Australian Government

Oceans Policy Science Advisory Group

A Marine Nation:

NATIONAL FRAMEWORK FOR MARINE RESEARCH AND INNOVATION

Prepared by the

Oceans Policy Science Advisory Group (OPSAG)

March 2009

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National Framework for Marine Research and Innovation

This document sets out the rationale for, key elements of and critical requirements for a National Framework for Marine Research and Innovation, and is based on extensive consultation with the marine R&D provider community.

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A Marine Nation: National Framework for Marine Research and Innovation

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Executive summary

A marine nation. Australia is an island continent with more than 70 per cent of its territory in the marine realm. The marine domain is crucial to our economy, through its resources and maritime transport supporting international trade, and to our national security. Inadequate investment in marine science is holding back the development of Australia's marine industries. Moreover, Australia's coasts and oceans host some of the most iconic marine life and habitats on the planet, and are a source of national pride and identity. With 85 per cent of the nation's population living within 50km of the ocean, the coastal marine environment requires careful stewardship for future generations. The surrounding oceans influence Australia's highly variable climate, and its coasts and oceans are vulnerable to climate change. How Australia uses, manages and conserves its marine industries and environmental assets for maximum economic, environmental and social outcomes will be a major factor in its future wellbeing and prosperity.

Opportunities and challenges. This Framework identifies the following major opportunities and challenges facing Australia's marine and coastal domain:

- **Opportunities for increased economic and energy security from marine and subsea resources**;
- **Conservation of marine biodiversity and ecosystem services**;
- **Management and protection of the marine coastal environment**;
- **Climate change**; and
- **National security and safety at sea**.

Marine research and innovation. This paper identifies the research, development and innovation required by government, industry and the community to maximise the potential benefits from this nation's marine resources. The Framework advocates a renewed national effort in marine science through nationally coordinated research involving all marine science providers and users. The National Framework for Marine Research and Innovation encompasses:

- **Exploration, discovery and sustainability**;
- **Observations, understanding and prediction**;
- **Marine industries development**; and
- **Engagement and knowledge transfer**.

Education and training. The paper emphasises the need to address marine science skills shortages and imbalances; and to provide career pathways for early career researchers.

Capability and infrastructure. The paper also identifies those elements in marine science capability and infrastructure that require ongoing and enhanced support and investment to ensure that Australia maintains and builds on its world-class capability in marine science and innovation.

These skills and infrastructure requirements are essential to ensuring that Australian marine science providers can deliver the knowledge, science, technology and innovation to capture the opportunities, meet the challenges and conserve the benefits and splendour of our marine domain for future generations.

Improved governance. The paper also sets out the requirements for oversight and coordination of an invigorated national research effort in marine research and innovation, including the need for an effective interface between marine science providers and policymakers/government (at all levels). In particular, governance of the proposed national framework should:

- **Bring together all marine science providers**;
- **Provide a cohesive strategy for investment**;
- **Provide an appropriate policy interface**; and
- **Provide for annual reporting and accountability**.

Summary of key issues:

- **A national approach.** Australia requires a renewed, strengthened and cohesive national approach to marine research and innovation, through more effective coordination and increased investment in Australian marine science guided by an agreed National Framework for Marine Research and Innovation.
- **Industry engagement.** Supporting the growth and development of Australian marine industries requires strong and expanded engagement between industry and marine research and innovation providers, based on the development of innovative technologies and solutions, and improved partnerships.
- **Skills.** Australian marine science suffers from acute shortages of skilled scientists and technologists including chemists, economists, engineers, geographers, mathematicians, microbiologists, modellers, physicists, statisticians and taxonomists. Shortages are compounded by the lack of career pathways for early career researchers.
- **Coordination and linkages.** Australian education and training in marine science, technology and innovation needs to provide for new human capability through better coordination, linkages and investment to meet current and future demand for qualified marine scientists and technologists, and redress the massive taxonomic knowledge gap in Australia.
- **Infrastructure investment.** Australia requires new investment in marine research and innovation infrastructure, particularly in national research vessel capability; novel technologies and remote sensing; ocean and coastal monitoring; integrated ocean observations; and improved data management and access.
- **Oversight.** A national steering committee for marine research and innovation should be appointed with responsibility for further developing and implementing the National Framework for Marine Research and Innovation, and for providing a high level interface with industry, managers and policy-makers.
- **Policy interface.** It is suggested that the Australian Government, jointly with States and Territories, consider mechanisms for providing a national, comprehensive and inclusive policy interface for interaction with the national steering committee for marine research and innovation, and to provide high-level focus and direction for its coasts and ocean domain.

A Marine Nation: National Framework for Marine Research and Innovation

The value of Australia's coasts and oceans

Australia lays claim to the third largest marine jurisdiction of any nation on Earth. This territory was extended by the United Nations Commission on the Limits of the Continental Shelf, which recently confirmed the location of the outer limit of Australia's continental shelf in nine distinct marine regions in areas beyond 200 nautical miles, extending its jurisdiction by an additional 2.5 million square kilometres to 13.5 million km^2 (see Appendix, Map 1). With this expansion of Australia's territory, the potential for new wealth from its resources has grown enormously, as has the responsibility to protect and sustainably use this valuable asset and to ensure this nation's ongoing security.

"The extension of Australia's marine jurisdiction is a major boost to Australia's offshore resource potential and also to our ability to preserve the marine environment on the seabed."

Martin Ferguson
Minister for Resources, Energy and Tourism

21 April 2008

Australia's coasts and oceans also have great social value, holding a special place in the national psyche, particularly since 85 per cent of the population lives within 50km of the coastline. Australia's oceans and coastal areas contain iconic treasures such as Ningaloo Reef and the Great Barrier Reef, the Kimberley Coast, the Great Australian Bight and the southern and Antarctic waters. All these areas have stunning biodiversity, much of which is endemic to the region and still largely unknown.

Australia's coastal regions and estuaries provide fisheries recruitment and ecosystem services, while its beaches, bays and reefs are the basis of a thriving international tourism sector. However, Australia's coastal communities (projected to continue growing) are placing major pressures on the coastal marine environment through urban development, agriculture, ports, harbours and marine transport, fisheries, tourism and recreation, storm water run off, wastewater discharge and pollution.

Most of Australia's exports and imports are shipped by sea. Its maritime borders need protecting in the face of illegal migration, illegal harvesting of marine resources and the accidental or deliberate introduction of marine pests and diseases.

"The Government's program of marine bioregional planning is helping us to better understand and protect the marine environment, conserve biodiversity and deliver greater certainty to decision-makers and the wider community about Australia's marine conservation priorities."

Peter Garrett
Minister for the Environment, Heritage and the Arts

10 November 2008

The oceans surrounding this island continent hold the key to Australia's climate. The cycles of droughts and floods are controlled by ocean circulation patterns and their interaction with the atmosphere in the Indian, Pacific and Southern Oceans. Droughts and floods, including the prolonged drought underway in parts of Australia, greatly affect Australia's economic, social and environmental wellbeing. To respond to the challenges and opportunities of Australia's highly variable climate, better climate forecasts based on improved observations and understanding of the ocean are essential.

The oceans also influence the rate and pattern of climate change. The evidence is now overwhelming that human activities are driving changes in climate. Australia, already the driest inhabited continent on Earth, is expected to get even warmer and drier in years to come. Better knowledge of future climate will depend on improved understanding of the role of the ocean in climate change. While reducing greenhouse emissions is essential, Australia will also have to adapt to a changing climate. The impacts of climate change will be felt both on land and in the oceans, with efficient and effective adaptation depending on knowledge of the future changes in temperature, rainfall and sea-level rise.

Of particular concern for the marine environment is that climate change impacts are expected to affect coastal and marine ecological and physical systems through rising sea levels and temperatures, as well as changes in land-based run-off, ocean currents, ocean acidity and the frequency and/or severity of major storms.

The full economic, environmental and social value of Australia's coasts and oceans is indeterminate. However, in terms of tangible economic value it is known that Australia's marine sector contributes significantly to the national economy (at least four per cent of GDP and growing faster than other sectors), through energy and food production, recreation and tourism. This growth is part of a global trend, as recognised by the OECD.

In 2005/06 Australia's international maritime trade was worth $249 billion, transporting 695 million tonnes of freight (Bureau of Infrastructure, Transport and Regional Economics, 2007). This number grew during the resources boom, with trade now worth over $340 billion (Department of Foreign Affairs and Trade, 2007).

A recent evaluation of Australia's marine industries (AIMS Index of Marine Industry, prepared annually for AIMS by Deloitte) shows rapid growth, with an increase of 42 per cent since 2000; and valued at $38 billion in 2006/07. It should be noted this is a conservative estimate as economic data are unavailable for many activities and non-economic values have not been included.

The AIMS Index identifies a diverse number of emerging industries, such as marine biodiscovery (marine organisms as a source of new materials and/or pharmaceuticals), seabed mining, carbon capture and storage, desalination and tidal power, that are too young to be valued accurately.

Insufficient investment in science to support Government decision making on new developments and policy proposals is causing economic loss to Australia, as current evaluations show. This inadequate investment is significantly reducing the potential for economic performance in the development of Australia's marine industries.

Maritime transport and services, maritime transport through ports, harbours and shipping are equally difficult to quantify, but provide essential infrastructure to support the aforementioned overseas trade. The OECD reports that global shipping volumes doubled between 1985 and 2007, and the container sector is expected to triple between 2000 and 2020 (OECD/ITF 2008). Associated with maritime transport is the need for ports and shipping channels to be built and maintained to cope with this rapid growth, as shown by the $1 billion Port Phillip Bay channel deepening project.

There are substantial opportunities for Australia to derive national benefit from its ocean territory. There are also major challenges inherent in the responsible management of its marine domain. If well managed and supported, our oceans will significantly enhance national wealth and wellbeing.

"To succeed and prosper, all industries need to embrace innovation and be willing to adopt new ways of doing things."

Kim Carr
Minister for Innovation, Science and Research

Marine Innovation Conference
20 May 2008

Opportunities and challenges for Australia's marine domain

Maximising the dividends from Australia's coasts and oceans, including sustaining marine environmental assets, depends on how the nation responds to the major opportunities and challenges in exploration, exploitation and conservation of marine resources.

Although complex and interlinked, these opportunities and challenges can be grouped into five distinct categories:

- **Opportunities for increased economic and energy security from marine and subsea resources**;
- **Conservation of marine biodiversity and ecosystem services**;
- **Management and protection of the marine coastal environment**;
- **Climate change**; and
- **National security and safety at sea**.

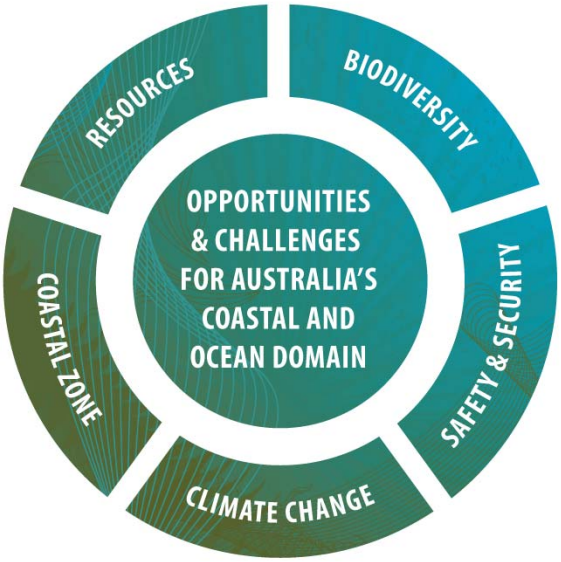


Figure 1: Opportunities and challenges for Australia's coastal and ocean domain

Opportunities for increased economic and energy security from marine and subsea resources

Oil and gas. The quest to secure marine oil and gas resources is intensifying. Over 90 per cent of Australia's liquid hydrocarbon and 74 per cent of the nation's natural gas production occurs in offshore areas. Increasing global demand for energy and fewer discoveries of new oil and gas fields are fuelling pressure for further exploration and extraction within Australia's exclusive economic zone (EEZ) and extended continental shelf. These areas remain under-explored, with less than 20 per cent of prospective offshore basins under licence. Allied to this challenge is the need for novel extraction technologies to increase recovery rates, and the need for more onshore processing plants and new shipping facilities.

Concomitant with the need for energy security are community and industry expectations and legislative requirements that offshore extraction and shore-based processing of Australia's hydrocarbon resources will have low environmental impact.

Many development delays and uncertainties in decision making are caused by the lack of environmental information to support regulatory processes that underpin sustainable development and the conservation of marine biodiversity. The challenge of ensuring the physical and environmental safety of operations in a hostile ocean environment will become even more demanding with a move to deeper waters further offshore.

Fisheries and aquaculture. Australia is in a strong position to ensure fisheries and marine aquaculture in Australian waters (and in its region) are appropriately managed to maintain profitability and long-term sustainability. Australia's decision to manage fisheries in an ecosystem rather than stock management framework, and its clear regulatory guidelines for aquaculture development, contrasts with that of many other nations.

A particular challenge for ecosystem-based fisheries management is that far too little is known about the processes that support ecosystem services and function, and the resilience of marine ecosystems. Further, more needs to be known about the economic and social drivers that govern the industry's operations and investment decisions.

Biodiscovery. The developing field of biodiscovery (investigating the physical and biological properties of chemicals and materials extracted from marine organisms) is globally acknowledged as offering the potential for a new range of applications in both health and materials sciences. A discovery program for Australia's marine and ocean domain is needed, to take advantage of this new opportunity for building national wealth.

Minerals. Exploration for and extraction of marine mineral resources (mineral sands, and potentially also mineral ores) is still in its infancy, both nationally and internationally. However, demand for these resources can be expected to make seabed mining a new frontier, requiring extensive programs directed at discovery; mapping and exploration; new technologies for extraction; and novel environmental information and management tools (to ensure a sustainable industry that maintains the marine environment during the recovery phase).

New economic activities. Finally, there is a push for new economic activities in the coastal zone directed at securing fresh water through desalination; renewable energy through tidal and/or wave power; and at climate change mitigation through capture and sequestration of carbon dioxide in subsea geological basins. Importantly, such developments will need to be considered in the context of ongoing coastal development and natural resource management.

Conservation of marine biodiversity and ecosystem services

The richness, diversity and relatively unspoiled nature of Australia's coastal and oceanic ecosystems, from the tropics to Antarctic waters, are a source of national pride and international attention, and add to Australia's attractiveness as a tourist destination.

Australia has demonstrated its commitment to the protection of its marine environment through being a signatory to international conventions such as the **Convention on the Conservation of Antarctic Marine Living Resources**, the **Convention on Biological Diversity**, and the **World Heritage Convention**.

Australia enacted its own **Environmental Protection and Biodiversity Conservation Act** in 1999, which is designed to manage the sustainable development and protection of the marine realm. Australia has gained world heritage listing for the Great Barrier Reef, Shark Bay (WA) and the Heard and McDonald Islands: and Commonwealth, State and Territory initiatives have also led to the creation of a national representative system of marine protected areas. It is worth noting that the Ningaloo coast and the Kimberley region of northwest Australia are being reviewed for world heritage assessment.

Almost all major cities and much of Australia's industrial activities and intensive agriculture are in the coastal zone, so it should be no surprise that urban development, recreation, tourism, urban and agricultural run-off and pollution, fisheries, aquaculture, shipping and dredging are stressing the resilience of Australia's coastal and ocean environment.

These stresses will be cumulative, and may be synergistic, possibly tipping marine ecosystems over thresholds of sustainability if the ecosystems and the interaction between stressors are not understood. Lack of knowledge and understanding of marine species and ecosystems and the absence of long-term monitoring are making the development of strategies for conserving marine biodiversity difficult and validation of the effectiveness of such strategies almost impossible.

Conservation management through public policy of managing marine ecosystem assets and the careful use of the ecosystem services they provide will deliver increased social and economic dividends for Australia against a trend where the world's marine systems are becoming increasingly polluted, depleted and unable to feed or support human populations.

Management and protection of the coastal marine environment

Coastal zone uses and impacts. The multiplicity of marine coastal zone uses and impacts is extremely complex, making management challenging. The development of integrated sustainable management tools and strategies for public policy development and administration of Australia's coastal waters and marine environment needs to take account of this complexity and requires companion studies in humanities and social science. Detailed marine observations and systems understanding are needed, interactively linked to social and economic instruments that can be used to sustain and govern development without destroying valuable ecosystems assets and public amenity.

In addition to the established coastal zone pressures from human settlement and economic and recreational activities, there is the emerging challenge of needing to develop Australia's ports, harbours and major shipping channels to support rapidly growing international trade which is critical to Australia's economy and wellbeing.

Marine and coastal zone impacts of climate change present a further level of complexity within coastal zone management.

Coastal zone management. The policy oversight for Australia's coastal marine environment is the responsibility of all levels of government, from Commonwealth, State and Territory to local council. The anticipated growth of Australia's coastal population will make integrated coastal zone management an even higher priority than it is today, as recognised in the 2006 **Framework for a National Cooperative Approach to Integrated Coastal Zone Management** prepared under the auspices of the Natural Resource Management Ministerial Council.

Climate change

Climate variability and climate change. The oceans strongly influence both climate variability (e.g. cycles of droughts and floods) and climate change driven by human activities. The oceans store vast amounts of heat and moisture and drive weather and climate patterns through the release of heat and moisture into the atmosphere. In Australia, the year-to-year variations of climate are largely controlled by changes in ocean temperature in the Indian and Pacific Oceans. Better observations and understanding of the oceans surrounding Australia are needed to provide Australian decision-makers in agriculture, water and other climate-sensitive industries with more reliable (and longer lead-time) forecasts of variability in rainfall and temperature patterns.

The rate of climate change depends strongly on the oceans, which have absorbed about one-third of all human emissions of carbon dioxide and hold almost 90 per cent of the global surface warming that has occurred since 1950. The Southern Ocean is particularly important: integrated around the Earth, it absorbs more heat and carbon than any other latitude band. A critical question is whether the Southern Ocean will continue to moderate the rate of climate change in this way into the future.

Uncertainties. Major uncertainties in how Australia will be affected by climate change can only be resolved by a more in-depth understanding of ocean processes. Improved projections, needed to plan for the future and guide the evaluation of adaptation and mitigation options, depend on ocean observations and the accurate representation of ocean processes in climate and Earth systems models.

Marine impact of climate change. One of the most serious impacts of climate change is sea-level rise, which is currently at a rate near the upper limit of projections by the Intergovernmental Panel on Climate Change (IPCC). While much recent attention has been given to the land-based impacts of climate change, marine impacts will be significant and will have widespread economic, environmental and social repercussions.

Rising temperatures and changes in ocean currents and acidification pose major threats to marine species and ecosystems (and are already impacting on coral reefs and fisheries around Australia). Given the importance of the Great Barrier Reef and Ningaloo Reef as both national treasures and centrepieces of a tourist industry worth many billions of dollars, the risk to reef ecosystems from climate change is a significant issue for Australia.

More generally, better understanding of climate change pressures on marine biological, physical and social systems will enable the impacts of climate change to be factored into adaptive management strategies.

National security and safety at sea

Maritime operations. The safety of maritime operations depends on real-time ocean observations and high-resolution forecasts of weather and ocean conditions. Operational ocean forecasting has recently been developed for the blue water domain, and is being extended for the coastal shelf. The products of this science are increased capability for key users such as the Royal Australian Navy in defence operations and the Australian Customs Service for border security (illegal migration and importation) and for patrolling to control illegal fishing in Australian waters (of major concern in northern Australia and the Southern Ocean).

Of particular interest to national security and defence are port approaches and the near shore zone, where activities such as mine countermeasures and amphibious operations require rapid assessment of marine environmental conditions involving a wide range of physical and geological properties. Methods of rapid sensing, data integration and modelling are required; including those that can be used in hostile environments, in peace keeping missions or disaster relief outside Australia. Other applications include marine shipping, marine rescue and safety at sea, marine accidents and pollution, commercial fishing and recreational boating.

Ocean observations and forecasting are also essential for the economically efficient operation and safety of offshore oil and gas operations, particularly in regions where there is a tropical cyclone risk. Operational and tactical demands from multiple users are rapidly growing, requiring significant advances in both ocean observing and ocean forecasting systems, aimed at real-time and regional applications.

Biosecurity. A separate but significant risk to marine security is the accidental or deliberate introduction of marine pests and diseases threatening Australia's coastal species and ecosystems, fisheries and marine aquaculture. This issue of biosecurity is now a recognised challenge that requires national expertise and research facilities.

Responding to the opportunities and challenges

Australian expertise. Australia's world renowned expertise in marine and oceans science derives from a number of national research agencies including the Australian Antarctic Division (AAD), the Australian Hydrographic Service (Defence), the Australian Institute of Marine Science (AIMS), the Bureau of Meteorology, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), Geoscience Australia (GA) and the Bureau of Rural Sciences. In addition there is considerable expertise in the university sector and museums. Significantly, there is also a major marine science interest and expertise in the Australian States and Territories, particularly in Departments of Primary Industries and Resources, Departments of Environment/EPA, Departments of Transport, and Geological Surveys (for a comprehensive listing see Appendix, Tables 1 and 2).

Partnerships. The Cooperative Research Centre for Antarctic Climate and Ecosystems (ACE CRC) has been operational since 1991, and the Australian Seafood CRC began in 2007. Other CRCs have had a focus on the Great Barrier Reef (1993-2006); the Torres Strait (2003-2006); the Coastal Zone (1999-2006); and Aquaculture (1993-2008). The past five years have seen a growth in other national partnerships and alliances of marine science providers, such as the Australian Ocean Data Centre Joint Facility (AODCJF), the recent funding initiatives for marine environmental research (Marine Biodiversity Hub and Marine and Tropical Science Research Facility) under the Commonwealth Environment Research Facilities (CERF) initiative, the establishment of the Integrated Marine Observing System (IMOS) under NCRIS (the National Collaborative Research Infrastructure Strategy) and the formation of the Centre for Australian Climate and Weather Research (CAWCR).

There are also a number of regional partnerships between universities, state, and national agencies, such as the Tasmanian Aquaculture and Fisheries Institute (TAFI), the Western Australian Marine Science Institution (WAMSI), the Arafura Timor Research Facility (ATRF), the Australian Maritime Hydrodynamics Research Centre (AMHRC), the Sydney Institute of Marine Science (SIMS), the Victorian Marine Science Consortium (VMSC) and the ARC Centre of Excellence in Coral Reef Studies (based at James Cook University).

Enhanced capability, coordination and collaboration. Feedback from providers and users of marine science during this paper's consultative process (Appendix, Table 5) indicates that to maximise sustained economic and social dividends from Australia's coasts and oceans while protecting their ecosystem integrity, greater capability and additional coordination and collaboration are needed to build concentrations of excellence and better disseminate knowledge. It is agreed that this can best be achieved through the development, funding and implementation of a National Framework for Marine Research and Innovation.

Investment. The recently released report on the **Review of the National Innovation System** states that Australia's investment in marine research and maritime industries is 'underweight'. It also recommends closer collaboration between publicly funded research agencies (PFRAs) and universities, and proposes 'marine industries' as one of nine national innovation priorities. The OPSAG initiative of developing a National Framework for Marine Research and Innovation meshes well with the National Innovation System Review recommendations.

A National Framework for Marine Research and Innovation

The proposed National Framework for Marine Research and Innovation addresses the identified opportunities and challenges in the marine and oceans sphere through three highly complementary and interlinked core elements, supported by a fourth element directed at engagement and knowledge transfer to ensure maximum effectiveness.

The proposed four elements of the national framework are:

- **Exploration, discovery and sustainability**;
- **Observations, modelling and prediction**;
- **Marine industries development**; and
- **Engagement and knowledge transfer**.

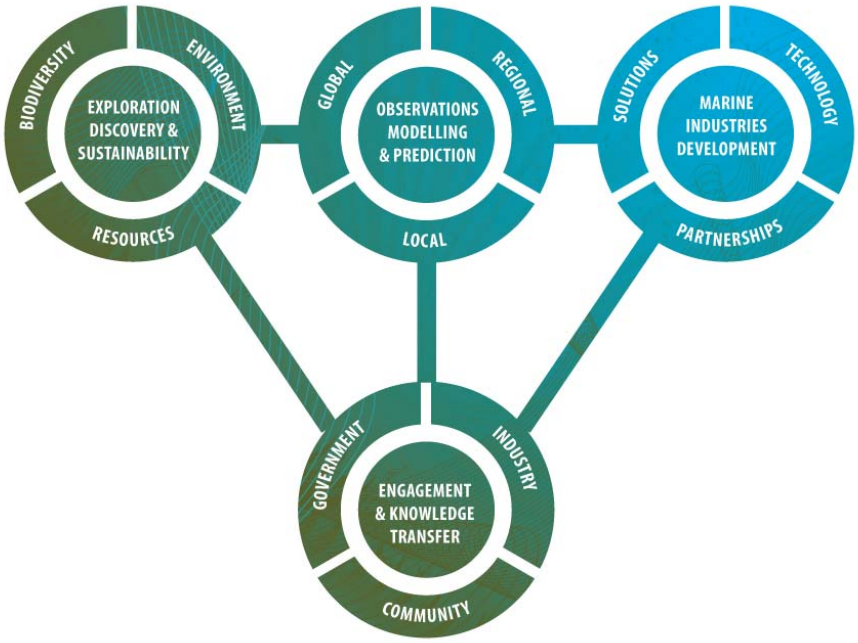


Figure 2: A National Framework for Marine Research and Innovation

Exploration, discovery and sustainability

The development of an integrated and collaborative marine exploration, discovery and sustainability program will provide the foundation for better informed management of Australia's marine resources, marine biodiversity, coastal zone, marine climate change impacts and marine safety and security. It will cover inshore to open ocean, and all scientific aspects: biological, geological, physical and chemical. It will have three major areas of endeavour:

Biodiversity. A program to identify, classify, map and conserve Australia's marine living resources through voyages of discovery and targeted, intensive regional studies and development of reference collections. In addition, long-term studies are needed to deliver information for ecosystem management and indicators of ecosystem health critical to ensure that future economic uses of Australia's coastal zone and extended EEZ are environmentally sustainable and socially acceptable. The marine biodiversity discovery program will also open up the potential for the identification and/or development of biomaterials and pharmaceuticals from newly discovered marine organisms.

Coastal and ocean environment. A program to further explore and document Australia's inshore coastal, continental shelf and deep ocean environment, including bathymetry, geology and geomorphology. This will provide information needed to deal with the combined challenges of coastal development and the physical impacts of climate change, and to chart the unknown aspects of Australia's ocean territory and surrounding oceans.

Subsea and seabed resources. A program to explore subsea oil and gas, and seabed minerals, based on geological surveys, profiling, remote sensing, seabed mapping and in situ seafloor sampling for all of Australia's extended continental shelf. Such a national commitment, using the latest and most innovative technology, will help Australia realise the potential of its offshore resources.

Observations, modelling and prediction

The marine environment is highly complex. It entails the physical environment of ocean processes and dynamics that drive ocean currents; the ocean-atmosphere-ice interactions that influence weather and climate; the highly complex biological and ecological interactions of marine living species and systems that sustain ocean life; and includes the impact of human systems, through the capture of resources, including the impact of global and/or regional pollution and economic and social activity.

This second major element of the proposed national marine framework is directed at integrated coastal and marine observations, and process studies for generation of knowledge and understanding that will enable the development of predictive models. It will involve developing and applying novel technologies and determining the complex biogeophysical properties and interactions of the marine and coastal environment, enabling researchers to represent this complex behaviour in mathematical and biophysical models and applications that can be used for adaptive and sustainable management of marine resources; marine protected areas and the coastal zone; and for predicting climate change and variability. The marine systems observations, understanding and prediction element will be carried out in three hierarchal approaches:

Global. A program directed at observations, characterisation, understanding and modelling of ocean processes and dynamics—critical to climate prediction, ocean forecasting, marine safety, and the successful management and protection of marine and subsea resources. A major aspect of this program will involve maintaining and expanding Australia's research and operational ocean observing systems and streamlining ocean data delivery.

Coastal and regional. A program directed at understanding marine biophysical systems at the coastal and regional level. This is essential for developing and supporting bioregional plans for Australia's oceans, including networks of marine protected areas; the management and ecological sustainability of Australia's fisheries; the safety and environmental impact of offshore exploration and recovery of oil and gas; and to underpin integrated coastal zone management.

Local. A program of activity aimed at local investigations of the biogeochemical and physical marine system, which, given both the proximity of urban and regional populations and the presence of large-scale economic activity, will require its own specialist focus, interactions and investigative tools. The studies are vital to integrated coastal zone management and to the development of adaptive strategies for coastal impacts of climate change.

Marine industries development

Australian marine industries are of major value to the nation and rapidly growing. Supporting this growth requires strong and expanded engagement with marine research and innovation providers, based on developing innovative technologies and solutions and creating formal partnerships. Therefore, to strengthen national capability in marine industries, the third element of the proposed national framework is directed at marine industries development. This envisages involvement in marine technology and engineering, materials science (new materials, advanced sensors), robotics and marine information and communications technology. The three focal areas are:

Innovative technology. A program directed at working with industry to develop new technologies that will provide competitive advantage and environmental effectiveness. Applications will include the economically important oil and gas industry, fisheries and aquaculture, and emerging industries such as seabed mining, tidal and wave energy generation and subsea carbon sequestration.

Innovative solutions. A program directed at a range of marine science innovations. These include novel applications of remote sensing technologies for surveying and mapping; the development of ocean forecasting applications for maritime transport and safety; and the development of new materials for use in marine applications.

Partnerships. A program aimed at building strong relationships with industry and government end users through creation of formal partnerships in marine research and innovation.

Engagement and knowledge transfer

The development and delivery of marine research and innovation requires effective engagement and close interactions between research providers and stakeholders. It also requires formulating shared visions of future requirements and effective and targeted information exchange, including the definition of their requirements by users of information, technology and outputs.

A significant aspect of this engagement is the recognition of the social and economic dimension of science and technology applications, particularly in developing and implementing response strategies in environmental management, conservation and development.

Community engagement, the building of stakeholder relationships, frequent dialogue, open access, the timely delivery of data and information and the effective technology transfer of marine research output are a paramount fourth element of the marine research and innovation response. There are three focal areas:

Industry. A program aimed at effective engagement and communication with Australia's marine industries, including knowledge and technology transfer. The program would cover all major sectors including fisheries and aquaculture, seabed and subsea resources, tourism, ports, maritime transport, infrastructure and safety.

Government. A program aimed at effective engagement and priority and direction setting, including knowledge transfer with policy makers at Commonwealth, State and Territory, and local government levels. The program would cover marine resources; biodiversity; coastal zone management; climate prediction and the marine impacts of climate change; and marine safety and security.

Community. A program aimed at informing and engaging the Australian community on the value of Australia's marine domain, and the marine opportunities and challenges facing Australia's coasts and oceans. The program would improve public interest in, understanding of and support for marine research and innovation and the value of Australia's marine domain. The use of indigenous knowledge and the engagement of indigenous Australians in the management of Australia's coastal and marine domain will be a special focus.

Skills and infrastructure requirements

The delivery of first-rate research and innovation in Australian marine science means putting in place the right skills, career paths, facilities and infrastructure to achieve the national objectives.

Education and training

Education and training challenges. Generating intellectual capital, developing and operating systems and successfully taking up marine research and innovation require marine scientists with the skills to address the nation's needs. Current research funding levels limit career paths in marine science, resulting in researchers leaving the discipline. Currently there is a severe mismatch between training and national need. Major education and training challenges are:

- Difficulty in attracting the brightest and most innovative students;
- Acute shortages in graduates with training in chemistry, economics, mathematics, microbiology, modelling, physics, statistics and taxonomy;
- Shortages in electrical and mechanical engineers to support marine and oceanographic research and monitoring operations, geophysics and engineering graduates to satisfy existing and anticipated future demand in marine industries, and insufficient training of taxonomists for biological monitoring operations and biosecurity initiatives;
- A lack of hydrographic surveying education and training courses in Australia (except Navy training); and,
- A lack of career pathways for early career researchers, resulting in a 'brain drain' from the discipline.

Universities, marine science agencies and museums are aware of these issues and are interested in further exploring opportunities to jointly improve education, training and retention to ensure the next generation of marine science graduates have the skills that Australia requires.

Partnerships. Successful partnerships between universities and national and/or state agencies provide models for further development of the national marine science education and training capability, particularly in areas of ocean science and marine ecology.

Strategies to improve education and research training would include facilitating increased participation of ocean scientists from marine science agencies in higher education and training, and increased funding opportunities (e.g. through the ARC) for joint projects between universities and marine science agencies. In particular, the national capability in marine research vessels (see below) offers a unique opportunity to provide marine science students with training opportunities at sea. Similarly, as Australian expertise in marine taxonomy is primarily located in museums, mechanisms for closer interactions between museum staff and universities/national/state agencies can be developed and expanded to encourage students to specialise in taxonomy, and to ensure that taxonomic expertise is passed on to the next generation and novel taxonomic techniques (e.g. barcode, 4-5-4 sequencing) are available in Australia.

Observational systems and infrastructure

Effective and productive marine research and innovation depends on widely accessible advanced observational tools, systems and infrastructure. By nature, they serve and benefit the common (marine science) good and not just a particular sector. The major infrastructure elements needed in support of a national program in marine research and innovation are:

Research vessel capability. Innovation in marine science needs access to multi-discipline equipped marine research vessels and marine observing systems. Due to the great intrinsic scientific value of Australian and adjacent international waters, scientific vessels from a number of countries routinely conduct research while in or transiting Australian waters. Australian researchers and agencies often make use of such opportunities for international collaboration and/or use of such facilities.
But this *ad hoc* system means that nationally significant research is conducted according to other

nations' or enterprises' timetables. There is a pressing and ongoing national requirement for blue-water research vessel capability and for a vessel with ice-breaking capacity equipped for operating at high latitudes. Inshore marine science requires multiple medium-sized research vessel capability.

This national research vessel capability needs to be supported with sufficient funding for marine expeditions, surveys, post-survey data analysis and the identification and curation of biological specimens. Although available resources may be maximised through increased coordination and sharing of facilities and ship-time, it should be noted that the capacity for Australia to undertake significant ship-based work within and beyond the EEZ is severely handicapped by the number, current range, age and capability of Australia's research ships.

Novel Technologies. The difficulty in accessing much of Australia's marine jurisdiction requires the use of novel technologies for monitoring, surveying, mapping and sampling. These include AUVs (autonomous underwater vehicles), ROVs (remotely operated vehicles), ocean gliders, new tags, wireless networks and novel sensors. For example, new sensor arrays of ocean measurement devices (temperature, conductivity, biophysical) have the potential to revolutionise monitoring of coastal regions.

Australia also requires coordinated investment in, and ongoing support for, the development of novel sensors especially to measure and monitor biodiversity and the collection and monitoring of biophysical and environmental marine data. The establishment of Australia's Integrated Marine Observing System (IMOS) addresses this need but continued commitment to the further development of IMOS is needed.

These novel technologies can also be used in voyages of discovery to study marine living organisms in remote locations. Currently, Australia has limited national capability in these areas, which is particularly pressing given the need for basic observational data, and the expanse of Australia's ocean territory and surrounding oceans.

Remote sensing. The observation of the marine domain by satellite, airborne, and shipborne instruments is a major research and operational tool in marine science. Australian applications in remote sensing include surveying, mapping and monitoring of coastal waters, shelf regions and the EEZ, with applications ranging from marine living resources to sea-bed and subsea resources, and from safety and security to ocean forecasting. Ongoing access to the latest remote sensing technology is vital to Australia's ocean observing capability, and requires both national capability and strong involvement and participation in international programs for ocean observing.

Coastal and Ocean Monitoring. Ocean monitoring and data assimilation is critical to climate prediction and for climate change detection and attribution, while long-term biophysical environmental data series in the marine environment are needed to examine trends, predict the future and enable successful adaptation to change. Australia should consider instigating a national initiative similar to the LTER (Long Term Ecological Research Network) initiatives in the United States.

Research stations. Research stations for the local study of the marine environment are important in the study of marine species and ecology and marine biophysical systems. They also provide opportunity for education and training. Australia needs ongoing coordinated and dedicated support for a network of research stations to facilitate scientific study of Australia's coasts, coral reefs and temperate/high latitude domain.

High performance supercomputing for modelling and data assimilation. Ocean forecasting and data assimilation for marine safety and security at sea; modelling for climate variability and climate change prediction; and development of adaptation responses to impacts of climate change are highly dependent on supercomputing. This becomes even more demanding as researchers take the necessary steps towards including social and economic data in a true 'Earth Systems' approach to biogeophysical modelling. To support this, Australia will need a strong commitment to making ongoing and strategic investments in high performance supercomputing, noting that this is also a major challenge for the national climate change science effort.

E-infrastructure. Access to marine data has hitherto been patchy, poorly valued and a real inhibitor to innovative cross-discipline research. Essential to effective functioning of Australian marine science

will be open access to a national, federated, distributed database system for marine data utilising common metadata standards and exchange formats. E-infrastructure will help bring diverse measurements together and facilitate the joint interpretation of data streams. This effort would build on current initiatives such as the Australian Ocean Data Centre Joint Facility (AODCJF), IMOS and AARNet.

Digitisation of priority marine science collections. Marine science depends on museums and other collection holders for data generation, management, curation, maintenance and delivery of digitised collection information across nationally distributed collections. Support for digitisation of priority marine science collections is required to fully unlock the value for marine researchers in Australia and overseas.

Biocontainment facilities. Aquatic pests and diseases are a growing threat to Australian fisheries and aquaculture and to the nation's estuaries, coasts and ocean environment. Outbreaks can have severe economic, social and environmental consequences. Secure aquatic physical/biological containment facilities are needed that will allow research on control strategies for marine incursions of pests and diseases, similar to existing facilities for the terrestrial environment.

Networking and collaboration

Efficient national and international networking and collaboration is essential for successfully delivering marine science and innovation, particularly given the complexity of the challenges and the scale of effort required. No single organisation or agency has the skills, capability and infrastructure to deliver the national outcomes. A number of successful national and regional partnerships in marine science have been noted earlier. The recently released WAMSI report A Turning of the Tide: Science for Decisions in the Kimberley Browse Marine Region, which outlines the business and science case for marine science investment in the Kimberley Browse region, highlights the requirement for networking and collaboration to address high priority national and regional needs.

Other than through OPSAG, there is no formal national network of marine science providers. National networking and coordination at high-level is needed to ensure the alignment of goals and the setting of national priorities; the development of mechanisms for coordination, sharing of resources and facilities and collaboration; and to provide a platform for effective and successful engagement with the many stakeholder communities in government and industry.

With respect to funding, multi-discipline, multi-platform, integration aspects of marine science require a broad marine science approach, rather than the discipline-by-discipline approach of some research funding schemes. This broad, integrated approach to funding of marine research and innovation should be used to encourage and facilitate collaboration and/or joint ventures between institutions, agencies and states.

The national framework will also provide mechanisms for bringing experts together from all agencies (including PhD students and post-doctoral fellows) for synthesis tasks in key areas where national assessments are urgently required.

Governance

Governance of a national framework for marine research and innovation will need to:

- Bring together all major marine research and innovation providers, in a national commitment on major research initiatives, outputs and outcomes for Australia, thereby maximising the returns on national investment in marine science;
- Provide for a clear and cohesive strategy for investment in marine research and innovation, with a comprehensive approach guiding national approaches to the required education, training, observational systems and infrastructure;
- Provide a policy interface across whole of government (Commonwealth, State and Territory), allowing for effective and successful information and technology transfer, information exchange and government input to marine research and innovation initiatives; and
- Provide for annual reporting against major agreed objectives and accountability for new government investments in marine research and innovation.

In the absence of other coordination mechanisms, OPSAG has taken carriage of bringing the science providers together to develop the current Framework in consultation with the users of marine science. To take responsibility for its further development and implementation, a more formal high-level steering committee (e.g. a national steering committee for marine research and innovation) will be needed, with a balanced representation from the marine science sector.

The development of a national framework must acknowledge that participating jurisdictions and agencies will continue to need to meet their fundamental commitments, which cannot be compromised.

A national steering committee for marine research and innovation

The proposed national steering committee for marine research and innovation would report to the appropriate Government policy interface (as discussed below) and have the responsibility to further develop, manage and implement the National Framework. Responsibilities would be to:

- Oversee major opportunities and challenges for Australia's coasts and ocean domain, and advise relevant governments and/or agencies (Australian, State/Territory, Local) of possible responses;
- Consult with marine industry stakeholders on priorities and directions in marine research and innovation;
- Develop national high-level priorities for marine research and innovation;
- Implement national marine research and innovation initiatives;
- Coordinate the national effort in marine research and innovation;
- Develop a national strategy for education, training and career pathways in marine research and innovation; and
- Provide high-level annual reports on developments and achievements in marine science, and accountability for new initiatives in marine research and innovation.

It is suggested that the establishment and implementation of this high-level steering committee would be a government responsibility, with its operation and responsibilities based on government/national needs, as decided in consultation with government and industry stakeholders and the marine science community.

A national policy interface

As summarised in Tables 1 and 2, responsibilities for the coastal and marine domain (especially when taking into account diverse areas such as tourism, subsea and seabed resources, maritime transport and marine industries) are shared by a large number of government departments and all levels of government.

It is therefore suggested that the Australian Government, jointly with States and Territories, consider mechanisms for a national, comprehensive and inclusive policy interface with the national steering committee for marine research and innovation, and to provide high-level focus and direction for its coasts and ocean domain. Such a national coasts and oceans policy interface would:

- Provide the critical (and currently missing) link between marine industries, marine science and marine policy and implementation across all levels of government;
- Provide an integrated overview of national directions for Australia's marine industries and marine environment; and
- Provide high-level priorities and directions for Australia's national effort in marine research and innovation.

Relationship to other national reviews, frameworks and initiatives

The Review of the National Innovation System was released in September 2008. Its recommendations, if accepted by Government, will lead to a stronger industry presence in marine research and innovation, with the potential for new and stronger industry partnerships in and/or support for marine science. Its recommendations also provide for stronger relationships between publicly funded research agencies (PFRAs) and universities, and increased investment in marine research, innovation and infrastructure.

The recommendations of the 2008 **Review of Cooperative Research Centres** are relevant, particularly regarding support for the continuation of a commitment to CRCs engaged in 'public good' science. This, in principle, opens the possibility of new CRC proposals in the marine industries and marine environment sphere. The 2008 House of Representatives **Inquiry into Research Training in Australian Universities** may be relevant, as it goes to the issue of capability. Also relevant are the outcomes of the **Review of Higher Education** (December 2008), given the strong presence of Australian universities in marine science, and the issues concerning coordinating and rationalising training and development to ensure Australia has the right skills base, as highlighted in this paper.

The Government's 2008 **Infrastructure Australia** initiative is also relevant, particularly with respect to transport infrastructure as it relates to ports and harbours and the marine and coastal impacts of changes and expansion.

As noted earlier in this document, the 2006 **Framework for a National Cooperative Approach to Integrated Coastal Zone Management** prepared under the auspices of the Natural Resource Management Ministerial Council, is still current and highly relevant to the discussion and objectives of the proposed marine framework.

The **Integrated Marine Observing System** (IMOS) is a nationwide collaborative program involving 27 institutions, funded under the National Collaborative Research Infrastructure Strategy (NCRIS). IMOS observes the oceans around Australia, including the coastal oceans and the 'bluewater' open oceans, and will need to be further strengthened and expanded under the proposed National Framework for Marine Research and Innovation.

NCRIS also funds the **Atlas of Living Australia** (ALA) project to develop a biodiversity data management system linking Australia's biological knowledge with its scientific and agricultural reference collections; including marine collections.

Given the role of the oceans in climate and climate change, there is synergy and common purpose between the National Framework for Marine Research and Innovation, and the **National Framework for Climate Change Science** being developed by the Department of Climate Change.

Australia's Ocean Policy was released in 1998 and continues to guide the direction of the Australian Government's programs in the marine environment. The policy provides for consistency in marine planning and management, while allowing for regional diversity. The original governance arrangements have changed substantially since their establishment in 1998. The National Oceans Ministerial Board was dissolved in 2004; the National Oceans Advisory Group now reports to the Minister for the Environment, Heritage and the Arts; and the National Oceans Office was incorporated into the Marine Division of the Department for the Environment, Water, Heritage and the Arts in 2004, and continues to have lead responsibility for regional marine planning.

The Marine and Coastal Committee (MACC) is an advisory committee to the Standing Committee of the Natural Resources Management Ministerial Council, and is concerned with issues of national significance relating to the conservation and ecologically sustainable development of marine and coastal ecosystems and resources. MACC also considers issues related to sustainable industry development in the marine and coastal zone.

The way forward

The current document represents the first step towards creating a National Framework for Marine Research and Innovation that is jointly owned and supported by marine science providers, government, marine industry stakeholders and the Australian community.

Key elements of the proposed framework have been submitted to the Review of the National Innovation System, which recognised marine science and marine industries as a national innovation priority. The way forward will include:

- Further stakeholder consultation;
- Briefing of relevant Government ministers and departments; and
- Briefing of, and consultation with, the Marine and Coastal Committee (of the Natural Resources Ministerial Council).

Detailed implementation of the Framework will depend on the responses to the current consultation process. Among the responses to date is the suggestion that Australia needs an audit of its current marine science investment, infrastructure and capability.

Summary and conclusions

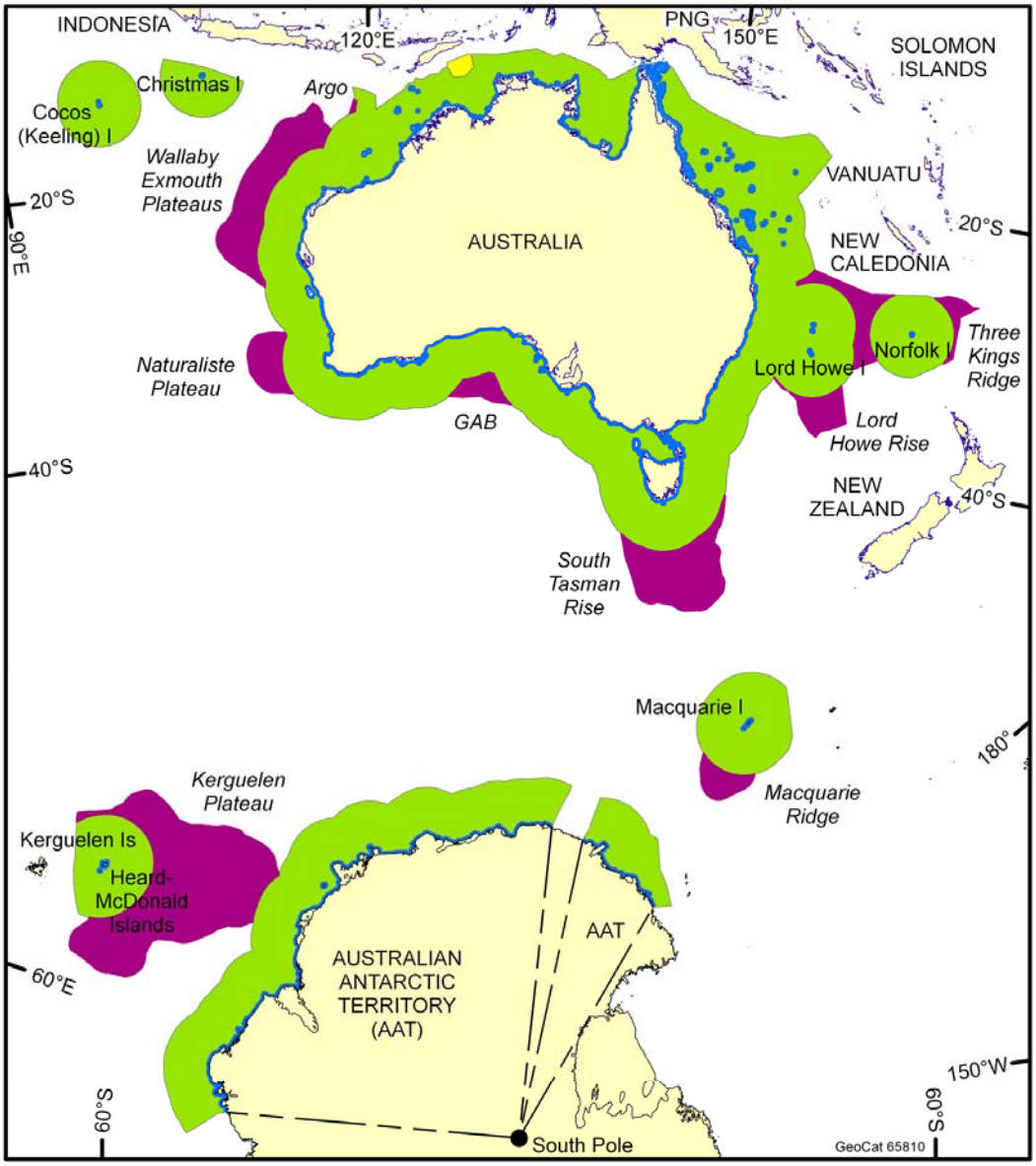
This National Framework for Marine Research and Innovation highlights the major opportunities and identifies the challenges facing Australia's marine and coastal domain and sets out the research, development and innovation required to respond to the opportunities and challenges and to inform decisions by government, industry and the community.

The Framework provides for a renewed national effort in marine science through increased investment in marine science, better planning, coordination, collaboration and communication; and identifies the skills and infrastructure needed to support a national program in marine research and innovation.

The Framework will enable Australia to seize the opportunity and successfully exercise its sovereign rights and responsibilities for its coasts and oceans, and highlights the need for a whole of government (Commonwealth, States and Territories) approach to the management of Australia's coast and ocean domain.

Appendix

Map 1: Australia's marine jurisdiction



AUSTRALIA'S CONTINENTAL SHELF CONFIRMED BY THE COMMISSION ON THE LIMITS OF THE CONTINENTAL SHELF

Territorial sea and internal waters

Areas of marine jurisdiction within 200 M of Australia and its external territories

Area of Australia's continental shelf beyond 200 M as confirmed by the Commission on the Limits of the Continental Shelf

Joint Petroleum Development Area under Timor Sea Treaty 2002

Note: The areas of continental shelf depicted to the north-west of Australia reflect the terms of the 1997 maritime boundary treaty with Indonesia which has not yet entered into force.

1 nautical mile (M) = 1852m

Table 1: Commonwealth engagement in understanding, managing and protecting Australia's coasts and oceans

Department	Agencies/responsibilities
Innovation, Industry, Science and Research	Australian Institute of Marine Science; Commonwealth Scientific and Industrial Research Organisation; Australian Nuclear Science and Technology Organisation; Australian Research Council; Cooperative Research Centres; Office of the Chief Scientist; National Collaborative Research Infrastructure Strategy; National Science and Technology Centre
Education, Employment and Workplace Relations	Universities; Higher Education Endowment Fund
Environment, Water, Heritage and the Arts	Australian Antarctic Division; Bureau of Meteorology; Great Barrier Reef Marine Park Authority; Great Barrier Reef Ministerial Council; Oceans Policy Science Advisory Group; Australian Biological Resources Study; Marine Division; Commonwealth Environment Research Facilities Program; Australian National Maritime Museum; National Museum of Australia
Climate Change	Climate change science, climate change adaptation, climate change mitigation
Resources, Energy and Tourism	Geoscience Australia; National Offshore Petroleum Safety Authority; Tourism Ministers' Council
Agriculture Fisheries and Forestry	Bureau of Rural Sciences; Australian Quarantine Inspection Service; Australian Bureau of Agriculture and Resource Economics; Biosecurity Australia; Fisheries Research and Development Corporation; Australian Fisheries Management Authority; Natural Resource Management Ministerial Council; Marine and Coastal Committee
Defence	Defence Science and Technology Organisation; Royal Australian Navy; Australian Hydrographic Service
Immigration and Citizenship	Australian Customs Service, Border Protection Command
Infrastructure, Transport, Regional Development and Local Government	National Maritime Safety Committee; Australian Marine Safety Authority

Table 2: State and Territory engagement in understanding, managing and protecting Australia's coasts and oceans

State	Departments/Institutes/Agencies
New South Wales	Department of Environment and Climate Change; Department of Primary Industries; Ports and Waterways; Australian Museum; Powerhouse Museum
Victoria	Department of Sustainability and Environment; Department of Primary Industries; Department of Transport; Museum Victoria
Queensland	Department of Environment; Department of Primary Industry and Fisheries; Queensland Transport; Queensland Museum
South Australia	Department of Primary Industry and Resources; Department for Transport, Energy and Infrastructure; Department for Environment and Heritage; South Australian Research and Development Institute; South Australian Museum; History Trust of South Australia
Western Australia	Department of Fisheries; Department of Environment and Conservation; Department of Industry and Resources; Western Australian Energy Research Alliance; Western Australian Marine Science Institution; Western Australian Museum
Tasmania	Department of Primary Industries and Water, Environment, Parks, Heritage and the Arts; Department of Infrastructure, Energy and Resources; Tasmanian Aquaculture and Fisheries Institute; Tasmanian Museum and Art Gallery
Northern Territory	Department of Regional Development, Primary Industry; Fisheries and Resources, Department of Natural Resources, Environment, the Arts and Sport; Museum and Art Gallery of the Northern Territory

Table 3: Australian Universities engaged in marine science and technology

Australian National University
Charles Darwin University
Central Queensland University
Curtin University of Technology
Deakin University
Edith Cowan University
Flinders University
Griffith University
James Cook University
Macquarie University
Monash University
Murdoch University
Queensland University of Technology
RMIT University
Southern Cross University
University of Adelaide
University of Melbourne
University of Newcastle
University of New England
University of New South Wales
University of Queensland
University of Sydney
University of the Sunshine Coast
University of Tasmania
University of Technology Sydney
University of Western Australia
University of Wollongong
Victoria University

Table 4: OPSAG member agencies

Australian Antarctic Division (AAD)
Australian Fisheries Management Authority (AFMA)
Australian Fisheries Management Forum (AFMF)
Australian Institute of Marine Science (AIMS)
Australian Marine Sciences Association
Australian Maritime Safety Authority (AMSA)
Bureau of Meteorology (BoM)
Bureau of Rural Sciences (BRS)
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Defence Science and Technology Organisation (DSTO)
Department of Environment Water Heritage and the Arts (DEHWA)
Department of Innovation, Industry, Science and Research (DIISR)
Fisheries Research and Development Corporation (FRDC)
Geoscience Australia (GA)
Great Barrier Reef Marine Park Authority (GBRMPA)
RAN Australian Hydrographic Service
RAN Directorate of Oceanography and Meteorology
State Governments/Marine and Coastal Committee (of the Natural Resource Management Ministerial Council)
Integrated Marine Observing System (IMOS) [observer]
Intergovernmental Oceanographic Commission Perth Regional Programme Office (IOC Perth) [observer]

Table 5: Agencies/organisations/networks consulted in the development of this Framework

ARC Network for Earth System Science
Antarctic Climate and Ecosystems CRC
Australian Antarctic Division
Australian Biological Resources Study
Australian Coral Reef Society
Australian Fisheries Management Authority
Australian Institute of Marine Science
Australian Marine Sciences Association
Australian Maritime Safety Authority
Australian Museum
Australian National Maritime Museum
Australian National University – Research School of Earth Sciences
Australian Nuclear Science and Technology Organisation
Australian Petroleum Production & Exploration Association
Bureau of Meteorology
Bureau of Rural Sciences
Centre for Australian Climate and Weather Research
CERF Marine Biodiversity Hub
Charles Darwin University
Council of Australasian Museum Directors
CRC for Greenhouse Gas Technologies
CSIRO Marine and Atmospheric Research
CSIRO Wealth from Oceans National Research Flagship
Curtin University of Technology
Defence Science and Technology Organisation
Department of Innovation, Industry, Science and Research
Department of the Environment, Water, Heritage and the Arts
Fisheries Research & Development Corporation
Fisheries Victoria
Flinders University

Geoscience Australia
Great Barrier Reef Marine Park Authority
Integrated Marine Observing System
James Cook University
Marine Geoscience Office (MARGO)
Murdoch University
Museum and Art Gallery of the Northern Territory
Museum Victoria
National Climate Change Adaptation Research Facility/Griffith University
NSW Department of Primary Industries
NSW Department of Environment and Climate Change
NT Department of Regional Development, Primary Industry, Fisheries and Resources
Ports Australia
Queensland Department of Primary Industry and Fisheries
Queensland EPA
Queensland Museum
RAN Australian Hydrographic Service
RAN Directorate of Oceanography and Meteorology
Reef and Rainforest Research Centre/MTSRF
South Australian Research and Development Institute
Sustainable Tourism CRC
South Australian Museum
Tasmanian Museum and Art Gallery
University of Melbourne
University of New South Wales
University of Queensland
University of Sydney
University of Tasmania
University of Western Australia
WA Department of Fisheries/WA Fisheries and Marine Research Laboratories
Western Australian Energy Research Alliance
Western Australian Marine Science Institution
Western Australian Museum

Australian Government
Oceans Policy Science Advisory Group

The Australian Government's Oceans Policy Science Advisory Group (OPSAG) promotes co-ordination and information sharing between Australian Government marine science agencies and the broader Australian marine science community.

Australian Government

Management Authority

Bureau of Rural Sciences

Technology Organisation

Department of the Environment, Water, Heritage and the Arts
Australian Antarctic Division

Department of Innovation, Industry, Science and Research

Department of Agriculture, Fisheries and Forestry
Fisheries Research and Development Corporation

Australian Institute of Marine Science

CSIRO

UNESCO

IMOS
Integrated Marine Observing System

AMSA
Australian Marine Sciences Association

hydro metoc

ROYAL AUSTRALIAN NAVY
AUSTRALIAN HYDROGRAPHIC SERVICE

AFMF

Australian State Governments / Marine and Coastal Committee (MACC)

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