9 September 2016

National Research Infrastructure Roadmap Taskforce
Research and Higher Education Infrastructure
Research and Economic Group
Australian Government Department of Education and Training

RE: 2016 National Research Infrastructure Capability Issues Paper

Thank you for the opportunity to contribute to development of the 2016 National Research Infrastructure Roadmap (2016 Roadmap).

The blue economy is a significant and growing part of Australia's broader economy, with our oceans expected to contribute $100 billion per annum by 2025. To achieve this potential, Australia will need excellent and relevant marine science to address grand challenges with respect to - marine sovereignty, security and safety; energy security; food security; biodiversity conservation and ecosystem health; urban coastal development; climate variability and change; and resource allocation.

In 2015, the National Marine Science Committee (NMSC) published a decadal plan, *National Marine Science Plan 2015-2025 Driving the development of Australia's blue economy* (the Decadal Plan). It focusses attention on the highest priority capabilities required to tackle these challenges and fulfil our blue economy's potential. The Plan details critical research infrastructure required to realise these goals including:

- an adequately funded national research vessel fleet consisting of bluewater, polar and shelf-scale vessels which allow exploration of the open oceans, Antarctic regions and continental shelf and coastal waters;
- observing systems that consist of in situ monitoring devices and satellites that provide observations from space – this includes sustaining and expanding the Integrated Marine Observing System (IMOS) to support critical climate change and coastal systems research;
- experimental facilities including research aquaria, research stations and analytical facilities;
- e-research infrastructure including an online network of marine and coastal data resources, and high-performance computing, modelling and research data infrastructure.

Access to this research infrastructure will enable implementation of priority initiatives set out in the Decadal Plan including:

1. a national marine baselines and long-term monitoring program, to develop a comprehensive assessment of our estate, and to help manage Commonwealth and State Marine Reserves;
2. coordinated national studies on marine system processes and resilience to enable understanding of development and climate change impacts on our marine estate;
3. a national ocean modelling system to supply the accurate, detailed knowledge and predictions of ocean state that defence, industry and government need;
4. a dedicated and coordinated science program to support decision-making by policymakers and marine industry;
5. marine science research training that is more quantitative, cross-disciplinary and congruent with the needs of industry and government.

The NMSC strongly supports development of the 2016 Roadmap. It will be vital to securing the research infrastructure required for Australia to address its grand marine challenges. Despite having the third-largest ocean territory on Earth and the significant contribution this resource can

and does make to our economy, Australia has a modest fleet of research vessels, a very small marine technology industry, and no domestic satellite capability. Effective and efficient coordination of marine research infrastructure is therefore particularly important for Australia, and the 2016 Roadmap will be invaluable in facilitating this.

The NMSC has prepared the attached Roadmap submission covering the broad range of research infrastructure required for developing Australia's blue economy. In particular, it should be noted that while the 2016 Roadmap Issues Paper lists marine science as an important part of the Environment and Natural Resource Management capability focus area, we would also like to emphasise the importance of marine science to such issues as energy, resources, food and national security.

Given the significance of a national research vessel fleet to these capability focus areas, the NMSC is providing a separate submission regarding research vessels. As an existing NCRIS capability, IMOS is also providing a separate submission which is fully supported by NMSC. A number of NMSC member organisations will provide institutional submissions with reference to marine research infrastructure. We hope that, taken collectively, these submissions provide useful and compelling feedback as to the opportunities available in the marine domain.

The Australian marine science community has fully embraced the concept of national research facilities. We realise that we need to rise above institutional and disciplinary perspectives and get behind the concept of national facilities that can be used by the whole community through appropriate management and access arrangements. We realise that we need to prioritise the infrastructure investments being advocated in order to maximise our chances of success in a competitive environment for publicly funded science. A small number of critical requirements have therefore been identified in our Decadal Plan, focused on securing, utilising, and accessing the infrastructure required.

The NMSC looks forward to continuing to work with the Australian Government to deliver excellent and relevant marine science, underpinned by world class marine research infrastructure, aimed at realising the full potential of Australia's future blue economy.

Yours sincerely

Tim Moltmann
Chair, National Marine Science Committee

Submission

2016 National Research Infrastructure Roadmap Capability Issues Paper

Submission No: ***(to be completed by Departmental staff)***	
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Would you like your submission to remain confidential, i.e. not published on the website?	**NO**

Question 1: Are there other capability areas that should be considered?

The capability areas are broad enough in principle. However marine science capability is narrowly confined to Environment and Natural Resource Management. The NMSC's Decadal Plan lays out a clear pathway for marine science to drive the development of Australia's blue economy. This includes important national science and research priorities in Food Security, Energy Security and Resources Security. The socio-economic benefits of excellent, impactful and innovative marine science are undersold in the Issues Paper, and it will be important to address this in the Roadmap as it must respond to the National Innovation and Science Agenda.

Question 2: Are these governance characteristics appropriate and are there other factors that should be considered for optimal governance for national research infrastructure?

As noted in section 3.3, Australia often maximises its investments in research infrastructure by linking into international projects and consortia. In return, overseas scientists also access Australian infrastructure to enhance their research outputs. As such, the optimal governance model should include access not just for private and public use but also for use by international stakeholders.

Question 3: Should national research infrastructure investment assist with access to international facilities?

Australian marine science is greatly enhanced through the use of international research infrastructure. Australia's Integrated Marine Observing System (IMOS) being enhanced by its integration into the Global Ocean Observing System (GOOS) is one such example. Ongoing access to international satellites, and the International Ocean Discovery Program (IODP) are other examples of where Australian marine scientists greatly benefit from access to international research infrastructure. Marine observation from space is a particularly good example of science that could not be undertaken in Australia at all without the access to international infrastructure as Australia does not have any domestic satellite capability. As such, yes, it is critical that national research infrastructure investment assists with access to international facilities.

Question 4: What are the conditions or scenarios where access to international facilities should be prioritised over developing national facilities?

- Where the science questions are global and Australian scientists need to be part of international communities to do the work required e.g. global ocean observing, global climate modelling.
- Where Australia does not have the necessary policies or supporting infrastructure e.g. satellites, ocean drilling vessels.

Question 5: Should research workforce skills be considered a research infrastructure issue?

Yes.

It is crucial that funding for research infrastructure covers the design, build, operation, maintenance, decommissioning and replacement of facilities. Suitable research workforce skills are critical, particularly in the operation and maintenance phases. One reason why NCRIS was successful is that as a research infrastructure program it paid due regard to whole of life costs, including operational costs. It enabled substantial technical capability to be developed at national scale. This advantage has been somewhat diminished over time, initially due to different funding regimes, and then due to ongoing uncertainty about future funding, making it difficult to retain skilled staff and develop meaningful careers. However the ten year commitment to NCRIS presents an opportunity to regain this advantage, which we strongly support.

While preparing its Decadal Plan, the NMSC collected the views of more than 500 scientists and end users on the skills base required by marine science to address the seven grand marine challenges. The greatest gaps identified were STEM skills; skills in multidisciplinary areas and emerging fields, such as integrated assessment modelling and earth system science, that integrate inputs from a wide range of disciplines; computational science, bioinformatics and the use of new 'omics disciplines (e.g. metagenomics, proteomics and metabolomics) in systems biology; and marine scientists with social science and economics skills.

None of these skills are specific to marine science (we need marine scientists who also have these skills) so a national approach to boosting such skills, such as was proposed by the Office of the Chief Scientist in *Science, Technology, Engineering and Mathematics: Australia's Future* and by the Government in *Vision for a Science Nation*, would be a valuable consideration of the 2016 Roadmap. Without such a long term, national approach to STEM skills development, there is a risk that the full benefits of research infrastructure investments will not be fully realised by the nation.

Question 6: How can national research infrastructure assist in training and skills development?

Marine science training and skills development requires significant hands-on experience. Research infrastructure is required to be available not just for research activities but also for training of future marine scientists. In the case of research vessels, this needs to be carefully planned to ensure training is conducted when it is compatible with research voyage objectives. The Collaborative Australian Postgraduate Sea Training Alliance Network (CAPSTAN), a post-graduate at sea training initiative on the RV *Investigator*, is a good example of what we should be striving for.

Question 7: What responsibility should research institutions have in supporting the development of infrastructure ready researchers and technical specialists?

Increased collaboration between educational and research institutions is required to ensure students complete their education with the skills required to effectively use national research infrastructure. This would ideally be guided by an overarching research infrastructure roadmap.

Question 8: What principles should be applied for access to national research infrastructure, and are there situations when these should not apply?

The national marine research community has risen above institutional and disciplinary perspectives to get behind the concept of national facilities that can be used by the whole community through appropriate management and access arrangements. In some cases open access is the most appropriate model e.g. for IMOS and the associated Australian Ocean Data Network (AODN), and island research stations. In other cases there needs to be merit based assessment e.g. for the Marine National Facility (RV Investigator), RSV Aurora Australis and Antarctic stations, National Computational infrastructure (NCI) and National Sea Simulator (SeaSim). Importantly, these assessment processes consider not just science quality, but also national benefit.

Question 9: What should the criteria and funding arrangements for defunding or decommissioning look like?

The NMSC, as stated in the Decadal Plan, believes that a lifecycle approach is required to build, operate, maintain, decommission and, importantly, refresh national marine research infrastructure during the next 10 years and beyond.

Question 10: What financing models should the Government consider to support investment in national research infrastructure?

Question 11: When should capabilities be expected to address standard and accreditation requirements?

Question 12: Are there international or global models that represent best practice for national research infrastructure that could be considered?

Question 13: In considering whole of life investment including decommissioning or defunding for national research infrastructure are there examples domestic or international that should be examined?

Question 14: Are there alternative financing options, including international models that the Government could consider to support investment in national research infrastructure?

Environment and Natural Resource Management

Question 18: Are the identified emerging directions and research infrastructure capabilities for Environment and Natural Resource Management right? Are there any missing or additional needed?

Emerging Directions

The NMSC's Decadal Plan identifies the following seven grand marine challenges: marine sovereignty, security and safety; energy security; food security; biodiversity, conservation and ecosystem health; urban coastal environments; climate variability and change; and research allocation. Only some of these are included in section 6.1.2 and the NMSC believes it would be valuable to include all of them in the 2016 Roadmap.

This section is very terrestrial in focus. It fails to mention Australia's 10.2 million km2 of ocean territory.

Section 6.1.1 states that "Recent advances will see future efforts shifting from how to collect and manage data to how to support data integration, modelling and analysis to improve prediction and reduce uncertainty." This may be true in some domains, but is not so true in marine science. In marine biogeochemical and ecosystem modelling we have very sophisticated approaches to "data integration, modelling and analysis" but in fact lack the data to reduce uncertainty. Below the surface of the ocean which can be seen by satellites, we do not have 'big data' and our challenge is to create it.

In section 6.1.2, splitting the discussion of challenges into southern and northern halves of the country makes no sense to us. It ignores the fact that Australia faces significant challenges in its tropical marine environment. Australia's tropical reefs, including the Great Barrier Reef, all of which make significant contributions to our blue economy, face significant threats from climate change (risks include ocean warming, ocean acidification, intensification of storm events and changes to the drought-flood cycle) and other pressures (such as predation by crown-of-thorns starfish and excess nutrients, fine sediments and pesticides). The NMSC thus recommends taking a more holistic view of national challenges.

Current Capabilities and Emerging Capability Needs

The text in sections 6.2.2 and 6.3 aligns with aspects of the NMSC's NMSP but should be broadened to include the below information.

In order for Australia to realise the significant benefits offered by its blue economy and maintain its leadership in marine science, we need a suite of both dedicated and broader research infrastructure including:

- an adequately funded national research vessel fleet consisting of bluewater, polar and shelf-scale vessels which allow exploration of the open oceans, Antarctic regions and continental shelf and coastal waters; in particular:
    - the research vessel *Investigator* needs to be funded for 300 days per year

    - the polar vessel *Aurora Australis* is fully utilised during winter, but has spare capacity at other times that could support a significant increase in marine science throughout the eastern Antarctic sector of the Southern Ocean
    - the small and ageing shelf-coastal research fleet needs to be replaced over the next decade
    - models for sharing national and international research vessel capacity should be explored.
- observing systems that consist of in situ monitoring devices and satellites that provide earth observation from space capabilities; in particular:
    - IMOS should be sustained and enhanced as the national provider of observations from open ocean, onto the continental shelf and into the coasts and estuaries
    - the NMSC recommends allocation of time on the *Investigator* and shelf-coastal research vessels is tightly coordinated with IMOS to ensure that the national observing system networks can be deployed and serviced at required intervals
    - continued access to earth observations from space through initiatives such as the Copernicus data hub, established by Geoscience Australia and the European Space Agency (ESA) to ensure data from the EU's Sentinel satellites are accessible in Southeast Asia and the South Pacific
    - access to data from dedicated geostationary satellites with optical visible imagery which would have a profound impact on Australian marine science as well as other areas of science (such as those studying terrestrial systems.
- experimental facilities, such as marine research aquaria; specialist research and analytical laboratories; and research stations in Antarctica, across the Great Barrier Reef and in temperate coastal locations, which are engine rooms for research, education and training, providing many young scientists with formative experiences working in and with the marine environment
- infrastructure for national marine baselines and long-term monitoring; in particular;
    - sustaining existing long-term monitoring programs, such as AIMS's Great Barrier Reef Long-term Monitoring Program and IMOS national reference stations
    - filling gaps in long-term monitoring programs that currently limit our ability to assess the impacts of climate change, resource extraction and decision-making by regulators, policymakers and industry on high-value ecosystems;
    - providing ocean information to enable sustainable management of human impacts on these systems and inform adaptation strategies for likely pressures associated with ocean warming and acidification.
- a national ocean modelling system (akin to what IMOS has achieved with observations and data), dedicated to developing and using a suite of national marine system models as the next important step in managing our marine estate
- access to e-research infrastructure; in particular
    - high-performance computing and modelling infrastructure with appropriate data storage
    - accelerated development of the Australian Ocean Data Network (AODN) as an online network of marine and coastal data resources, giving Australian marine science a competitive edge by ensuring valuable data can be readily accessed, used and reused in building national marine baselines

- enhanced focus on translating data and scientific outputs into information than can actually be used by decision makers.

It is important to note that the NMSC does not seek to duplicate research infrastructure for marine science purposes. Wherever possible we will seek access to national research infrastructure which can be focused on solving marine science questions, looking to build dedicated marine research infrastructure only where necessary e.g. research vessels, marine observing systems, research aquaria. Such an approach requires clear and coherent articulation of infrastructure requirements across the national innovation system; something the 2016 Roadmap will be well placed to do. In some instances, Australian scientists do need to access international infrastructure such as the International Ocean Discovery Program (IODP). Such international infrastructure should be included in any stocktake of research infrastructure used nationally.

Question 19: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Australia should continue to engage with international satellites missions and the Group on Earth Observations (GEO), IODP, and the Global Ocean Observing System (GOOS).

Australia is currently underutilising the blue water research vessel capability provided by the RV *Investigator* (it only has funding to operate for 180 out of a possible 300 days). As a result, Australian scientists are being locked out of opportunities to participate in major international programs within our region. A current example is the Second International Indian Ocean Expedition (IIOE-2), a five-year multi-national ocean science program being conducted in a region of significant strategic importance to our country. Constraints on access to RV Investigator mean that there are currently no Australian voyages planned as contributions to IIOE-2, missing a major opportunity for cooperation with India, Indonesia and other countries on the Indian Ocean rim.

Question 20: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Environment and Natural Resource Management capability area?

Advanced Physics, Chemistry, Mathematics and Materials

Question 21: Are the identified emerging directions and research infrastructure capabilities for Advanced Physics, Chemistry, Mathematics and Materials right? Are there any missing or additional needed?

Question 22: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 23: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Advanced Physics, Chemistry, Mathematics and Materials capability area?

National Security

Question 27: Are the identified emerging directions and research infrastructure capabilities for National Security right? Are there any missing or additional needed?

The NMSC's views on water security are covered in the above response to chapter 6 - Environment and Natural Resource Management.

The NMSC believes that marine sovereignty, security and safety as well as food, energy and resources security are important parts of national security and that these are missing from the capability issues paper. Our marine estate is a vital yet challenging contributor to Australia's sovereignty, national security and safety and is increasingly more important for our food, energy and resources security. Marine stakeholders, including the shipping industry, coastal managers, port operators, the offshore oil and gas industry, defence, border protection, the aquaculture and fishing industries, tourism, recreational boating, coastal engineers and emergency managers, all require accurate and up-to-date information about sea state, atmospheric conditions and geohazards, to support their multiple uses of the jurisdiction. There is a constant need for information at timescales that stretch from hours to weeks—whether it is for industry operations, or for prediction, prevention, mitigation or compliance activities, out at sea or along the coast. Meeting these needs is a constant challenge, but particularly so in the case of extreme weather events which remain poorly understood and a challenge to predict. Their impact is also disproportionately strong, and climate change is predicted to increase the intensity and frequency of some events. These extreme events include both physical and biological natural hazards such as destructive winds, waves and storm surges, tropical cyclones, flooding, surface and subsurface currents, temperature extremes, beach erosion, algal blooms, coral bleaching and invasive species.

In order to address these challenges, we need to:

- create a comprehensive national observing system, covering open ocean to coastal and littoral zones, and which includes in situ measurements, remote sensing and a national information infrastructure
- invest in state-of-the-art national computational infrastructure to develop short-to-medium range (days to weeks), uncoupled and coupled biophysical models for analyses and forecasts, from open ocean to coastal and littoral zones
- use overseas experiences and expertise through collaboration wherever possible and appropriate.

Question 28: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 29: Is there anything else that needs to be included or considered in the 2016 Roadmap for the National Security capability area?

Underpinning Research Infrastructure

Question 30: Are the identified emerging directions and research infrastructure capabilities for Underpinning Research Infrastructure right? Are there any missing or additional needed?

The identified emerging directions and research infrastructure capabilities identified align with the marine science research infrastructure requirements detailed in the NMSP and above (chapter 6 - Environment and Natural Resource Management).

Question 31: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 32: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Underpinning Research Infrastructure capability area?

Data for Research and Discoverability

Question 33: Are the identified emerging directions and research infrastructure capabilities for Data for Research and Discoverability right? Are there any missing or additional needed?

The NMSC recommends that the AODN (see above in Environment and Natural Resource Management) be noted as a current and emerging capability that has embedded a data centric approach into Australian marine science.

The NMSC also recommends that data standards be included in this section. While research data storage and other infrastructure, such as the Australian National Data Service, are crucial for this capability focus area, it can be difficult, sometimes impossible, to effectively use data when there isn't a clearly defined standard because similar datasets with different 'structures' cannot be combined.

Furthermore, the NMSC recommends that data prediction be included in the desirable new capabilities section. For instance instead of saying "…from data capture through to simulation and modelling and to dissemination…" the NMSC recommends "…from data capture through to simulation, modelling and prediction and to dissemination…"

Question 34: Are there any international research infrastructure collaborations or emerging projects that Australia should engage in over the next ten years and beyond?

Question 35: Is there anything else that needs to be included or considered in the 2016 Roadmap for the Data for Research and Discoverability capability area?

Other comments

If you believe that there are issues not addressed in this Issues Paper or the associated questions, please provide your comments under this heading noting the overall 20 page limit of submissions.