about investment of the first $8 million (M) of new funds are outlined. Although these decisions had to be made in advance of the Strategy being finalised, they are shown to be well-aligned.

This Five Year Strategy will inform, and be informed by, the process for finalising decisions about the new funds and related co-investment. It will be evolved during 2009 in the spirit of national collaboration that underpins the existence of IMOS.

Tim Moltmann, IMOS Director **11th September 2009**

1. Introduction

IMOS commenced operation in May 2007, funded for four years to June 2011.

In the Federal Budget of May 2009, IMOS was provided with an additional $52M. This will enhance its operation for the second half of the initial funding period (2009-11), and extend it to June 2013.

The Federal Budget decision provides strong reconfirmation of the initial IMOS Plan, and further direction in terms of requirements for enhanced monitoring capability in the Southern Ocean, and extended coverage in northern Australian waters.

This decision is a significant milestone in the creation and development of the research infrastructure required to enable sustained observation of Australia's vast ocean territory under changing climatic conditions.

It coincides with:

- a mid-term review of IMOS 'Phase I', and
- the IMOS Ocean Portal going live - we now have a critical mass of equipment in the water, and the information infrastructure in place to ensure that all IMOS data is discoverable, usable and deliverable over the internet.

As such, it is timely to re-establish the forward strategy for IMOS.

The purpose of this Five Year Strategy (2009-13) is to ensure that the Australian marine & climate science community has an agreed approach to ocean observing that builds on the strengths of national collaboration, adapts to new knowledge gained as we observe our oceans, and responds to emerging global trends.

(N.B. All acronyms and abbreviations are spelt out when first used in this document. A 'List of IMOS Acronyms and Abbreviations' is also provided as Attachment 1.)

2. Background

Planning for the creation of an Australian integrated marine observing system began in 2005. The Oceans Policy Science Advisory Group (OPSAG) formed a working group 'to consider options and needs for Australian ocean observations, and to prepare a proposal for an Australian Integrated Ocean Observing System (AusIOOS)'. AusIOOS was intended to support both the research and operational service communities. The AusIOOS Working Group reported in May 2005 – see http://www.cmar.csiro.au/publications/docsandreports/AusIOOS_WG_FinRep.pdf

Consistent with international trends, the AusIOOS Working Group recommended:

1. two linked components in global (ocean basin/climate) and coastal,
2. strong international engagement in the global component,
3. a coastal component integrated via national backbone & regional nodes, and
4. national consensus on products and user feedback into ongoing design.

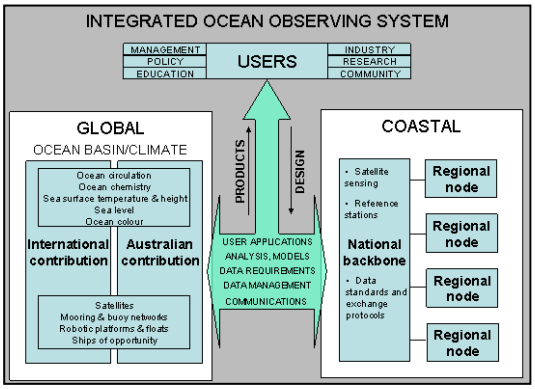

Figure 1 – AusIOOS recommendation

The process undertaken to develop the AusIOOS report meant that Australian marine and climate science was well-positioned to engage with development of the National Collaborative Research Infrastructure Strategy (NCRIS). When the NCRIS Roadmap was released in February 2006, one of the (16) priority capability areas was an Integrated Marine Observing System. It is important to note that, as a research infrastructure program, NCRIS only addressed the research component of the AusIOOS vision, not the operational services component.

In response to the NCRIS Roadmap, Dr Trevor Powell was appointed to facilitate development of an IMOS Investment Plan (November 2006) which laid the basis for the initial IMOS Funding Agreement (May 2007) - see http://imos.org.au/fileadmin/user_upload/shared/IMOS%20General/documents/internal/IMOS%20Funding%20Agreement%20Signed%20Contract-small.pdf

The IMOS Office was established at the University of Tasmania in February 2007, and Professor Gary Meyers appointed as the founding IMOS Director.

The NCRIS Roadmap was reviewed in August 2008. It highlighted the recent expansion of Australia's marine jurisdiction, and noted that 'a long-term commitment to a sustained and enhanced IMOS is necessary to delivering the capability required to understand and manage Australia's marine environment' – see http://ncris.innovation.gov.au/Documents/2008_Roadmap.pdf

IMOS was then enhanced and extended in the May 2009 Federal Budget – see http://www.innovation.gov.au/General/Corporate/Documents/supersciencemarineclimate_budgetfactsheet0910.pdf

3. The Goals of IMOS

IMOS was established 'to transform the way in which marine observational data is collected, from the current fragmented research proposal or institutional driven basis, to one in which the acquisition and provision of critical observational data on Australia's ocean environment is determined by a national strategic approach'.[1]

This national strategic approach is designed to:

- 'provide the long term context for research into environmental change in the ocean,
- allow specific research studies to be conducted in a global, national and regional context, and
- allow oceanographic and associated biological phenomena to be investigated at a geographic and temporal scale that has hitherto been extremely limited'.[2]

It was also noted that 'Implementation of IMOS will be a step towards the establishment of an operational observing system leading to ocean forecasting services analogous to meteorological services'.[3]

The goals of IMOS are:

1. 'To provide sustained ocean and associated observational data and infrastructure capability that meets the broad needs of the Australian marine, oceanographic and climate research communities,
2. To provide free and timely discoverability of and access, by electronic means, to quality assured observational data to the marine research community, and
3. To involve the marine and climate research community in defining future needs and to strengthen the technical and operational capability of the marine community and hence sustain the marine observing paradigm into the longer term'.[4]

These goals, as articulated in mid-2007, remain valid for the period 2009-13.

[1] IMOS Project Plan, Attachment A to the 2007 Funding Agreement, Section 4.4 - Project Goals and Evaluation
[2] ibid
[3] ibid
[4] ibid

4. The Initial IMOS Plan (2007-11)

Through the facilitated, national process that gave rise to IMOS, two fundamental constructs emerged that enabled the marine and climate science community to determine what needed to be done, and how best to do it. These came to be known as Nodes and Facilities.

Nodes are the construct that has enabled IMOS to move away from a 'fragmented research proposal or institutional driven basis', to a 'national strategic approach'. The initial IMOS Plan described the role of Nodes as follows:

> *The Nodes play a critical role in IMOS and developing the Nodes will be a major task during the first 18 months of IMOS. Nodes in IMOS represent the scientific opinion of the marine research community. They provide the scientific rationale for IMOS, develop research goals and identify the need to obtain specific streams of data. The Nodes will also regularly provide advice to the IMOS Office on assessment of the technical implementation of IMOS and scientific merit of research undertaken with IMOS data. The Nodes will be required to integrate regional research objectives into a national scientific perspective on marine-observing. Finally Nodes will provide advice on the strategic review to be held in early 2009.* [5]

Consistent with the original AusIOOS recommendation, the science community established:

- a Bluewater and Climate Node, and
- Regional Nodes in the Great Barrier Reef, New South Wales, Southern Australia, and Western Australia.

Key points to note are as follows:

1. The four regional Nodes that emerged did so because local conditions were conducive to those science communities developing a science rationale to address questions of regional relevance within a national/global context i.e.
    a. in the GBR though a focus on the Great Barrier Reef World Heritage Area,
    b. in NSW via the Sydney Institute of Marine Science (SIMS),
    c. in SA through Marine Innovation South Australia (MISA), and
    d. in WA via the Western Australian Marine Science Institution (WAMSI) and its forerunners.
2. Nodes were required to have a formal structure, and the ability to marshal the resources (people, time and money) required to sustain themselves.
3. It was acknowledged that the Nodes were at varying levels of organisation, and would require further development.
4. It was acknowledged that there were gaps in the Node structure, and that development of new and/or expanded Nodes would be encouraged.

Coherence across the regional Nodes has been managed by having a strategic research focus on 'the impact of major boundary currents on continental shelf environments, ecosystems and biodiversity'.[6] The coastal 'national backbone' was not established as a formal construct.

[5] IMOS Project Plan, Attachment A to the 2007 Funding Agreement, Section 4.3 – Specific Roles
[6] 'The Australian Integrated Marine Observing System', Journal of Ocean Technology 2008, Vol. 3 No. 3, p81

Facilities are the construct that has enabled IMOS to leverage the fragmented ocean observing capability that existed across Australia, and build it into a suite of national facilities with critical mass, playing to institutional strengths, and providing the sustained observations to address big science questions posed via the Nodes. A key requirement of the Operators of Facilities was that they had or could develop the capability required to sustain marine operations over time.

A summary of the 11 Facilities funded under the initial IMOS plan is as follows:

Facility	Operator(s)	Capability
Bluewater & Climate Facilities		
Argo Australia (Argo)	Commonwealth Scientific and Industrial Research Organisation (CSIRO)	National leader in this successful global program
Enhanced measurements from Ships Of OPportunity (SOOP)	CSIRO, Australian Institute of Marine Science (AIMS), Bureau of Meteorology (BOM)	Commonwealth agencies with track record in global programs
Southern Ocean Time Series (SOTS)	University of Tasmania (UTAS), BOM, CSIRO	Leveraging Australian strength in Southern Ocean via the Antarctic Climate and Ecosystems Cooperative Research Centre (ACE CRC)
Coastal Currents & Water Properties Facilities		
Australian Coastal Ocean Radar Network (ACORN)	James Cook University (JCU)	National leaders in technology that is underutilised in Australia
Australian National Facility for Ocean Gliders (ANFOG)	University of Western Australia (UWA)	Progressive group working with technology new to Australia
Australian National Mooring Network (ANMN)	CSIRO, AIMS, Sydney Institute of Marine Science (SIMS), South Australian Research and Development Institute (SARDI), Curtin University of Technology (CUT)	National leadership, capacity building in regions
Coastal Ecosystems Facilities		
Australian Acoustic TAgging and Monitoring System (AATAMS)	SIMS	Leadership in a maturing technology with global reach
Autonomous Underwater Vehicle (AUV)	SIMS	Existing infrastructure and engineering expertise
Facility for Automated Intelligent Monitoring of Marine Systems (FAIMMS)	AIMS	Global leader in coral reef systems, trialling 'next gen' approach in focused case study
Data Facilities		
e-Marine Information Infrastructure (eMII)	UTAS	Delivery mechanism linked to IMOS Office, building on the Bluenet project's Metadata Entry and Search Tool (MEST)
Satellite Remote Sensing (SRS)	CSIRO, AIMS, BOM, Geoscience Australia (GA)	Commonwealth agencies with track record in global programs
Leadership and Management		
IMOS Office	UTAS, supported by CSIRO	Based on expression of interest, competitively assessed

Key points to note are as follows:

1. The Facilities were funded under IMOS, not the Nodes.
2. This was achieved by Operators (legal entities) owning and operating the designated equipment, employing the staff, incurring the expenditure etc.
3. The University of Tasmania, supported by CSIRO, took on the role of Lead Institution. It entered into a contract with the Department of Innovation Industry Science and Research (DIISR), formerly the Department of Education Science and Training (DEST), then sub-contracted with the Operators of the Facilities and Sub-Facilities.
4. The annual flow of funding to Operators was linked to contractual milestones for the delivery of specific data-streams.

By all objective measures, the establishment of IMOS using Nodes and Facilities has been a success:

- Data is now being delivered through the Ocean Portal,
- All annual milestones have been met,
- The marine and science community has remained actively engaged,
- IMOS has begun to be recognised as an essential element of the national infrastructure (e.g. in the National Framework for Marine Research and Innovation, and the National Framework for Australian Climate Change Science), and
- Its funding has been enhanced and extended.

Lessons have been learned, and there are changes and developments at the national, regional and global levels that require response. These will be considered in following sections.

However the fundamental constructs are considered to have 'stood the test' during the initial phase of IMOS, and this Five Year Strategy will be built on the continuation of a Node and Facility structure.

5. Investment Parameters

Initial IMOS funding under NCRIS was $50M over four years, and interest will add an estimated $2.35M i.e. $52.35M in total. Co-investment by partners is fundamental under the IMOS model. Total co-investment of $42.11M is being provided in the initial phase (see Figure 2) - $14.68M in cash and $27.43M in-kind.

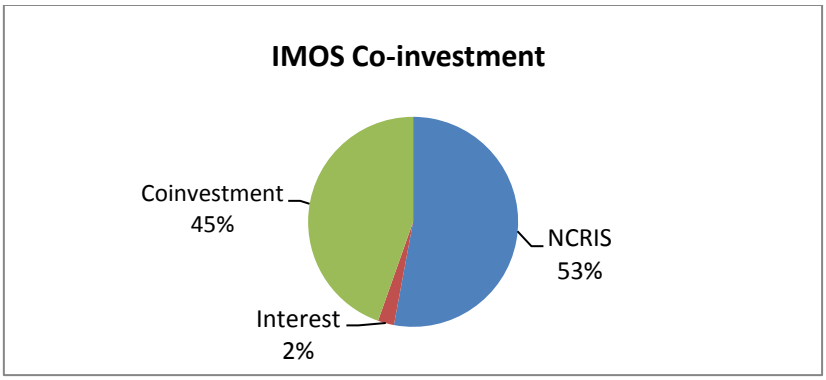

Figure 2

The funding profile by Facility is quite heterogeneous, with one very large Facility (ANMN), several moderately sized Facilities, and a number of small Facilities. Funding by Facility is shown in Figure 3.

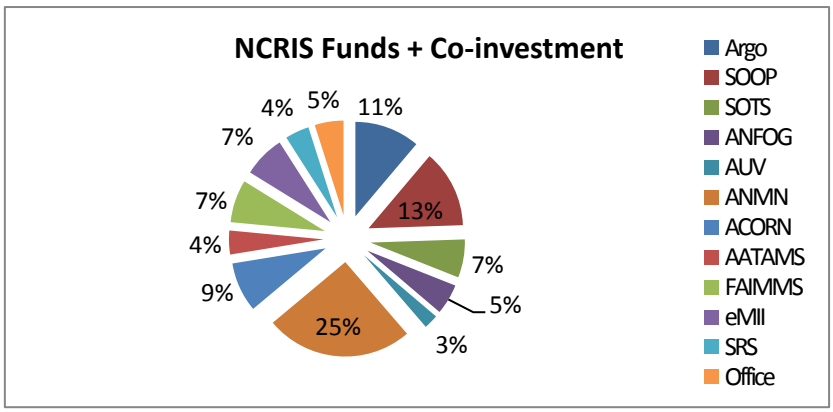

Figure 3

All Facilities are co-invested at some level, though the level varies as shown in Figure 4.

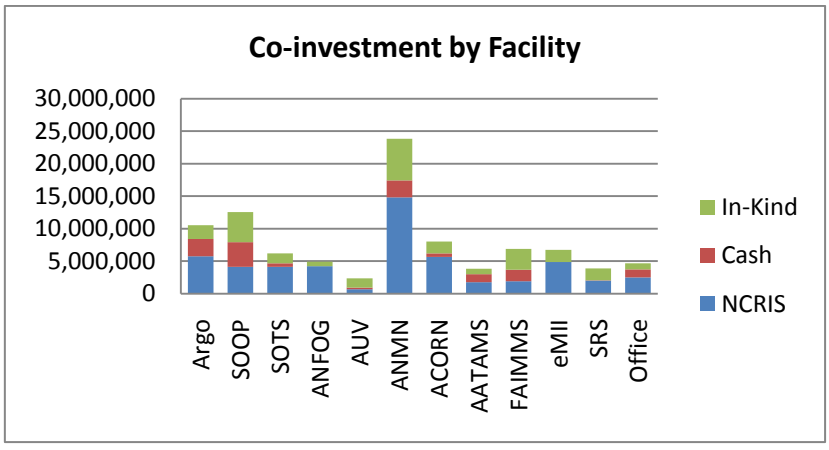

Figure 4

As IMOS is funded by Facility, the funding profile is not normally reported by Node. However by classifying the Facilities into Bluewater and Coastal, and looking at deployment of Coastal Facilities across the Regional Nodes, a reasonable estimate can be made as shown in Figure 5. Points to note include (a) balance between blue-water and regional components, (b) relative homogeneity across regional Nodes, noting that FAIMMS is currently GBR only, and (c) other deployments outside the Nodes, principally in Ningaloo and Tasmania.

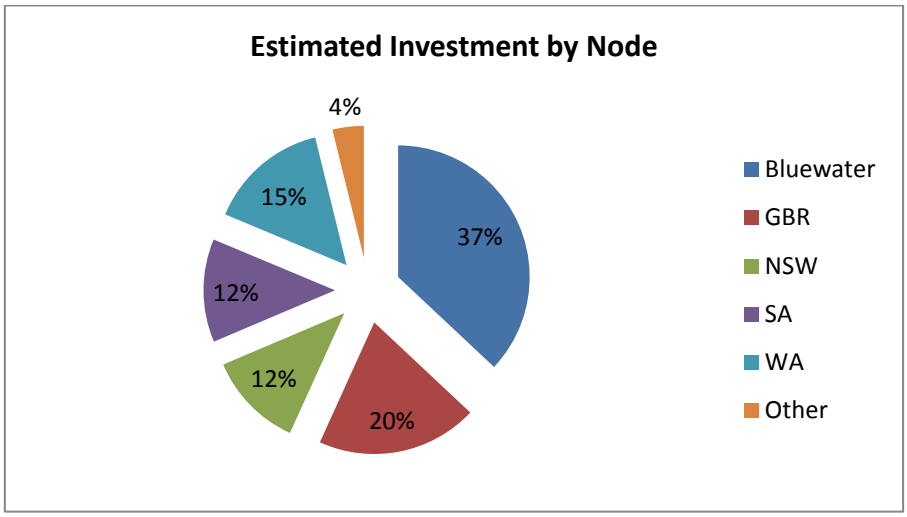

Figure 5

Cash co-investment by Node is shown in Figure 6. Only cash co-investment is shown, as in-kind co-investment comes in a wide variety of forms making analysis by Node very difficult, and potentially misleading. The vast majority (76%) of cash co-investment is in the Bluewater & Climate Node (through national and international climate science programs) and the GBROOS Node (through the Queensland State Government). The South Australian State Government has co-invested in an additional coastal radar installation. Co-investment by the Canadian-based Ocean Tracking Network (OTN) is not Node specific, noting that it is managed by SIMS through the AATAMS Facility. The Tasmanian State Government and University of Tasmania have co-invested in having IMOS headquartered in Hobart.

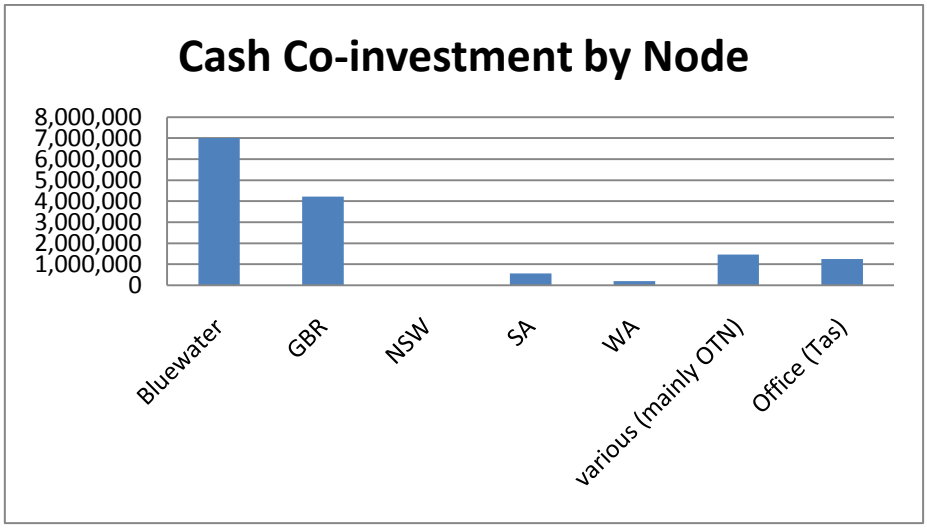

Figure 6

The profile of NCRIS and EIF funding to 2013 is shown in Figure 7. This funding will peak at $27.5M in 2009-10 (as a result of IMOS having to ramp up in the early years), dropping back to $20M in 2010-11, then $18M pa in 2011-13.

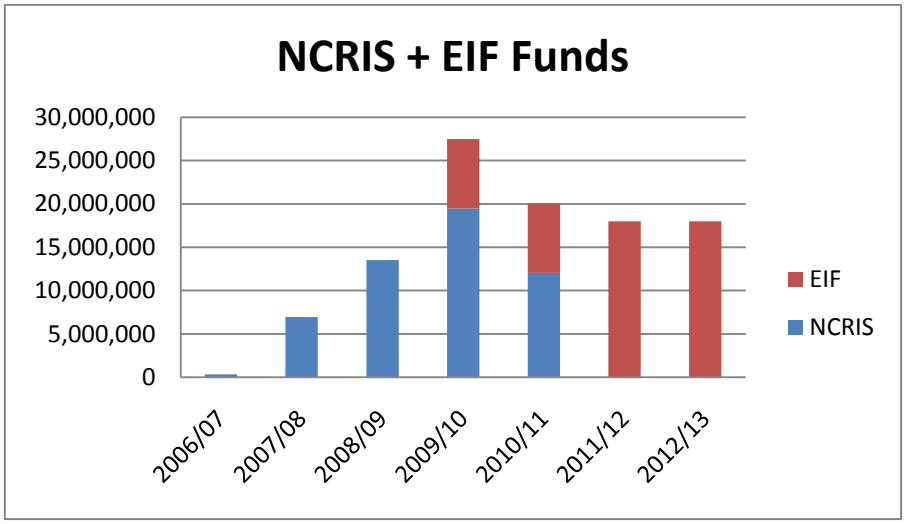

Figure 7

In implementing this strategy, it will be important for the marine and climate science community to actively grapple with the trade-off between our ability to take on new observations and data streams, and the cost of sustaining the current suite of observations and moving towards real time. Ongoing investment required to sustain and develop nationally-agreed data streams will be clearly identified as an input to forward planning.

6. Lessons Learned

The mid-term review of IMOS 'Phase I' is a primary source of lessons learned to date. Findings of the review covered Nodes and Facilities, and spanned short-term/operational to long-term/strategic issues. The emphasis here is on the latter. The full report can be found at http://imos.org.au/fileadmin/user_upload/shared/IMOS%20General/Review_papers/Report_of_the_IMOS_Mid-Term_Review_-_final_29Jan09.pdf

6.1 Nodes

(a) Bluewater and Climate

- In summary, the review found that although observations undertaken for this Node are clearly being integrated in addressing key questions about the role of oceans in the climate system, it is less clear how these observations will lead to improved understanding of the impact of major boundary currents on continental shelf environments, ecosystems and biodiversity, which is the focus of the Regional Nodes.
- The response of the Bluewater Node was that output to the Regional Nodes is mainly delivered through operational analysis (e.g. via BLUElink>), and climate analysis (e.g. via ACCESS – the Australian Community Climate and Earth System Simulator).
- This response was considered to be plausible, but it does highlight the need for IMOS to be more explicit about how observations in the Bluewater and Climate Node are contributing to BLUElink> and ACCESS model outputs, and how the Regional Nodes are combining those outputs with their observations (e.g. through downscaling, and nested modelling approaches) to improve understanding of the impact of boundary currents on the shelf.

(b) GBROOS

- The findings and responses highlight the fact that, in some Nodes in particular, timing of the Review was premature relative to ramp up of IMOS delivery.
- Specific issues about observations relevant to acidification, cross-shelf observations and coverage of the top third of the GBR will need to be addressed in the forward planning.

(c) NSW-IMOS

- It was noted that SIMS, as the lead institution, is still a very new organisation, and that it requires further institutional support from within NSW in order to strengthen the Node.
- The key scientific issue highlighted was understanding East Australian Current (EAC) eddies and their impact on the ecosystems of the continental shelf. An aspiration to expand the scope of NSW-IMOS into the whole of South East Australia was considered to be premature given the state of development of the Node.

(d) SAIMOS

- The focus on upwelling phenomena in this Node was noted as appropriate, given their economic importance for SA.
- It was also noted that there needs to be better linkages with WAIMOS in order to establish a more integrated approach to the Leeuwin Current[7].

(e) WAIMOS

- A number of issues were raised about progress being behind schedule, lack of clarity about uptake of data, and interaction with related initiatives such as WAMSI. These were followed-up as a result of the Review.
- The need for integration across areas of focus (around Perth, at Two Rocks, and at Ningaloo) was also noted.
- As highlighted above, there is a need for better linkages with SAIMOS in order to establish a more integrated approach to the Leeuwin Current.

6.2 Facilities

Many of the review findings on Facilities are quite specific/operational.

The key strategic issues that emerged across Facilities are as follows:

- Ensuring that Facilities achieve critical mass and national reach, which may require
    - some resolution of conflicts between different interests within a single Facility,
    - building capability to mitigate key reliance on individuals, and
    - creating new sub-facilities.
- Actively managing any gaps between potential impact and current delivery.
- Ensuring the outputs of Facilities are integrated in addressing science questions posed by Nodes.

6.3 National Overview

A national overview was prepared by the IMOS Office as part of the review. It noted that 'a major challenge for IMOS is to maintain a focus on a national approach to ocean observing'. In practice, through the first two years of IMOS operation, this challenge has been tackled by having a strategic research focus on the impact of major boundary currents on continental shelf environments, ecosystems and biodiversity.

The review findings and responses reinforce the appropriateness of this focus on the major boundary currents. However they also highlight some fuzziness within IMOS about how best to achieve it. Outcomes of the review suggest that responsibility for understanding the impact of major boundary currents on the continental shelf is shared between the Bluewater and Regional Nodes.

[7] Throughout this document, 'Leeuwin Current' should be taken to include the Leeuwin, Flinders and shelf current system.

In assessing the most appropriate response to this major challenge for IMOS, it is worth considering the following:

1. The original design of IMOS included an integrated Coastal component, with a national backbone and a series of regional nodes. The national backbone was to include (at least) satellite remote sensing, national reference stations, and information infrastructure. While the SRS, National Reference Station (NRS – in ANMN) and eMII Facilities are all in place in IMOS, it is timely to consider whether or not the cumulative impact of delivery by these Facilities is providing, or has the potential to provide, the national backbone originally envisaged.

2. Spatial coverage of Australia's major boundary current systems by IMOS infrastructure is, understandably, less than complete. Figure 8 shows a representation of these systems, noting that there is much biophysical complexity not represented in this simple diagram. Figure 9 shows the area of interest of the IMOS nodes. Clearly, we have major spatial gaps.

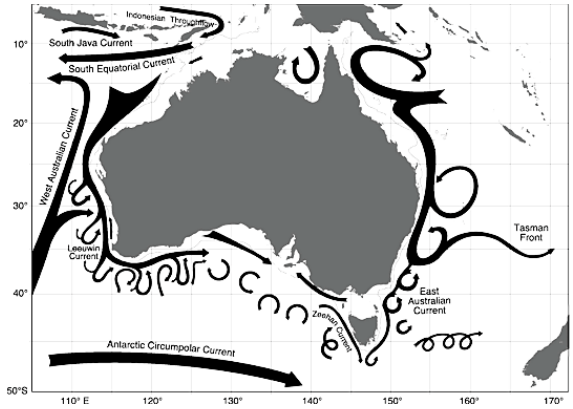

Figure 8

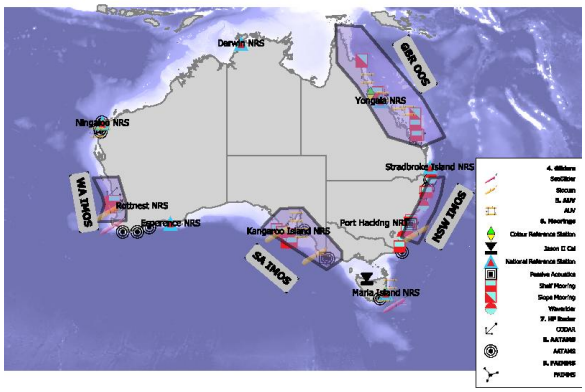

Figure 9

In summary, IMOS will need to ensure that there is a coherent, national strategy for monitoring the major boundary currents, be it cross-Node, within-Node, or through some other construct.

7. Changes and Developments

7.1 Changes

The major change to be accommodated within this Five Year Strategy is that the enhancement and extension of IMOS is being funded from the Education Investment Fund (EIF), not NCRIS.

Under NCRIS, the University of Tasmania was contracted to 'establish, operate and provide access to an Integrated Marine Observing System'.[8] Under EIF, the University has been contracted to 'enhance and extend...IMOS...through creation and development of additional infrastructure'.[9]

The detailed implications of this change are still being discussed with DIISR, but two things are clear from a strategic perspective.

Firstly, IMOS was established to create and develop research infrastructure in the form of systematic, repeated data collection over many years, delivered openly and in a timely manner to national and international marine research communities. Each day IMOS continues, these data streams will grow, and will evolve through greater integration and value-adding. The change from NCRIS to EIF does not alter the core business of IMOS.

Secondly, funding provided by the Commonwealth under NCRIS represents a little more than half of the resources available to IMOS. 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, and discussions with these partners will be informed by any implications of the change from NCRIS to EIF.

7.2 Developments

Significant developments within the last 12 months or so, that have the potential to influence IMOS over the next five years, are as follows:

(a) <u>National, by Federal Government Portfolio</u>

Innovation, Industry, Science and Research

- The National Framework for Marine Research & Innovation, developed by OPSAG in advance of the 2009 Federal Budget.
- The Marine and Climate Super Science initiative, which included (in addition to $52M for IMOS)
    - Replacement of Australia's blue-water marine research vessel capability
    - New tropical marine research facilities for AIMS in Townsville and Darwin

[8] IMOS Project Plan, Attachment A to the 2007 Funding Agreement, Section 1.1 – Objectives of the Project
[9] Interim IMOS EIF Project Plan, Section 1.1 – Objectives of the Project

    - New high performance computing facilities for climate change, earth systems science and national water management
    - Extension and enhancement of the Terrestrial Ecosystem Research Network (TERN).
- Other announcements in the 2009 Federal Budget, including
    - EIF, Round Two
        - New building for the UTAS Institute of Marine and Antarctic Studies (IMAS)
        - Enhancement of facilities at SIMS
    - Increased funding for the Atlas of Living Australia (ALA)
    - Information and Communication Technology infrastructure investment, across all States, including funding for creation of an Australian research data commons through the Australian National Data Service (ANDS)
    - Super Science Fellowships - targeted at early career, 100 in two rounds over three years.

Climate Change

- The National Framework for Australian Climate Change Science, developed by the Department of Climate Change prior to the 2009 Federal Budget. This framework includes commitments to:
    - ACCESS, the suite of coupled climate system models (including of the ocean) being developed by the Centre for Australian Weather and Climate Research (CAWCR).
    - Sustained climate observations, with priority data streams identified, including:
        - changes in ocean salinity and temperature, and in sea ice extent and thickness, in the Southern Ocean
        - measurement of the fluxes of carbon, water and energy between the Earth's surface and the atmosphere
        - changes in sea level, and
        - changes in ocean acidity.
- The National Climate Change Adaptation Research Facility (NCARF), and the Adaptation Research Network for Marine Biodiversity and Resources (ARN-MBR).

Environment, Water, Heritage and Arts

- Continuation of Marine Bioregional Planning under the Environmental Protection and Biodiversity Conservation Act (which itself is being reviewed over the coming 12 months). Final plans for all bioregions to be completed by June 2010.
- A proposal to develop a National Environmental Information System (NEIS).
- Under the Marine and Coastal Committee (MACC), development of a national approach to marine, coastal and estuarine indicators.
- Global Environment Fund and Australian Government support for implementation of the Arafura and Timor Seas Ecosystem Action project.

Agriculture, Fisheries and Forestry

- The Department of Agriculture, Fisheries and Forestry (DAFF) Climate Change Research Program.

Resources, Energy and Tourism

- United Nations confirmation of Australia's jurisdiction over an additional 2.5 million square kilometres of seabed, in April 2008.
- Planned developments in the Browse Basin, offshore of the Kimberley coast in WA.

(b) Regional/Institutional

- Potential development of a regional marine science program in the Kimberley Browse region, as suggested in the WAMSI-sponsored report 'A Turning of the Tide' (August 2008).
- Establishment of the UWA Oceans Institute, and the UWA and AIMS joint research fund.
- Establishment of the Charles Darwin University (CDU) and AIMS joint research fund at the Arafura Timor Research Facility (ATRF).
- The Co-operative Framework on Tropical Science, Knowledge and Innovation (TSKI), involving the Northern Territory, Queensland and Western Australian State Governments.
- Creation of IMAS at UTAS, in collaboration with the Tasmanian Government, CSIRO and the Australian Antarctic Division (AAD).
- Extension of the ACE CRC for another 5 years.
- Establishment of a large Ecosciences Precinct in South East Queensland (SEQ), with a focus on climate change and environmental research. Approximately 1,000 scientists from Queensland Government agencies and CSIRO will be collocated, in close proximity to the University of Queensland.
- Funding for the Australian National Network in Marine Science (ANNiMS), initially involving UTAS, UWA and JCU.

(c) Global

The international context for ocean observing is complex and inter-connected. An overview is provided as Attachment 2. Key points are as follows:

- Difficulty in gaining the commitment and investment required to transition towards a sustainable, operational observing system, and the relative lack of progress in the coastal module, are problems across the global ocean observing community. Australia is by no means alone in grappling with these issues.
- There is global interest in a basin-scale Southern Ocean Observing System (SOOS), and an Indian Ocean Observing System (IndOOS).
- It will be important to maintain a coherent, national strategy for Australian regional engagement in global ocean observing programs.

8. IMOS Strategic Priorities, 2009-13

Based on an analysis of the information summarised in the previous sections - background and goals, ongoing commitment to a Node and Facility structure, investment parameters, lessons learned, changes and developments - ten strategic priorities have been identified.

In summary, the IMOS Strategy will be to drive a national, collaborative approach to sustained ocean observing, designed to answer big science questions posed through the Nodes. Integration across time, space and depth scales, across physics, chemistry and biology, and between observing and modelling, will be further developed. The aim will be to enable open and timely use of data streams via an Australian (ocean) research data commons. Strong, mutually-beneficial partnerships between the institutions that make up the marine and climate component of the National Innovation System will be fundamental. The ten strategic priorities are as follows:

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 ACCESS, and its forerunners such as POAMA). 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 proposed by John Parslow[10]. 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.

[10] 'Marine Biogeochemical Connections' AMSA 2009

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 PICO and related initiatives such as US-IOOS and EuroGOOS.

4. Ongoing development of Regional Nodes

The existing Regional Nodes will be further strengthened and developed. For example, GBROOS will expand into a whole-of-Queensland Node, and WAIMOS will extend into northern Australian waters.

All State and Territory Governments will be engaged in the ongoing development of Regional Nodes. So too will the Universities and National Agencies working in the Regions. For example, NT will be engaged with WAIMOS extension into northern Australian waters, and Victoria will be engaged in further development of SAIMOS (Southern Australian IMOS).

Where desirable from a scientific perspective, and feasible from a governance perspective, Regional interests will be converged by developing the existing Node structure. IMOS will aim to have fewer, larger Nodes, consistent with its national mandate. NT engagement in WAIMOS and Victorian engagement in SAIMOS are examples of how this might evolve.

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 MACC, and the proposed NEIS).
- Greater engagement with ALA and TERN, with a focus on the discoverability and interoperability of biological data streams.

A risk associated with the model of linked global and coastal components adopted by IMOS is that blue-water ecosystems may not be particularly well-catered for. This will require specific attention within the Bluewater and Climate Node.

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 prioritisation, and efficacy. 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. eMII has received an additional $1.3M to develop the AODN concept during 2009-11, and IMOS will continue to look for opportunities to leverage the successes of eMII in marine information management through the Information and Communication Technology infrastructure investments announced in the 2009 Federal Budget, particularly the creation of an Australian research data commons by ANDS.

9. Ensuring the data is 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. Prospective targets include the UTas/CSIRO Quantitative Marine Science (QMS) Program, SIMS, AIMS@JCU, the UWA/AIMS joint research fund, the CDU/AIMS joint research fund, ANNiMS, ARN-MBR and Super Science Fellowships. 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. Engagement with OPSAG on further development and implementation of the National Marine Research and Innovation Framework will be important in this respect.

9. Investing the first $8M of EIF Funding in 2009-10

As a condition of the funding provided in the Federal Budget, an Interim Project Plan was required for the first $8M to be invested in 2009-10. The IMOS Office worked with the Nodes and Facilities, and the Advisory Board, to come up with a plan that was approved by DIISR - see below. Although this plan was developed in advance of the Strategy, the range of factors informing the Strategy was taken into account, in particular the requirement for enhanced monitoring capability in the Southern Ocean, and extended coverage in northern Australian waters. As such, the Interim Project Plan is considered to be well-aligned with the Strategy as now articulated.

Facility	Southern Focus	Northern Focus	Enhancement
Australian ARGO facility ($1.8M – CSIRO)	Deployment of ice capable floats. Increased deployment of floats in Southern Ocean. ($0.9M)		Increased deployment of standard floats to move towards completion of southern hemisphere array. Increase variables monitored to include oxygen as appropriate ($0.9M)
Australian National Facility For Ocean Gliders ($1.5M – UWA)	Seagliders to be deployed on transects from SOTS site to Hobart ($1M)	Seagliders to be purchased & deployed in North East Queensland outside of the Great Barrier Reef ($0.5M)	Assess the ability of ANFOG to deliver nationally on a sustainable basis, including consideration of the development of collaborative mechanisms with local operators around Australia.
Australian National Mooring Network (ANMN) (1.8M – CSIRO, SIMS, SARDI, AIMS)		New National Reference Station in situ monitoring outside of Stradbroke Island ($0.6M)	CO_2 & PH added to selected National Reference Stations. Acoustic current profile measurements added to all National Reference Stations ($1.2M)
Northern Australian Observing System ($1.7M)		Wide consultation to determine the marine observing needs in Northern Australia; implementation of the initial suite of instruments ($1.7M)	
Australian Acoustic Tagging & Monitoring System ($1.2M – SIMS)	Instrumentation of Southern Ocean marine creatures and seals in the Great Australian Bight with tracking and oceanographic sensors utilising satellite communications for data recovery. ($1M)	New acoustic receiver curtains to detect tagged animals in Queensland, extending the global Ocean Tracking Network. ($0.2M)	
09/10 Total $8M	**$2.9M**	**$3.0M**	**$2.1M**

Attachment 1 – List of IMOS Acronyms and Abbreviations

AAD – Australian Antarctic Division
AATAMS - Australian Acoustic TAgging and Monitoring System
ACCESS – Australian Community Climate and Earth System Simulator
ACE CRC – Antarctic and Climate Ecosystems Cooperative Research Centre
ACORN - Australian Coastal Ocean Radar Network
AIMS – Australian Institute of Marine Science
AIMS@JCU - Australian Institute of Marine Science at James Cook University
ALA - Atlas of Living Australia
ANDS – Australian National Data Service
ANFOG - Australian National Facility for Ocean Gliders
ANMN - Australian National Mooring Network
ANNiMS - Australian National Network in Marine Science
AODN - Australian Ocean Data Network
Argo – the international project collecting and distributing data from autonomous profiling floats
ARN-MBR - Adaptation Research Network for Marine Biodiversity and Resources
ATRF – Arafura Timor Research Facility
AuScope – the NCRIS capability supporting characterisation of the structure and evolution of the Australian continent
AusIOOS - Australian Integrated Ocean Observing System
AUV - Autonomous Underwater Vehicle
BLUElink> - the project delivering ocean forecasts for the Australian region
BOM – Bureau of Meteorology
CAWCR – Centre for Australian Weather and Climate Research
CDU – Charles Darwin University
CLIVAR – Climate Variability and Predicability
CSIRO – Commonwealth Scientific and Industrial Research Organisation
CUT – Curtin University of Technology
DAFF - Department of Agriculture, Fisheries and Forestry
DEST - Department of Education Science and Training
DIISR - Department of Innovation Industry Science and Research
EAC – East Australian Current
EIF – Education Investment Fund
eMII - e-Marine Information Infrastructure
EPBC Act – Environment Protection and Biodiversity Conservation Act
EuroGOOS – European Global Ocean Observing System
FAIMMS - Facility for Automated Intelligent Monitoring of Marine Systems
GA – Geoscience Australia
GBR - Great Barrier Reef
GBROOS – Great Barrier Reef Ocean Observing System
GODAE - Global Ocean Data Assimilation Experiment
GOOS - Global Ocean Observing System
ICSU - International Council for Science
ICT – Information and Communications Technology
IGBP - International Geosphere Biosphere Program
IMAS – Institute of Marine and Antarctic Studies
IMOS – Integrated Marine Observing System

IndOOS - Indian Ocean Observing System
IOC - Intergovernmental Oceanographic Commission
IOCCP - International Ocean Carbon Coordination Project
JCOMM - Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology
JCU – James Cook University
Leeuwin – the warm ocean current flowing southwards near the Western Australian Coast
M - million
MACC - Marine and Coastal Committee
MAFRI – Marine and Freshwater Research Institute
MEST – Metadata Entry and Search Tool
MISA - Marine Innovation South Australia
NCARF – National Climate Change Adaptation Research Facility
NCRIS - National Collaborative Research Infrastructure Strategy
NEIS - National Environmental Information System
NOAA – National Oceanic and Atmospheric Administration
NRS – National Reference Station
NSW - New South Wales
NSW IMOS - New South Wales Integrated Marine Observing System
OceanSITES - OCEAN Sustained Interdisciplinary Time series Environment observation System
OOPC - Ocean Observations Panel for Climate
OPSAG - Oceans Policy Science Advisory Group
OTN - Ocean Tracking Network
PICO - Panel for Coastal Observations
POAMA – Predictive Ocean Atmosphere Model for Australia
QMS - Quantitative Marine Science
SA - South Australia
SAIMOS – Southern Australian Integrated Marine Observing System
SARDI – South Australian Research and Development Institute
SCAR - Scientific Committee on Antarctic Research
SCOR - Scientific Committee on Oceanic Research
SEQ – South East Queensland
SIMS - Sydney Institute of Marine Science
SOOP - Ships Of OPportunity
SOOS - Southern Ocean Observing System
SOTS - Southern Ocean Time Series
SRS - Satellite Remote Sensing
TERN - Terrestrial Ecosystem Research Network
UN – United Nations
UNEP - UN Environment Program
US-IOOS – United States Integrated Ocean Observing System
UTAS – University of Tasmania
UWA – University of Western Australia
WA - Western Australia
WAIMOS – Western Australian Integrated Marine Observing System
WAMSI - Western Australian Marine Science Institution
WMO - World Meteorological Organisation

Attachment 2 – Overview of the global context for IMOS

The international context for ocean observing is complex and inter-connected. In broad terms there is an intergovernmental dimension driven through the UN system, and an international science dimension through the International Council for Science (ICSU) and its various bodies and initiatives, including the Scientific Committees on Oceanic Research (SCOR), and Antarctic Research (SCAR), and the International Geosphere Biosphere Program (IGBP). The emphasis here is on commitments to sustained ocean observing via the intergovernmental dimension.

The Global Ocean Observing System (GOOS) is led out of the Intergovernmental Oceanographic Commission (IOC), and co-sponsored by the World Meteorological Organisation (WMO), UN Environment Program (UNEP) and ICSU. GOOS has a climate/open ocean module, and a coastal ocean module.

A recent paper by Keith Alverson[11] (Director of the GOOS Project Office) and a recent review by James Baker (ex-National Oceanic and Atmospheric Administration - NOAA)[12] are of relevance to IMOS. Significant progress is reported, with 60% of the planned in-situ networks in place for the climate module (Alverson). However both documents note problems in gaining the commitment and investment required to transition towards a sustainable, operational observing system, and the relative lack of progress in the coastal module. These issues are familiar to us in Australia, reinforcing that we are by no means alone. Key members of the IMOS community, including members of the Advisory Board, are well-engaged with GOOS, and it will be important to obtain maximum benefit from their ongoing engagement as we grapple with what are clearly global challenges.

Specific issues relating to GOOS are as follows:

- Via its scientific steering committee (John Gunn of AAD is a member), GOOS seeks advice and guidance from the Ocean Observations Panel for Climate (OOPC), and the Panel for Coastal Observations (PICO). GOOS implementation is through the Joint WMO-IOC Technical Commission for Oceanography and Marine Meteorology (JCOMM) for climate and through the GOOS Regional Alliances for coastal.
- For the IMOS Bluewater and Climate Node, the global context established by OOPC and JCOMM is very important. Whilst Australia is not currently represented on OOPC (Neville Smith of BOM was chair from 1996 to 2002), Australian researchers are active (sometimes as Chairs) in the Climate Variability and Predictability (CLIVAR) Ocean Basin Panels, which advise OOPC. Senior staff from BOM are well represented in JCOMM, which provides global coordination for ship observations (including SOOP), data buoys, and tide gauges. JCOMM also covers associated programs including Argo, the International Ocean Carbon Coordination Project (IOCCP) and the OCEAN Sustained Interdisciplinary Time series Environment observation System (OceanSITES) in which senior scientists involved with IMOS are well-represented. So links to the IMOS community are strong. Two points are of interest here:

[11] 'Filling the Gaps in GOOS', Journal of Ocean Technology, Vol. 3 No. 3 2008 pp 19-23
[12] 'Planning and Implementation for GOOS – A Consultant Study...', D. James Baker, 28 May 2009

    - GOOS identifies the basin-scale Indian Ocean Observing System (IndOOS) as an element of the Indian Ocean Regional Alliance. The CLIVAR-GOOS Indian Ocean Panel was chaired by Gary Meyers from 2004 to 2009. The tropical zone of IndOOS is developing rapidly with multinational resources, and there is an opportunity for IMOS to link the development of coastal observing in northern Australia to IndOOS, including sustained observation of the Indonesian throughflow.
    - GOOS identifies the Southern Ocean Observing System (SOOS) as a 'developing Regional Alliance'. SOOS development is being led by Steve Rintoul (CSIRO), sponsored by the SCAR/SCOR Expert Group on Oceanography and the CLIVAR Southern Ocean Panel. From an IMOS perspective, SOOS is a potentially exciting development that needs to be considered within the context of the Bluewater and Climate Node.
- For the IMOS Regional Nodes, the global context established by PICO and the Regional Alliances is relevant, though as noted in recent reports/reviews, it is currently much less mature. Engagement by the IMOS community in Coastal GOOS is strong. John Parslow (CSIRO) is a member of PICO, and Nick D'Adamo (BOM) runs the GOOS Perth Regional Office, and is active in Indian Ocean GOOS, Western Australian GOOS and Pacific Island GOOS. It is worth noting that Australia is engaged in a number of GOOS Regional Alliances – Indian Ocean, Western Australian, Pacific Island and (potentially) South East Asian. Maintaining a coherent, national strategy for regional engagement will be important from an IMOS perspective. We are beginning to build stronger links with colleagues in the US-IOOS and EuroGOOS Regional Alliances who, like IMOS, are pursuing an integrated approach.
- GOOS also sponsors Pilot Projects, and the following are particularly relevant to IMOS:
    - The Global Ocean Data Assimilation Experiment (GODAE) emerged from OOPC in 1997 and has been influential in the successful establishment of BLUElink> ocean forecasting in Australia. It is currently moving from a data assimilation 'experiment' towards a long-term international program for Ocean Analysis and Forecasting called, GODAE OceanView, with close links to GOOS and JCOMM. Andreas Schiller (CSIRO) is co-chair of the new program, and the links between IMOS and global developments in ocean analysis and forecasting need to continue and strengthen.
    - The Ocean Tracking Network (OTN) is a major, global project led from Dalhousie University in Canada that is planning to track thousands of marine animals around the world using acoustic telemetry technology while at the same time building a record of climate change data that can be analysed and applied. The IMOS AATAMS Facility is a partner in the OTN.

Another significant global development is the 'OceanObs'09' meeting in Italy in September 2009. It is ten years since the last meeting, and the Community White Papers being developed are expected to form the basis of consensus building and planning for the next decade. IMOS will be well-represented at the meeting.

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