May 2014

IMOS Strategy **2015-25**

IMOS Integrated **Marine Observing** System

Need, Capability, Impact

1. Executive Summary

VISION - By 2025, Australia will have a continuously growing time series of essential ocean variables for marine and coastal environments. This will enable cutting edge research on contemporary problems, and provide a scientific basis for informed decision making about our vast and valuable marine estate.

This IMOS Strategy (2015-25) sets out the priorities for Australia's Integrated Marine Observing System as it enters a second decade of operation. The document is based around three strategic imperatives of Need, Capability, and Impact.

IMOS was established in 2006-7 as one of 12 foundation capabilities supported under the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS), and it has grown to become a very significant component of the national research infrastructure fabric.

IMOS now routinely operates a wide range of observing equipment throughout Australia's coastal and open oceans, making all of its data accessible to the marine and climate science community, other stakeholders and users, and international collaborators.

Australia has the third largest ocean territory on the planet, providing massive social, economic and environmental benefits to our nation. A modest level of ongoing investment in IMOS as the national marine observing system has proven to make very good sense, providing both an independent capability to assist Australia in managing its own marine estate, and a significant attractor of international collaboration and co-investment. The overwhelming feedback from the international community is that Australia has 'got it right' with IMOS, and opportunities for enhanced collaboration are blossoming.

With annual core funding of $18M since 2009-10, IMOS requires investment of $20M per annum from July 2015 to sustain its current level of activity in real terms. It requires a multi-year commitment from Australian Government in order to plan its operations effectively and efficiently, and to have the confidence of current and potential co-investors. Partners are currently co-investing $25M per annum, making IMOS a $45M enterprise. So there is a lot at stake.

Nine strategic priorities have been identified in developing this Strategy. As a package they are intended to ensure that IMOS is focused on Australia's grand challenges, provides distinctive scientific capability, and is positioned within the National Innovation System so that its outputs have real influence on outcomes. These nine strategic priorities are as follows:

1. Engage all national stakeholders with a need for systematic and sustained observing of Australia's marine environment in the ongoing design and implementation of the system.
2. Continue to focus on turning observations and data into time series of essential marine and coastal variables, providing timely support to a wide range of science and research, meeting current and future needs.
3. Collaborate as a strong partner in the global ocean observing enterprise, to generate synergies from international efforts and provide leadership within the Australasian region.
4. Sustain established IMOS capability so as to realise full value from investments to date, and avoid loss of value through discontinuity. Evolve established capability in response to scientific and technological developments, and performance and delivery.
5. Position IMOS capability so as to maximise benefits from related investments in remote sensing, vessel operation, marine data management, and ocean and coastal modelling.
6. Articulate major gaps, develop costed solutions, and work with partners and stakeholders to identify opportunities for addressing them.
7. Continue to evolve the observing system in response to national priority setting.
8. Sustain effort in areas where impact is high. Focus effort on increasing relevance and impact in sectors with unrealised potential.
9. Build partnerships with State Governments and marine industries around the core investment by Australian Government.

Key mechanisms for implementation are identified for all of the strategic priorities, with some mechanisms addressing multiple priorities. IMOS is a mature national research infrastructure capability with an established track record, as evidenced throughout this Strategy. It has well developed systems of planning, management, reporting, and review already in place, providing confidence that the strategic priorities can be addressed across the coming decade.

The ocean provides Australia with unique competitive advantages as a marine nation. Systematic observation of our ocean territory can make a significant contribution to the knowledge and understanding required to fully realise potential benefits. With sustained commitment to IMOS as our national marine observing system, the science community and its stakeholders and users can proceed with confidence and deliver value to Australia that demonstrably exceeds investments made.

Dr Ian Poiner - Independent Chair, IMOS Advisory Board

2. About IMOS

IMOS is Australia's Integrated Marine Observing System (http://imos.org.au/). Its mission is:

- to undertake systematic, sustained, scientifically-robust observation of Australia's vast and valuable ocean estate; and
- turn these observations into data, time series, products and analyses that can be used and reused for broad societal benefit.

Since 2006, IMOS has been routinely operating a wide range of observing equipment throughout Australia's coastal and open oceans, making all of its data accessible to the marine and climate science community, other stakeholders and users, and international collaborators.

IMOS is one of the national research infrastructure capabilities currently supported under the Australian Government's National Collaborative Research Infrastructure Strategy (NCRIS). It has been awarded $130M of Australian Government funding over nine years (2006-15), with matching co-investment of $170M. IMOS has therefore become a very significant component of the national research infrastructure fabric over the last decade and its future needs to be secured.

IMOS operates as a multi-institutional collaboration. This is crucial to its success as no single institution has the capability and capacity required to operate a national scale system. Through effective implementation of a collaborative research infrastructure model, IMOS has coalesced fragmented and sub-critical institutional-level capabilities into a national capability that is much more than the sum of its parts.

IMOS is led by the University of Tasmania in partnership with the CSIRO, Australian Institute of Marine Science, Bureau of Meteorology, Australian Antarctic Division, Geoscience Australia, Sydney Institute of Marine Science (encompassing the University of New South Wales, Sydney University, Macquarie University and University of Technology Sydney), University of Western Australia, Curtin University, James Cook University and the South Australian Research and Development Institute.

These institutions collectively operate a portfolio of marine observing technologies called 'Facilities', deploying equipment from the open ocean onto the continental shelf and into the coast, measuring physical, chemical and biological variables. This level of integration has only been possible through multi-institutional collaboration and a clear focus on access to data. It represents a highly efficient model for implementing a national marine observing system. A summary of Facilities, showing the situation 'before and after' IMOS, is included as ATTACHMENT 1.

The users and stakeholders of a national marine observing system are much broader than just the operating institutions. They include other research agencies and universities, Australian Government departments, State Governments, marine industries and international collaborators. IMOS has responded to the challenge of broad engagement by creating a series of 'Nodes' to include all of these stakeholders and collectively provide the science rationale for a national scale system. There is an open ocean Node and five regional nodes covering Australia's shelf and coastal oceans. Nodes are a crucial source of input to science and implementation planning that guides the design of IMOS as a national system. This planning has been internationally peer-reviewed, and is periodically updated to reflect developments in scientific understanding, technological innovation, and national priority setting. Full details on IMOS Science and Implementation Planning can be found at http://imos.org.au/plans.html.

The partnerships established through IMOS Facilities and Nodes are fundamental to its success to date, and are essential to realising potential benefits over the coming decade. These partnerships provide mechanisms for cash and in-kind co-investment, as well as pathways for uptake and use of the data, and relevance and impact of the science and research that IMOS enables.

3. IMOS Strategy 2015-25

To achieve its vision, IMOS must lay out a strategy that addresses (1) current and future need for a national marine observing system; (2) ongoing development of the capability required for a national marine observing system; and (3) the means by which we ensure our observational and data management capability meets current and future need, and delivers real impact.

3.1 Need

IMOS 2025 Strategic Priorities - Need

- Engage all national stakeholders with a need for systematic and sustained observing of Australia's marine environment in the ongoing design and implementation of the system.
- Continue to focus on turning observations and data into time series of essential marine and coastal variables, providing timely support to a wide range of science and research, meeting current and future needs.
- Collaborate as a strong partner in the global ocean observing enterprise, to generate synergies from international efforts and provide leadership within the Australasian region.

Australia is a marine nation[1], with the third largest ocean territory on Earth. We generate massive wealth from marine industries, estimated at $42 billion per annum[2] and growing rapidly. As an island continent, our borders are maritime and we are connected to our neighbours by the ocean. We have a highly urbanised population living in coastal cities, consuming a wide range of ecosystem services from the marine environment. We are extremely sensitive to ocean-influenced climate and weather, through drought, flood, cyclones and storms. Our ocean territory contains marine biodiversity of globally significant conservation and tourism value, ranging from the high tropics to Antarctica.

There is much we do not yet know and understand about our ocean territory, limiting the degree to which social, economic and environmental benefits can be realised by current and future generations. Australia's vast offshore sedimentary basins are under-explored, yet hold significant promise for hydrocarbon production[3] as the challenges of deeper water operation are overcome. Ocean renewable energy holds considerable promise, from waves, tides, currents and thermal energy conversion. Many of the ocean processes that drive climate, weather and marine systems have large uncertainties, limiting the value of projections of future states. Much greater understanding about linkages between physical, biogeochemical and ecosystem processes in the ocean is required. Most of the marine biodiversity in Australia's ocean territory is yet to be discovered[4].

Marine and climate science therefore has a key role to play in Australia's national wellbeing, as reflected in the health and lifestyle of the population and the security and sustainability of the environment in which we live. There is a need to study ocean change on multi-decadal timescales, to fully understand the ocean's role in climate variability and extreme weather, to monitor ocean processes that link global phenomena to regional and local impacts, and to understand and eventually be able to forecast the responses of marine ecosystems to variability and change.

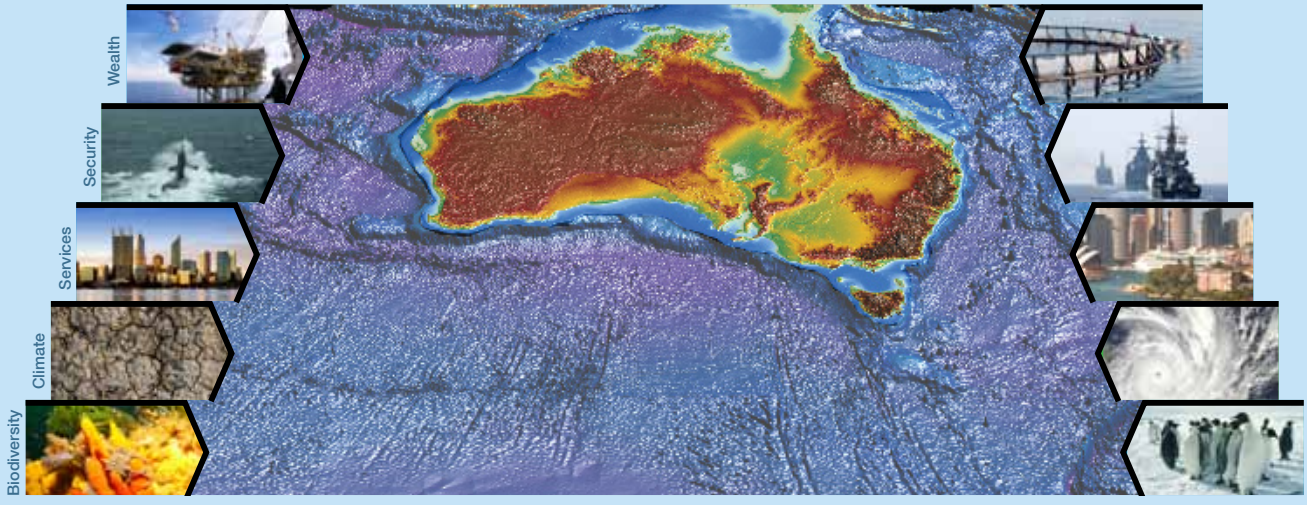

Figure 1: Drivers for systematic and sustained observation of Australia's marine environment

1. Marine Nation 2025: Marine Science to Support Australia's Blue Economy - http://www.aims.gov.au/opsag.
2. The AIMS Index of Marine Industry 2012 - http://www.aims.gov.au/publications.html
3. Towards Future Energy Discovery, Geoscience Australia 2011 - http://www.ga.gov.au/energy.html
4. Marine Biodiversity in the Australian Region, Butler, Rees, Beesley and Bax, PLOS One, August 2010 http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0011831

Rear Admiral Mark Purcell, Royal Australian Navy
"If the Navy is not able to access and analyse environmental knowledge, deployment plans can be flawed by the use of platforms not suited to the environment, surveillance intentions can be thwarted by the inability of sensors to meet requirements and weapons may prove ineffective against key targets. Knowledge of the maritime environment is a vital element for operational success."

Mike Seymour, Shell Australia
"Large projects have long lead times, are designed to have 20-30-40 year lifespans, and so lend themselves to partnership & collaboration between industry and the scientific community... There is much we don't know about Australia's marine environment, and so from our perspective, the ability to draw upon world class scientific expertise (as exists here in Australia) is absolutely key."

Dr Shailesh Nayak, Secretary, Ministry of Earth Sciences, Government of India
"...Systematic scientific time-series will not only improve the knowledge and understanding of climate variability, but also help decision making. I believe that it is important to continue to sustain these ocean observation networks for a longer period, in terms of assessing the climate variability and changes...I would like to take this opportunity to compliment you and your team for the tremendous work done under IMOS of Australia. We will be happy to continue working with you in the future, and extend support required."

Addressing these big science questions requires the most up-to-date research infrastructure for systematic collection of observations, and management and analysis of resulting data sets. It requires an IMOS. Only by creating time series of key marine and coastal variables will we be able to properly understand the nature and rate of change in marine systems, and its attribution to natural and anthropogenic causes. The Australian marine and climate science community is investing considerable effort in science and implementation planning to guide ongoing development of IMOS in this respect, providing the best available scientific advice on what to observe, how, where, when and why.

The Australian public is clearly demanding more of marine and climate science. There is much contention over management of multiple uses in marine world heritage areas, port expansion, development of offshore oil and gas reserves, marine protected areas and management of fisheries, and confidence in climate models. A common problem across these issues is the historical lack of an adequate observational basis on which to build modelling and experimental studies, meaning that our understanding of coasts and oceans is inadequate to inform policy and management. IMOS has been a game changer in providing Australia with systematic planning and implementation of national scale marine observing facilities, and a national marine information infrastructure enabling open access to all data. It has made an excellent start in addressing historical inadequacies, and must be sustained if we are to build the baselines and time series required.

Australia's integrated marine observing effort has to be considered within an international context. The ocean is a globally connected system, and marine observing is an international endeavour. By giving it priority at the national level we attract significant collaboration from the world's most scientifically advanced nations, and establish a leadership position in our region. A modest level of annual investment in IMOS as the national marine observing system has proven to make very good sense to date, providing both an independent capability to assist Australia in managing its own marine estate, and a significant attractor of international collaboration and co-investment.

These factors combine to define the **Need** for ongoing investment in IMOS. The societal benefits are significant, the role of science and research is clear, and the demand for significant improvement in the observational base and availability of data is compelling.

A national collaborative approach is particularly suitable for marine observing and data management. No one jurisdiction or institution, public or private, has the capability, capacity, resources or mandate to do the job alone. IMOS has demonstrated that a single national collaborative system can be implemented, effectively and efficiently. With an appropriate level of Australian Government investment in place, the established partnerships required to address current and future needs can be maintained and grown.

IMOS will pursue three strategic priorities under the Need imperative, in the areas of (1) national engagement, (2) data as infrastructure, and (3) international collaboration.

Key mechanisms for implementation will include:

- Ongoing development of IMOS science and implementation planning that is broadly based and peer reviewed.
- Formation of partnerships with major research programs delivering marine and climate science into policy, management, and operations, across government, industry and society.
- Engagement with higher level frameworks and roadmaps guiding the Australian National Innovation System.
- Open access to all IMOS data and ongoing development of a broader Australian Ocean Data Network (AODN) in partnership with other data custodians.
- Embedding all IMOS Facilities in relevant international programs.
- Engagement with the global ocean observing community (through the Global Ocean Observing System and Group on Earth Observations), with regional scale multinational communities (such as the Indian Ocean Observing System), and with national partners through bi-lateral arrangements (e.g. New Zealand).

3.2 Capability

IMOS 2025 Strategic Priorities - Capability

- Sustain established IMOS capability so as to realise full value from investments to date, and avoid loss of value through discontinuity. Evolve established capability in response to scientific and technological developments, and performance and delivery.
- Position IMOS capability so as to maximise benefits from related investments in remote sensing, vessel operation, marine data management, and ocean and coastal modelling.
- Articulate major gaps, develop costed solutions, and work with partners and stakeholders to identify opportunities for addressing them.

As outlined in Section 2, IMOS has provided Australia with a step-change in its marine observing capability over the last decade. Investments in IMOS Facilities have been carefully targeted to take advantage of developments in marine sensors, autonomous platforms, data and computing. They are integrated from the open ocean, onto the continental shelf, and into the coast, across physical, chemical, and biological variables. Our Facilities and Nodes encompass a wide range of research and user needs across disciplines and jurisdictions. As a result, IMOS has become an essential component of the national research fabric, and Australia has become a much more highly valued partner in the global ocean observing enterprise.

It can be difficult to convey how significant an achievement this really is. Australia's marine domain is vast, wild, deep, complex and dynamic. Yet it is largely 'out of sight and out of mind' for urban and regional Australians on a daily basis. Successful implementation of IMOS has required an unprecedented level of multi-institutional collaboration, significant growth in technical and engineering capacity (~80 FTE funded through IMOS), greatly enhanced cooperation with government and industry partners, and extensive international collaboration.

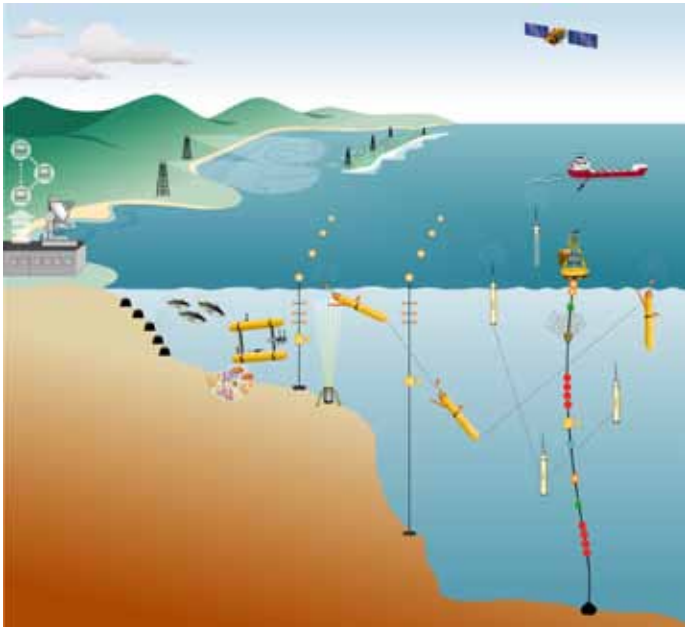

Figure 2: IMOS capability, from space to seafloor, open ocean to coast, physics to biology

The core elements of IMOS capability are well established. A summary of current Facilities is included as ATTACHMENT 1, and more detailed examples of benefits generated are shown in this section – see boxed text. IMOS business systems and routine reporting enable regular, evidence-based assessment of performance across the dimensions of (i) equipment deployment and recovery, (ii) data availability, (iii) uptake and use of data, and (iv) relevance and impact of scientific outputs. In summary, IMOS works and it needs to be sustained.

Argo Australia

Over the last decade a game-changing robotic technology (called the Argo float) has revolutionised our ability to observe the global ocean to 2,000 metres deep. IMOS deployments of just 30 floats per annum along with other national and international deployments have resulted in 10% of the global array of 3,800 floats delivering a continuous data stream for the Australian region.

Acoustics on fishing vessels

It is now understood that successful fisheries and conservation management requires an ecosystem based approach. However the ecosystem models being used have large uncertainties at the centre of the food web (small fish, crustaceans, squids). Using multi-frequency acoustic devices mounted on fishing vessels, IMOS is delivering new information about distribution and abundance of these species for use in research that informs management decisions.

Calibration and validation of satellite measurements in the Southern Hemisphere

Satellites monitoring the height of the ocean (called altimeters) are the tool of choice for studying sea level rise. Precise measurement from space pushes these satellite systems to their limits and some high quality measurements from within the ocean are required. State-of-the-art GPS buoys maintained by IMOS provide the only altimeter calibration and validation sites in the Southern Hemisphere.

Continued support from 2006-15 through NCRIS and related programs indicates that IMOS is seen as a critical national research infrastructure. The Australian Government's 2014 National Commission of Audit (NCOA) has reinforced the need to commit ongoing funding for critical research infrastructure in Australia:

> *Without ongoing funding, established facilities will not deliver their maximum benefit to the research community and much of the value of the initial investment will be lost. Should established facilities be required to close, the cost of re-establishment would be significantly more than that required for their ongoing operation and maintenance.*[5]

Science and technology are dynamic and will inevitably drive the evolution of observational and data management capability into the future. IMOS will manage this evolution by routinely assessing its portfolio from the perspective of 'readiness', as recommended by the Global Ocean Observing System[6]. Mature research capability will be maintained, with an increasing focus on efficiency over time. Where operational utility begins to outweigh research need, consideration should be given to transitioning out of the research environment, noting that this will require close cooperation with relevant operational agencies and a clear framework for transition. Newer capabilities being piloted by IMOS will be matured if successful, or discontinued if not.

Proof-of-concept activities being undertaken within the research environment will be evaluated by IMOS for suitability as next generation pilot capabilities. In this way, IMOS will ensure that its capability continuously evolves to meet current and future needs.

With IMOS established as Australia's *in situ* marine observing system, nationally integrated and globally connected, a completely different scale of capability can be contemplated (see *Figure 3*).

In considering the role of IMOS within this broader view of capability, it is important to note that:

- Australia has no domestic research satellite capability, and is totally reliant on collaboration with international partners to access ocean remote sensing data and products. Provision of high quality in situ observations for calibration and validation of satellite products is therefore a very important role for IMOS to play as a contributing partner to international satellite missions.
- Commissioning of a new blue-water research vessel (RV Investigator) in mid 2014 is very welcome, however Australia's overall research vessel capacity remains extremely modest for a country with the third largest ocean territory on Earth.

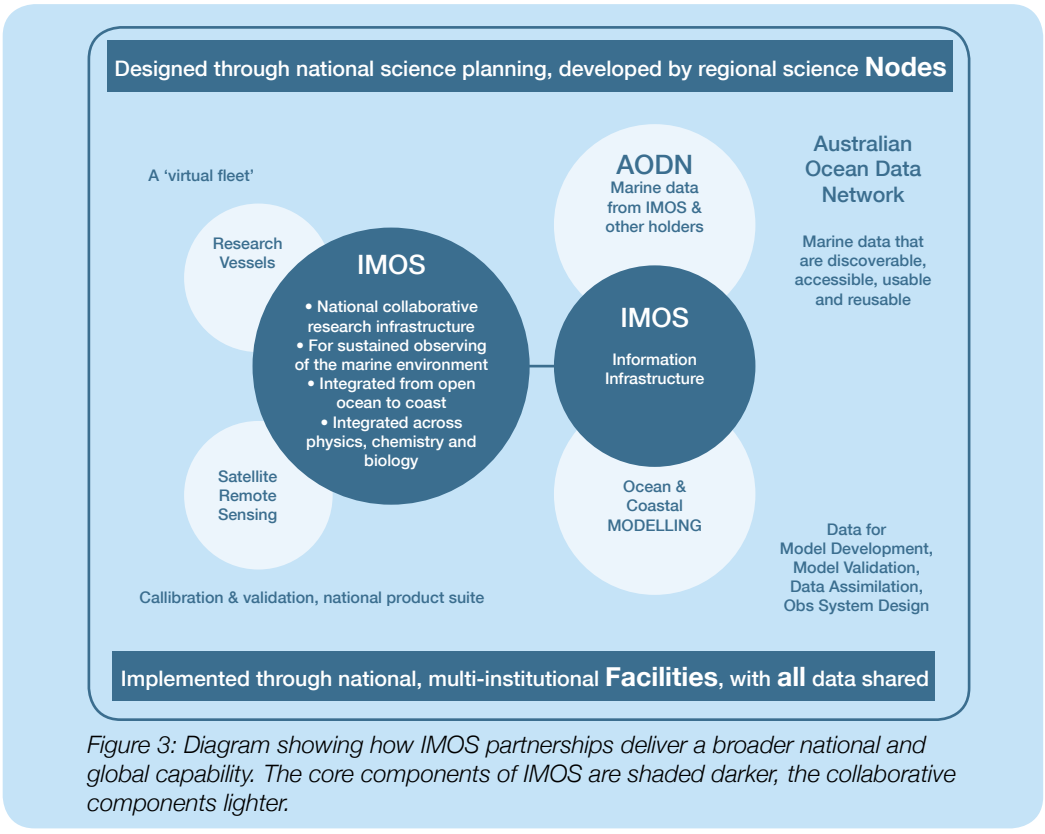

Figure 3: Diagram showing how IMOS partnerships deliver a broader national and global capability. The core components of IMOS are shaded darker, the collaborative components lighter.

5. NCOA, Appendix Volume 2, page 32 - http://www.ncoa.gov.au/report/docs/appendix_volume%202.pdf
6. Framework for Ocean Observing, http://wwwoceanobs09.net/foo/

- The marine information infrastructure developed within IMOS is being used to operate Australia's national Ocean Data Network (AODN), and there is considerable potential to expand this network into new areas including industry-funded marine data collection.
- Significant progress has been made in regional ocean modelling and ocean forecasting that is informed by IMOS observations and data, and we are now well placed to move into the next phase with model-data synthesis as an organising principle.

With a clear national mandate as Australia's integrated marine observing system, IMOS is uniquely positioned to facilitate value adding partnerships across satellite and vessel platforms, marine data custodians, and ocean and coastal modelling activities. Broader connections are also being fostered with related environmental research data activities in terrestrial, atmospheric and geological domains, creating the type of trans-disciplinary research infrastructure required for science of the whole Earth system.

Various national planning and consultative processes have identified the need to grow IMOS capability beyond its current scope. Major gaps are in the deep ocean, the ice zone, and in areas of the coastal zone where high social/economic/environmental value justifies intensified effort. It would not be effective to establish separate observing systems to address these gaps from a whole-of-ecosystem perspective, nor efficient from a cost perspective. For example in the coastal zone, IMOS has laid down a national backbone which includes an information infrastructure, satellite remote sensing validation and processing capability, and strong relationships with coastal modelling activities. It also has spatially explicit infrastructure deployed in the form of coastal radars, coastal gliders, vessel based sampling (e.g. from ferries), moored reference sites, benthic survey sites, animal tracking networks and wireless sensor networks – all capabilities which could readily be extended if required.

Building on established relationships nationally and internationally, IMOS is well positioned to play a key role in addressing these gaps over time. IMOS has already demonstrated that with appropriate levels of core investment in place, partnerships can be established to grow the capability required to meet such emerging needs.

These factors combine to define the **Capability** imperative for IMOS. Three strategic priorities will be pursued, in the areas of (1) sustaining and evolving IMOS capability, (2) positioning IMOS capability to maximise national benefit, and (3) identification and addressing of major gaps.

Key mechanisms for implementation will include:

- Ongoing evidence based assessment of IMOS performance (covering equipment deployment and recovery, data availability, uptake and use of data, and relevance and impact of scientific outputs).
- Ongoing assessment of the readiness of marine observing capability, from proof-of-concept, to pilot, to mature.
- Partnering with vessel operators to create a 'virtual fleet' of Australian research vessels, international research vessels operating in the region, and commercial vessels.
- Partnering with satellite agencies on calibration and validation, and provision of national products.
- Open access to all IMOS data and ongoing development of a broader Australian Ocean Data Network (AODN) in partnership with other data custodians.
- Structured engagement with coastal and ocean modelling activities, through joint projects (e.g. in ocean reanalysis), national workshops, and targeted infrastructure investment at the model-data interface (such as 'virtual laboratories').
- Identification and addressing of major gaps through:
  - Ongoing development of IMOS science and implementation planning;
  - Formation of partnerships with major research programs; and
  - Engagement with higher level frameworks and roadmaps guiding the Australian National Innovation System.

3.3. Impact

IMOS 2025 Strategic Priorities - Impact

- Continue to evolve the observing system in response to national priority setting.
- Sustain effort in areas where impact is high. Focus effort on increasing relevance and impact in sectors with unrealised potential.
- Build partnerships with State Governments and marine industries around the core investment by Australian Government.

Bringing need and capability together in a way that has high impact at national scale requires clear strategy, strong leadership, and good governance. IMOS has achieved this by:

- Attracting the Australian research institutions with the most capability in marine observing to operate as a single, national, collaborative entity;
- Making all of the data collected openly accessible to the entire research community and other users;
- Establishing multiple pathways for uptake and use of data to generate a wide range of science outputs, from peer reviewed publications to operational forecasts; and
- Ensuring relevance of science outputs by aligning with national research priorities and partnering with major research programs across all relevant sectors of government, industry and society.

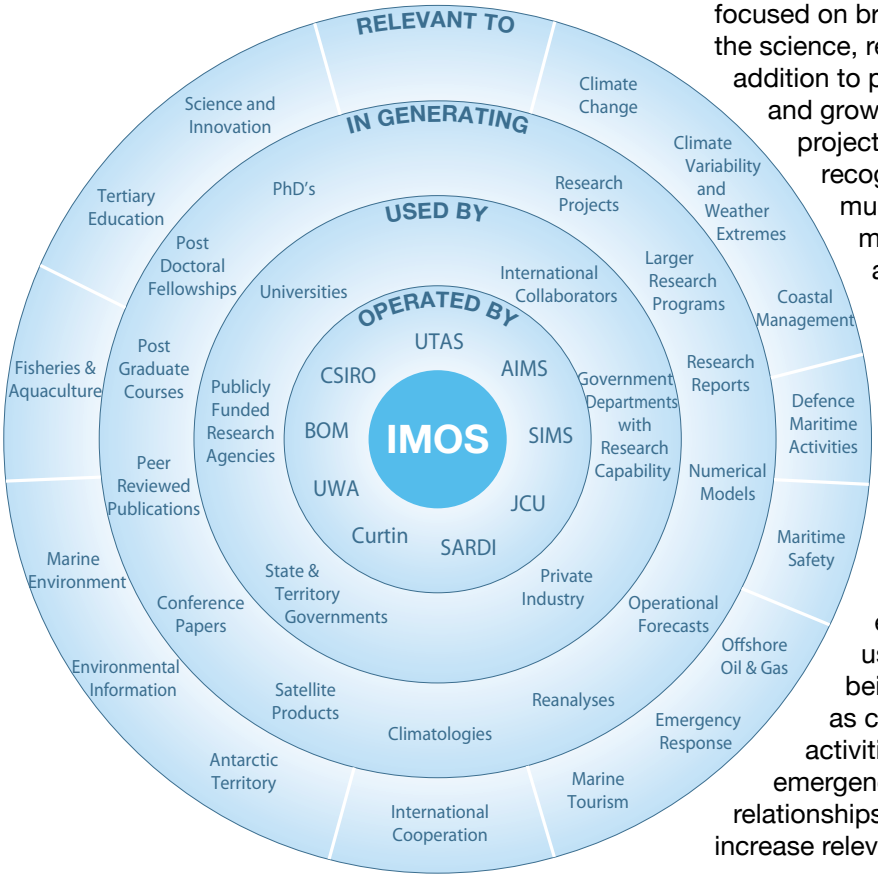

Figure 4: The IMOS 'circle diagram'.

The IMOS 'circle diagram' (see *Figure 4*), which is designed to be read from inside to out, illustrates how the system is operated by selected institutions but available for use by the entire community through open data access, generating a wide range of outputs that are relevant across portfolios and sectors. Within the IMOS community, this is how we have come to think about impact.

Having successfully negotiated an establishment phase in 2006-9 and a growth phase in 2009-11, IMOS entered a sustained observing phase in 2011-15. It is important to note that that these phases have been driven by developments in priority setting within the National Innovation System. No doubt further developments will emerge over the coming decade. IMOS has been adaptable enough to respond to these developments, and will need to continue evolving if it is to be assessed as having high impact into the future. We believe that an unrelenting focus on the IMOS mission will stand the test of time; systematic, sustained, scientifically-robust observation of Australia's vast and valuable marine estate, turning these observations into data, time series, products and analyses that can be used and reused for broad societal benefit.

Scientific output has increased dramatically in recent years. In each of the last three completed annual reporting cycles, publications and reports using IMOS data have grown by 40% per annum, to over 2,000 in total (cumulative to date)[7]. IMOS has increasingly focused on broadening its relevance and impact beyond the science, research and tertiary education sector. In addition to providing observations and data to a large and growing number of research projects, student projects and teaching courses, IMOS is now recognised as an essential partner in large, multi-institutional research programs across multiple sectors. Consistent with needs articulated in Section 3.1, these programs range across marine industries, maritime defence, coastal management, climate and weather, and marine biodiversity.

There is potential to do much, much more over the coming decade. In sectors such as climate change, climate variability and weather extremes, marine environment, and fisheries & aquaculture, many new opportunities are expected to emerge through increasing use of time series and data sets already being generated by IMOS. In sectors such as coastal management, defence maritime activities, maritime safety, offshore oil & gas, and emergency response, work is underway to build the relationships and co-invested partnerships required to increase relevance and impact to new levels.

7. IMOS Annual Highlights document, 2012-13 - http://imos.org.au/highlights.html

Sectors (outer layer of 'circle diagram')	Examples of IMOS Impact[8]
Science and Innovation Tertiary Education	• Contributed to 160 postgraduate projects, 343 journal publications, 213 research projects [All as at 30 June 2013]
Climate Change Climate Variability and Weather Extremes Coastal Management	• Key findings in IPCC Assessment Report 5 (AR5) relied on sustained ocean measurements made as part of the global ocean observing system • Upper ocean heat content (measured by Argo floats) explains 'missing heat' in the Earth's energy budget • 2014 State of Climate Report by CSIRO and Bureau of Meteorology draws on ocean observations
Defence Maritime Activities	• Ocean forecasting capability used by the Royal Australian Navy relies on real time ocean observations (BLUElink project)
Maritime Safety	• Search for Malaysian Airlines Flight MH370 using IMOS products and computer models informed by observations
Offshore Oil & Gas Emergency Response Marine Tourism	• Observations and data being used in a whole of ecosystem study in the Great Australian Bight to inform sustainable development of offshore oil and gas reserves
International Cooperation	• Cooperation with Timor Leste to monitor the Indonesian Through Flow, a critical 'choke point' in the global ocean circulation • Capacity building in marine observing and data management e.g. in Brazil
Marine Environment Environmental Information Antarctic Territory	• Coral bleaching risk to the Great Barrier Reef managed using products based on IMOS observations (ReefTemp project) • Observations informing development of computer models for the Great Barrier Reef, including drivers of reef water quality and Crown of Thorns Starfish outbreaks (eReefs project) • New source of Antarctic Bottom Water formation confirmed using measurements taken by satellite-tagged elephant seals
Fisheries & Aquaculture	• Oceanographic input to management of Western Australian fisheries in a changing environment (including Rock Lobster) • Oceanographic input to management of reef fish and scallop fisheries in Queensland • Observations informing development of computer models used to assess carrying capacity of South Australian gulfs for fisheries and aquaculture

The partnerships required to maximise relevance and impact go beyond Australian Government portfolios, and include State Governments and marine industries. IMOS has already been successful in attracting significant cash co-investment from State Governments ($15M to date) to extend the system in areas of priority for these jurisdictions, and to build capacity in these regions. Partnerships with industry are currently focused on access to platforms (such as ships of opportunity) and access to data, and there is considerable potential yet to be realised in these areas.

These factors combine to define the **Impact** imperative for IMOS. Through broadly based science and implementation planning, open data access, targeted partnering, and international engagement, IMOS has clearly established itself as a 'need-driven' national capability that is underpinning significant impact, nationally and globally. With ongoing support, we are confident that cumulative benefits will increasingly exceed historical investments.

Three strategic priorities will be pursued, in the areas of (1) continuing to respond to national priority setting, (2) sustaining and focusing effort based on current and potential impact, and (3) building partnerships with State Governments and marine industries around core investment by Australian Government.

Key mechanisms for implementation will include:

- Engagement with higher level frameworks and roadmaps guiding the Australian National Innovation System.
- Formation of partnerships with major research programs delivering marine and climate science into policy, management, and operations, across government, industry and society.
- Playing a strong role in the development of operational oceanography capability within Australia, guided by user requirements in sectors such as coastal management, defence maritime activities, maritime safety, offshore oil & gas, and emergency response.
- Using IMOS regional Nodes to continue building on established relationships with State Governments, leveraging the IMOS national backbone and intensifying regional and local activity in priority areas through co-investment.
- Open access to all IMOS data and ongoing development of a broader Australian Ocean Data Network (AODN) in partnership with other data custodians, with a particular emphasis on marine industries and State Governments.

In summary, IMOS is entering its second decade of operation with a clear focus on the strategic imperatives of need, capability and impact. Nine strategic priorities have been set, and key mechanisms for implementation have been identified. Successful execution of this strategy will ensure that by 2025, Australia has a continuously growing time series of essential ocean variables for marine and coastal environments. This will enable cutting edge research on contemporary problems, and provide a scientific basis for informed decision making about our vast and valuable marine estate.

8. Examples mostly drawn from recent 'Marine Matters' newsletters - http://imos.org.au/marine_matters.html

Attachment 1: 'Before' & 'After' IMOS

IMOS Facility	Before IMOS	IMOS 2015
Argo Floats	Argo at pilot scale in Australia from 2000 Partial investment from 2005	Global design density reached in 2008, with 10% of global array in the Australian region Second decade of Argo from 2011
Ships of Opportunity (SOOP)	Historical SOOP observations, largely physical	Expansion and integration of SOOP observations, including biology (plankton, bio-acoustics) and in partnership with industry
Deepwater Moorings	No continuously occupied Deepwater Moorings in the Australian region	Southern Ocean Time Series and Air-Sea Fluxes Major Boundary Currents – East Australian Current, Indonesian Throughflow Antarctic Shelf (bottom water)
Ocean Gliders	No use of gilders by the Australian research community	Twenty glider fleet, coastal and deep ocean, operating nationally
Autonomous Underwater Vehicles (AUV)	No routine use of AUV's by the Australian research community	In-demand national capability covering a national network of reference sites
National Reference Stations	Three long-term stations, maintained serendipitously, monthly sampling only	Seven National Reference Stations, continuous sensor-based sampling plus regular vessel-based sampling
Shelf and Coastal Mooring Arrays	Virtually no continuously occupied mooring arrays in Australia's shelf and coastal oceans	Continuously occupied mooring arrays in NW WA, SW WA, SA, NSW, SEQ and GBR
Ocean Radar	One ARC-funded pilot deployment of Ocean Radar on the GBR	National network of six sites streaming data continuously
Animal Tagging and Monitoring	No national coordination of tagging and monitoring projects Limited contribution to global tagging programs (e.g. Southern Ocean)	Extensive, highly co-invested national network of acoustic listening stations, with 40 million detections and counting Structured satellite tagging programs in Southern Ocean and on Australia's southern coast
Wireless Sensor Networks	No functional marine sensor network in Australian waters	GBR-wide sensor network in place, with 35 million observations and counting
Satellite Remote Sensing	Lack of national coordination regarding *in situ* observations from Australia being made available to international groups developing products used by Australian scientists	Nationally coordinated efforts in sea surface temperature, ocean colour and altimetry Strengthened engagement by Australian scientists on international science teams
Marine Information Infrastructure	Vision for an AODN since 2005, but no functional infrastructure in place	Open access IMOS Ocean Portal launched in June 2009 Now recognised as a world leading marine information infrastructure

An Australian Government Initiative

National Collaborative Research Infrastructure Strategy

UNIVERSITY of TASMANIA

IMOS is a national collaborative research infrastructure, supported by Australian Government. It is led by University of Tasmania in partnership with the Australian marine & climate science community.

www.imos.org.au

The Operators of the IMOS infrastructure are:

sims sydney institute of marine science

JAMES COOK UNIVERSITY AUSTRALIA

Curtin University

Australian Government

Australian Institute of Marine Science

CSIRO

The University of Western Australia

Australian Government Bureau of Meteorology

Government of South Australia

SARDI South Australian Research and Development Institute

Text: Tim Moltmann, IMOS, University of Tasmania, Hobart, Tasmania.
Ian Poiner, Independent chair, IMOS Advisory Board.

Cover and in text photo credits: Rob Harcourt, Macquarie University; A Slotwinski, CSIRO; Australian Institute of Marine Science; CSIRO; Scott Bainbridge, Australian Institute of Marine Science; Kim Brooks, Australian Institute of Marine Science.

Figure 1 photo credits: ExxonMobil Australia, Petuna Seaffod; Royal Australian Navy; Tourism Western Australia; Tourism New South Wales; CSIRO; Bureau of Meteorology; Rob Harcourt, Macquarie University; Australian Antarctic Division.Design by Fiona Brine.

Figure 2 credit: Design by CSIRO Creative Services.