

National Marine Science **Plan**

Science program to support **Decision-making**

# Towards a nationally integrated approach to experimentation for managing and enhancing Australia's coastal marine ecosystems

Working Group Report

S U M M A R Y

NATIONAL  
**MARINE**  
SCIENCE  
– COMMITTEE –

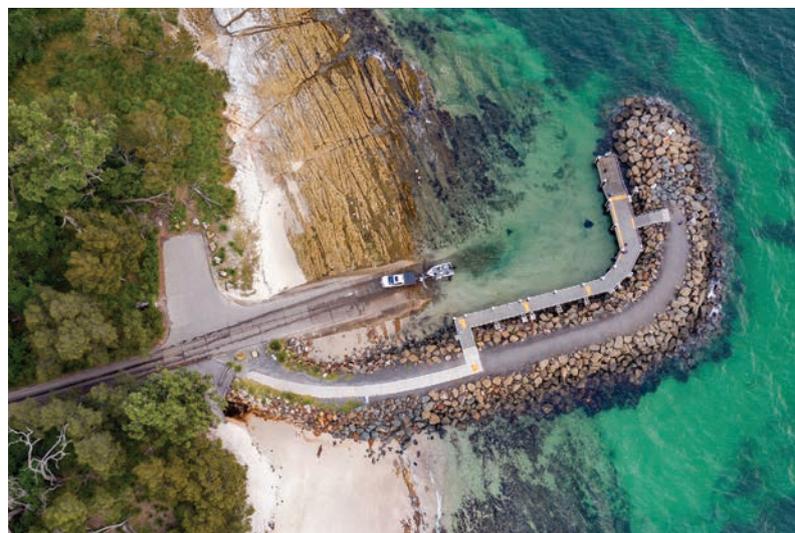
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## CITATION

This document is a summary of:  
Steinberg P, Anthony K, Coleman M, Eyre BD, Gribben P, Negri A, Bay LK, Connell S, Dafforn K, Humphrey C, Marzinelli E, Randall CJ, Swearer S, Wernberg T, Byrne M, Coleman R, Vila Concejo A, Connolly R, Dittmann S, Gillanders B, Hoey A, Hurd C, Hyndes G, Kelaher B, Kendrick G, Przeslawski R, Sherman C & Wright J (2022). National Marine Science Plan science program to support decision-making: towards a nationally integrated approach to experimentation for managing and enhancing Australia's coastal marine ecosystems. Working Group report to the National Marine Science Committee, Australia.

Front cover: Experimental testing of restoration in a temperate kelp (crayweed) forest. Experiments like these, in habitats where crayweed is now extinct, allow for large scale restoration of this foundational species to its former habitat. Image: John Turnbull, [www.marineexplorer.org](http://www.marineexplorer.org)



## Acknowledgement of Country |

The National Marine Science Committee acknowledges the Traditional Custodians and Elders of the land and sea on which we work and observe, and recognises their unique connection to land and sea. We pay our respects to Aboriginal and Torres Strait Islander peoples past, present and future.

## Summary |

Australia's coastal marine ecosystems have enormous economic, environmental and socio-cultural value. They are a vital part of Australia's marine natural capital, with assets and services valued at tens of billions of dollars.

Our coastal ecosystems are also some of the most threatened and vulnerable systems within our marine estate. Many coastal ecosystems are deteriorating due to pressures such as climate change, pollution, urbanisation, agriculture and increasing coastal development. These challenges are projected to continue and increase in future.

Research is urgently required to better understand and respond to these challenges. This includes observational and modelling approaches but also, critically, experimental approaches. Experiments are the essential tool for determining causality and the mechanisms which drive change in a system. Experimental insights are critical for supporting adaptive management, rehabilitation and restoration of coastal ecosystems.

A nationally integrated experimental approach is urgently needed to address the key challenges to Australia's coastal ecosystems and ensure the ongoing management, rehabilitation and enhancement of these ecosystems. The challenges include understanding the drivers of change

for these ecosystems and their impacts, determining the level of resilience of ecosystems or species to these impacts, and enabling the development of solutions that can help minimise the impacts, enhance ecosystem resilience and rehabilitate degraded systems.

A nationally integrated experimental approach to coastal management must be focused at the ecosystem level, be collaborative, have adequate investment and leverage existing expertise, infrastructure and facilities. A national strategic plan is required to drive the national experimentation approach to coastal management. The framework is best applied by targeting individual ecosystems.

This report provides a summary of the National Marine Science Committee report entitled *Towards a nationally integrated approach to experimentation for managing and enhancing Australia's coastal marine ecosystems*. The committee's report outlines an approach to Recommendation 3 of the National Marine Science Plan.



## Background: National Marine Science Plan |

The National Marine Science Plan draws together the knowledge and experience of Australia's marine research organisations, universities and government departments, including more than 500 scientists. It outlines the science needed to develop the knowledge, technology and innovation to support Australia's marine ecosystems and grow our blue economy.

The plan focuses on driving actions and investment to address seven interconnected grand challenges facing Australia's marine estate. These are: marine sovereignty, security and safety; energy security; food security; biodiversity conservation and ecosystem health; urban coastal development; climate variability and change; and resource allocation.

The National Marine Science Plan will ensure marine science across Australia addresses the grand challenges with cutting-edge research that integrates social and economic factors and is conducted at the scales required. To do this, Australia needs a coordinated, national approach that harnesses the collective capability of our marine science community working collaboratively with industry, government and community.

The plan sets out high-level recommendations for tackling the grand challenges to help Australia fulfil our blue economy potential and prosper as a marine nation.

This report provides a summary of the National Marine Science Committee's *Towards a nationally integrated approach to experimentation for managing and enhancing Australia's coastal marine ecosystems Working Group Report, 2022*, by Professor Peter Steinberg and colleagues (available at [www.marinescience.net.au](http://www.marinescience.net.au)). The committee's report outlines an approach to the following National Marine Science Plan recommendation:

**Recommendation 3. Facilitate coordinated national studies on marine system processes and resilience to enable understanding of development and climate change impacts on our marine estate.**

Access the National Marine Science Plan at: [www.marinescience.net.au/nationalmarinescienceplan](http://www.marinescience.net.au/nationalmarinescienceplan)



# Australia's coastal ecosystems: valuable and vulnerable |

Australia's coastal marine ecosystems have enormous economic, environmental and socio-cultural value. They are a vital part of Australia's marine natural capital, with assets and services valued at tens of billions of dollars.

The value of these ecosystems extends well beyond the economic benefits. A healthy and vibrant coastal marine environment is a core value for Australians. Our coastal ecosystems are places of belonging and custodianship for traditional owners. As a result, the overall value of our coastal marine ecosystems cannot be easily translated into a monetary value.

Coastal ecosystems are threatened and vulnerable. Many coastal ecosystems are deteriorating due to pressures such as climate change, pollution, urbanisation, agriculture and increasing coastal development. Coral cover on the Great Barrier Reef has declined due to mass bleaching events. Hundreds of kilometres of kelp forests along Australia's temperate coasts have been lost. Comparable declines have also been observed for other major habitat-forming organisms, such as oyster reefs, mangrove forests and seagrass, with climate change a critical pressure.

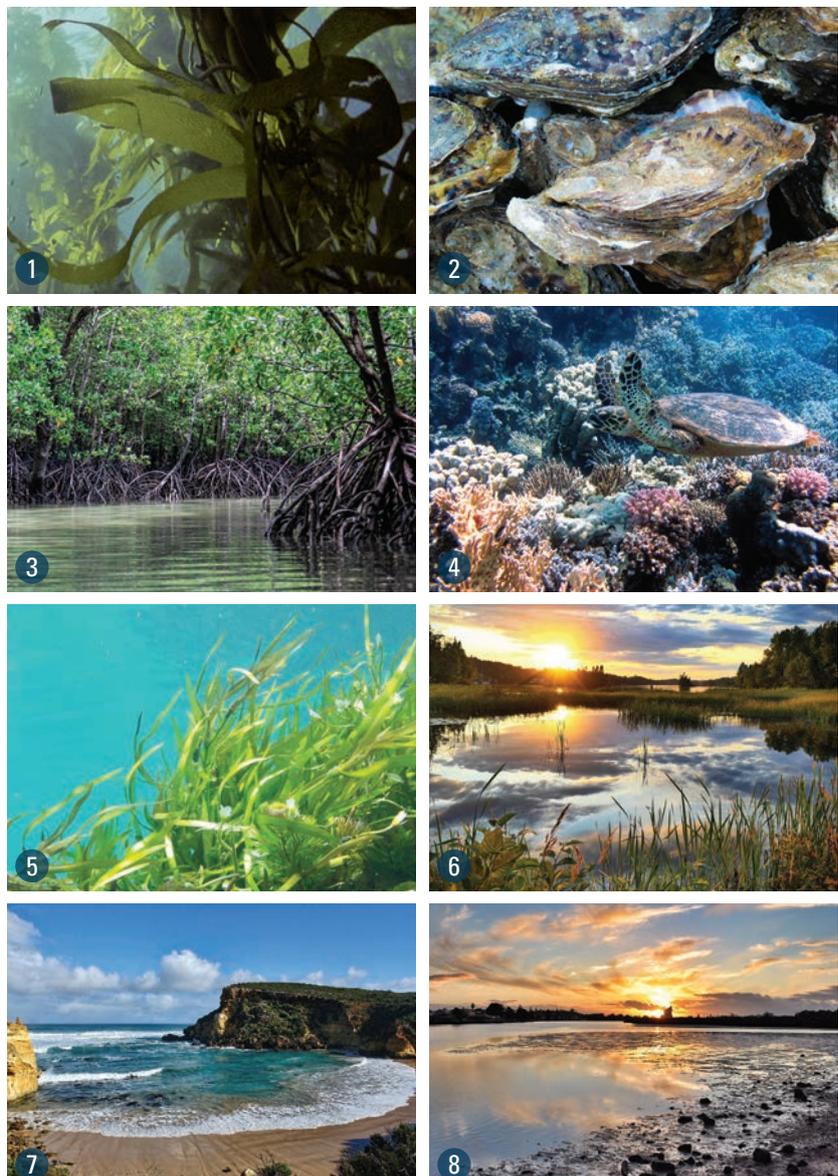
The challenges faced by coastal marine ecosystems will continue to increase. This will result in ongoing decline and loss of critical marine ecosystems and species, reduced biodiversity and a loss of ecological functions and services.

There is an urgent need to understand the dynamics of coastal ecosystems and enhance their resilience and rehabilitation.

“ *The value of these ecosystems extends well beyond the economic benefits.* ”

**Figure 1:** Common Australian coastal marine ecosystems:

1. Kelp forests
2. Oyster reefs
3. Mangrove forests
4. Coral reefs
5. Seagrass meadows
6. Wetlands and saltmarshes
7. Beaches
8. Estuarine sediments



# Experimentation to manage and enhance coastal marine ecosystems |

The National Marine Science Plan recommends facilitating and coordinating national studies on marine system processes and resilience to understand the impacts of development and climate change on our marine estate (Recommendation 3). This recommendation is built on an experimental approach to these challenges.

## What are experiments?

Science is built on three approaches to understanding a system: observations, modelling and experimentation. Experimentation is the essential tool for determining causality and explaining the mechanisms and processes that drive change. Experiments involve manipulating a system in a planned and controlled manner, followed by measurement and analyses of the system's response.

While monitoring and observations can tell us what has happened, and modelling can make predictions about what may happen, experiments are the primary approach for testing, modelling and predicting the consequences of current and future conditions. To use a medical analogy, epidemiological studies (observations) can tell us about the prevalence of a disease, but we need clinical trials (experiments) to determine whether a drug can cure or prevent that disease. Experimental insights are critical for supporting adaptive management, rehabilitation and restoration of coastal marine ecosystems.

Experiments can be conducted in a laboratory or in the field, each having advantages and constraints. Laboratory experiments enable the manipulation of variables that are challenging to influence in the natural world (such as ocean acidification). But ultimately, field-based experiments are best placed for testing the interactions, resilience and response of whole systems in the real world.

Experiments are ideally performed at the scale relevant to the system being studied, the scale of the key drivers and the ecosystem response. However, large-scale experiments are rare in marine systems due to the lack of coordinated governance and necessary resources.

Marine coastal ecosystems are well suited to experimental approaches. They are generally accessible, shallow water habitats for which the foundational organisms are large and/or immobile, such as kelp, oysters, corals, seagrasses or mangroves.



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



Experiments may be conducted in the field (top left – testing kelp restoration approaches) or in a laboratory (bottom left – testing the impacts of ocean warming on corals).

“ Experimentation, in which a researcher manipulates a system and then measures its response, is a fundamental component of science-informed management.



Image: Leah Wood, SIMS

## Drivers of change, resilience and solutions

Experiments are crucial for understanding the dynamics and resilience of coastal ecosystems. They help provide insights into these systems at both small and large scales and enable testing of management and rehabilitation interventions.

An experimental approach allows us to address three questions critical to the ongoing management and enhancement of Australia's marine coastal ecosystems:

1. What are the **drivers of change** for these systems, by what mechanism do they act and what are their impacts?
2. What is the **resilience** of ecosystems to these impacts, including the ecosystems' resistance to threats and their recovery following an impact?
3. What **solutions** can help minimise the impacts, enhance the resilience of an ecosystem or rehabilitate a degraded system?

Right: A nationally integrated approach to experimentation will address critical questions on drivers of change, resilience and solutions to manage and enhance Australia's coastal ecosystems.

## SOLUTIONS

- Management of drivers of change
- Spatial zoning and marine protected areas
  - Restoration
  - Rehabilitation
- Assisted evolution



## DRIVERS OF CHANGE

- Ocean warming and heatwaves
- Ocean acidification
- Coastal development
- Poor water quality
- Fishing and extractive industries
- Species interactions

## RESILIENCE

- Resistance to perturbation
- Recovery from perturbation
- Feedback loops and hysteresis
  - Natural adaptation
  - Connectivity

## Benefits of a national approach |

A national framework for an experimental understanding of our coastal ecosystems is needed to develop new, large-scale approaches for effective management and rehabilitation.

Australia's coastal ecosystems occur at scales ranging from regional to national, along thousands of kilometres of coastline. These ecosystems are affected by drivers of change that also occur at regional, national or even global scales (such as climate change). To understand and address the challenges these ecosystems face and to mitigate and adapt to the observed and projected changes, Australia requires a nationally integrated experimental approach to inform resilience-based coastal ecosystem management and policies.

Most existing marine national programs, such as the Integrated Marine Observation System (IMOS), focus on observational or modelling approaches. While Australian scientists have participated in experimental approaches at a national or even global scale, these studies are rare and are usually motivated by individual research programs. This means they do not necessarily align with national goals and priorities.

A coordinated national approach to experiments is lacking in Australia.



Professor Bradley Eyre uses an experimental approach to trace microphytobenthos nitrogen through the biogeochemical processes and food web. Image: Joanne Oakes

“ A nationally integrated, experimentation approach is critical for testing and improving solutions in a future where our oceans and ecosystems are rapidly changing.

## Australia on the front foot

Australia has the opportunity to lead the world in establishing the first integrated national experimental framework for coastal ecosystems.

Our researchers have played a critical role in the evolution of marine science, including in experimental approaches, and our marine science community is coherent and integrated. We have a well-established national observation system, and many coastal universities and government agencies have facilities that enable controlled manipulation of environmental conditions and support field-based experimentation.

Australia is well placed to support an integrated, national approach to experimentation. However, strategic and national investments in these capabilities, infrastructure and facilities are needed to drive the next steps toward a nationally integrated experimental capacity.

The need is urgent. Australian environmental management agencies and government departments are increasingly adopting active adaptive management that incorporates and relies on experimental approaches.

## A large-scale experimentation exemplar: Reef Restoration and Adaption Program

Experimentation is particularly well suited for testing approaches to ecosystem restoration and rehabilitation, but most marine restoration efforts in Australia are still small-scale. However, experiments are beginning to lead to larger-scale efforts for some systems, such as the Reef Restoration and Adaptation Program (RRAP). The RRAP is one of the most substantial recent investments in Australian marine science. It includes experiments to support the

development of large-scale restoration and rehabilitation of the Great Barrier Reef. The RRAP is based on an initial investment of approximately \$100 million.

The RRAP is an exemplar of how experimentation can underpin a large-scale approach aimed at building resilience through ecosystem restoration and rehabilitation. A national, strategic approach like the RRAP is urgently needed for coastal ecosystems other than coral reefs to ensure these systems remain resilient.

# Framework for a nationally integrated experimental approach |

A nationally integrated experimental approach to coastal management must be focused at the ecosystem level, be collaborative, have adequate investment and leverage existing expertise, infrastructure and facilities. A national strategic plan is needed, with a framework applied at scale, recognising the characteristics of different ecosystems.

## Investment and collaboration

Investment in the management and rehabilitation of coastal ecosystems other than coral reefs at a scale comparable to that of the RRAP is critically needed to sustain the value and use of these coastal systems.

A nationally integrated experimental approach to coastal management needs to be based on collaboration and integrated governance. It must include leading research and management expertise, cutting-edge research capability and infrastructure, and standardised experimental approaches wherever possible.

There is considerable infrastructure and capacity that could support a national experimental approach. A national approach would leverage Australia's existing capabilities, infrastructure and facilities and coordinate these resources cost-effectively.

## Developing a national strategic plan

A national experimental strategic plan would yield evidence-based insight into what management actions will be effective as our coastal environments change, including the degree of intervention needed for each ecosystem. It will identify priority functions, processes and species that will enhance resilience.

## Applying the framework to key ecosystems

Australia's marine coastal ecosystems are diverse and widespread. Like the RRAP program for corals, a national approach to coastal management should be focused on integrated experimental programs tailored to other key coastal ecosystems, such as marine macrophytes, oyster reefs and estuarine sediments. These ecosystems are among the foundational components of Australia's coastal waters and exemplify the social, economic and environmental values of coastal marine habitats.





## Conclusion and recommendations |

**The challenges Australia's coastal systems face and the value they contain are significant. A nationally integrated experimental approach is critically needed to support evidence-based coastal ecosystem management and policies.**

As our coasts continue to experience rapid environmental change and increasing pressures, a nationally integrated experimental approach to coastal management will provide a framework for understanding the drivers impacting these ecosystems. It will inform the development of effective and suitable large-scale restoration and rehabilitation solutions and guide the prioritisation of intervention efforts and resources. This will help to enhance the resilience of Australia's unique and valuable marine coastal ecosystems now and in the future.

**The following recommendations are provided to assist in developing a nationally integrated experimental approach to managing Australia's marine coastal ecosystems.**

1. **Invest** in a national experimental approach targeted at key coastal ecosystems other than coral reefs at a scale comparable to that of the Reef Restoration and Adaption Program.
  2. **Develop** an integrated and cohesive marine experimentation strategic plan to link existing and new capabilities, capacities and facilities and prioritise and drive activities and investment.
  3. **Use** existing integrated national marine initiatives as templates for plans for key coastal ecosystems.
  4. **Support** the national coordination of marine science facilities and capabilities and strong national-level governance.
  5. **Leverage** underlying infrastructure and capacity and invest in new marine experimental facilities to enhance a national network.
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# NATIONAL MARINE SCIENCE – COMMITTEE –

## NATIONAL MARINE SCIENCE PLAN

Towards a nationally integrated approach to experimentation for  
managing and enhancing Australia's coastal marine ecosystems

Working Group Report

### SUMMARY

The full technical report, and a PDF of this summary,  
are available at

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