

REVIEW OF THE NATIONAL INNOVATION SYSTEM

SUBMISSION ON MARINE R&D AND INNOVATION

by the

OCEANS POLICY SCIENTIFIC ADVISORY GROUP (OPSAG)

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Declaration of interests and affiliations relating to the subject of the Review

OPSAG is the peak marine science advisory body to the Australian Government; its role includes the promotion of coordination among Australian Government marine science agencies and across the broader marine science community.

Member agencies:

Australian Antarctic Division (AAD)
Australian Fisheries Management Authority (AFMA)
Australian Fisheries Management Forum (AFMF)
Australian Institute of Marine Science (AIMS)
Australian Maritime Safety Authority (AMSA)
Bureau of Meteorology (BoM)
Bureau of Rural Sciences (BRS)
Commonwealth Scientific and Industrial Research Organisation (CSIRO)
Deakin University/National Oceans Advisory Group (NOAG)
Defence Science and Technology Organisation (DSTO)
Department of Education Employment and Workplace Relations (DEEWR)
Department of Environment Water Heritage and the Arts (DEHWA)
Fisheries Research and Development Corporation (FRDC)
Geoscience Australia (GA)
Great Barrier Reef Marine Park Authority (GBRMPA)
Integrated Marine Observing System (IMOS)
Intergovernmental Oceanographic Commission Perth Regional Programme Office (IOC Perth)
Royal Australian Navy (RAN)
State Governments/Marine and Coastal Committee (of the Natural Resource Management Ministerial Council)

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Executive summary

Australia lays claim to the third largest marine jurisdiction of any nation on earth. At over 14 million km² it is nearly twice the surface area of the Australian continent. The marine sector contributes significantly to our national economy (at least 4% of GDP and growing faster than other sectors), through food and energy production, recreation and tourism. Australia's oceans have iconic environmental significance, with national and international treasures such as the Ningaloo and Great Barrier Reefs, the Kimberley Coast, and southern and Antarctic waters; with stunning biodiversity, much of it endemic to our region. Our oceans also have great social value, holding a special place in the national psyche, particularly since 85% of our population lives within 50km of the coast.

Today Australia's ocean domain is under stress from climate change, there is mounting pressure to increase exploration for energy and mineral resources, our coastal regions are under stress from population growth and human impact, and marine biodiversity needs to be protected. In addition, there is a growing need to protect Australia's maritime borders and to ensure the safety of those operating in and on our oceans.

Covering a wide range of interacting disciplines, marine and oceans R&D offers the prospect of better utilisation and protection of Australia's entire ocean and coastal areas. However, the marine sector spans multiple Commonwealth departments, agencies, universities, as well as Commonwealth-State domains. Thus, to deliver maximum benefit from targeted R&D focussed on the nation's future needs Australia requires the development of an integrated framework for marine R&D.

There are five major drivers of innovation for Australia's marine and ocean territories

1. Climate change. Understanding/predicting climate change and its relationship with Australia's ocean domain remains a significant challenge. The oceans and their rich biodiversity, including our entire coastal zone, will be severely affected by the impacts of global climate change. Sea-level rise, increasing sea temperatures, acidification and extreme weather will impact on all biological systems and coastal areas, including man-made infrastructure such as marinas, harbours and off-shore platforms. New marine monitoring systems, prediction tools and technologies will be required to understand how our ocean ecosystems will respond to climate change impact, and for the development of appropriate adaptation strategies and mitigation measures. Climate change impacts on marine environment and the coastal zone will be a huge driver of innovation.

2. Sustainable use of marine resources. Given that existing global oil reserves and discoveries appear close to having peaked ('peak oil'), the pressure for new discoveries will soon, if not already, be supreme. Rising global and national demand for oil and gas will require highly innovative ways of exploring and recovering marine oil and gas resources. Discovery and exploration of Australia's off-shore mineral wealth is still in its infancy; during its anticipated growth and expansion it will require major innovation, in geophysics, technology, and in sustainable management methodologies to minimise adverse short and long-term environmental impact. Major innovation will be needed to deliver the new exploration and recovery technologies required for the sustainable development of these industries.

3. Preserving marine biodiversity. Rising demand for food from a burgeoning global population will require innovation in how the marine environment is managed. In a changing world, the pressure of human activity on global fish stocks has to be balanced by a strong commitment to preserve and conserve. Already this has resulted in significant innovation in policy instruments for managing global and regional fisheries and the shift to aquaculture production. Even so, most of Australia's marine environment is still unexplored and the processes that sustain it are poorly understood. Australia will need highly innovative marine R&D to ensure that we have sufficient and accurate information on the state of the marine environment to inform future policy. Marine R&D also offers the potential to capitalise on the uniqueness of Australia's marine biodiversity, by exploration for and research on marine natural products with drug-like qualities (biodiscovery).

4. Coastal zone development. Australia's marine coastal environment is under major pressure. This includes rapid urban development and population growth, particularly on the southeastern seaboard. Other pressures are tourism, fisheries, aquaculture, marine industries and shipping. Agriculture, due to run-off, has a major impact, as the coastal and coastal shelf systems of Australia are dependent on their associated terrestrial catchments. The protection and preservation of the rich biodiversity and the social amenity of Australia's coastal environment requires immediate investment in marine and coastal research, and the development of practical theories and tools for integrated coastal zone management thus enabling effective decision-making by policy makers and environmental managers.

5. Security and safety. As an island continent, Australia's national security is very much dependent on its ability to manage and protect its ocean territories. Australia's northern coastal region is vast, remote and has importance to Australia's future in the context of environmental, economic and social benefits. Already, the Government has had to invest additional resources to try to curb illegal fishing and illegal migration and there is a likely future need to ensure security of energy resources. To support strong actions on illegal fishing, we need expert assessments of its impact on marine biodiversity. To ensure effective defence, border security and safety of operations at sea we require innovations in marine support systems and infrastructure.

Australia needs to make the sustainable use and protection of Australia's EEZ a National Innovation Priority

The impact of climate change on the marine environment and infrastructure; new oil, gas and mineral resources on offer from Australia's ocean territory; the need to protect marine ecosystems and biodiversity and the opportunity for new marine biotechnology industries; rapid population growth and environmental pressure on Australia's seaboard; and the critical role of our oceans in national security, lead us to the view that sustainable use and protection of Australia's EEZ is a prime candidate for a National Innovation Priority.

Systemic weaknesses/challenges

- *Effective and productive innovation in the marine R&D sector depends on sound and widely accessible infrastructure. Current systemic weaknesses in research vessel capability, long-term biophysical data, and high performance supercomputing must be addressed.*
- *The current framework for cooperation and collaboration among institutions should be maintained and strengthened, with particular emphasis on the supporting framework for operating funds.*

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- *Attracting the brightest and most innovative students to marine and ocean sciences is a major challenge. At the moment there are insufficient new marine and geophysics graduates coming through the university system to satisfy existing and anticipated future demand.*
- *Australia needs to build on the current level of cooperation and research partnerships by developing a national framework for marine R&D and innovation that will allow the definition of, and investment for, the grand challenges for the safe protection and utilisation of Australia's EEZ.*

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Key challenges and opportunities for Australia

Economic opportunities and challenges for Australia's ocean domain:

- To grow and remain globally competitive over the forthcoming decades, Australia's oil and gas industry must increase its exploration success and recovery factors for offshore oil reservoirs; develop novel production technologies to enable commercial access to Australia's remote offshore gas resources; and better understand and mitigate risks from ocean and climatic processes.
- To realise the vast potential for wealth generation from seabed mineral resources, our minerals industry needs a cutting edge exploration program, including the associated development of new technologies for recovering the resources in an economically viable and environmentally sustainable way.
- To ensure long-term sustainability, our world-renowned and rapidly growing ocean/coastal-based tourism/recreation industry requires proactive environmental and socio-economic planning, particularly in areas where industry development competes for and/or threatens ecosystem services.
- To regain profitability and ensure long-term sustainable yields, Australia's fisheries and aquaculture sector requires innovative, sustainable harvest strategies to reduce their environmental footprint.
- To capitalise on a global resurgence in biotechnology, and to gain the largely untapped benefits of its marine biodiversity, Australia needs to invest in marine biodiscovery and assist in the development of a marine component to its growing biotechnology industry.

Environmental opportunities and challenges for Australia's ocean domain:

- To deliver more reliable and robust weather forecasts, seasonal forecasts and climate predictions and to better predict ocean circulation and dynamics for use in 'industrial', defence and management applications, ocean science requires better, more integrated ocean observations and a greater understanding of ocean processes and dynamics.
- To allow managers to successfully mitigate or adapt to climate change impacts on marine systems and ecosystems, these likely impacts will need to be defined and quantified.
- To enable the sustainable use of our oceans and coastal regions, we need systems for predicting and monitoring biodiversity, and robust indicators to allow large-scale assessment of marine ecosystem status against nationally agreed criteria.
- To manage major industrial development in, or beside, our oceans (e.g. oil and gas extraction and processing, port development/dredging, pulp mills, desalination plants, tidal/wave energy generation) over the next 10-20 years, we will need novel, innovative and sophisticated methodologies in environmental impact assessment.

Socioeconomic challenges for Australia's ocean domain:

- To enable socially acceptable planning and decision-making with respect to the utilisation of marine resources and coastal zone use and development, we need to understand the societal values associated with our coastal and marine regions.

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- To allow economic, environmental and social trade-offs between marine industries to be quantified, we will require an in-depth understanding of the economic contribution of different industries to national and regional economies.
- To protect our borders and safeguard our marine territories Australia needs more effective and efficient surveillance, and new technology and capabilities in ocean forecasting.
- To maximise biodiversity conservation at minimum cost to industry will require the development of market-based policy instruments.

Australia needs a coherent, integrated and forward looking approach to marine R&D and innovation that addresses the economic, environmental and social challenges of the utilisation and preservation of its ocean territories.

Marine R&D and the three facets of innovation

Knowledge production: Australia has a well-developed marine R&D presence in the 'knowledge production' segment of the innovation cycle. Research primarily through the five publicly funded research agencies (AIMS, CSIRO, BoM, GA and AAD) and universities is internationally competitive and highly regarded. However, this effectiveness is reduced by weaknesses in some areas of capability, infrastructure and resourcing (expanded on below).

Knowledge application: Collaboration and partnerships between key marine R&D players and major users (Royal Australian Navy, AFMA, policy-makers, marine industries) have been highly effective. Uptake of the outcomes of marine R&D is very high in specific areas such as policy, ocean forecasting, management of World Heritage Areas and exploration for marine resources, but limited by much of the ocean/marine environment still being unknown or poorly explored and understood.

Diffusion and absorption: Diffusion of innovation in marine R&D to the wider community and industry is strong in areas such as oceans and climate, marine protected areas, and exploration on the north west shelf. However, in other areas (tourism, shipping, marine recreation, marine biotechnology and coastal zone development), the fragmented nature of the marine sector limits innovation delivery and uptake. With the growing pressures of 'peak oil', 'climate change', 'food security' and 'marine conservation', we envisage the opportunity for extensive innovation driven by the need for new resources, adaptation to climate change and community desire to preserve marine biodiversity.

A future framework for Australian marine R&D will have to address the barriers and limitations across all three facets of marine R&D innovation.

Comments on systemic weaknesses

W1. Inadequate infrastructure provision for research and development facilities in marine R&D.

Research vessel capability. Innovation in marine R&D is critically dependent on access to marine research vessels and observing systems. This is particularly urgent with respect to Australian Government funding support for the Marine National Facility as the current research vessel capability in Australia is insufficient to meet current and projected needs into the 21st century. With the *Southern Surveyor* being at the end of its useful life, the need for blue-water research vessel capability must be urgently addressed by Australia making a commitment to having a world-class Marine National Facility. There are allied concerns about adequate research vessel

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capability for servicing Australia's requirements and responsibilities at high latitudes and in Antarctic waters.

Long term biophysical data. The current lack of long-term biophysical environmental data series in the marine environment severely limits our ability to examine trends, predict the future and successfully adapt to change. To support the ecologically sustainable development of our ocean territories, Australia requires coordinated investment in, and ongoing support for the development of novel sensors especially to measure and monitor biodiversity and the collection and ongoing monitoring of biophysical and environmental marine data. Australia should consider instigating a national initiative similar to the LTER (Long Term Ecological Research network) initiatives in the US and continue to invest in the development of Australia's Integrated Marine Observing System (IMOS).

High performance supercomputing. Ocean modelling, climate change modelling and, increasingly, ecosystem modelling are all highly dependent on supercomputing as researchers take the necessary steps towards inclusion of social and economic data in a true "Earth Systems" approach to biogeophysical modelling. To support this, Australia will need a strong commitment to making strategic and ongoing investments in high performance supercomputing, where at present we are well off the global pace. The current underinvestment is a material risk to the future of Australian marine and oceans R&D.

Effective and productive innovation in the marine R&D sector depends on sound and widely accessible infrastructure. Current systemic weaknesses in research vessel capability, long-term biophysical data, and high performance supercomputing must be addressed.

W2. Institutional development and evolution.

Institutional development and structure in the Australian marine/oceans R&D community is good and there is better cooperation and constructive collaboration today than at any time in the past.

OPSAG, in its role of promoting coordination among Australian government marine science agencies and across the broader marine science community, has contributed to cross-agency interaction and coordination. The recent establishment of two marine hubs (Biodiversity and Marine and Tropical Science Research Facility) under the Commonwealth Environment Research Facilities (CERF) initiative and IMOS have also strengthened collaboration between publicly funded research agencies (PFRAs), universities and users.

Institutions are limited by fragmentation of investment, particularly with respect to operating funds. For example, funding for marine expeditions and marine surveys is insufficient to make optimal use of allocated vessel time on the Marine National Facility. Thus proponents may be allocated ship time but be unable to access the necessary funding to pay the costs of equipment transport or hire, victualling, travel to and from the vessel, and (perhaps most importantly) post-survey analysis of samples and data.

The current framework for cooperation and collaboration among institutions should be maintained and strengthened, with particular emphasis on the supporting framework for operating funds.

W3. Capability and learning challenges in marine R&D

To enable the effective and sustainable use of Australia's unique marine environment, we require our own Australian expertise. For example, in Earth systems science, with the Australian climate dramatically affected by the Indian, Pacific and Southern oceans, Australia requires its own expertise for climate variability and climate change predictions and assessments.

Australia's ability to protect its unique coastal and ocean marine environment and ecosystems is similarly dependent on a strong national capability in marine ecosystem science including marine microbiology. Rapid and continued development of off-shore oil and gas resources indicates a growing need for graduates in geophysics and marine engineering.

At present there is a skills shortage in technologists who can design, operate and maintain the most recent innovations in marine instruments and observing systems. While the existing tertiary structure provides training for PhD level research, training of marine technologists—electrical and mechanical engineers to support research—with a post-graduate marine certificate or diploma is not available.

The existing tertiary structure is not optimal as there are barriers to ocean scientists from marine R&D agencies contributing to higher education and training. This arises in part due to the requirements of ARC funding which ultimately impact on the ability of the marine science community to work together to train (and retain) the next generation of marine scientists.

Successful partnerships between CSIRO and the University of Tasmania, AIMS and James Cook University, AIMS and ANU, CSIRO/AIMS and the University of Western Australia and Murdoch University, provide models for further development of this capability, particularly in areas of ocean science and marine ecology.

Attracting the brightest and most innovative students to marine and ocean sciences is a major challenge. At the moment there are insufficient new marine and geophysics graduates coming through the university system to satisfy existing and anticipated future demand.

W4. Structural adjustment issues and transitional problems in economic change, often arising from technology 'lock in'.

The conservation of Australia's marine environment through the development of regional marine planning requires a greater and more defined understanding of the cost-benefits of structural adjustment in marine, coastal and catchment industries. With the advent of integrated coastal zone management, we can expect the need for in-depth understanding of structural adjustment issues to grow.

W5. Networking and collaboration in marine R&D

There are a number of local and regional initiatives that have been very successful in bringing universities and PFRAs together within mission orientated consortia.

Examples are the joint venture between James Cook University and AIMS (AIMS@JCU), AIMS and Australian National University through the Arafura Timor Research Facility (ATRF), the joint PhD program in quantitative marine science between CSIRO and the University of Tasmania (CSIRO-UTAS), the Western Australia Marine Science Institution (WAMSI) and the Australian Community Climate and Earth-

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System Simulator (ACCESS) project which is a collaboration between CSIRO, BoM and universities to develop a next generation climate and Earth systems model for Australia.

In Sydney, four universities (Macquarie University, University of Sydney, University of NSW and University of Technology Sydney) have established the Sydney Institute of Marine Science a joint venture aimed at integrating research and education. The Institute has associate members from the NSW State marine agencies, one federal agency (DSTO) and the Universities of Newcastle and Wollongong.

The Integrated Marine Observing System (IMOS) is a nation-wide collaborative program designed to observe the oceans around Australia, including the coastal oceans and the 'bluewater' open oceans. Twenty-seven separate institutions are involved in the new facility, which is funded under the National Collaborative Research Infrastructure Strategy (NCRIS).

The Integrated Ocean Drilling Program (IODP) is the world's largest multinational geoscience program and includes almost all OECD countries. Australia joined IODP in 2008 and participating Australian institutions include sixteen Universities as well as AIMS, CSIRO and the Australian Nuclear Science and Technology Organisation (ANSTO). IODP carries out deep scientific drilling around the world's oceans and fosters the development of new technologies and concepts in geoscience.

Contemporary international trends, particularly in the areas of Earth system science, climate change impacts and climate change adaptation, suggest that Australia needs to develop funding mechanisms that can further promote collaboration and bring together key Australian expertise from PFRAs and universities for major projects.

The recent Commonwealth Environment Research Facilities (CERF) initiatives are a step in the right direction, but the scope for each CERF research hub, and the level and duration (3 years) of available funding are still limited (see also comments under ToR1).

Australia needs to build on the current level of cooperation and research partnerships by developing a national framework for marine R&D and innovation that will allow the definition of, and investment for, the grand challenges for the safe protection and utilisation of Australia's EEZ.

Comments on the seven questions

Q1-3. Are we asking the right questions: innovation challenges in marine R&D

There are five major innovation challenges in the marine and oceans sphere:

- (1) The need to deal with climate change and the marine impact of climate change.***
- (2) The need to discover/identify/utilise new marine resources (oil and gas, minerals, renewable energy, marine biotechnology, biological resources).***
- (3) The ongoing need to preserve and protect marine biodiversity.***
- (4) The need to protect our coastal marine environment.***
- (5) The need for national security***

Climate change. Climate change provides just one example where a "better world" is inextricably linked to innovation. Highly innovative research and systems are required to deliver in-depth understanding and prediction as to why and how climate is changing, and climate change will drive the need to provide novel systems and technologies for climate change mitigation and adaptation. The oceans and

their rich biodiversity, including our entire coastal zone, will be severely affected by the impacts of global climate change. Sea-level rise, increasing sea temperatures, acidification and extreme weather will impact on all biological systems and coastal areas, including man-made infrastructure such as marinas, harbours and off-shore platforms. New marine monitoring systems, prediction tools and technologies will be required to understand how our ocean ecosystems will respond to climate change impact, and for the development of appropriate adaptation strategies and mitigation measures. Climate change impacts on marine environment and the coastal zone will be a huge driver of innovation.

Sustainable use of marine resources. Given that existing global oil reserves and discoveries appear close to having peaked ('peak oil') the pressure for new discoveries will soon, if not already, be supreme. Rising global and national demand for oil and gas will require highly innovative ways of exploring and recovering marine oil and gas resources. Discovery and exploration of Australia's off-shore mineral wealth is still in its infancy; during its anticipated growth and expansion it will require major innovation, in geophysics, technology, and in sustainable management methodologies to minimise adverse short and long-term environmental impact. In Australia, a projected \$100 billion of oil and gas developments planned or underway for the NW Shelf, Timor and Arafura Seas will require extensive R&D and drive development of a scale not previously experienced along the coastline of Northern WA and the Northern Territory.

Preserving marine biodiversity. Innovative systems are imperative for the management of marine resources. Rising demand for food from a burgeoning global population will require innovation in how the marine environment is managed. In a growing and changing world, the pressure of human activity on global fish stocks has to be balanced by a strong commitment to preserve and conserve. Already this has resulted in significant innovation in policy instruments for managing global and regional fisheries and managing the shift to aquaculture production. Even so, most of Australia's marine environment is still unexplored and the processes that sustain it are poorly understood. Australia will need highly innovative marine R&D to ensure that we have sufficient and accurate information on the state of the marine environment to inform future policy. Marine R&D also offers the potential to capitalise on the uniqueness of Australia's marine biodiversity, by exploration for and research on marine natural products with drug-like qualities (biodiscovery).

Coastal zone development. Australia's marine coastal environment is under major pressure. This includes rapid urban development and population growth, particularly on the southeastern seaboard. Other pressures are tourism, fisheries, aquaculture, marine industries and shipping. Agriculture, due to run-off, has a major impact, as the coastal and coastal shelf systems of Australia are dependent on their associated terrestrial catchments. The protection and preservation of the rich biodiversity and the social amenity of Australia's coastal environment requires immediate investment in marine and coastal research, and the development of practical theories and tools for integrated coastal zone management thus enabling effective decision-making by policy makers and environmental managers.

Security and safety. As an island continent, Australia's national security is very much dependent on its ability to manage and protect its ocean territories. Australia's northern coastal region is vast, remote and has importance to Australia's future in the context of environmental, economic and social benefits. Already, the Government has had to invest additional resources to try to curb illegal fishing and illegal migration and there is a likely future need to ensure security of energy resources. To support strong actions on illegal fishing, we need expert assessments of its impact on marine biodiversity. To ensure effective defence, border security and safety of operations at sea we require innovations in marine support systems and infrastructure.

By 2012, Australia will have regional marine plans for the entire EEZ, and a national marine reserve system, starting a new paradigm in Australia's management of its marine biodiversity/resources. To deliver the necessary underpinning science, a framework for Australian marine R&D will be essential, both to set the vision of what is required, as well as to provide the foundation for a cohesive funding program that can go beyond CERF to deliver critical capability and infrastructure.

Q4-5. Barriers to take up of new marine and oceans technology

The most significant challenge for Australia's ocean domain is to increase the social and economic benefits from our oceans whilst preserving the long-term environmental benefits, values and ecosystem services.

We note that in Europe there is a strong drive towards a maritime services policy to cover the multiple dimensions of environment, energy, shipping, innovation, fisheries, information and communication technology, ports, integrated coastal zone management and spatial planning (climate change), marine clusters and jobs. It is highly likely that Australia will need to follow a similar path.

Lack of knowledge of our marine environment and its current state is in itself a barrier to innovation and the take-up of marine R&D outcomes, contributing to uncertainty in the application and impact of policy measures, and leading to inefficiencies and lack of sustainability.

Q7. Prioritising our innovations effort: Marine and oceans R&D as a priority for national innovation

Australia, through its marine focussed PFRA's and a number of universities, has the expertise and capability to deliver the required marine and ocean science and innovation for the national benefit. However at the moment Australia's oceans do not feature prominently in the National Research Priorities (see our comments under ToR2 below).

Today Australia's ocean domain is under stress from climate change, there is pressure to explore for energy and mineral resources, our coastal regions are under stress from population growth and human impact, and marine biodiversity needs to be protected. In addition, there is a need to protect Australia's maritime borders and to ensure the safety of those operating in and on our oceans.

Covering a wide range of interacting disciplines, marine and oceans R&D offers the prospect of better utilisation and protection of Australia's entire ocean and coastal areas. However, the marine sector spans multiple Commonwealth departments, agencies, universities, as well as Commonwealth-State domains. Thus, to deliver maximum benefit from targeted R&D focussed on the nation's future needs Australia requires the development of an integrated framework for marine R&D.

There is a strong case for making marine and oceans R&D a priority area for national innovation, ensuring that Australia capitalises on the huge challenges and opportunities represented by its ocean domain.

Comments against the Terms of Reference

ToR 1: Identify a set of principles to underpin the role and participation of the public sector in innovation.

Marine resources are typically publicly owned, and the lead time for major projects in marine R&D, from inception to implementation, is often very long (typically 5-10 years). Although there are significant outcomes for marine and resource industries, the principal beneficiaries of the research are the national interest and the community-at-large. This combination of national interest and long lead times makes marine and ocean research particularly appropriate for, and dependent on, public sector funding.

Australian marine R&D has a strong record of placing great emphasis on innovation; in ocean observing systems, new observing technologies, voyages of discovery, theoretical interpretation and modelling of ocean dynamics and climate change, as well as observations and modelling of marine ecosystems.

Major recent achievements have all been due to core funding by government for agencies such as CSIRO, AIMS, BoM, AAD and GA, supplemented by the Marine National Facility and the CERF hubs.

Many achievements have required additional support, such as from the Australian Climate Change Science Programme in climate change research and the Royal Australian Navy in operational ocean prediction.

In the national interest and to build effective national capacity, Australia should (a) support strong coordination mechanisms among marine R&D agencies, (b) facilitate efficient national support of infrastructure (as in IMOS, the NMF, etc.), and (c) support marine environmental R&D and innovation facilities (consistent with making marine and oceans R&D a National Innovation Priority).

ToR 2: Develop a set of national innovation priorities to complement the national research priorities, ensuring the objectives of research programs and other innovation initiatives are complementary.

Climate change, oceans, marine resources and the marine environment are not dealt with in a cohesive or unified manner in the current National Research Priorities (NRPs).

Climate change is dealt with under the priority of 'An Environmentally Sustainable Australia' by the NRP sub-goal of 'Responding to climate change and variability'. But the massive impact global and regional climate change is going to have on all levels of the economy, the environment and socially, is not covered by the NRPs.

In our view, climate change will become a major driver of new technology, social change and innovation. Any future priority framework (whether for national research or for national innovation) will need to address this.

Marine resources are noted under the NRP sub-goal of 'Sustainable use of Australia's biodiversity' but the context does not fully capture the major responsibilities and opportunities offered by Australia's massive ocean territory. Oceans and marine resources get a further mention under the NRP sub-goal of 'Transforming existing industries'. Marine biodiversity is referred to under the priority of 'Safeguarding Australia' through the NRP sub-goal of 'Protecting Australia from invasive diseases and pests'. There is reference to Australia's ocean territories under the NRP sub-goal

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of 'Transformational defence technologies' where there is specific mention of Australia's substantial maritime region of responsibility.

However, the consequences of being fragmented over several NRP sub-goals are that the national priorities fail to provide strong priority and/or policy focus for Australia's marine environment and resources. This has to be addressed in the next round of national priority setting.

A third major area of national interest, currently not reflected in the NRPs, is the sustainable use and protection of Australia's coastal environment, where, in the face of rapid development and population pressure, there is urgent need for science and a system that enables integrated coastal zone management.

The impact of climate change on the marine environment and infrastructure; new oil, gas and mineral resources on offer from Australia's ocean territory; the need to protect marine ecosystems and biodiversity and the opportunity for new marine biotechnology industries; rapid population growth and environmental pressure on Australia's seaboard including the shift of agriculture to the wetter north; and the critical role of our oceans in national security, lead us to the view that sustainable use and protection of Australia's EEZ is a prime candidate for a National Innovation Priority.