



National Marine Science Plan  
Science program to support **Decision-making**  
**Establishing and supporting a  
national marine baselines  
and monitoring program**  
Working Group Report

TECHNICAL REPORT

NATIONAL  
**MARINE**  
SCIENCE  
— COMMITTEE —



# NATIONAL MARINE SCIENCE — COMMITTEE —

Prepared by the National Marine Science Committee,  
with Toni Moate as Chair and Kim Picard as Deputy Chair.

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# Summary |

A key recommendation in the National Marine Science Plan 2015–2025 (NMSP, 2015; hereafter the National Marine Science Plan) is ‘Establish and support 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’.

The National Marine Science Committee (NMSC) established a working group to provide advice on establishing and supporting a national program. This report provides the working group’s advice and recommendations for establishing and supporting a national program.

## Needs, benefits and challenges

A national approach to the systematic collection and reporting of priority marine baselines and monitoring data is critical for the effective management of Australia’s marine resources and iconic ecosystems, and a sustainable and enduring blue economy. A national approach to baselines and monitoring is not just focusing on priorities that occur at a continental scale, it can also include multi-jurisdictional phenomena, along with development of the required national capabilities and capacities. An effective national approach to baselines and monitoring will provide two primary benefits. The first is a fit-for-purpose, evidence-based understanding of the status of and trends in marine ecosystems, as well as cause-and-effect relationships within socio-ecological systems that include the response of these systems to policy and management interventions. The second is the cost-effective and coordinated use of available resources to establish marine baselines and conduct monitoring.

There is a broad range of challenges that need to be understood and overcome to reap the benefits of a national approach to marine baselines and monitoring. Some of the more significant challenges include the need for clarity on the purpose of and priorities for long-term monitoring programs; the need to harmonise approaches across disciplines and sectors to collect, manage and provide accessible data; and the need to secure enduring commitment from partners across all jurisdictions, along with long-term funding.

“*There is a broad range of challenges that need to be understood and overcome to reap the benefits of a national approach to marine baselines and monitoring.*”

## Key elements of a national approach

To succeed in developing a national approach to marine baselines and monitoring data, we will need to establish a user-driven process, learn from the insights provided by existing initiatives, and, where appropriate, build on established programs. Australia is not starting with a blank slate. International programs, such as the Global Ocean Observing System (GOOS), provides important perspectives on the establishment of a successful large-scale collaborative monitoring program.

Within Australia, an increasing number of government agencies and science institutions are also working together to enhance coordination and integration of marine monitoring to facilitate reporting at regional and national scales. This report highlights insights from the GOOS, the Integrated Marine Observing System (IMOS), the Reef 2050 Integrated Monitoring and Reporting Program and the New South Wales (NSW) Marine Integrated Monitoring Program. We consider the four programs above and identify common key elements for establishing and supporting a national marine baselines and monitoring program for Australia. Regional initiatives advancing Integrated Environmental Assessments are established focal points for cross-sectoral collaboration and investment, providing opportunities to advance a national approach to baselines and monitoring.

## Current approach to marine baselines and monitoring

There is a spectrum of formal and informal mandate and oversight arrangements for baselines and monitoring programs in Australia, including those for commercial fisheries management, marine park and reserve management, maritime emergencies, ocean and coastal observing, and release of offshore petroleum acreage. The working group completed an audit of marine baselines and monitoring programs in Australia, identifying 371 programs. Most monitoring programs focused on biological, chemical and physical attributes, with approximately 50 per cent of programs reporting a focus or partial focus on biological attribute data. Approximately 9 per cent of programs identified their spatial scale as national, while 84 per cent identified their scale as either statewide, regional or local.

National standards for collecting and managing biological, chemical and physical attribute data are used by some programs (e.g. Australian Marine Park baselines and monitoring, IMOS facilities and Reef Life Survey), but most programs are not using common national standards. Further, audit results suggest that only 30 per cent of Australia's marine baselines and monitoring data are open access, while 50 per cent are either restricted or confidential. There are a number of established national reporting mechanisms (e.g. State of the Environment reporting, State of the Climate reporting, commercial fisheries status reporting, status of Australia's birds reporting, pollution inventory reporting), but the audit revealed a highly diverse set of arrangements for reporting. The working group completed a rapid readiness assessment for monitoring high-level attributes at a national scale in Australia's marine and coastal environments. The assessment considered 53 attributes (i.e. physical, biochemical, biological, ecosystem and pressures variables) and identified 27 'bright spots' and nine 'warm spots' that could form the basis of a national approach to baselines and monitoring. The audit also identified the programs supporting these attributes.

## Advice and recommendations

Advice to the NMSC on a national approach to marine baselines and monitoring includes general conclusions. The key points are:

1. There is considerable support for a national approach to marine baselines and monitoring in Australia and we are well positioned to build on our experience, insights and existing programs.
2. Effective mandate and oversight arrangements will be critical to advancing a national approach.
3. There is a need to identify a limited set of baselines and monitoring priorities designed to meet national needs.
4. Commitment to develop the 'national marine data landscape' is central to success.
5. Links between national needs, prioritised variables, national monitoring networks and specific reporting mechanisms/outputs need to be clearly articulated.

The working group identified two options to establish a national approach to marine baselines and monitoring: the 'step-change' (new money) collaborative program and the 'incremental' (existing money) collaborative approach. These options are not mutually exclusive.

The working group presents six recommendations for consideration by the NMSC:

1. Discuss and agree on the preferred mechanism for establishing an explicit mandate to advance a national approach to marine baselines and monitoring. Ideally, the mechanism extends beyond the National Marine Science Plan to capture parties that are not part of the NMSC (e.g. relevant state and territory government agencies, Indigenous organisations and industry).
2. Discuss and agree on a preferred governance model to advance a national approach to marine baselines and monitoring. Ideally, the model needs to include relevant parties that are not part of the NMSC (e.g. relevant state and territory government agencies, Indigenous organisations and industry).
3. Establish an ongoing NMSC subcommittee to support the NMSC in promoting and advancing a national approach to marine baselines and monitoring. The NMSC should establish terms of reference, appoint a chair and secretariat, and call for subcommittee members.
4. Propose a set of principles and common framework for a national approach to marine baselines and monitoring to guide decision-making and promote coordination.
5. Consider the two options (step-change collaborative program and incremental collaborative approach) presented in this report for establishing and advancing a national approach to marine baselines and monitoring and determine the committee's level of support for these options and their role in advancing either one or both options.
6. Consider options for promoting the establishment of a national marine baselines and monitoring program. Options could include things like establishing a brand to promote a national approach, championing and sponsoring an inaugural annual or biennial national baselines and monitoring symposium, or implementing a virtual roadshow to promote a national approach to targeted stakeholders (e.g. Ministers, members of parliament, department heads, key Indigenous groups and industry groups).

# Part 1: Purpose and aim of report |

## Key messages

- A key recommendation in the National Marine Science Plan is ‘Establish and support 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’.
- The NMSC established a working group to provide advice on establishing and supporting a national program.
- This report provides the working group’s advice and recommendations for establishing and supporting a national program.

## Directive from the National Marine Science Committee

The NMSC established a working group to provide advice to ‘Establish and support 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’ (Appendix A for the working group’s terms of reference). The National Marine Baselines and Monitoring Working Group has focused on progressing two specific goals articulated within the National Marine Science Plan:

1. Undertake systematic collection of environmental, social and economic baseline data describing Australia’s marine estate.
2. Establish a National Marine System Monitoring Program to track changes in the marine estate.

Collectively, the goals of the National Marine Science Plan were crafted to address the seven main challenges identified in the plan: (i) marine sovereignty, security and safety; (ii) energy security; (iii) biodiversity conservation and ecosystem health; (iv) food security; (v) urban coastal environments; (vi) climate variability and change; and (vii) resource allocation (Figure 1).

The objective of the national marine baselines and monitoring program is to aggregate existing social, economic and environmental datasets held by government agencies, universities and industry, and establish methods and data standards for developing environmental baselines and long-term monitoring. The program would also provide the opportunity to advance the inclusion of baselines and monitoring data collected by Indigenous programs, recognising that Aboriginal and Torres Strait Islander organisations are becoming increasingly interested and skilled in establishing monitoring programs focused on culturally important habitats and species, and the pressures that affect them.

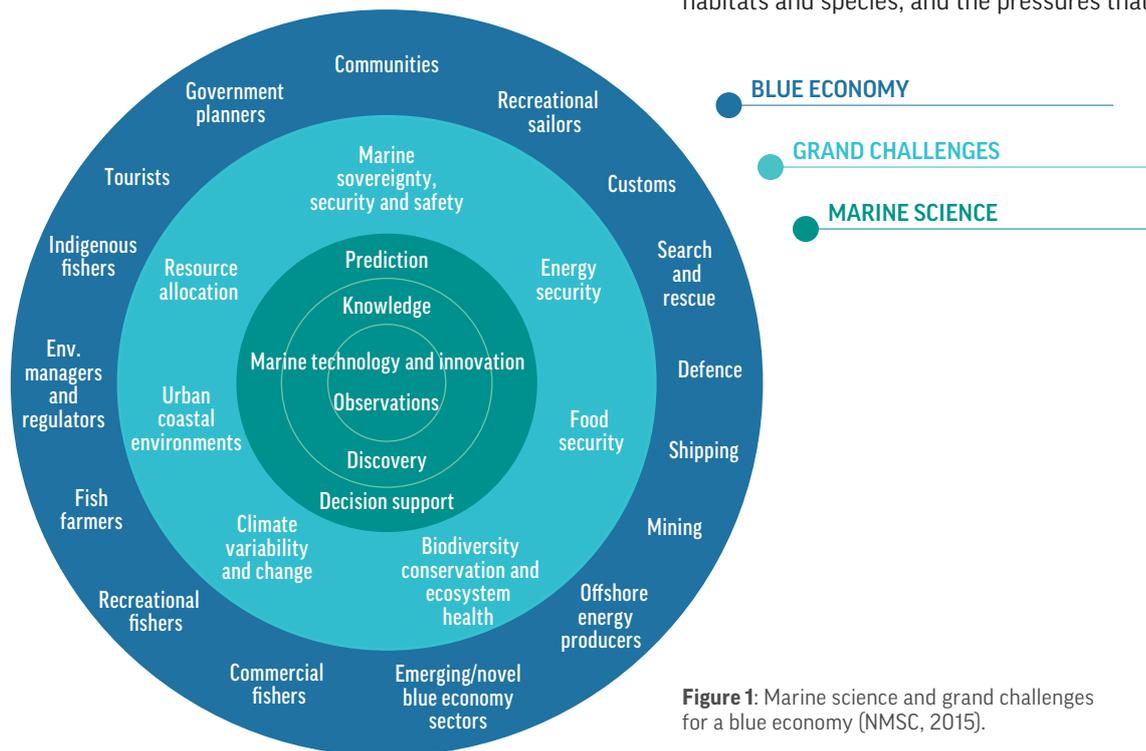


Figure 1: Marine science and grand challenges for a blue economy (NMSC, 2015).



Australia's investments in science infrastructure (e.g. IMOS, Marine National Facility, Australian Research Data Commons) and performance management and assessment systems (e.g. monitoring, evaluation, reporting and improvement systems for marine parks and fisheries; Status of Australian Fish Stocks Report) provide important cornerstones for establishing and advancing a national approach. The program would provide the basis for a coordinated and cost-effective approach to marine baselines and monitoring in Australia, which would enhance existing sector, national and state-based programs; meet the requirements of national reporting (e.g. State of the Environment, State of the Climate); support assessment of impacts of cumulative pressures on high-value systems; and better support national reporting against international agreements and commitments (e.g. United Nations Sustainable Development Goals, Convention of Biological Diversity targets, High Level Panel for a Sustainable Ocean Economy).

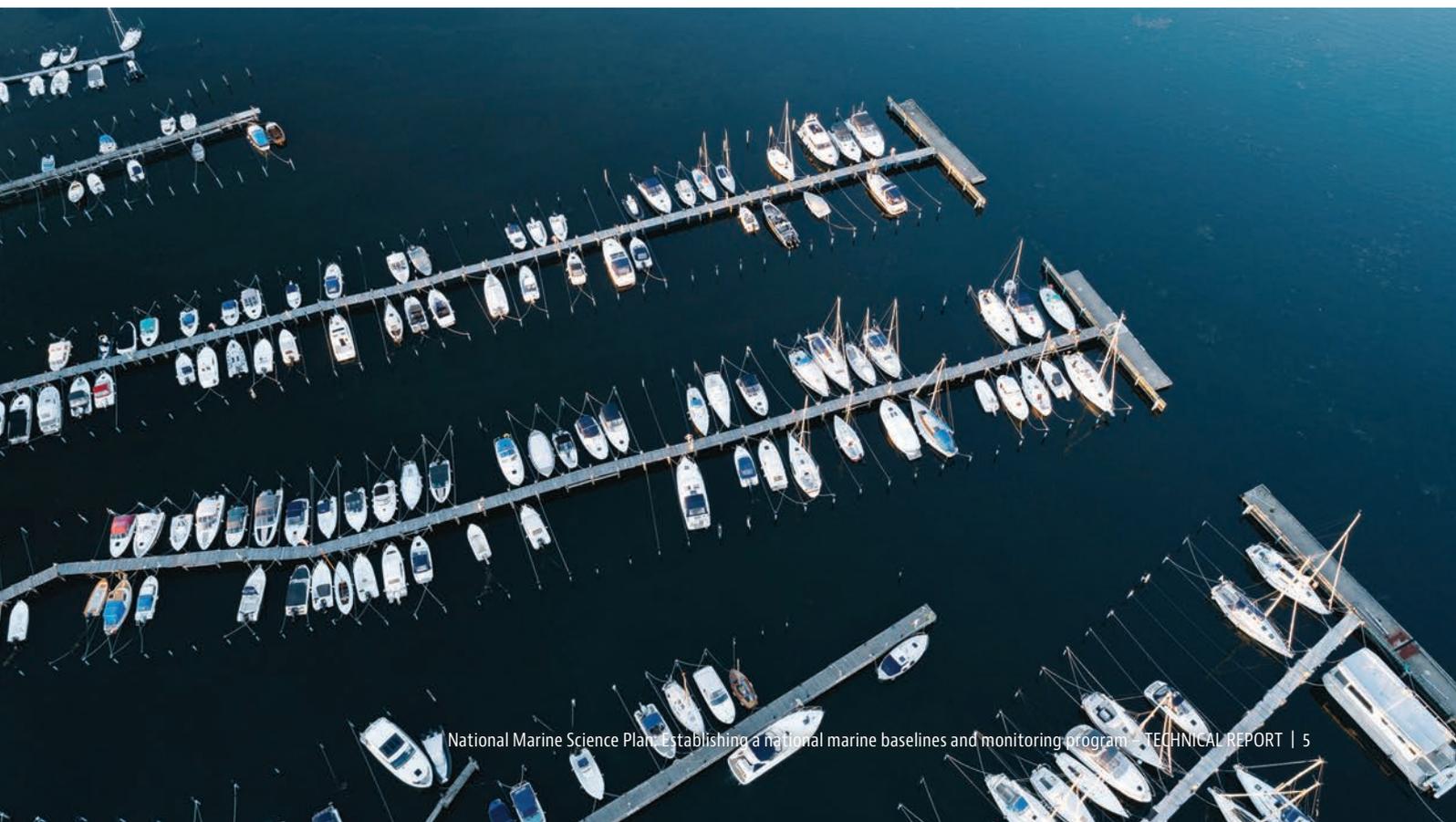
The working group has brought together key individuals within Australia, including representatives from state and Commonwealth agencies and research institutions, to formulate advice and recommendations to establish a national marine baselines and monitoring program that is supported as a partnership between the Commonwealth and the states. The program needs to provide information about the status, trends and resilience of marine systems, to help support the decisions of managers, policymakers and industry.

The program should bring together, where appropriate, existing monitoring efforts to inform assessment and reporting at national and regional scales, and against international commitments.

## Aim of report

The aim of this report is to provide advice to the NMSC about establishing and supporting a national marine baselines and monitoring program. This program will (i) provide a comprehensive assessment of our estate that enables robust and consistent assessment and reporting across jurisdictions and scales, and (ii) help manage Commonwealth and state marine reserves (recommendation 2 in the National Marine Science Plan). The sections that follow are structured around:

- understanding the needs and benefits of a national approach
- understanding the key elements of a national approach
- providing an overview of the existing approaches to baselines and monitoring in Australia
- identifying where we have developed capability (readiness levels) for national monitoring and the important programs that support this
- providing advice about establishing and supporting a national approach.



## Part 2: Needs, benefits and challenges of a national approach to baselines and monitoring |

### Key messages

- A national approach to the systematic collection and reporting of priority marine baselines and monitoring data is critical for the effective management of Australia's marine resources and iconic ecosystems, and a sustainable and enduring blue economy.
- An effective national approach to baselines and monitoring will provide two primary benefits. The first is a fit-for-purpose, evidence-based understanding of the status of and trends in marine ecosystems, as well as of the cause-and-effect relationships within socio-ecological systems, including the response of these systems to policy and management interventions. This benefit also enables national comparisons and allows for observed changes at local scales to be contextualised at regional and national scales. The second benefit is the cost-effective and coordinated use of available resources to establish marine baselines and conduct monitoring.
- There is a broad range of challenges that need to be understood and overcome to reap the benefits of a national approach to marine baselines and monitoring. Some of the more significant challenges include the need for clarity on the purpose of and priorities for long-term monitoring programs; the need to harmonise approaches across disciplines and sectors to collect, manage and provide accessible data; and the need to secure enduring commitment from partners across all jurisdictions, along with long-term funding.

### Need for a national approach

By 2025, it is estimated that Australia's marine industries will contribute around \$100 billion each year to our economy, with our oceans and coasts providing a further \$25 billion worth of ecosystem services (NMSC, 2015). Marine ecosystem services provide and support a broad range of social, cultural and economic values, with a large proportion of the Australian population dependent upon these services to support their wellbeing. These benefits are both direct, through such things as recreation, cultural practices and the harvest of food and energy sources, and indirect, through ecosystem services such as climate regulation, coastal protection and carbon sequestration. These benefits are fundamental to a growing 'blue economy' in such areas as marine transportation, energy generation, seafood production and tourism.

Australia's marine environments and ecosystem services are under threat from a range of pressures operating at global, regional and local scales, thereby affecting the benefits that communities derive from marine ecosystems. The many cumulative pressures affecting our marine environment include sea level rise, acidification, ocean warming, natural disasters (e.g. cyclones, tsunamis and heatwaves), unsustainable harvesting, physical disturbance, plastics and

other forms of pollution. Australia's NMSC (2015) highlighted that a national approach to establishing marine baselines and monitoring is needed to:

- improve seasonal and long-term climate prediction to inform adaptation responses
- assess the potential of oceans to provide resources and bioproducts
- create an inventory and assessment of risks to environmental assets
- differentiate between the changes resulting from human use and those driven by natural variability
- evaluate the economic and social effectiveness of management actions (e.g. fishing, tourism, ports and energy)
- provide the context and evidence base for the management of marine industries, the evaluation of regulatory regimes, and the conservation and/or recovery of high-value assets
- determine the effectiveness of marine conservation measures for marine protected areas in state and Commonwealth waters, as well as the effectiveness of those for unprotected areas.

A national approach to the systematic collection and reporting of priority marine baselines and monitoring data is critical for the effective management of



Image: Andrew Martini, CSIRO

Australia's marine resources and iconic ecosystems, and a sustainable and enduring blue economy. By bringing a range of currently disparate monitoring efforts into a coordinated, long-term national marine monitoring program, we would be able to better understand the vulnerability and resilience of our marine systems, and better support the decision-making and resource management of marine park managers, policymakers, marine industries and regulators. A national approach to baselines and monitoring is not just focused on priorities that occur at a continental scale, it can also include multi-jurisdictional phenomena, along with development of the required national capabilities and capacities.

## Benefits of a national approach

An effective national approach to baselines and monitoring will provide two primary benefits. The first is a fit-for-purpose, evidence-based understanding of the status and trends in marine ecosystems, as well as of the cause-and-effect relationships within socio-ecological systems, including the response of these systems to policy and management interventions. This benefit also enables national comparisons and for observed changes at local scales to be contextualised at regional and national scales. Developing the capability and capacity to understand these cause-and-effect relationships is critical to meet Australia's needs from a national approach outlined in the section 'Need for a national approach'. Establishing collaborative mechanisms to understand how these needs relate to each other and align with the priorities of policymakers and managers is fundamental to achieving this primary benefit.

The second benefit is the cost-effective and coordinated use of available resources to establish marine baselines and conduct monitoring, and these benefits flow from:

- identifying shared priorities across jurisdictions, sectors, institutions and programs
- promoting development of complementary capability among jurisdictions and institutions and minimising duplication, recognising that in a nationally coordinated approach, skills, infrastructure and capability can be shared through collaborative arrangements. A number of examples emerged from working group discussions, with the most prominent of these relating to increased cost-effectiveness for the collection, storage and sharing of monitoring data
- growing funding to support baselines and monitoring and broadening the base of funding contributors.

The cost-effectiveness benefits of a national approach will ultimately manifest in a broad range of current and developing programs of the Australian Government, state and territory governments, industry and academic institutions, for example:

- monitoring, evaluation, reporting and improvement programs for Australian Marine Parks, marine protected areas and other protected places such as World Heritage Areas, Indigenous Protected Areas and Ramsar sites
- implementing Australia's strategy and action plan for a common approach to environmental economic accounting
- reporting on State of the Environment by state and territory governments and the Australian Government
- monitoring, evaluation, reporting and improvement programs for marine resource use; for example, a national approach could help to improve Status of the Australian Fish Stock reports by improving coordination of monitoring and reporting on bycatch, non-target species and marine habitats
- monitoring, evaluating, reporting and improving programs designed to understand pressures on the marine environment and ecosystem services, including adapting to climate change and responding to natural disasters

- generating greater impact from deployment of ocean observing equipment, for example through Australia's IMOS
- monitoring, evaluation, reporting and improvement to meet international commitments, for example the United Nations Sustainable Development Goals and Convention on Biological Diversity.

## Challenges of a national approach

There is a broad range of challenges that need to be understood and overcome to reap the benefits of a national approach to marine baselines and monitoring. Some of the more significant challenges of a national approach relate to the need for clarity on the purpose of and priorities for long-term monitoring programs; the need to harmonise approaches across disciplines and sectors to collect, manage and provide accessible data; and the need to secure enduring commitment from partners across all jurisdictions, along with long-term funding.

Australia has the world's third largest exclusive economic zone and an extensive coastline, including estuaries and offshore islands. Not surprisingly, the collective list of marine baselines and monitoring interests of Australia's government agencies, industries, Indigenous communities and science institutions is very long. A primary challenge for establishing, developing and maintaining a national marine baselines and monitoring program is coming to a shared understanding among participating partners that a national program cannot be all things to all people. Providing clarity about the purpose of the program and identifying a realistic set of priorities is critical to success. Furthermore, the concept of a baseline is being interpreted in a variety of ways in marine policy, management and science communities. Baselines and monitoring need to be separated and clearly defined as part of establishing a national approach.

A national approach to baselines and monitoring will not start with a clean slate, as it would bring together existing baselines and monitoring activities from a range of science disciplines that exist at the program and/or project level and have been operating effectively for some time. Harmonising existing approaches to baselines and monitoring to establish and develop a multidisciplinary national approach presents a significant challenge. Developing a common language and logic will be critical for advancing a national approach, as will the need to recognise and understand regional differences, needs and drivers, particularly in the coastal zone.

An effective national program for marine baselines and monitoring will have a multi-decadal vision aligning with the needs and priorities of its participating partners. Multi-decadal programs are ultimately exposed to the vagaries of political, institutional, technological and environmental cycles and events – change is inevitable. Regardless, an enduring commitment from participating partners is critical for sustaining a multi-decadal collaborative approach that relies on those with the capacity to collect and manage data meeting the needs of those needing to understand the status of and trends in condition and cause-and-effect relationships within socio-ecological systems.

A multi-decadal national approach to marine baselines and monitoring needs adequate funding to establish a program and develop and maintain the required capabilities and capacity to address the priority needs of participating partners. Agreement on who should pay for monitoring can present significant challenges, particularly in a collaborative setting where there may be numerous partners involved in monitoring or benefiting from monitoring. The vagaries of budgetary cycles and shifting or emerging policy or management priorities exacerbate this challenge, particularly in terms of sustaining funding for multi-decadal monitoring programs. A national approach will need to include a mechanism to provide scope for the evolution of the program in response to emerging priorities, particularly in the absence of additional funds.



# Part 3: Key elements of a national approach to baselines and monitoring |

## Key messages

- To succeed in developing a national approach to marine baselines and monitoring data, we will need to establish a user-driven process, learn from the insights provided by existing initiatives and, where appropriate, build on established programs.
- GOOS provides important international perspectives on the establishment of a successful, large-scale, collaborative monitoring program. Within Australia, an increasing number of government agencies and science institutions are working together to enhance coordination and integration of marine monitoring to facilitate reporting at regional and national scales. This report highlights insights from GOOS, IMOS, the Reef 2050 Integrated Monitoring and Reporting Program and the NSW Marine Integrated Monitoring Program.
- We consider the four programs above and identify common key elements for establishing and supporting a national marine baselines and monitoring program for Australia.

The National Marine Science Plan seeks to establish a program that will provide a comprehensive assessment of our marine estate and help manage Commonwealth and state marine reserves. To succeed in developing a national approach to marine baselines and monitoring data, we will need to establish a user-driven process, learn from the insights provided by existing initiatives and, where appropriate, build on existing programs. We are not starting with a blank slate. Important international perspectives on the establishment of a successful, large-scale, collaborative monitoring program can be gained from examining GOOS. Within Australia, an increasing number of government agencies and science institutions are working together to enhance coordination and integration of marine monitoring to facilitate reporting at regional and national scales. For example, IMOS, the Reef Integrated Monitoring and Reporting Program for the Great Barrier Reef World Heritage Area and the NSW Marine Integrated Monitoring Program are user-driven initiatives that provide valuable insights into the key elements required to establish and support a national approach to marine baselines and monitoring.

## Insights from the Global Ocean Observing System

GOOS provides a potential framework and benchmark for coordinating Australian baselines and monitoring programs. Established in 1991, GOOS is a sustained collaborative system that coordinates observations around the global ocean for three critical themes: climate, operational services and marine ecosystem health. These themes correspond to the GOOS mandate to contribute to the operational ocean services of the United Nations Framework Convention on Climate Change; the United Nations Convention on Biological Diversity; and

the Intergovernmental Oceanographic Commission/ World Meteorological Organization, respectively. The system encompasses in situ networks, satellite systems, governments, United Nations agencies and individual scientists. It is designed to observe scientifically and societally relevant phenomena, covering physical, biogeochemical, biological and ecosystem variables.

There are several important elements to GOOS that provide for system oversight and coordination of ocean observing at a global scale:

1. A three-tiered governance model provides oversight, expert advice on system requirements and coordination of observation networks.
2. A core set of principles has been constant for more than 20 years:
  - implement through user-driven design
  - maintain sustained observations
  - ensure regular evaluation
  - set global standards and best practices
  - encourage open data sharing
  - develop capacity.
3. A Framework for Ocean Observing guides implementation of an integrated and sustained ocean observing system, including the setting of requirements, assessing readiness of observation technology, and assessing the usefulness of data and products for users.
4. Essential ocean variables have been identified to promote and focus coordination between funding agencies and observing networks; develop and use standards for data collection and management standards; and maximise the utility of data.

Figure 2: The Integrated Marine Observing System.



# IMOS Integrated Marine Observing System



IMOS undertakes systematic and sustained observing of Australia's marine estate.



Operates a portfolio of platform-based Facilities to acquire ocean observations.

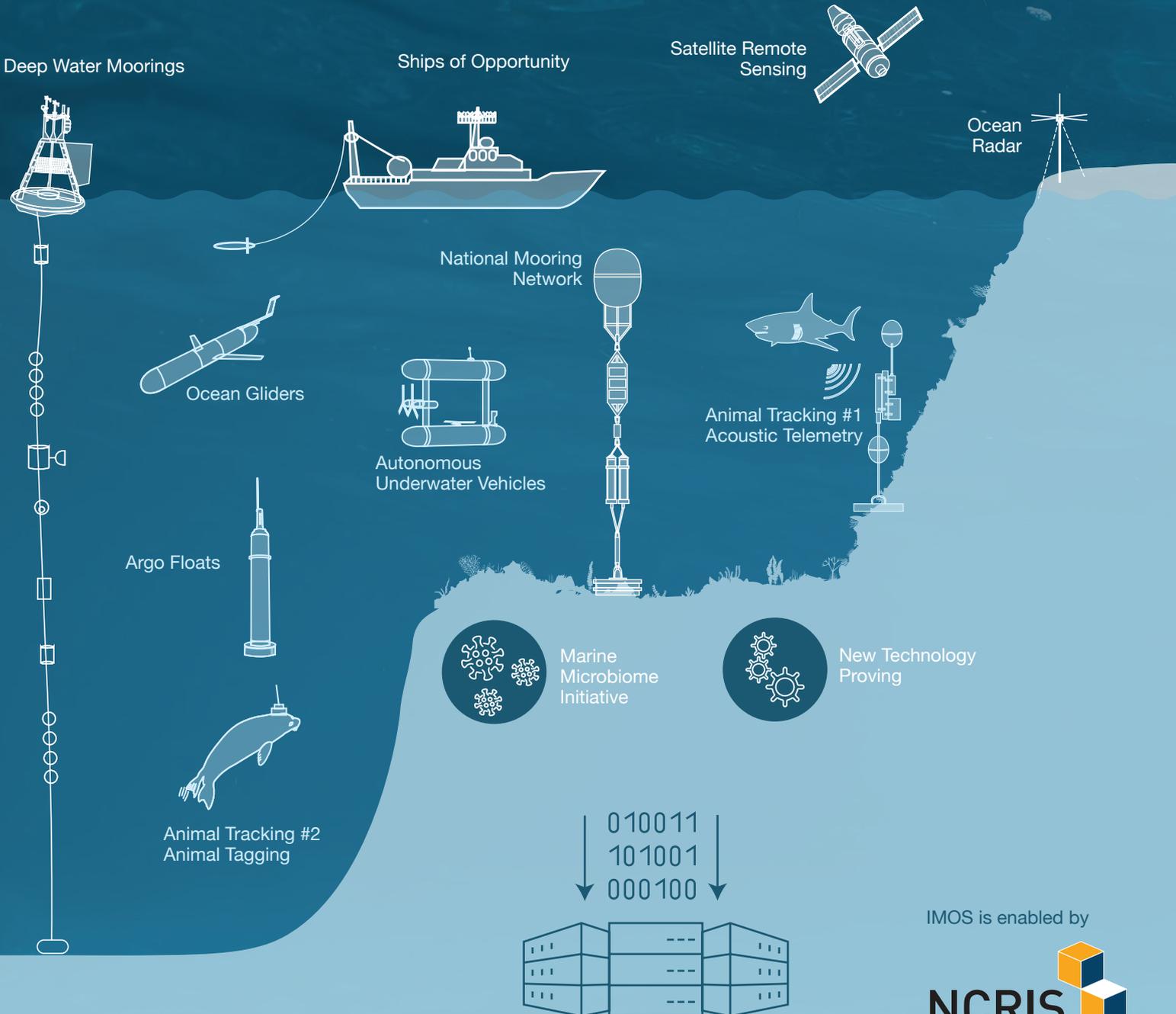


Plans its operations through internationally peer-reviewed science processes.



Engages with users across universities, governments, and industries to drive uptake and impact.

## Our Facilities include



5. GOOS Regional Alliances are coalitions or institutions that share GOOS principles and goals. GOOS served as a mechanism to unite these largely national programs, many of which were established to identify, enable and develop sustained ocean monitoring and services to meet regional and national priorities. Australia's IMOS is one of 13 regional alliances focusing on the systematic and sustained observing of vast areas of ocean territory at national scales, making data openly accessible for science, research and decision-makers.
6. The GOOS 2030 Strategy provides the vehicle for designing, building and widening the use of the necessary observations and information systems. There is also a roadmap for implementing the strategy.
7. GOOS projects have been designed and implemented to advance innovation and expand the observing system into new areas and capabilities, services and product delivery.

The principles applied by GOOS could be used to establish a framework for coordination of Australian baselines and monitoring programs by focusing efforts on key elements (e.g. essential ocean variables), assessing the readiness level of elements of these programs and helping to facilitate data sharing and synergistic activities.

## Insights from national initiatives designed to coordinate and integrate monitoring

### Integrated Marine Observing System

Australia's IMOS has been operating a wide range of observing equipment throughout Australia's coastal and open oceans since 2006. IMOS is designed to be a fully integrated national system, focused on long-term observations at ocean-basin and regional scales, covering physical, chemical and biological variables. IMOS was established with a vision that states: 'By 2025, Australia will have a continuously growing time series of essential ocean variables for marine and coastal environments. This will enable cutting edge research on contemporary problems and provide a scientific basis for informed decision-making about our vast and valuable marine estate.' Planning and operations are underpinned by nine strategic priorities:

1. Engage all national stakeholders with a need for systematic and sustained observing of Australia's marine environment in the ongoing design and implementation of the system.
2. Continue to focus on turning observations and data into time series of essential marine and coastal variables, providing timely support to a wide range of science and research, meeting current and future needs.

3. Collaborate as a strong partner in the global ocean observing enterprise, to generate synergies from international efforts and provide leadership within the Australasian region.
4. Sustain established IMOS capability to realise full value from investments to date and avoid loss of value through discontinuity. Evolve established capability in response to scientific and technological developments, and performance and delivery.
5. Position IMOS capability to maximise benefits from related investments in remote sensing, vessel operation, marine data management, and ocean and coastal modelling.
6. Articulate major gaps, develop costed solutions, and work with partners and stakeholders to identify opportunities for addressing them.
7. Continue to evolve the observing system in response to national priority setting.
8. Sustain effort in areas where impact is high. Focus effort on increasing relevance and impact in sectors with unrealised potential.
9. Build partnerships with state governments and marine industries around the core investment by the Australian Government.

IMOS observations are guided by peer-reviewed science and implementation planning, undertaken across the Australian marine and climate science community through a series of regional nodes, in consultation with key stakeholders from industry, government management agencies, and research institutions. The science planning is driven by a range of mechanisms including the National Marine Science Plan, the National Climate Resilience and Adaptation Strategy, the Global Ocean Observing System 2030 Strategy and the United Nations Decade of Ocean Science for Sustainable Development 2021–2030. Implementation is directed by the IMOS decadal strategy and the IMOS 5-year plan.

IMOS operates a portfolio of platform-based facilities to collect systematic and sustained observations of Australia's marine environment (Figure 2) and is one of the world's most comprehensive and successful ocean observing systems. IMOS uses documented procedures agreed upon as Australian standards and recognised under the Ocean Best Practices System. All IMOS data are made openly and freely available to the marine and climate science community, key stakeholders and end-users, and international collaborators through the Australian Ocean Data Network (AODN) Portal using findable, accessible, interoperable and reusable (FAIR) data principles and accepted data standards. IMOS data are taken up and used thousands of times, creating impact and benefits at local, national and global scales.

IMOS is a joint venture of seven of Australia's top marine research institutes, with the University of Tasmania as lead agent. It is a national infrastructure capability enabled by the National Collaborative Research Infrastructure Strategy. IMOS supports a number of regional and state programs, including the Reef 2050 Integrated Monitoring and Reporting Program and the New South Wales Marine Integrated Monitoring Program.

## Reef 2050 Integrated Monitoring and Reporting Program

A comprehensive and up-to-date understanding of the Great Barrier Reef, its values, the processes that support it and the pressures that affect it is fundamental to making informed decisions regarding the protection and restoration of the Great Barrier Reef. In 2015, the Australian and Queensland Governments released their overarching strategy for management of the Great Barrier Reef – the Reef 2050 Long-Term Sustainability Plan. Under the plan, the Reef 2050 Integrated Monitoring and Report Program was established to both develop a knowledge system that enables resilience-based management of the Great Barrier Reef and provide managers with a comprehensive understanding of how the Reef 2050 Long-Term Sustainability Plan is progressing.

The intent of the Reef 2050 Integrated Monitoring and Report Program is not to duplicate existing arrangements but to coordinate and integrate existing monitoring, modelling and reporting programs across disciplines. This is achieved through:

- Establishing a collaborative approach between organisations that use or generate reef-related monitoring data, science outcomes or reporting. The program's governance is underpinned by a partnership approach, coordinated by the Great Barrier Reef Marine Park Authority (GBRMPA), which includes the Australian and Queensland Governments, the Australian Institute of Marine Science (AIMS), the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and IMOS. Traditional owners of the Great Barrier Reef are also represented in the governance arrangements to ensure effective engagement with all information providers to generate a holistic understanding of the complex social-cultural-ecological reef system.

This partnership approach enables both knowledge and funding to be leveraged to deliver increased efficiencies, cost-effectiveness and improved alignment and coverage of monitoring programs.

- Establishing a purpose-focused design, based on information and detail from a range of experts and stakeholders, to provide the basis for effective management decisions on the reef. A structured decision-making process showed that a monitoring activity design based on management purpose, rather than thematic groups would provide the best opportunity to deliver an integrated monitoring framework.
- Establishing a transparent adaptive management process that links effective monitoring to meaningful indicators and objectives. Accessible feedback loops can support targeted information sharing, empower communities and facilitate interpretation and translation into improved information gathering and ongoing implementation of leading best practice.

The Reef 2050 Integrated Monitoring and Report Program is currently in its implementation phase, with the current work program focusing on:

- Accessing information: this priority relates to integrating existing information technology systems used by multiple partners, and also developing improved systems to store and present data. The aim of this work is to make information more FAIR by decision-makers.
- Guiding management actions: translating information and knowledge to provide decision-makers with practical tools that analyse and present the information needed for resilience-based management. Examples include:
  - diagnostic tools to help understand current reef health
  - prognostic tools to help predict how the reef may respond to pressures and to test possible management decisions
  - a decision-support framework to guide application of these tools by managers.

The program's design utilised an extensive range of expertise from both Commonwealth (GBRMPA, CSIRO, Bureau of Meteorology, AIMS) and state institutions (Queensland Department of Agriculture and Fisheries and Department of Environment and Science), traditional owners and research institutions (James Cook University, Queensland University of Technology,

University of Queensland) organised into thematic expert groups to consider the monitoring required to:

1. enable reporting against the Reef 2050 Long-Term Sustainability Plan
2. inform the development of the 5-yearly Great Barrier Reef Outlook Report
3. meet the specific information requirements of Great Barrier Reef managers
4. identify synergies and cross-discipline opportunities for monitoring and modelling.

One of the roles of the thematic expert groups was to collate existing monitoring programs and the extensive range of indicators, organised against the Driver, Pressure, State, Impact, Response framework, and identify priority indicators that are presently the most likely to describe the health of the Great Barrier Reef. This detail was then put through a structured decision-making process that showed that a monitoring activity design based on management purpose, rather than thematic groups would enable evaluation of Reef 2050 Long-Term Sustainability Plan progress and the collection of information to quantify the condition and trend of:

1. the status and ecological function of ecosystems within the Great Barrier Reef World Heritage Area
2. the Great Barrier Reef's diversity of species and ecological habitats
3. Indigenous and non-Indigenous heritage values
4. reef water quality
5. community values and knowledge, in relation to protecting the Great Barrier Reef.

The process of developing the Reef 2050 Integrated Monitoring and Report Program has been guided by the Integrated Monitoring Framework for the Great Barrier Reef World Heritage Area.

## New South Wales Marine Integrated Monitoring Program

The Marine Estate Management Authority was established in 2013 and brings together the heads of the NSW Government agencies with key marine estate responsibilities. It advises the NSW Government on policies, priorities and the direction of management of the marine estate. The establishment of the authority was supported by new legislation, the *Marine Estate Management Act 2014*, and an independent panel of social, economic and environmental experts – the Marine Estate Expert Knowledge Panel. The Marine Estate Management Authority developed underpinning principles for managing the NSW marine estate and a decision-making process

where the final step is to 'be accountable – monitor, evaluate and report on the effectiveness of the management options to ensure they are working'.

In 2018, the Marine Estate Management Authority released the Marine Estate Management Strategy 2018–2028, which provides the overarching framework for coordinated management of the marine estate to deliver its vision for 'a healthy coast and sea, managed for the greatest wellbeing of the community, now and into the future'. The strategy sets out management actions and objectives across nine initiatives that are designed to address priority threats to the marine estate identified by a statewide threat and risk assessment.

Progress towards implementing the Marine Estate Management Strategy and delivering the vision is measured and reported through the Marine Integrated Monitoring Program. The program has three key purposes:

1. Monitor the condition and trend of environmental assets and community benefits.
2. Evaluate the effectiveness of management initiatives and actions that aim to reduce priority threats and risks.
3. Fill knowledge gaps that were identified as part of the statewide threat and risk assessment process.

A multi-agency steering committee has strategic oversight of the Marine Integrated Monitoring Program, and technical working groups (environmental, social, cultural and economic) are accountable for the development and delivery of the program, including technical reports detailing condition and trend monitoring and prioritisation of key knowledge gaps. Independent expert advice on monitoring is provided by the Marine Estate Expert Knowledge Panel.

Monitoring and evaluation areas relate to the specific Marine Estate Management Strategy initiatives associated with water quality; habitat management and restoration; impacts on wildlife; climate change; boating impacts; and some fishing activities. Specific condition and pressure indicators are being measured across a range of environmental assets, with the range of indicators and spatial scale of monitoring expected to expand during the implementation of the strategy.

The social, cultural and economic component is evaluated through a community wellbeing framework, which includes an integrated set of wellbeing indicators. This framework will build on relevant indicators identified for monitoring management effectiveness by identifying and filling gaps relevant to monitoring community benefits and filling knowledge gaps. The monitoring program aims to measure and detect changes in community wellbeing at a local and statewide scale within the NSW marine estate.

IMOS includes a New South Wales Node that helps support a number of Marine Estate Management Authority objectives, with a strong focus on understanding the East Australian Current, in particular:

- to observe decadal changes and climate variability of the East Australian Current using common platforms and metrics
- to investigate the East Australian Current, its separation from the coast and the resultant eddy field along the coast of South East Australia
- to quantify oceanographic processes on the continental shelf and slope off eastern Australia, south of the Great Barrier Reef
- to integrate the ecosystem response with oceanographic processes.

Indicators will be monitored over the life of the Marine Estate Management Strategy and data collection and management will comply with the NSW Information Management Framework and Open Data Policy. Data storage methods differ between and within contributing Marine Estate Management Authority agencies, and Marine Integrated Monitoring Program data are currently stored across multiple open access data portals. A Marine Estate Management Strategy/Marine Integrated Monitoring Program-specific data portal is currently being developed.

Information collected through the Marine Integrated Monitoring Program will be used in formal evaluations over the life of the Marine Estate Management Strategy, which will provide insights for continuous improvement as part of an adaptive management approach. The results of these evaluations will be communicated through report cards aimed at targeted stakeholders (engaged community), decision-makers, general community (engageable community), and responsible agencies.

## Key elements of a national approach to baselines and monitoring

The four initiatives described in the previous sections (i.e. GOOS, IMOS, the Reef 2050 Integrated Monitoring and Reporting Program, and the NSW Marine Integrated Monitoring Program) have different contexts, but all share the need to integrate and coordinate a broad range of existing and developing baselines and monitoring programs to meet the needs of users, within the limits of resources available to data users and data generators. The common key elements collectively provide valuable insights about how to establish and support a national marine baselines and monitoring program for Australia. These are:

- a mandate for observing/monitoring
- oversight committee(s) to direct or coordinate the observations/monitoring program

- expert committee(s) to provide advice (e.g. observations, monitoring, standards and data management)
- principles to guide decision-making for establishing and supporting observations/monitoring
- priorities for focusing coordination and investment of observations/monitoring
- a strategy for developing observations/monitoring programs (e.g. vision, mission and objectives)
- a framework for promoting coordination of observations/monitoring (e.g. language, logic and processes)
- distributed observing/monitoring networks
- standards for data collection and management
- reporting products for observations/monitoring
- projects to develop or expand observations/monitoring program.

## Relationship to Integrated Environmental Assessments

Baselines and monitoring programs provide data for Integrated Environmental Assessments. These are iterative and are adaptive processes (by design), which are of greatest value to society when they are revised to incorporate updated or new monitoring data. These processes rely on ongoing monitoring and assessment of indicator variables. A key for connecting baselines and monitoring with integrated environmental assessment is identifying the environmental, social and economic data needs of integrated environmental assessment so they can inform decisions to prioritise investments in monitoring. For example, such needs include identification of priority environmental, social and economic attributes for monitoring; formation of monitoring networks; and development and maintenance of data collection and management standards.

A recent analysis compiled for Australia's NMSC (Smith et al., 2021) identified eight Australian examples of integrated environmental assessment in marine and coastal areas at various stages of development. They are the Great Barrier Reef, Gladstone Harbour, NSW Marine Estate, Victorian Coastline, South East Australia Fisheries Management Strategies, Spencer Gulf and Ningaloo Coast. These regional initiatives represent established focal points for cross-sectoral collaboration and investment in the marine environment and provide opportunities to advance a national approach to baselines and monitoring.



## Part 4: Current approach to baselines and monitoring |

### Key messages

- There is a spectrum of formal and informal mandate and oversight arrangements for baselines and monitoring programs in Australia, including those for commercial fisheries management, marine park/reserve management, maritime emergencies, ocean and coastal observing, and release of offshore petroleum acreage.
- An audit of marine baselines and monitoring programs in Australia identified 371 programs. Most monitoring programs focused on biological, chemical and physical attributes, with approximately 50 per cent of programs reporting a focus or partial focus on biological attribute data. Approximately 9 per cent of programs identified their scale as national, while 84 per cent identified their scale as statewide, regional or local.
- National standards for collecting and managing biological, chemical and physical attribute data are used by some programs but most programs are not using common national standards.
- The AODN has established itself as Australia's central repository for a standards-based approach to managing Australia's marine physical, biogeochemical and biological data.
- Only 30 per cent of Australia's marine baselines and monitoring data is open access, while 50 per cent is either restricted or confidential.
- While there are few examples of established national reporting mechanisms (e.g. State of the Environment reporting, State of the Climate reporting, commercial fisheries status reporting, status of Australia's birds reporting, pollution inventory reporting), in general reporting channels for monitoring and baselines data are highly diverse.
- A rapid assessment of national-scale monitoring readiness across 53 attributes (i.e. physical, biochemical, biological, ecosystem and pressures variables) identified 27 'bright spots' and nine 'warm spots' that could form the basis of a national approach to baselines and monitoring.

Marine monitoring has a long history in Australia that extends back to the First Peoples, where the insights of monitoring are embedded in the traditional knowledge and cultural practices of Australia's Aboriginal and Torres Strait Islanders. Since colonisation, marine monitoring has been an important part of marine science in Australia, in particular to understand the marine environment and its resources and to understand changes to these. Indeed, some of the National Reference Station sites operated by IMOS have been collecting data for over 70 years. More recently, there has been a push to ensure that monitoring programs are providing scientific evidence to inform decision-making on sustainable use of resources, biodiversity conservation, ecosystem health, human health and maritime safety.

An important step towards establishing and supporting a national program for marine baselines and monitoring supported by the Australian, state and Northern Territory Governments is generating a shared understanding of the current situation and arrangements. These insights, combined with understanding of the needs and benefits of a national approach, provide clarity about the magnitude of the gap between where we are, where we would like to be and the opportunities to build on existing approaches to bridge the gap. This section provides a general description of the current approach to marine monitoring and baselines, including insights from a national audit of marine baselines and monitoring programs (Appendix B), and a rapid assessment of readiness for monitoring marine variables at a national scale (Appendix C).

## Overview of current approach to baselines and monitoring

Marine baselines and monitoring programs or initiatives exist across governments, universities, industry and the community throughout Australia. There are a number of motivations for these programs and initiatives, including:

- informing investment decisions and environmental assessments
- meeting conditions of environmental approvals
- compliance monitoring
- understanding effectiveness of management
- reporting on status and trends of the environment.

There is considerable variation in the mandates, oversight arrangements, scale, scope, standards and methods, and reporting and funding arrangements of these programs and initiatives. The working group conducted a national audit of past and existing baselines and monitoring programs (Appendix C) to provide a snapshot of arrangements.

### Mandates and oversight arrangements

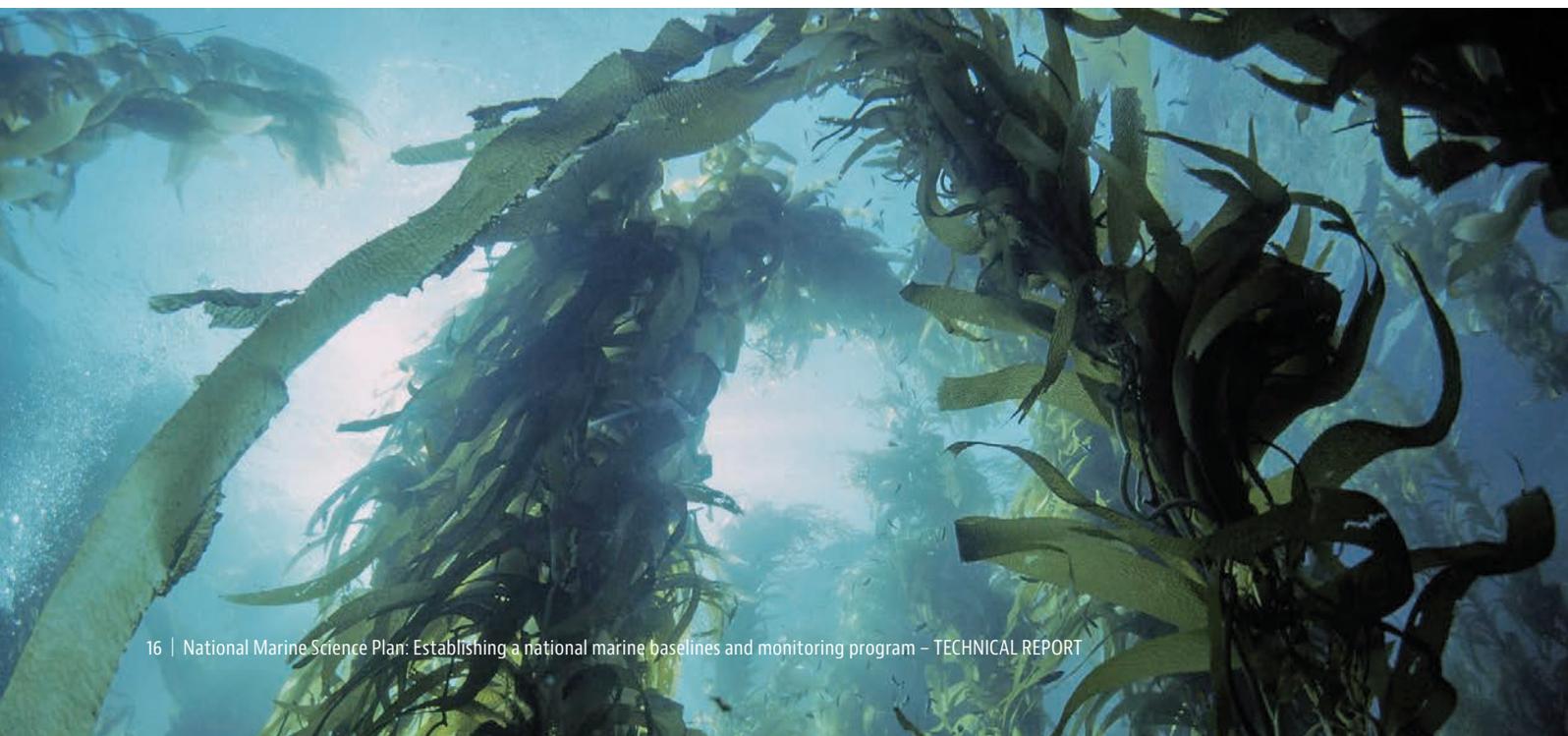
There is a spectrum of formal and informal mandate and oversight arrangements for marine baselines and monitoring in Australia. Arrangements are typically specific to jurisdictional, sectoral and/or community interest. Some mandates and oversight arrangements are embedded in legislation or policy (e.g. programs associated with commercial fisheries, marine reserves and parks, and environmental protection), some in formal partnership agreements (e.g. IMOS is part of the National Collaborative Research Infrastructure Strategy), and others in charitable organisations (e.g. Reef Life Survey).

State governments and the Northern Territory Government have mandates for numerous baselines and monitoring programs including: the health of estuaries or bays, pollution levels, commercial fisheries management, marine species and marine habitats protection, marine reserves and parks, and maritime emergencies. Approximately 84 per cent of programs captured in the audit identified their scale as either statewide, regional or local.

The Australian Government has mandates for numerous baselines and monitoring programs, including those for commercial fisheries management, Australian Marine Park management, maritime emergencies, ocean and coastal observing, and release of offshore petroleum acreage. Approximately 9 per cent of programs captured in the audit identified their scale as national.

Academic institutions are making an increasing contribution to baselines and monitoring, with the principal program being IMOS. The National Environmental Science Program (NESP) Marine Biodiversity Hub has also provided an important mechanism for universities to contribute national approaches to marine baselines and monitoring. Universities are also partnering with citizen scientists to support monitoring programs. These can vary in scale from global (e.g. Reef Life Survey) to national (e.g. RedMap) to regional (e.g. Seagrass-Watch and the Victorian Coastal Monitoring Program).

Aboriginal and Torres Strait Islanders have enduring rights, responsibilities, interests and aspirations for marine and coastal environments. To continue to deliver cultural responsibilities for sea country and lore, Aboriginal and Torres Strait Islander peoples have formed organisations to manage land and sea programs. Some have also established joint management arrangements



with government agencies. Many are traditional owner organisations, following cultural protocols and exercising cultural authority on behalf of specific traditional owner groups. These organisations can have partnerships with other organisations that also contribute to heritage management, and some have on-ground management capacity through ranger programs. There is also growing involvement of Aboriginal and Torres Strait Islander peoples in the economic opportunities associated with marine and coastal environments.

Entities like the Torres Strait Regional Authority, Northern Australia Indigenous Land and Sea Management Alliance and the Indigenous Saltwater Advisory Group operating in the Kimberley region are advancing partnerships with Australia’s government agencies and marine science organisations to implement and improve baselines and monitoring (Box 1). For example, traditional owner groups in the Kimberley with sea country within the borders of state marine reserves have also entered into joint management arrangements with the Western Australian Government, facilitating the development of shared monitoring priorities, indicators and methodologies. The Torres Strait Regional Authority recently prepared the first State of the Environment regional report card for the Torres Strait, including status and trends for 16 key values.

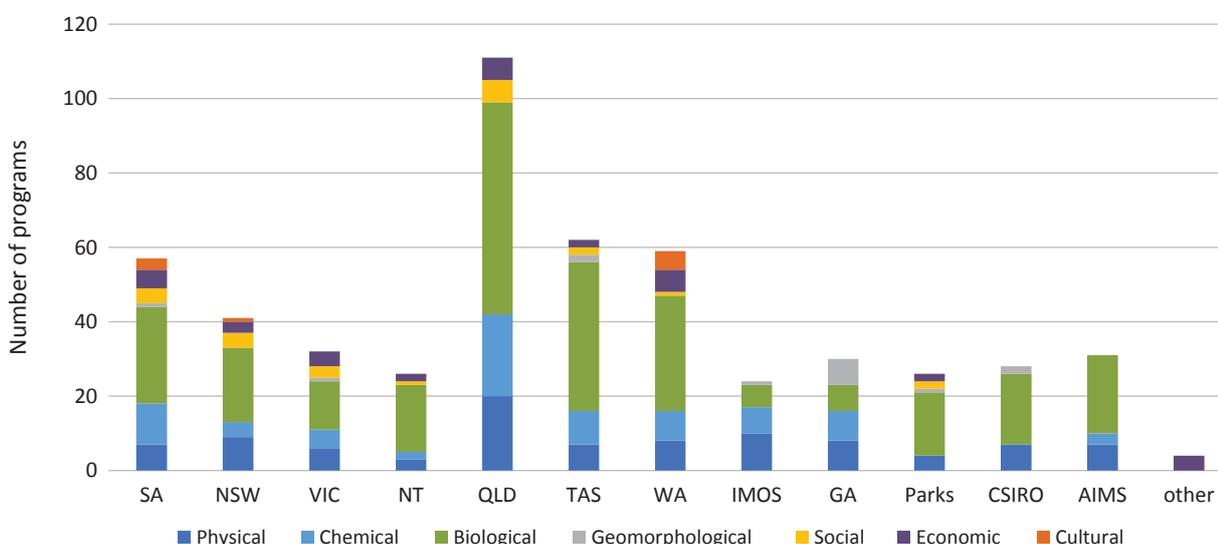
### Scope of baselines and monitoring

Marine baselines and monitoring are focused on a diverse range of attributes. The working group’s 2019–20 audit of programs identified 371 programs (noting some duplication between targeted organisations). Programs include a mix of biological, physical, chemical, social, economic and cultural attributes (Figure 3). Most monitoring programs focus on biological, chemical and

physical attributes, with approximately 50 per cent of programs reporting a focus or partial focus on biological attribute data. A recent analysis by Barrett and Monk (2021) provides a good summary of progress towards a nationally integrated benthic biodiversity monitoring program in Australia. Conversely, programs collecting social, economic and cultural attribute data were less common (5 per cent, 6 per cent and 2 per cent, respectively). These patterns appear to be consistent across state jurisdictions included in the audit.

### Use of standards for collecting and analysing data

Standard procedures for data collection and analysis are critical for baselines and monitoring as they promote spatial and temporal integration of data collected by different people in different places and at different points in time. The audit generated a broad range of responses from agencies and institutions about the use of standards for data collection. Respondents did not provide any information (i.e. field left blank) for more than half of the programs identified in the audit. For those programs that did include an entry, most referred to published methods in reports. Standards, often referred to as methods, appear to be relatively constrained to specific sectors, and a relatively small group of these appear to be used across multiple jurisdictions. These include: IMOS standards for data collection and analysis, standards used to assess and report on the status of commercial fisheries, standard operating procedures for marine sampling in Australian waters developed by the NESP Marine Biodiversity Hub and AusSeabed, standards used by the Reef Life Survey and those used by environmental protection agencies, the National Pollution Inventory, and maritime environmental emergencies.



**Figure 3:** Scope of marine baselines and monitoring programs across Australia based on the results of a national-scale audit of 371 programs conducted from 2019 to 2020. (IMOS – Integrated Marine Observing System; GA – Geoscience Australia; Parks – Parks Australia; AIMS – Australian Institute of Marine Science)

## KIMBERLEY INDIGENOUS SALTWATER ADVISORY GROUP



**HOW THE KIMBERLEY INDIGENOUS SALTWATER ADVISORY GROUP WORKS:** An Indigenous approach in which Indigenous groups (left in the figure above: including the Mardi Jawi Rangers, Nyul Nyul rangers, Kara Jarri Rangers, Wunambal Gaambera, Dambimangari Rangers, Balangarra Rangers, Nyangumarta rangers, Yawuru and Mayjala) created a regional indigenous-led saltwater science and management forum (centre in the figure above: Indigenous Saltwater Advisory Group, ISAG) to share information, advice, resources, collaborations and opportunities between the Indigenous groups and federal and state government agencies and science institutes.

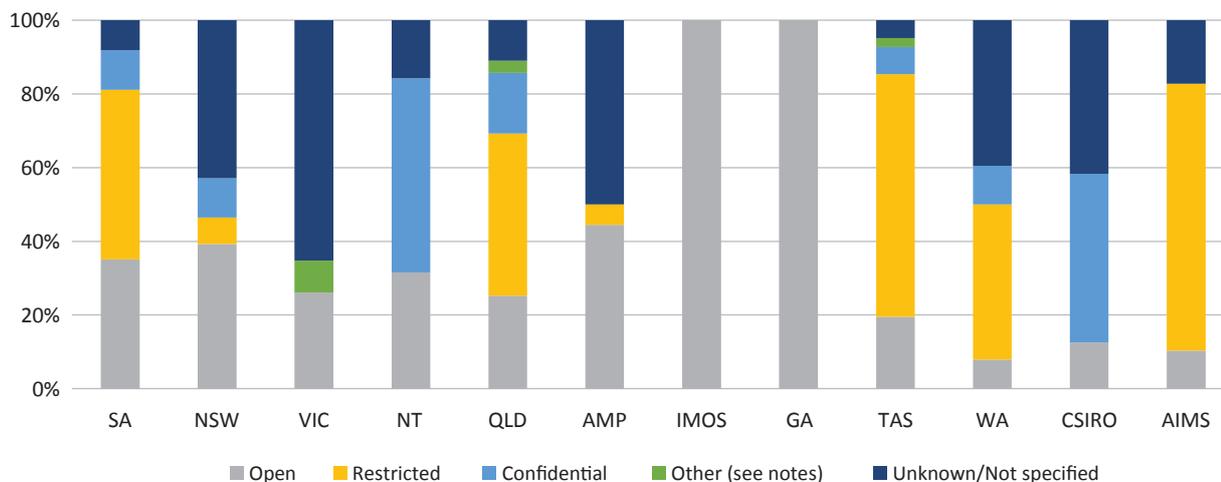
In north-west Western Australia, Indigenous groups with native title along 90 per cent of the remote Kimberley coastline have organised to create a regional Indigenous-led saltwater science and management forum. This forum creates efficiencies and regional focus for Indigenous managers and all major state and federal marine science bodies operating in the region.

Known as the Kimberley Indigenous Saltwater Advisory Group, it is steadily progressing an agenda of collaborative science for management to meet regional saltwater research and monitoring priorities with livelihood outcomes for Indigenous communities.

Unlike mainstream approaches to monitoring, this Indigenous approach avoids the pitfalls of duplication and misalignment by looking at the marine environment as a whole. Unrestricted by state and federal agency jurisdictional boundaries, it also avoids monitoring for monitoring's sake.

In only its third year of operations, the Kimberley Indigenous Saltwater Advisory Group has convened a series of major marine science and management forums; coordinates collaborative regional-scale marine fauna baselines projects; performs an advisory function for Parks Australia for the management of their north-west Australian Marine Parks; and has provided a catalyst for state and federal marine science agencies and institutions to move forward together.

Despite these efficiencies, successes and the long-term regional monitoring potential of the Kimberley Indigenous Saltwater Advisory Group approach, the key challenge is to maintain the forum. Financial support from the agencies who benefit from this important service is sought, including, AIMS, CSIRO, Parks Australia, and the Western Australian Department of Biodiversity, Conservation and Attractions and Department of Primary Industries and Regional Development.



**Figure 4:** License types for marine baselines and monitoring data in Australia based on the results of a national-scale audit conducted from 2019 to 2020. (IMOS – Integrated Marine Observing System; GA – Geoscience Australia; AMP – Australian Marine Parks; AIMS – Australian Institute of Marine Science)

## Use of standards for managing data

Standards for managing data are critical for baselines and monitoring as they promote FAIR principles. There is a broad range of arrangements for baselines and monitoring data and, of these, several appear to be specific to the needs of jurisdictions and sectors. The AODN has established itself as Australia’s central repository for managing physical, biogeochemical and biological marine data. It provides a standards-based interoperable online network of marine and climate resources. The AODN functions as an IMOS capability and delivers all the data collected from IMOS observing infrastructure and other datasets where possible. Increasingly, universities and state government offices are contributing data resources to the AODN, and delivery of data to the AODN is being included in significant national and regional research programs.

Audit results show there is considerable variation in licensing conditions for baselines and monitoring data in Australia, with much of it being restricted or confidential (Figure 4). Furthermore, only 28 per cent of programs reported that metadata records were published online and 20 per cent reported that data were accessible online. The CARE Principles for Indigenous Data Governance have also emerged to assert greater control over the application of and use of Indigenous data and Indigenous knowledge for collective benefit. The CARE principles are people- and purpose-orientated, reflecting the importance of data in advancing Indigenous interests and self-determination.

## Reporting arrangements

Reporting arrangements for baselines and monitoring in Australia are highly variable. At the national scale, there are a number of established reporting mechanisms including: State of the Environment reporting, State of the Climate reporting, commercial fisheries status reporting, status of Australia’s birds reporting and pollution inventory reporting. There are also emerging reports that will add to these, for example, the monitoring, evaluation, reporting and improvement framework for Australian Marine Parks; the State and Trends of Australia’s Ocean Report, produced by IMOS as a direct contribution to state and Commonwealth State of the Environment reporting; and the Reef Life Explorer for Reef Life Survey. Some of the national-scale reports are complemented by similar reporting activities at regional levels (e.g. Great Barrier Reef Outlook Report) or at the levels of state and territory governments (e.g. State of the Environment reporting, commercial fisheries status reporting and pollution inventory reporting). The Status of Australian Fish Stocks Report and National Pollution Inventory reporting provide standout examples of reporting underpinned by national standards for assessment and reporting. The results of the audit indicate that most reporting for baselines and monitoring is done via technical reports and academic literature.

As a requirement of the *Environment Protection and Biodiversity Conservation Act 1999*, the State of the Environment Report, which provides a national overview of the state of Australia’s environment, is tabled in parliament every 5 years. The marine and coasts chapters of the State of the Environment report provide a national synthesis that draws together information from many

baselines and monitoring programs. However, there is not currently a formalised process for doing this, and because the report is typically drawn together over a short period at the end of each 5-year cycle, some relevant baselines and monitoring activities may be missed.

## Rapid readiness assessment for national-scale monitoring of variables

The working group completed a qualitative rapid readiness assessment for monitoring high-level attributes at a national scale in Australia's marine and coastal environments. The rapid assessment provides insights to how existing programs and initiatives can contribute to establishing a national approach to monitoring. It also gives insight into the gaps and weakness that may need to be addressed.

The assessment focused on 53 physical, biogeochemical, biology, ecosystem and pressure variables:

- 13 physical variables, 11 of which correspond to GOOS essential ocean variables, with the variables of bathymetry and sediments also added
- 8 biochemical variables, all of which are GOOS essential ocean variables
- 13 biology and ecosystem variables which all align with the GOOS essential ocean variables; some of the variables were split
- 19 pressure variables, all of which align with the pressures used to inform the national risk assessment for the Australian Marine Park network, which was designed to align with national State of the Environment reporting and regional-scale environmental assessments conducted for the Great Barrier Reef World Heritage Area and NSW marine estate.

The assessment did not include social and economic attributes or Indigenous cultural and heritage attributes, as the working group determined that readiness levels at the national scale were generally low at this stage. It should be noted, however, that good progress is being made at regional scales with initiatives (e.g. the Socio-Economic Long-Term Monitoring Program in the Great Barrier Reef, the Torres Strait State of the Environment Report, and the NSW Marine Integrated Monitoring Program).

The rapid assessment asked six questions for each of the 53 variables, with answers being provided by working group members and/or targeted experts. The six questions focused on understanding

readiness for monitoring and reporting for specific variables at a national scale (as opposed to a regional or local scale). The questions were:

- Is there a defined national process for deciding on the need for this variable?
- Are there defined national agreements on how this variable should be monitored?
- Is there a managed national monitoring network for this variable?
- Are there agreed national standards for sample design and data collection for this variable?
- Are there agreed national standards for data management for this variable?
- Is there an agreed national data product and reporting mechanism for this variable?

There were three possible answers for each question: yes, partial or no. Each answer option was accompanied by a short descriptor. Below, we categorise the results of the assessment at the variable level to identify bright, warm and cold spots. Bright spots are programs or initiatives considered to have high readiness levels for national-scale monitoring, warm spots have moderate readiness levels, and cold spots have low readiness levels. The following method was used to categorise bright, warm and cold spots:

- bright spots – yes to at least five questions
- warm spots – yes for at least two questions and partial for two questions
- cold spots – does not satisfy warm spot criteria
- to be advised – not yet assessed.

Appendix C provides more information about the assessment methods and the results. There are a number of caveats to be considered when interpreting the results of the rapid assessment (Appendix C) – above all this is a high-level assessment based on advice from available experts.

## Physical variables

The assessment identified 12 bright spots (Table 1) for national-scale monitoring and reporting. This group of variables largely aligns with the field of oceanography and ocean observations and has demonstrated a history of collaboration across institutions to harmonise regional data collection to inform national perspectives. These variables have established systems defining national needs; national agreement on how to monitor; established national monitoring networks; standards for data collection and management; and a national reporting mechanism.

Important existing programs and initiatives supporting these bright spots are:

- IMOS National Mooring Network, Argo Floats, Ships of Opportunity, Satellite Remote Sensing, Deep Water Moorings, Ocean Gliders, AODN
- Australian Baseline Sea-Level Monitoring Project – sea surface height (Bureau of Meteorology, in partnership with states)
- Wave rider buoy programs – sea state (CSIRO, Bureau of Meteorology, IMOS, state governments)
- AusSeabed – bathymetry (Geoscience Australia – Box 2)
- National Marine Sediments Database – sediments (Geoscience Australia)
- HydroScheme Industry Partnership Program – bathymetry (Australian Hydrographic Office).

**Table 1:** Summary of rapid readiness assessment for national-scale monitoring of physical variables in Australia's marine environment.

<b>Bright spots</b>	Sea state Ocean surface stress Sea surface height Sea surface temperature Subsurface temperature Surface currents Subsurface currents Sea surface salinity Subsurface salinity Ocean surface heat-flux Bathymetry Sediments
<b>Warm spots</b>	None identified
<b>Cold spots</b>	None identified
<b>To be advised</b>	Sea ice

## BOX 2

### AUSSEABED

Established in 2018, AusSeabed is a national program led by Geoscience Australia that brings the seabed mapping community together to build and promote the value of seabed data to Australia's blue economy. The program is leveraging the shared agreement across government, industry and the research sector of the value of seabed data (e.g. bathymetry, backscatter, shallow sub-surface and seabed sediments data) as a national information resource that describes a fundamental property of Australia's marine environments. With this agreement on the national need for seabed data, AusSeabed is focused on: national coordination of seabed mapping activities; promoting the adoption of standards for data collection, processing and management; and delivering technical solutions to improve the discoverability and access to seabed data.

The AusSeabed program is governed by an executive board comprising senior officers from the Australian Hydrographic Office, AIMS, Australian Antarctic Division, CSIRO/Marine National Facility and Geoscience Australia, and a steering committee that directs the annual work plan for AusSeabed, with representation from Commonwealth and state governments, industry and universities. The steering committee has worked to develop a 10-year work program as part of the AusSeabed Strategic Plan 2030. This plan sets out the vision that by 2030 all available seabed mapping data within the Australian marine estate will be readily and openly available, and new data acquisition will take into account the needs of a wide range of users. This will facilitate collaborations between government, research institutions and the private sector, while contributing to the blue economy and opening up new avenues for scientific investigation.

The AusSeabed program is also engaged with the global GEBCO-Nippon Foundation Seabed 2030 Project, providing the opportunity to build international links and share knowledge and capability.

## Biogeochemical variables

The assessment identified four bright spots (Table 2) for national-scale monitoring and reporting: oxygen, nutrients, inorganic carbon and particulate matter. For all four variables, there are established systems defining national needs; national agreement on how to monitor; established national monitoring networks; standards for data collection and management; and established national reporting mechanisms. Important existing programs and initiatives supporting these bright spots are:

- IMOS National Mooring Network and National Reference Stations
- Ships of Opportunity
- AODN.

**Table 2:** Summary of rapid readiness assessment for national-scale monitoring of biogeochemical variables in Australia's marine environment.

<b>Bright spots</b>	Oxygen Nutrients Inorganic carbon Particulate matter
<b>Warm spots</b>	None identified
<b>Cold spots</b>	None identified
<b>To be advised</b>	Transient tracers Nitrous oxides Dissolved organic carbon Stable carbon isotopes

## Biology and ecosystem variables

The assessment identified five bright spots (Table 3) for national-scale monitoring and reporting: plankton biomass and diversity, zooplankton biomass and diversity, fish abundance and distribution (fishery dependent and fishery independent) and microbe biomass and distribution. For all five variables, there are established systems defining national needs; national agreement on how to monitor (Box 3); established national monitoring networks; standards for data collection and management; and established national reporting mechanisms (Box 4). Important existing programs and initiatives supporting these bright spots are:

- commercial fisheries monitoring, assessments and reporting (Australian Fisheries Management Authority (AFMA), state and territory governments)

- status of Australian Fish Stocks reporting (Fisheries Research and Development Corporation (FRDC), in partnership with the Australian Government and state governments)
- Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) Fisheries Status Report (ABARES, AFMA)
- IMOS Ships of Opportunity, National Mooring Network and National Reference Stations, Satellite Remote Sensing, Microbiome Initiative, Acoustic Telemetry, AODN
- estuarine baseline (CSIRO).

The assessment identified seven warm spots (Table 3) for national-scale monitoring and reporting of biological and ecosystem variables: marine bird abundance and distribution; marine reptile abundance and distribution; marine mammal abundance and distribution; hard coral cover and composition; seagrass cover and composition; macroalgal canopy cover and composition; and mangrove cover and composition. For all seven variables there are established systems defining national needs and national reporting mechanisms. These variables have partially established systems for national agreement on how to monitor; established national monitoring networks; and standards for data collection and management. The important existing programs and initiatives supporting these warm spots are:

- Reef Life Survey
- AODN
- Australian Temperate Reef Collaboration
- Redmap
- Mangrove Watch
- Coral Reef Watch
- Coral Watch
- Reef Check (mostly Qld)
- Seagrass-Watch (mostly Qld).

The assessment of some variables relates to specific habitats or depth ranges rather than the same level of maturity existing across all marine and coastal ecosystems. This particularly relates to the fishery-independent assessment of fish abundance and distribution.

**Table 3:** Summary of rapid readiness assessment for national-scale monitoring of biology and ecosystem variables in Australia's marine environment.

<b>Bright spots</b>	Plankton biomass and diversity Zooplankton biomass and diversity Fish abundance and distribution (fishery dependent) Fish abundance and distribution (fishery independent) Microbe biomass and distribution
<b>Warm spots</b>	Marine bird abundance and distribution Marine reptile abundance and distribution Marine mammal abundance and distribution Hard coral cover and composition Seagrass cover and composition Macroalgal canopy cover and composition Mangrove cover and composition
<b>Cold spots</b>	Invertebrate abundance and distribution

### BOX 3

## NATIONAL STANDARDS FOR MONITORING AUSTRALIA'S MARINE WATERS

The Marine Biodiversity Hub (funded by the National Environmental Science Program) developed a suite of field manuals to ensure that data collected by marine sampling platforms at different times and places across Australia are directly comparable.

The Marine Sampling Field Manuals for Monitoring Australia's Marine Waters support the national-scale monitoring and observing of Australia's marine environment, while also connecting to global initiatives through the Ocean Best Practices System. With more than 136 contributors from 53 agencies, the manuals include information on marine survey design, pre-survey planning, gear deployment and retrieval, and data management. They provide consistent, defensible methods for collecting data that can be compared with other regional and national collections and are endorsed by researchers, managers and technicians from multiple agencies with a variety of experience and subject-matter expertise.



### BOX 4

## STATUS OF AUSTRALIAN FISH STOCK REPORTS

The Status of Australian Fish Stock Reports are a series of assessments of the biological sustainability of a broad range of wild-caught fish stocks against a nationally agreed framework. The reports examine whether the abundance of fish and the level of harvest from the stock are sustainable.

The 2018 reports examined 120 species; this is 90 per cent of the total of Australia species commercially fished. More details about Australian fisheries are available [here](#).

When the first Status of Australian Fish Stock Reports were developed in 2012, they were the first to span across all jurisdictions to provide comparable results across Australia. Previously, each state, territory and the Commonwealth would carry out their own assessment. A lack of consistency across these would make it difficult to compare and stocks spanning across multiple jurisdictions proved difficult to adequately manage.



## Pressure variables

The assessment identified six bright spots (Table 4) for national-scale monitoring and reporting of pressure variables: oil/chemical spills, species extraction, outbreaks of disease, ocean acidification, sea level rise and altered ocean currents. For all six variables, there are established systems defining national needs; national agreement on how to monitor; established national monitoring networks; standards for data collection and management; and established national reporting mechanisms.

Important existing programs and initiatives supporting these bright spots are:

- Australian, state and Northern Territory programs supporting environmental maritime emergencies (Australian Maritime Safety Authority; National Offshore Petroleum Safety and Environmental Management Authority; and state and Northern Territory Government)
- commercial fisheries monitoring, assessment and reporting (AFMA, state and territory governments)
- status of Australian Fish Stocks reporting (FRDC, in partnership with the Australian Government and state governments)
- ABARES Fisheries Status Report (ABARES, AFMA)
- IMOS Ships of Opportunity, National Mooring Network, Satellite Remote Sensing, AODN, Argo Floats, Deep Water Moorings, Ocean Gliders, Ocean Radar, Ocean Current
- Australian Baseline Sea-Level Monitoring Project (Bureau of Meteorology, in partnership with states).

The assessment identified two warm spots (Table 4) for national-scale monitoring and reporting of pressure variables: incidental catch of species of conservation concern, and storm activity and extreme events. For both these variables, there are established systems defining national needs and national standards for data collection but partial arrangements for the other considerations of the rapid assessment.

**Table 4:** Summary of rapid readiness assessment for national-scale monitoring of pressure variables in Australia's marine environment.

<b>Bright spots</b>	Oil/chemical spills Species extraction Outbreaks of disease Ocean acidification Sea level rise Altered ocean currents
<b>Warm spots</b>	Storm activity and extreme events Incidental catch of species of conservation concern
<b>Cold spots</b>	Outbreaks of pests Marine debris Seafloor habitat damage Wildlife disturbance Vessel strike Noise pollution Light pollution Physical habitat disturbance
<b>To be advised</b>	Contaminants Sediment run-off Nutrients and organic matter

Image: Bob Beattie, CSIRO



# Part 5: Advice and recommendations for a national approach |

## Key messages

- Advice to the NMSC on a national approach to marine baselines and monitoring includes general conclusions. The key points are: (i) there is considerable support for a national approach to marine baselines and monitoring in Australia, and we are well positioned to build on our experience, insights and existing programs; (ii) effective mandate and oversight arrangements will be critical to advancing a national approach to marine baselines and monitoring; (iii) we need to identify a limited set of national monitoring priorities designed to meet the needs of data users; (iv) commitment to develop the 'national marine data landscape' is central to success; and (v) links between societal needs, prioritised variables, national monitoring networks and specific reporting mechanisms and outputs need to be clearly articulated.
- The working group identified two options to establish a national approach to marine baselines and monitoring: the 'step-change' (new money) collaborative program and the 'incremental' (existing money) collaborative approach. These options are not mutually exclusive.
- The working group provides six recommendations for consideration by the NMSC.

## General conclusions of the working group

The National Marine Baselines and Monitoring Working Group came to the following general conclusions:

1. There is support among participating agencies, institutions and jurisdictions for advancing a national approach to marine baselines and monitoring that meets society's needs. This is a challenging long-term mission that requires a mandate and an enduring national oversight mechanism with balanced participation from data collectors and data users.
2. We understand the key elements for establishing and developing a national approach to baselines and monitoring based on insights and learnings from a number of global, national and regional approaches (see Part 3).
3. An explicit mandate and effective oversight and coordination arrangements are critical to establishing an enduring national approach. Oversight and coordination arrangements need to strike a balance between top-down and bottom-up interests. Oversight arrangements need to include a high-level group that: sets overall program direction; identifies shared priorities across jurisdictions, sectors, institutions and programs; promotes coordination and complementary capability among jurisdictions and institutions, recognising that skills infrastructure and capability can be shared through collaborative arrangements; ensures there are effective mechanisms for maintaining and periodically reviewing standards and best practices for data collection and management; and reviews program progress. It must have the right mix of interests (i.e. data collectors and data users) from the Australian Government, state and territory governments, universities, Indigenous communities and industry. A limited number of lower-level coordination groups need to be established to focus on advancing national needs (see Part 2, section 'Need for a national approach'). This approach could be characterised as a polycentric governance arrangement.
4. Development of a national approach needs to complement what is already in place - not seek to dissolve and replace it. There is a rich tapestry of existing baselines and monitoring programs and networks in Australia, and some of these have mature governance arrangements, are embedded in sectoral administrative arrangements, and maintain effective data collection networks. Part 4 of this report identifies these existing initiatives and bright spots that could be used to establish the base of a national program (see Parts 3 and 4). There are a number of regional integrated environmental assessment initiatives that provide opportunities to advance a national approach to marine and coastal baselines and monitoring (see Part 3, section 'Relationship to integrated environmental assessment').

5. An integrated national approach to marine baselines and monitoring that includes environmental, social, cultural and economic variables is likely to generate a long list of needs. The success of a national program will be dependent on identifying a limited set of baselines and monitoring priorities designed to meet national needs (see Part 2, section 'Need for a national approach'). This will be critical for focusing coordination and investment efforts, with success these can be built on with time.
6. Commitment to develop the 'national marine data landscape' is central to the success of a national approach to baselines and monitoring, as is the use, maintenance and periodic review of common standards and best practice for collecting and managing data (e.g. current procedures in the AODN). Establishing a national-level expert group that can provide advice on integrating a national approach to baselines and monitoring into the national marine data landscape is required (e.g. with refinement to its terms of reference, the AODN Technical Advisory Group could perform this role).
7. A national approach needs to clearly articulate links between national needs, prioritised variables, national monitoring networks and specific reporting mechanisms and outputs. These connections need to be promoted to demonstrate the need for and benefits of a national approach.
8. The concept of a baseline is being interpreted in a variety of ways in marine policy, management and science communities. Baselines and monitoring need to be separated and clearly defined as part of establishing a national approach.

## Options and opportunities for establishing and developing the national approach

The working group identified two options to establish a national approach to marine baselines and monitoring: the 'step-change' (new money) collaborative program and the 'incremental' (existing money) collaborative approach. Both approaches must be informed by clear priorities that align with national needs as these will be used to identify the regional programs (see Parts 3 and 4) and bright spots (see Part 4) that will form the foundation for building a national approach.



## Step-change collaborative program

### > Characteristics

The approach would be characterised by a strategic 'step-change' in national marine baselines and monitoring in Australia. A new national monitoring mandate and oversight/expert arrangements would be created to establish, direct and oversee a national program.

A key early task would be to develop and subsequently implement a 10-year strategic plan for a national program for marine baselines and monitoring. The plan would include the following elements:

1. Definition of a clear and nationally agreed vision and mission.
2. Identification of a limited number of themes to be addressed by a national approach to baselines and monitoring to promote building capacity and coordination across monitoring networks to meet the national needs.
3. Definition of priority regions and variables to be targeted in a national program, recognising that national- and regional-scale reporting is the primary focus.
4. Establishment of national monitoring networks focused on developing and maintaining capability and capacity for monitoring priority variables, including the development, use and maintenance of data collection standards within the network, recognising the importance of striking an appropriate balance between enhancing existing monitoring networks and developing new monitoring networks to address agreed priorities and variables (see Part 4).
5. Development of the 'national marine data landscape' to accommodate the needs of national baselines and to ensure all monitoring networks are using best practice and all datasets are compliant with FAIR and CARE principles.
6. Establishment of a national digital monitoring index that maps the links between program themes, regions, variables and specific reporting outputs.
7. Advancement of harmonised reporting, where appropriate, across jurisdictions and sectors to meet the evolving needs of data users (e.g. State of the Environment reporting, Status of Australian Fish Stocks reporting).
8. Establishment of measures of success to provide term-bound broad targets for implementing the plan, for example, in the short term (by end of 2023), medium term (by end of 2025) and longer term (by 2030). This could link with the observing and monitoring objectives of the United Nations Decade of the Ocean. Measures of success could be focused on baselines and monitoring themes, regions and variables.

### > Requirements

This approach would require a significant investment of 'new money' from governments. The approach would require strong support and commitment from senior levels in the Australian Government and state governments, and support from marine industry champions, universities, environmental non-governmental organisations and Indigenous organisations.

### > Opportunities

At this point, there are no obvious government grants or program opportunities that align with the characteristics and requirements of this mission. The Australian Government's engagement in the High Level Panel for a Sustainable Ocean Economy may produce opportunities through the development of a 'sustainable ocean plan' and this could align well with other big picture initiatives such as the United Nations Decade of Ocean Science for Sustainable Development and implementation of Environmental Economic Accounting: A Common National Approach – Strategy and Action Plan. In the near future, the Australian Government will also issue its response to the recent 10-year review of the *Environmental Protection and Biodiversity Conservation Act 1999*. The review provides advice on a quantum shift in the quality of data and information to support the reforms recommended by the review, including the need for new, legally enforceable National Environmental Standards.

## Incremental collaborative approach

### > Characteristics

This approach would be characterised by a strategic incremental change in national marine baselines and monitoring in Australia, advanced as opportunities arise. A new national mandate and oversight arrangements would be established to direct and oversee the development of the national approach. Oversight arrangements would need to include participation from Australian Government and state government agencies and include national science providers.

A key early task would be to build on this report by securing project funding to develop and promote a national approach. The project could include the following:

- Establishment of a set of high-level principles to guide collective decision-making for establishing and supporting a national approach to marine baselines and monitoring. The principles should be designed to emphasise the need to connect science endeavour with national needs and promote a nationally coordinated approach. For example, they might include the importance of identifying priority themes, regions and variables, the formation of networks and coordination, the requirement for standards-based approach, and the requirement for periodic review of purpose and progress.

- Establishment of a national framework for a national approach. The framework would be used to facilitate a common language and logic to connect institutions and jurisdictions that participate in the national approach (i.e. it is not a straight-jacket).
- Adoption of a 'no regrets' limited set of founding national baselines and monitoring themes, regions, variables, distributed networks and deliverables to promote engagement, impact and investment in developing a national approach to marine baselines and monitoring.
- Identification of funding opportunities in the short term to medium term to ensure these programs address their requirements.
- Organisation of a national workshop(s) to promote discussion and collaboration about advancing a national approach.
- Establishment of a brand to promote a national approach to marine baselines and monitoring.

### > Requirements

To secure project funding, the approach would require strong support and commitment from the NMSC and state government agencies that are demonstrating a progressive approach to marine monitoring and baselines. It would also require support from progressive marine industry champions, universities, environmental non-governmental organisations and Indigenous organisations.

### > Opportunities

At this point, there are several opportunities to secure funding to advance the incremental collaborative approach. They are:

- pooled contributions from participating NMSC members and associates
- project funding from the NESP Marine and Coastal Hub and Climate Systems Hub
- securing project funding from Australian Research Data Commons to advance elements related to advance the national marine data landscape aspects
- enhancing the terms of reference for AODN to provide technical advice on integrating a national approach to baselines and monitoring into the national marine data landscape
- securing project funding from the IMOS New Technology Proving Facility to develop capability for monitoring priority variables
- identifying institutional champions for specific monitoring priorities
- aligning the national approach to the implementation of Environmental Economic Accounting: A Common National Approach – Strategy and Action Plan

- securing ship time on research vessels to advance marine baselines and monitoring (e.g. the Marine National Facility, Solander, Bluefin, Falkor)
- collaborating with the Australian Hydrographic Office to ensure that investments in the HydroScheme Industry Partnership Program are contributing to advance a national approach to marine baselines and monitoring
- collaborating with regional integrated environmental assessment initiatives (see Part 3, section 'Relationship to integrated environmental assessment')
- promoting the importance of and funding for implementation of monitoring, evaluation, reporting and improvement systems for marine parks and reserves (e.g. monitoring, evaluation, reporting and improvement systems for Australian Marine Parks).

Image: Jakob Weis, University of Tasmania



## Recommendations for establishing and developing the national approach

The working group provides six recommendations for consideration by the NMSC:

1. Discuss and agree on the preferred mechanism for establishing an explicit mandate to advance a national approach to marine baselines and monitoring. Ideally, the mechanism extends beyond the National Marine Science Plan to capture parties that are not part of the NMSC (e.g. relevant state and territory government agencies, Indigenous organisations and industry).
2. Discuss and agree on a preferred governance model to advance a national approach to marine baselines and monitoring. Ideally, the model needs to include relevant parties that are not part of the NMSC (e.g. relevant state and territory government agencies, Indigenous organisations and industry).
3. Establish an ongoing NMSC subcommittee to support the NMSC in promoting and advancing a national approach to marine baselines and monitoring. The NMSC should establish terms of reference, appoint a chair and secretariat, and call for subcommittee members.
4. Propose a set of principles and common framework for a national approach to marine baselines and monitoring to guide decision-making and promote coordination.
5. Consider the two options (step-change collaborative program and incremental collaborative approach) presented in this report for establishing and advancing a national approach to marine baselines and monitoring and determine the committee's level of support for these options and their role in advancing either one or both options.
6. Consider options for promoting the establishment of a national marine baselines and monitoring program. Options could include things like establishing a brand to promote a national approach, championing and sponsoring an inaugural annual or biennial national baselines and monitoring symposium, and implementing a virtual roadshow to promote a national approach to targeted stakeholders (e.g. ministers, members of parliament, department heads and key Indigenous groups or industry groups).



Image (right): John Turnbull, [www.marineexplorer.org](http://www.marineexplorer.org)



“ *There is support among participating agencies, institutions and jurisdictions for advancing a national approach to marine baselines and monitoring that meets society’s needs.* ”

# Glossary |

Term	Definition or equivalent terms
Activity	Actions by either individual users or sectors.
Approach	Method or framework for working through the problem.
Asset	The physical features of the system (not including people) that can be defined as environmental assets, cultural assets and infrastructure assets.
Baseline	A 'time zero' measure or assessment of a variable against which future measures are referenced.
Communities	People who live close enough to affected areas that they have an immediate and tangible interest in the outcomes (e.g. some First Nations groups, local property owners or recreational user groups).
Community wellbeing	The combination of economic, social and environmental benefits.
Hazard	Any activity, event or substance that can cause damage to individuals or to valued aspects of a system (including system function). A failure to act can also pose a hazard.
Impact	A marked effect or influence on an individual or valued aspects of a system. More recently the term 'effect' rather than 'impact' has become more widely used as responses are not always negative, but all sources of change should be noted for planning purposes.
Indicator	A metric that tracks the state of a system attribute of interest – it may be a direct measure or it might be a more easily sampled proxy, and it may measure system condition or pressure.
Monitoring	Collection of data on specified indicators that allows an assessment of the extent and trend of progress towards achievement of objectives.
Objective	A desired outcome – can be specific to a particular stakeholder group or set in policy.
Outcome	The consequence of a process; what changes once the process is complete.
Pressure	Stressor exerting influence on the system, potentially creating disruption/disturbance (typically and anthropogenic activity or environmental driver).
Public	Group who lacks a direct connection to the outcomes but nonetheless has an interest in contributing (e.g. specific interest groups).
Risk	The likelihood of an undesired event occurring or of suffering a loss or damage as a result of a hazard.
Stakeholders	Groups who have a professional or personal interest sufficient to justify engagement (e.g. some First Nations groups, government regulators, industry representatives, NGOs).
Value	In the context of an Integrated Ecosystem Assessment, a value is equivalent to an attribute, asset or 'feature that is special'. This terminology is related to the broader definition from psychology that values are the standard a culture uses for discerning what is desirable/good/just in society. In this broader context, values are deeply embedded and are central to conveying a culture's beliefs (tenets or convictions held by that culture to be true).

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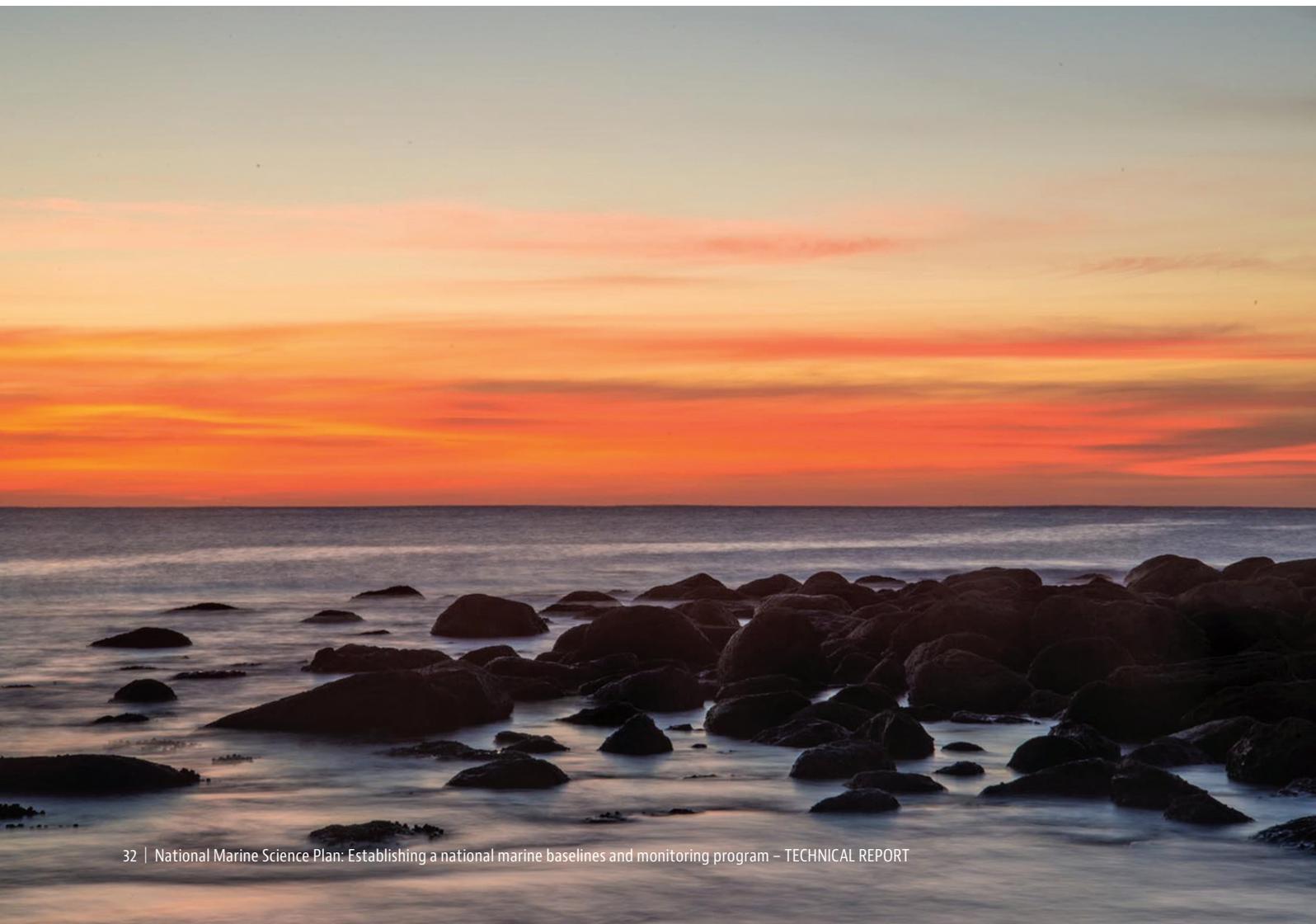




## Scope and functions of working group |

The specific scope and functions of the National Marine Baselines and Monitoring Working Group are:

- Conduct a high-level audit of the marine environmental, social and economic baselines and monitoring programs and data collections for Australia's marine environment.
- Identify what baselines and monitoring are required, particularly considering research-user requirements, for managing and conserving marine ecosystems.
- Identify the major gaps in the nation's current approach to baselines and monitoring and identify opportunities and provide recommendations to fill major gaps.
- Provide advice to the NMSC 'to establish and support a national marine baselines and long-term monitoring program'. For example, advice for establishing a national integrated framework for marine monitoring that will provide for a multi-sectoral approach that includes biophysical, social, cultural and economic data.
- Identify principles that will guide decision-making and encourage participation of the nation's jurisdictions and relevant stakeholders in a national marine baselines and long-term monitoring program.
- Foster collaboration between relevant jurisdictions, research institutions and management agencies in developing advice to establish and support a national marine baselines and long-term monitoring program.
- Identify opportunities, where appropriate, to establish standardised methods and procedures that will be fundamental to establishing a national marine baselines and long-term monitoring program. For example, the planning and coordination of monitoring activities and management, sharing, analysis, comparison, integration and reporting of monitoring data.
- Identify opportunities to establish and support the initiatives and recommendations provided to the NMSC.



## National-scale audit of coastal and marine monitoring |

The NMSC requested the National Marine Baselines and Monitoring Working Group (hereafter referred to as working group) to conduct a high-level audit of the marine environmental, social and economic baselines and monitoring programs and data collections for Australia's marine environment.

This represents the first national-scale audit of marine baselines and monitoring in Australia. The results of the audit provide context for the working group's advice to the NMSC on establishing a national approach to marine baselines and monitoring in Australia and will be a valuable asset for informing discussions and decision-making to advance a national approach supported by the Australian Government, the state governments and Northern Territory Government.

### Methods

The working group conducted the high-level audit in two phases over a period of two years using in-kind resourcing provided by participating agencies and institutions (i.e. the audit was not a formally funded project). The audit was targeted at institutions participating in the NMSC and Commonwealth, state and territory jurisdictions (i.e. CSIRO, AIMS, IMOS, Geoscience Australia, Parks Australia, Institute for Marine and Antarctic Studies, South Australian Research and Development Institute, Great Barrier Reef Marine Park Authority, Victorian Government, New South Wales Government, Queensland Government, Western Australian Government, Northern Territory Government). Institutional champions were identified and subsequently coordinated the provision of information for participating institutions.

The first phase of the audit was used to initiate collection of information, demonstrate the audit process and outputs, and get broader buy-in from participating institutions. A review of the process and information outputs and gaps was conducted at the end of the first phase of the audit. The second phase involved a refined request for information and targeted identified gaps. Types of information included in the audit were:

- state/organisation
- program title
- primary purpose of program (primary)
- scope – physical, chemical, biological, social, economic
- high level objective (primary)
- defined attributes
- lead organisations
- contact person
- geographic coverage

- location
- baseline and/or monitoring
- temporal coverage (first year-last year)
- standard procedures/protocols for data collection/analysis
- where results are reported
- reporting frequency
- links to national/regional research infrastructure
- whether funding for future monitoring has been secured
- data accessibility
- how to access data
- whether funding for future monitoring has been secured
- whether data is currently accessible online
- data licensing
- web services.

Information collected in the audit was a mix of free-text fields (e.g. program titles, primary purpose of program, high-level objective of programs, lead organisations, location and where results are reported) and fixed category selections (e.g. scope of program, defined attributes, geographic coverage and aspects of data discovery and accessibility). Audit information was captured in a Microsoft Excel spreadsheet.

### Caveats and gaps

The results of the audit must be interpreted in the context of the following caveats and gaps. The working group has invested significant time in the audit to provide a snapshot of historical and current coastal, marine and oceanic baselines and monitoring in Australia, but it does not provide a complete picture. For example, the audit did not include participation from the Australian Fisheries Management Authority, Torres Strait Regional Authority, Australian Antarctic Division, Bureau of Meteorology or marine industries groups/consultants. Participation from these agencies is likely to add entries to the audit.

The working group did not define 'marine baselines and monitoring program' with the view of generating a broad perspective of potential building blocks for a national approach. Some programs incorporated in the audit are clearly ongoing monitoring programs (e.g. AIMS Long

Term Monitoring Program, CSIRO Southern Ocean Time Series, IMOS National Mooring Network, South Australia's Commercial Fisheries Monitoring Program, Western Australia's Marine Turtle Survey, Victoria's Subtidal Reef Monitoring Program, Tasmania's Derwent Estuary Water Quality Monitoring Program and NSW's Marine Integrated Monitoring Program). Some programs have been initiated as baselines and have been repeated as opportunity has allowed (Parks Australia/NESP Marine Biodiversity Hub surveys and the CSIRO marine habitat surveys), while others were completed as one-off baseline surveys with the intention that they will be repeated in time (i.e. they have not yet been repeated), as opportunity allows (e.g. University of Tasmania Scalefish Netting Baseline).

The audit provides information from a range of perspectives (e.g. state and territory governments, Australian Marine Park Managers, IMOS and Australian Government science agencies) and includes duplication for some national programs servicing multiple jurisdictions or institutions (e.g. IMOS facilities and Reef Life Survey). Responses by participating institutions did not always provide the full suite of requested information. For example, many institutions did not provide information on reporting arrangements, links to national infrastructure and funding arrangements.

## Summary of the audit findings

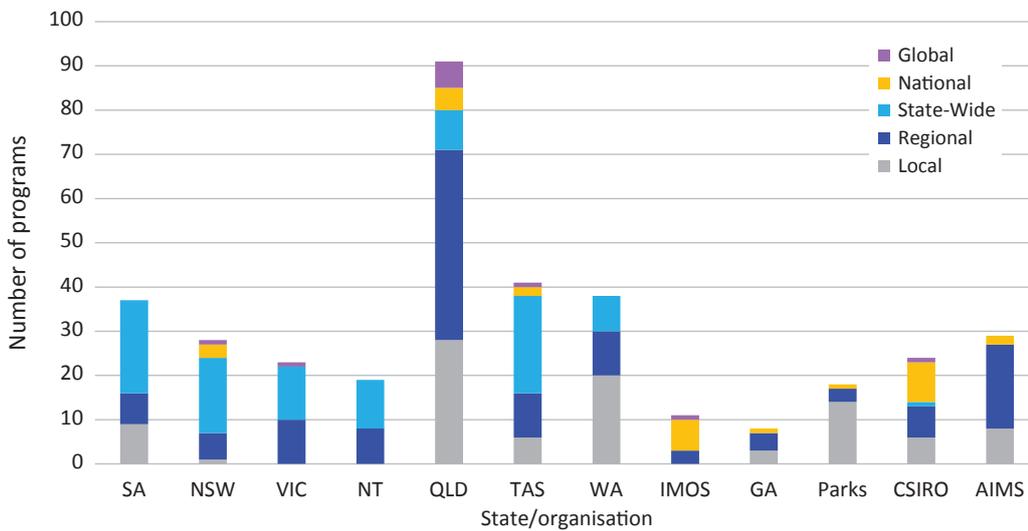
The working group's 2019–20 audit of marine baselines and monitoring programs identified 371 programs (noting some duplication between targeted institutions). Key points to note are:

- Spatial scale of programs: programs have operated/ are operating at a range of spatial scales (Figure B1). Nine per cent of identified programs are reported as operating at a national scale, with the majority operating at statewide, regional or local scales.
- Purpose of programs: the audit identified a broad range of purposes for baselines and monitoring programs. There is a strong cross-institutional national theme for understanding state and trends in oceanographic phenomena (e.g. currents, salinity, temperate, acidity) and IMOS is a conspicuous operator in many of these, particularly the deeper-water initiatives. Major themes common across state and territory jurisdictions are marine reserves, fisheries management, water quality in estuaries/bays, habitat condition (in particular seagrass, mangroves, macroalgae and coral), listed threatened migratory species (in particular seabirds, turtles, marine mammals).
- Scope of programs: programs include a mix of biological, physical, chemical, social, economic and cultural attributes (Figure B2). Most baselines and monitoring programs are reported to focus on biological, chemical and physical attributes with approximately 50 per cent of programs reporting a focus or partial focus on biological attribute data. Figure B3 uses a select essential ocean variable to demonstrate how the biological, chemical and physical attributes of reported programs relate to the interests of participating jurisdictions/ organisations. Conversely, programs collecting social, economic and cultural attribute data are much lower in number (5 per cent, 6 per cent and 2 per cent, respectively). These patterns appear to be relatively consistent across baselines and monitoring for state jurisdictions included in the audit.
- Use of standards for data collection: the audit generated a broad range of responses from targeted institutions on use of standards for data collection. Respondents did not provide any information (i.e. field left blank) for more than half of the programs identified in the audit. For those programs that did include an entry, most referred to published methods in reports. Standards, often referred to as methods, appear to be relatively constrained to specific sectors, and a relatively small group of these appear to be used across multiple jurisdictions. These include: IMOS standards for data collection and analysis; standards used to assess and report on status of commercial fisheries; standard operating procedures for marine sampling in Australian waters developed by the NESP Marine Biodiversity Hub; standards used by the Reef Life Survey; and those used by environmental protection agencies, the National Pollution Inventory and maritime environmental emergencies.
- Data management arrangements: audit results show there is considerable variation in licensing conditions for marine baselines and monitoring data in Australia, with results indicating that approximately 30 per cent of data is open access and 50 per cent is either restricted or confidential (Figure B4). Twenty-five per cent of programs reported in the audit did not provide information for this field (i.e. field was either empty or they did not know). IMOS and Geoscience Australia appear to be standout performers in the group of participating institutions. Furthermore, 28 per cent of programs identified a URL for metadata and 18 per cent of these were reported as open access data. Approximately 12 per cent of reported programs provided a URL for web services.

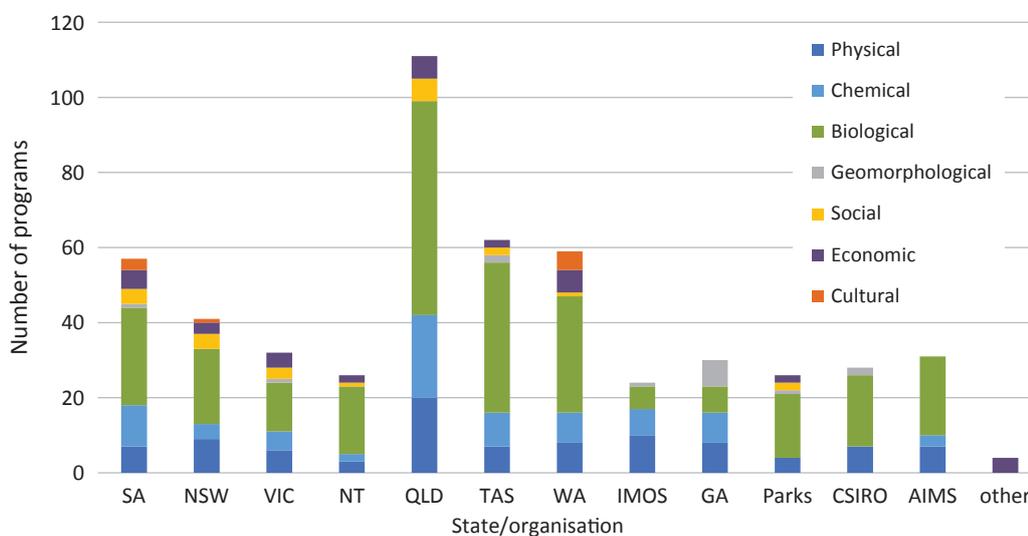
- Reporting arrangements: the results of the audit indicate that there is a great variety of arrangements (and interpretations of what reporting represents) for reporting on findings of marine baselines and monitoring programs. More than half of the programs indicated that baselines and monitoring results were reported in either technical reports or scientific papers. Results suggest that either the majority of monitoring programs (90 per cent) are not aligned with national reporting mechanisms (e.g. State of the Environment reporting, State of the Australian Fisheries reporting, State of the Climate reporting, IMOS State and Trends of Australia's Oceans) or that respondents did not know or have easy access to this information. Approximately 5 per cent of reported programs indicated that results were not reported at the time of the audit.

- Funding arrangements: respondents did not provide information for almost half of all programs identified in the audit. Approximately 27 per cent of respondents identified that future funding had been secured for the following periods:
  - 14 per cent had funding for at least 1 year
  - 9 per cent had funding for at least 3 years
  - 1 per cent had funding for 5-10 years
  - 0.3 per cent had funding beyond 10 years.

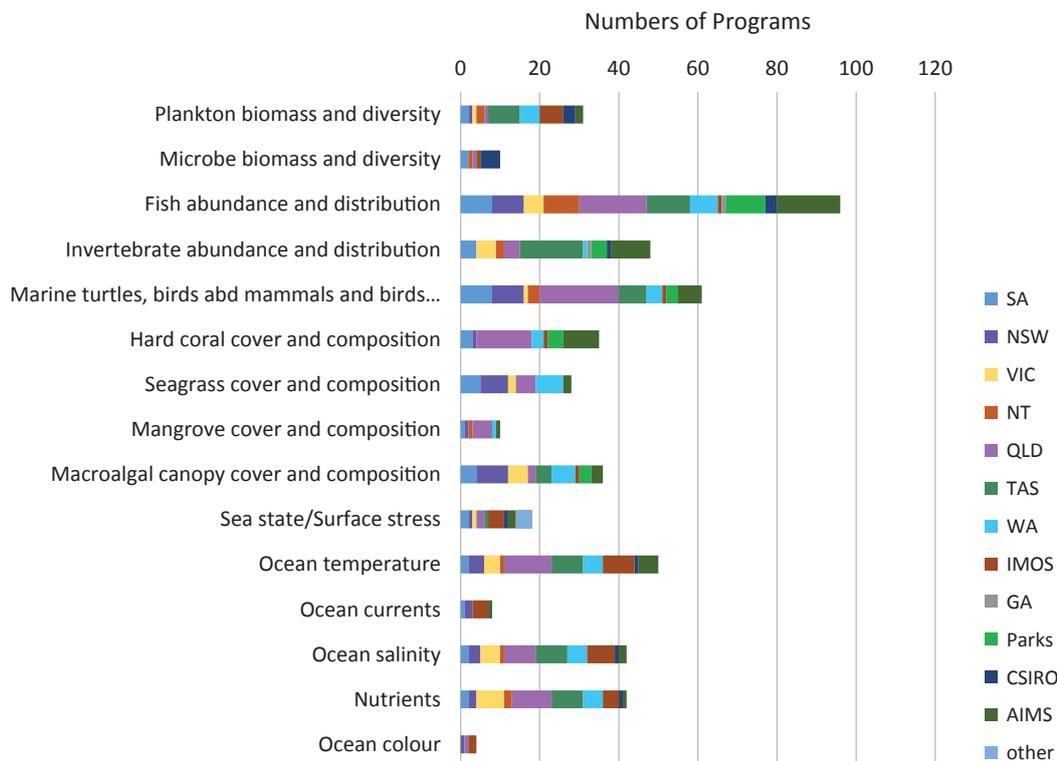
Approximately 27 per cent of programs were identified as either not having secured funding or the funding status being unknown to the reporter.



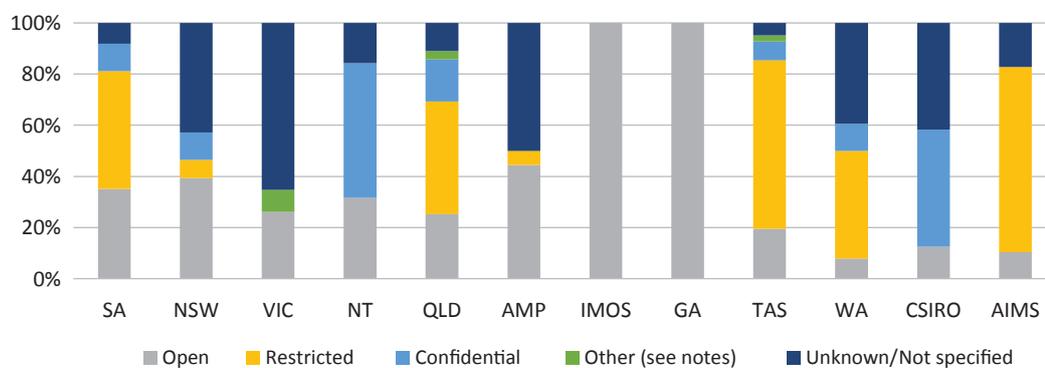
**Figure B1:** Spatial scale of Australia's marine baselines and monitoring programs for organisations and jurisdictions targeted in a national audit conducted from 2019 to 2020.



**Figure B2:** Scope of Australia's marine baselines and monitoring programs for organisations and jurisdictions targeted in a national audit conducted from 2019 to 2020.



**Figure B3:** Contribution of jurisdictions/ organisations to Australia's marine baselines and monitoring for select essential ocean variables, based on results of a national audit conducted from 2019 to 2020.



**Figure B4:** Data licensing arrangements for Australia's marine baselines and monitoring programs (n = 371) based on the results of a national audit conducted from 2019 to 2020.



## Assessment of maturity for monitoring variables |

The working group completed a rapid readiness assessment for monitoring high-level attributes at a national scale in Australia's marine and coastal environments. The assessment provides insights to how existing programs and initiatives can contribute to establishing a national approach to monitoring. It also gives insight into the gaps and weakness that may need to be addressed.

The assessment focused on 53 physical, biogeochemical, biology, ecosystem and pressure variables:

- 13 physical variables, with 11 of these corresponding to GOOS essential ocean variables, with the variables of bathymetry and sediments added
- 8 biochemical variables, all of which are GOOS essential ocean variables
- 13 biology and ecosystem variables, with these aligning with the GOOS essential ocean variables (some of the variables were split to a lower level to enhance the findings of this assessment)
- 19 pressure variables, all of which align with the pressures used to inform the national risk assessment for the Australian Marine Park network, which was designed to align with national State of the Environment reporting and regional-scale environmental assessments conducted for the Great Barrier Reef World Heritage Area and NSW marine estate.

The assessment did not include social and economic attributes or Indigenous cultural attributes, as the working group determined that readiness levels at the national-scale were generally low at this stage. It should be noted, however, that good progress is being made at regional scales with initiatives such as the Socio-Economic Long-Term Monitoring Program and the Torres Strait State of the Environment Report.

The rapid assessment asked six questions and provided a simple set of decision rules to select one of three answer options for each question (Table C1).

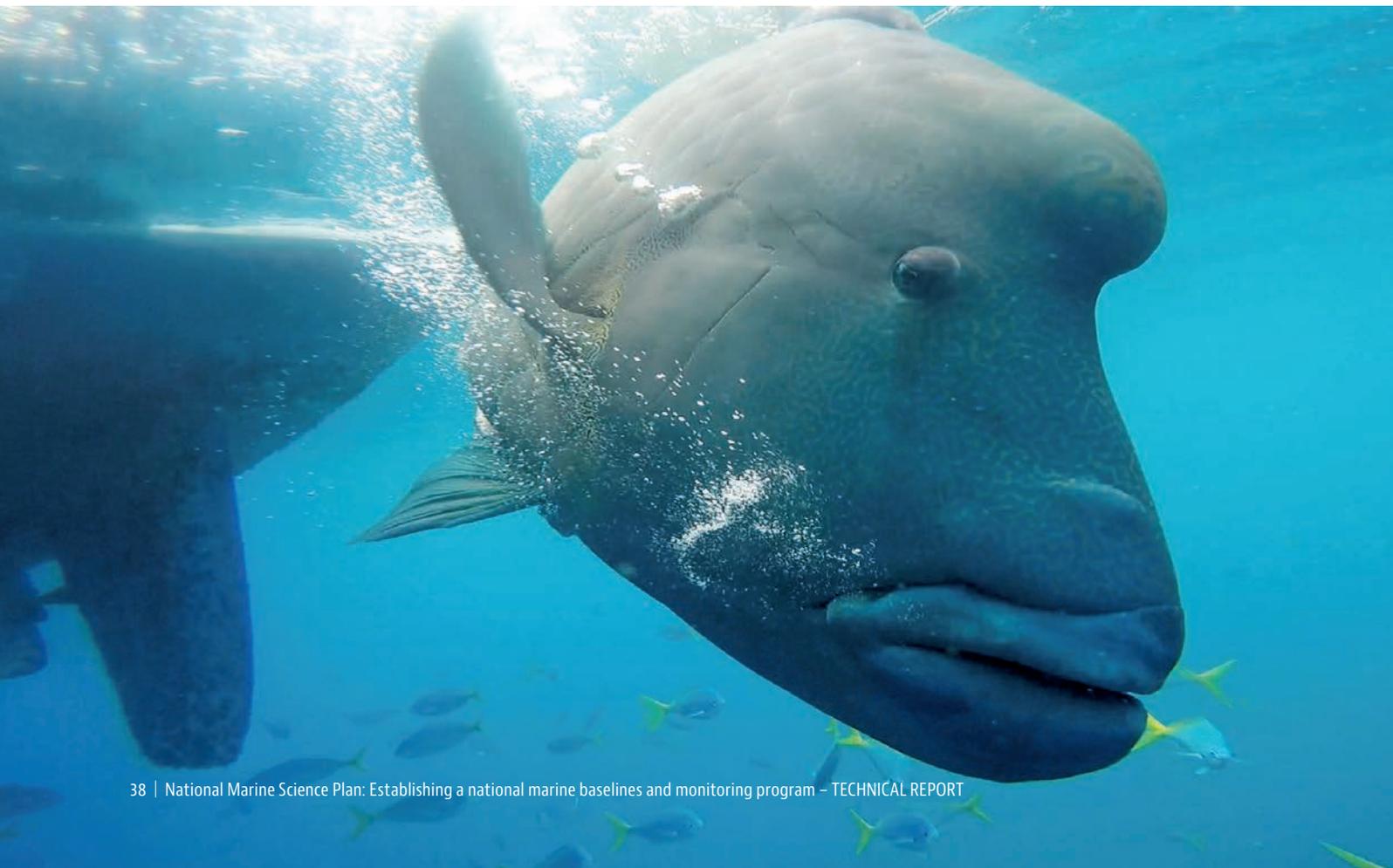
The six questions focused on understanding readiness for monitoring and reporting for specific variables at a national scale (as opposed to a regional or local scale). Answers to questions were provided by targeted experts (Table C2).

The following caveats should be noted for using the results of the rapid assessment:

- The attributes used in this assessment are high-level representations of marine baselines and monitoring 'indicators'. Splitting these attributes into lower-level representations (e.g. variables, sub-variables or metrics) would produce a more considered and informed assessment, but it would also produce a much longer list of considerations. A high level of representation was selected for reasons of practicality. Where possible, we used essential ocean variables in this assessment because they include lower-level representations (i.e. sub-variables, supporting variables and complementary variables). This level of detail will be useful for informing future discussions about establishing a national approach.
- The assessments of attributes were determined on the basis of expert advice, and in some cases the assessments were informed by consideration of working group members and advice from one to two experts. The working group targeted individuals with expertise in areas that directly align with specific attributes. Efforts were made to target individuals with current national-scale knowledge of specific attributes, for example experts engaged in current national-scale processes for assessing status and trends of indicators in the 2021 State of the Environment Report and experts identified on essential ocean variable specification sheets.

**Table C1:** Questions and decision rules for a rapid assessment of readiness levels for monitoring physical, biogeochemical, biology, ecosystem and pressure variables at a national-scale in Australia's marine environment.

Assessment descriptors	Description of what is required to achieve this rating		
	Yes	Partial	No
Is there a defined national process for deciding on the need for this variable?	A decision-making process and need clearly defined	A decision-making process is available, but the need is not defined	No decision-making process or need has been identified
Is there defined national agreement on how this variable should be monitored?	Monitoring agreement defined and agreed	Monitoring objectives agreed by some parties	No agreed monitoring objectives exist
Is there a managed national monitoring network for this variable?	Managed monitoring network in place	Monitoring network in place but limited management and national coordination	No managed monitoring network in place
Are there agreed national standards for sample design and data collection for this variable?	National standards applied for design and data collection	Sample design and data collection standards in development	No agreed sample design and data collection standards in place and not coordinated
Are there agreed national standards for data management for this variable?	National standards applied for data management	Data management standards in development	No agreed data management in place and not coordinated
Is there an agreed national data product and reporting mechanism for this variable?	National data products and reports developed and communicated	Data products and reports in development	No national data products and reports in development



**Table C2:** Results of a rapid assessment of readiness levels at end of 2020 for monitoring 53 physical, biogeochemical, biology, ecosystem and pressure variables at a national scale in Australia's marine environment.

Attributes/indicators	Is there a defined national process for deciding on the need for this variable?	Is there defined national agreement on how this variable should be monitored?	Is there a managed national monitoring network for this variable?	Are there agreed national standards for sample design and data collection for this variable?	Are there agreed national standards for data management for this variable?	Is there an agreed national data product and reporting mechanism for this variable?
<b>Physical variables</b>						
Sea state	Y	Y	Y	Y	Y	Y
Ocean surface stress	Y	Y	Y	Y	Y	Y
Sea ice	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Sea surface height	Y	Y	Y	Y	Y	Y
Sea surface temperature	Y	Y	Y	Y	Y	Y
Subsurface temperature	Y	Y	Y	Y	Y	Y
Surface currents	Y	Y	Y	Y	Y	Y
Subsurface currents	Y	Y	Y	Y	Y	Y
Sea surface salinity	Y	Y	Y	Y	Y	Y
Subsurface salinity	Y	Y	Y	Y	Y	Y
Ocean surface heat flux	Y	Y	Y	Y	Y	Y
Bathymetry	Y	Y	Y	Y	Y	Y
Sediments	Y	Y	Y	Y	Y	P
<b>Biogeochemistry</b>						
Oxygen	Y	Y	Y	Y	Y	Y
Nutrients	Y	Y	Y	Y	Y	Y
Inorganic carbon	Y	Y	Y	Y	Y	Y
Transient tracers	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Particulate matter	Y	Y	Y	Y	Y	Y
Nitrous oxide	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Stable carbon isotopes	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed	Not assessed
Dissolved organic carbon	P	N	N	N	P	N

Table C2 continued >

Table C2 continued from previous page

Attributes/indicators	Is there a defined national process for deciding on the need for this variable?	Is there defined national agreement on how this variable should be monitored?	Is there a managed national monitoring network for this variable?	Are there agreed national standards for sample design and data collection for this variable?	Are there agreed national standards for data management for this variable?	Is there an agreed national data product and reporting mechanism for this variable?
<b>Biology and ecosystems</b>						
Phytoplankton biomass and diversity	Y	Y	Y	Y	Y	Y
Zooplankton biomass and diversity	Y	Y	Y	Y	Y	Y
Fish abundance and distribution (fishery dependent)	Y	Y	Y	Y	Y	Y
Fish abundance and distribution (fishery independent)	Y	Y	Y	Y	Y	Y
Marine bird abundance and distribution	Y	P	P	P	P	Y
Marine reptile abundance and distribution	Y	P	P	P	N	Y
Marine mammal abundance and distribution	Y	P	P	P	P	Y
Hard coral cover and composition	Y	P	P	P	P	Y
Seagrass cover and composition	Y	P	P	N	P	Y
Macroalgal canopy cover and composition	Y	P	P	P	P	Y
Mangrove cover and composition	Y	P	P	P	P	Y
Microbe biomass and diversity (*emerging)	Y	Y	Y	Y	Y	Y
Invertebrate abundance and distribution (fishery independent) (*emerging)	N	N	N	N	N	N

Table C2 continued from previous page

Attributes/indicators	Is there a defined national process for deciding on the need for this variable?	Is there defined national agreement on how this variable should be monitored?	Is there a managed national monitoring network for this variable?	Are there agreed national standards for sample design and data collection for this variable?	Are there agreed national standards for data management for this variable?	Is there an agreed national data product and reporting mechanism for this variable?
<b>Pressures</b>						
Oil/chemical spills	Y	Y	Y	Y	Y	Y
Wildlife disturbance	P	N	N	N	N	N
Vessel strike	Y	N	N	N	P	P
Noise pollution	P	N	N	N	N	N
Seafloor habitat damage	P	Y	P	P	P	P
Species extraction	Y	Y	Y	Y	Y	Y
Incidental catch of species of conservation concern	Y	Y	Y	Y	P	P
Light pollution	P	N	P	P	P	N
Marine debris	Y	P	P	P	P	P
Physical habitat disturbance	P	N	N	N	N	N
Outbreak of disease	Y	Y	Y	Y	Y	Y
Outbreak of pest species	Y	P	P	P	P	P
Contaminants	P	P	N	N	N	N
Sediment run-off	P	P	P	P	N	N
Nutrients and organic matter	P	N	N	N	N	N
Storm activity/ extreme events	Y	P	P	Y	P	N
Altered ocean currents	Y	Y	Y	Y	Y	Y
Ocean acidification	Y	Y	Y	Y	Y	Y
Sea level	Y	Y	Y	Y	Y	Y



Image: John Turnbull, [www.marineexplorer.org](http://www.marineexplorer.org)



“ *A national approach to the systematic collection and reporting of priority marine baselines and monitoring data is critical for the effective management of Australia's marine resources and iconic ecosystems, and a sustainable and enduring blue economy.* ”









# NATIONAL MARINE SCIENCE — COMMITTEE —

## NATIONAL MARINE SCIENCE PLAN

Establishing and supporting a national marine baselines and monitoring program  
Working Group Report

### **TECHNICAL REPORT**

This full technical report, and a PDF of the summary,  
are available at

[www.marinescience.net.au](http://www.marinescience.net.au)

