Commonwealth Marine Reserves Review

Report of the Expert Scientific Panel

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Dear Minister

I am pleased to provide you, as the Minister for the Environment, with the *Commonwealth Marine Reserves Review: Report of the Expert Scientific Panel*, prepared as part of the Australian Government's Commonwealth Marine Reserves Review. As Chair of the Expert Scientific Panel, I would like to thank the Panel members—Professor Colin Buxton, Mr Peter Cochrane, Professor Sabine Dittmann and Dr. Julian Pepperell—for their significant contributions to this report.

This expert scientific report has been produced in response to the terms of reference that you prepared for the Commonwealth Marine Reserves Review. The report has been informed by an extensive literature review, evidence presented through Commonwealth Marine Reserves Review public submissions, and direct consultation with marine scientists from a range of organisations around Australia. This process was supported by the secretariat who I thank for their excellent work in supporting the review.

The review of the science and the associated findings and recommendations made in this report fall into three broad areas: the process used to design the reserve networks; the current state of knowledge about marine reserves and protection of marine biodiversity, with a particular focus on research undertaken since the reserves were proclaimed in 2012; and the requirements for future management of the Commonwealth marine reserves estate.

In parallel to our expert scientific review, the Commonwealth Marine Reserves Review Bioregional Advisory Panels conducted a broad consultation process to ensure all affected stakeholders had the opportunity to put forward their views, and to advise on possible alternative reserve design within the outer boundaries and options for reserve management. In undertaking this task, the Bioregional Advisory Panels sought specific scientific advice from the Expert Scientific Panel on a range of matters. This advice is documented in our report.

I commend this Expert Scientific Panel Report to you for your consideration in the future management of Australia's Commonwealth marine reserves.

Yours sincerely

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Chair
Commonwealth Marine Reserves Review Expert Scientific Panel
12 December 2015

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Executive summary

In response to a range of concerns raised by a number of parties about the 40 new Commonwealth marine reserves (CMRs) established in 2012, the Australian Government initiated a review of the design and management of these reserves. Key concerns were the adequacy of consultation and the scientific evidence underpinning the establishment of the reserves. The Expert Scientific Panel (ESP) was subsequently appointed to review the science of reserve design and advise the Government on how to strengthen the science underpinning reserve management into the future. In parallel, the Bioregional Advisory Panel (BAP) was appointed to conduct a broad consultation process to ensure all affected stakeholders had the opportunity to put forward their views and to advise on possible alternative reserve design within the CMR outer boundaries and options for reserve management. The BAP used advice from the ESP to assist in this task.

The ESP's findings to assist the work of the BAP and its recommendations to the Australian Government have been informed by an extensive literature review, evidence presented through the BAP public submission and stakeholder survey processes, and direct consultation with marine scientists from a range of organisations around Australia and marine reserve managers.

The ESP's review of the science and associated findings and recommendations fell into three broad areas, which are reflected in this summary and in the content of this report.

Looking back (chapter 2)

The ESP is satisfied that the marine bioregional planning programme, which was based on the Integrated Marine and Coastal Regionalisation of Australia and complemented by scientific workshops, peer-reviewed publications and literature reviews, was a sound basis and drew upon the best available information for designing the CMR networks.

The ESP is also satisfied that the process that underpinned the 2010 Fishing Gear Risk Assessments (FGRAs) was sound but that the findings will need to be updated as new information becomes available.

The ESP recognises that, while the best available scientific knowledge and tools were utilised in designing the CMR estate in line with the Goals and Principles for the Establishment of a National Representative System of Marine Protected Areas (NRSMPA) in Commonwealth waters, socio-economic factors were also significant considerations in finalising the location and zoning of the reserves.

Current state of knowledge (chapter 3)

The zoning and associated management arrangements that the Australian Government adopted, which are based on International Union for Conservation of Nature (IUCN) standards and guidelines, provide a robust approach for achieving the objectives of the NRSMPA in Commonwealth waters. However, it must be informed by appropriate science, and the ESP notes that the knowledge base is growing.

There is a large body of scientific literature that clearly demonstrates the value of no-take zones (Marine National Park Zones and Sanctuary Zones in CMRs) for biodiversity conservation and as scientific reference sites to measure change within and outside the CMR estate. While no-take zones are arguably the most effective biodiversity conservation measure, they are but part of a suite of spatial management approaches in the multiple-use CMR estate. In addition, Habitat Protection Zones play an important role in accommodating a range of uses while at the same time providing effective protection for habitats by prohibiting those activities that damage habitat or are otherwise inconsistent with management objectives.

New scientific information assisted the ESP in addressing issues raised in the BAP consultations, assessing the conservation values for a number of CMRs and the revision of several of the 2010 FGRAs. ESP findings in relation to new information were communicated to the BAP for consideration in developing zoning options within the CMR outer boundaries.

Looking to the future (chapter 4)

A robust adaptive management approach is required if management investment for the CMR estate is to be effective and efficient. Well-targeted, long-term scientific research, monitoring and evaluation are essential. Baseline information is critical for measuring environmental change and management effectiveness. Initial baselines must be established and data collected as soon as possible across the estate before this opportunity is lost. While Australia’s current marine research capabilities and infrastructure should be harnessed for this purpose, significant new and ongoing investment will be needed to provide adequate coverage of the vast CMR estate.

New and existing marine research and monitoring data must be maintained for the long term and be readily accessible to the scientific community, reserve managers and other relevant users. This will contribute to the adaptive management of CMRs and the management of Australia’s Exclusive Economic Zone in general.

Opportunities exist for public–private partnerships to increase investment and realise the benefits of marine research and monitoring in CMRs. CMR management must tap into these opportunities through effective collaboration, strong governance mechanisms and good strategic planning.

Citizen science also provides unique opportunities for involving users in monitoring and management and delivering cost-effective ways of collecting appropriate data. Citizen science can complement formal research programmes or be integrated into them depending on circumstances.

In this report the ESP makes the following specific recommendations to Government:

Managing the Commonwealth marine reserve estate effectively

1. The Expert Scientific Panel recommends the adoption of an adaptive management approach for the Commonwealth marine reserve estate and that the first management planning cycle include a period for transition to this approach.

Research in the Commonwealth marine reserve estate

2. The Expert Scientific Panel recommends the development of a research, monitoring and evaluation framework that will support robust evidence-based decision-making in the management of the Commonwealth marine reserve estate. Such a framework should be designed in a way that it is consistent with that used for environmental reporting in Australia.

   The Expert Scientific Panel recommends the development and management of knowledge brokering between Parks Australia, state jurisdictions, private enterprise, the research community and citizen science.

Information gaps identified by the Expert Scientific Panel review

3. The Expert Scientific Panel (ESP) recommends the establishment of a series of baselines and development of benchmarks in each network across the Commonwealth marine reserve estate. Further, the ESP stresses that early baseline and benchmark establishment is critical to enable a sound assessment of the effectiveness of subsequent reserve management.

   The ESP further recommends that this be done in partnership with the marine research community.

   The ESP endorses the recommendation in the National Marine Science Plan 2015–2025 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*'. In addition the ESP encourages a Government commitment to maintaining investment in marine infrastructure and capabilities.

4. The Expert Scientific Panel recommends that the social and economic sciences be part of the research investment made to support management of the Commonwealth marine reserve estate.

Effectiveness of zones

5. The Expert Scientific Panel recommends that the Director of National Parks facilitate and encourage research and research collaborations that assist in the evaluation of the efficacy of different zone types.

Threats and mitigation of threats

6. The Expert Scientific Panel recommends that, in developing a research, monitoring and evaluation framework for the Commonwealth marine reserve estate, existing and potential threats be identified and prioritised. Some baseline and benchmark sites within the estate should be established to assist in detecting threats and their impacts.

Requirements for managing effectively

7. The Expert Scientific Panel recommends institutionalising a transparent approach to research and management within Parks Australia as part of building relationships with the research community.

   The Expert Scientific Panel considers the research and monitoring requirements framework set out in table 4.1 is sound and recommends it as an input to the development of a Parks Australia research and monitoring strategy for the Commonwealth marine reserve estate, with the reserves in the South-east Commonwealth Marine Reserves Network included in its scope.

Managing the proposed research, monitoring, data and evaluation framework

8. The Expert Scientific Panel strongly recommends that approvals and support for research and monitoring activities in the Commonwealth marine reserve estate require that the raw data and metadata obtained through these activities are made publicly accessible through the Australian Ocean Data Network to enable independent examination and analysis.

Data acquisition and management

9. The Expert Scientific Panel (ESP) recommends that existing marine research and monitoring data be maintained in the long term and that it is made readily accessible to the scientific community, reserve managers and other relevant users so that they may contribute to the adaptive management of Commonwealth marine reserves and the management of Australia's Exclusive Economic Zone.

   The ESP recommends that Parks Australia becomes an active contributor and core partner in the Australian Ocean Data Network.

   The ESP recommends the continuing support of the Integrated Marine Observation System (noting that the National Marine Science Plan also makes this recommendation) and the Australian Ocean Data Network as vital to the future success of the monitoring and management framework of the Commonwealth marine reserve estate.

   The ESP recommends that the Australian guidelines for the ethical conduct of research be emphasised in the collection and use of data.

Facilitating the setting of research priorities

10. The priority research investments that the Expert Scientific Panel recommends to the Government as making a significant contribution to the management of the Commonwealth marine reserve estate are:

    - the research, monitoring, data and evaluation framework should be established, together with baseline studies

- if a national strategy for the development of platforms and sensors is established then linking research planning for the Commonwealth marine reserve estate with it is important
- if the National Marine Science Plan 2015–2025 is adopted in some form then there should be clear linkages between its execution and the needs of the Commonwealth marine reserve estate.

Chapter 1 Introduction

Australian governments have been committed to the establishment of a National Representative System of Marine Protected Areas (NRSMPA) since 1998. In 2007 the first network of Commonwealth marine reserves (CMRs) was proclaimed with the establishment of 14 reserves in the South-east Marine Region. In November 2012, 40 new CMRs were proclaimed in the South-west, North-west, North, Temperate East and Coral Sea, finalising the Australian Government's contribution to the NRSMPA.

Management plans for these new reserves were drafted following their proclamation. However, the Australian Government re-proclaimed the reserves in December 2013, which had the effect of setting aside the management plans. This was the first step in the Government's commitment to reviewing the new reserves and how they were to be managed. The Commonwealth Marine Reserves Review (the CMR Review) commenced in August 2014 with the release of the terms of reference and announcement of the appointment of panel members. The CMR Review had two interrelated streams:

(i) The Expert Scientific Panel (ESP) addressed the science underpinning the current CMRs and their future management.

(ii) The Bioregional Advisory Panels (BAP) enhanced consultation with stakeholders about the CMRs.

The ESP was appointed to advise on the science underpinning the CMRs and make recommendations for strengthening it into the future. Options for zoning and allowable uses were considered, as were options for addressing the most significant information gaps hindering robust, evidence-based decision-making for the management of CMRs. The ESP also considered future priorities for research and monitoring of biodiversity, especially those relating to the understanding of threats to marine biodiversity.

Concurrently, the BAP, comprising three panel members for each of the five marine regions and two co-Chairs, was appointed to consult across commercial, recreational and charter fishing groups, community and Indigenous groups, environmental interest groups, and tourism and other marine industry groups to identify areas of contention with the reserves. They were tasked with developing options for zoning and management arrangements to address these contentions and make recommendations for improving the inclusion of social and economic considerations into decision-making for marine reserves, with particular regard for their management, including suggestions for ongoing engagement of regional stakeholders.

The two BAP co-Chairs, who were also members of the ESP, provided a link between the two panels and assured that deliberations and findings from the ESP could be considered for the work of the BAP. Specifically, they made formal requests for scientific findings by the ESP on issues that emerged from their consultations. In this report the ESP presents a number of findings it made to assist the work of the BAP. In addition, the ESP makes recommendations to Government consistent with its terms of reference. These recommendations are directed at the establishment of a robust adaptive management framework for the CMRs into the future.

The full terms of reference for the CMR Review are at appendix 1.

The structure of this report reflects the systematic approach of the ESP in addressing its terms of reference. The scope of the ESP terms of reference did not extend to the outer boundaries of the CMR estate—a position foreshadowed by the Minister for the Environment in his media release following the re-proclamation of the reserves in December 2013 and made in a statement at the time of the International Union for Conservation of Nature (IUCN) World Parks Congress in November 2014. Mindful of the work of the BAP, in relation to its first specific term of reference:

> *i) advise on options for zoning, and zoning boundaries, and allowed uses consistent with the Goals and Principles;*

the ESP confined itself to consideration of the science underpinning zoning and specific questions referred to it by the BAP. The ESP's second and third specific terms of reference are closely interrelated:

> *ii) advise on future priorities for scientific research and monitoring relating to marine biodiversity within the marine reserves, especially any relating to the understanding of threats to marine biodiversity within the marine reserves;*
>
> *iii) advise on options for addressing, the most significant information gaps hindering robust, evidence-based decision-making for the management of the marine reserves.*

The ESP's approach on these issues was based on a review of the available science and consultation with national scientific experts in these areas. The ESP expects that a number of its findings and recommendations to the Government will help to inform those charged with the future planning and management of the CMR estate.

In chapter 2, the ESP reviews the process and science that informed the design and zoning of the 40 reserves proclaimed in 2012. This included, among other things, the Government's marine bioregional planning programme and the Integrated Marine and Coastal Regionalisation of Australia (IMCRA).

In chapter 3, the ESP outlines significant new science that has become available since the reserves were designed and proclaimed and how this might inform future zoning and management. In order to do this, references are made to earlier science as appropriate.
This chapter of the ESP report has been informed by:

- a literature review
- public submissions from the BAP consultation process that addressed ESP terms of reference
- a Marine Science Expert Forum, hosted by the ESP, which brought together marine scientists from a range of organisations around Australia

- other direct communications with marine scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and other research organisations.

Every endeavour was made to obtain and review all relevant new scientific information to inform chapter 3 and associated findings. Many chapter 3 findings are framed as advice to the BAP on areas of contention identified through the consultation process and formally communicated to the ESP by the BAP.

Lastly, in chapter 4 the ESP has drawn on all of the above to identify:

- information gaps that hinder robust management of the marine reserves
- future priorities for scientific research within the CMRs, especially any relating to threats to marine biodiversity
- a necessary communications approach to support the recommendations made.

Chapter 2 History of Commonwealth marine reserves in Australia and review of the science used for the design of the 2012 reserves

The development of marine protected areas (MPAs) in Australia commenced in 1937 with the declaration of the first Queensland Island National Parks, with protection extending for one mile beyond the low water mark. The Australian and Queensland governments cooperated in establishing the Great Barrier Reef Marine Park (GBRMP) in 1975.

Marine reserves in Commonwealth waters outside of the GBRMP also have a long history, with the Lihou Reef and Coringa-Herald National Nature Reserves (now part of the Coral Sea CMR) proclaimed in 1982 (DoE a).

Subsequently, the number and extent of Commonwealth and state marine reserves have expanded and the Commonwealth's component of Australia's MPA estate now covers approximately 3.2 million km^2, which is about 36 per cent of the waters within the Australian Government's marine jurisdiction. The CMR Review covers those Commonwealth marine reserves (CMRs) in the South-west, North-west, North and Temperate East networks and the Coral Sea reserve—covering an area of approximately 2.4 million km^2.

The design, establishment and management of the CMR estate have been influenced initially by the experience gained through the establishment of GBRMP and the development of marine science in Australia and by international developments in both marine protection and, more generally, biodiversity protection. This extends to the requirements of international treaties to which Australia is a party.

The establishment of the Expert Scientific Panel (ESP) as part of the CMR Review recognises the foundational importance of science to CMR decision-making by the Australian Government. However, the ESP recognises that the interests of industry, recreation, conservation and management will all, rightly, continue to be important considerations in Government decisions on marine reserves into the future. Historical context is important for the ESP, which was asked to consider both the science used to inform the design of the current CMR estate and what science may be needed in the future to 'ensure robust, evidence-based decision-making'. This chapter provides that historical context and, in doing so, addresses the question of the way science was used in establishing the expanded CMR estate in 2012.

2.1 Policy and legal framework

Following the enactment of the *Seas and Submerged Lands Act 1973* and the establishment of the GBRMP in 1975, the ruling of the High Court in 1975 on the *Seas and Submerged Lands Act* and the Offshore Constitutional Settlements reached with the states in the late 1970s set out, among other things, arrangements for:

- the establishment of additional marine parks within Australia’s Exclusive Economic Zone (EEZ)
- separately, the management of offshore fisheries (AG 1980).

Marine reserves and fisheries continue to be managed separately and for complementary but distinct purposes in Commonwealth waters. In this context, recreational fishing remains under state jurisdiction (Gullett 2009), generally to the edge of Australia’s EEZ. Regulatory arrangements for other activities (commercial fishing and mining being the most extensive) in Australia’s offshore waters vary depending on the activity (see appendix 2). However, the Environment Protection and Biodiversity Conservation (EPBC) legislation provides the Director of National Parks with a broad range of controls over activities within CMRs.

Australia ratified the Convention on Biological Diversity (CBD) in 1993, and the 1996 National Strategy for the Conservation of Australia’s Biological Diversity (the Biodiversity Strategy) (DEST 1996) was subsequently developed and agreed by Commonwealth, state and territory governments to meet commitments made under the CBD and the Intergovernmental Agreement on the Environment (1992) (CoA 1992). The Biodiversity Strategy included a key objective to establish and manage a comprehensive, adequate and representative (CAR) system of protected areas covering Australia’s terrestrial and marine biological diversity.

The Biodiversity Strategy recognised that the existing marine and estuarine MPA system in particular was inadequate to maintain biological diversity. The Biodiversity Strategy recommended expansion of marine parks and reserves to encompass representative examples of Australia’s marine environments.

A comprehensive policy for ecosystem-based marine and coastal management was released in 1998 (Australia’s Oceans Policy), which set out the framework for integrating regional marine planning with the development of a National Representative System of Marine Protected Areas (NRSMPA) (CoA 1998).

Australia’s Oceans Policy included a three-year, $50 million programme for the commencement of regional marine planning, including identifying current and emerging threats to ecosystem health and development of management strategies and frameworks to address them. A key component of the policy was to accelerate development of the NRSMPA, including development of new MPAs and improved management of existing ones for conservation purposes, and to give regional security for industry access to ocean resources (CoA 1998).

Also released in 1998 were the Guidelines for Establishing the National Representative System of Marine Protected Areas (the ANZECC Guidelines) (ANZECC 1998). The ANZECC Guidelines, developed by the Australian and New Zealand Environment and Conservation Council (ANZECC) Task Force on Marine Protected Areas, were prepared to assist government agencies in the development of the NRSMPA and to assist stakeholders in understanding the process. The work of the ANZECC Task Force represented a strong commitment by all Australian governments to the development and implementation of a national network of reserves, with the primary goal being:

> *to establish and manage a comprehensive, adequate and representative system of MPAs to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels* (ANZECC 1998).

The ANZECC Guidelines include the CAR principles, described as:

- **Comprehensiveness**: The NRSMPA will include the full range of ecosystems recognised at an appropriate scale within and across each bioregion.
- **Adequacy**: The NRSMPA will have the required level of reservation to ensure the ecological viability and integrity of populations, species and communities.
- **Representativeness**: Areas that are selected for inclusion in MPAs should reasonably reflect the biotic diversity of the marine ecosystems from which they derive.

The ANZECC Guidelines also outline additional principles for the development of the NRSMPA, including a regional framework, the inclusion of highly protected areas (International Union for the Conservation of Nature (IUCN) Categories I and II in each bioregion), use of the precautionary principle (CoA 1992), appropriate consultation to address social, economic and cultural issues as required by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), Indigenous involvement (to recognise and incorporate interests of Indigenous peoples) and principles relating to decision-making (integration of long- and short-term environmental, economic, social and equity considerations).

In late 2007, building on lessons learnt from the design and recent proclamation of the South-east CMR Network, the Australian Government published the Goals and principles for the establishment of the National Representative System of Marine Protected Areas in Commonwealth waters (the Goals and Principles) (DoE b) to clarify how the Australian Government was to apply the ANZECC Guidelines to Commonwealth waters. They did not replace the ANZECC Guidelines but, rather, interpreted them to take account of the significant dearth of biological information for offshore and remote waters (the Goals and Principles are discussed in more detail below).

The Oceans Policy laid the foundation for the development of Regional Marine Plans (see section 2.2 below), which have been developed and implemented over the ensuing years, with the South-east Marine Region as the prototype. A 2002 Review of the Implementation of the Oceans Policy (TFG International 2002) noted that the South-east planning process would be an effective template for subsequent plans. Fourteen CMRs were proclaimed by the Australian Government in the South-east Marine Region in 2007 and they continue to be managed by the Director of National Parks in accordance with the EPBC Act and the South-east CMR Network Management Plan, which came into effect in 2014. The South-east CMR Network is not part of the CMR Review but will be a component of any estate-wide CMR planning in the future (in relation to research and monitoring needs, for example) that occurs as a result of the CMR Review.

Figure 2.1 shows the development of the CMR estate from the 1998 release of the Oceans Policy and ANZECC Guidelines through to the proclamation of the new CMRs in 2012.

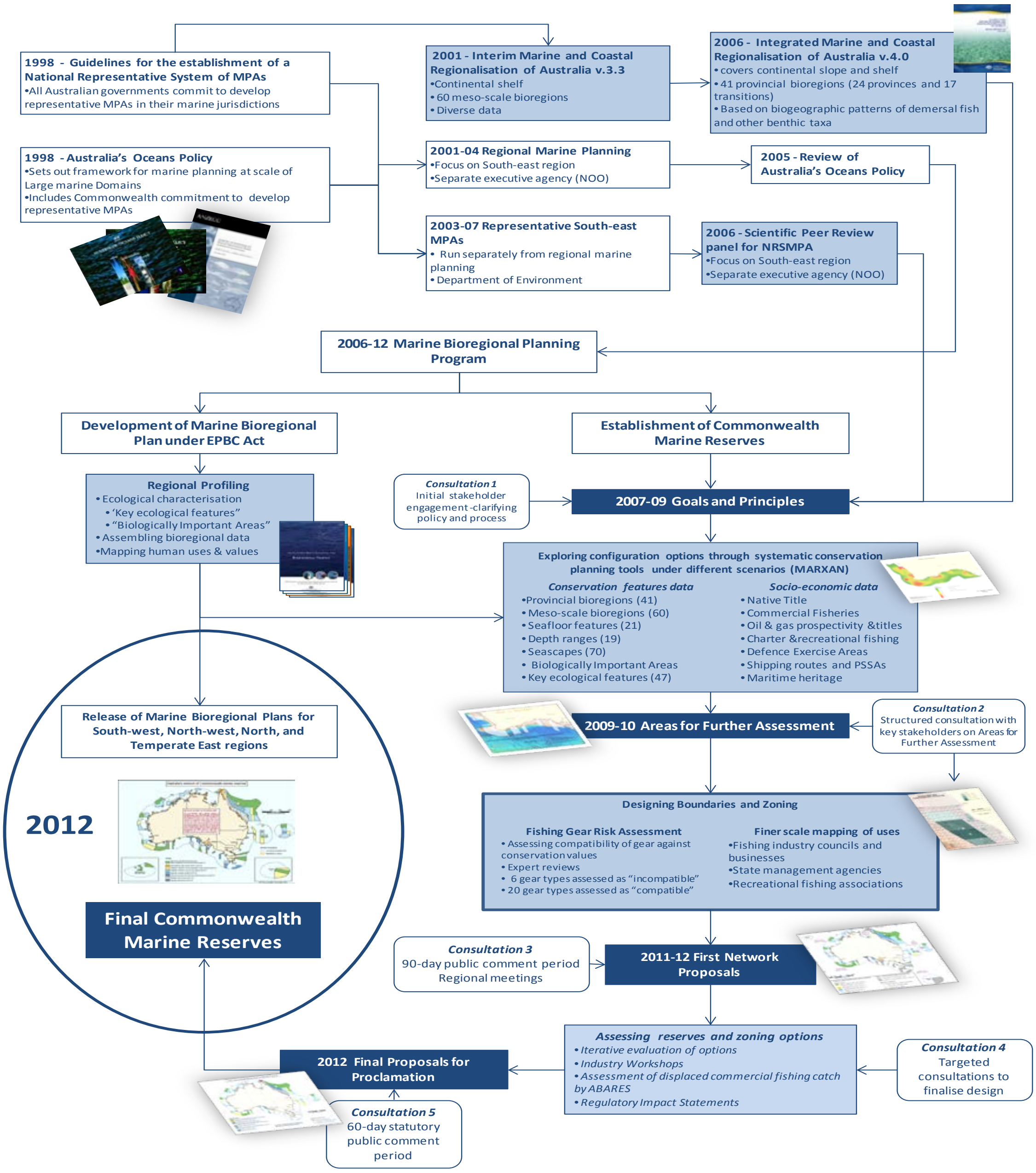

Figure 2.1 The development of Commonwealth marine reserves and marine bioregional planning from 1998 to 2012

The development of Australia's NRSMPA has been a key element in meeting obligations under the CBD. The establishment of the NRSMPA is also consistent with the 2002 World Summit on Sustainable Development (Rio+10) commitment to establishing representative networks of MPAs by 2012. In 2010, Australia and the other parties to the CBD adopted the Aichi Biodiversity Targets. Target 11 is that:

> *by 2020, at least ... 10 per cent of coastal and marine areas especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well connected*

systems of protected areas and other effective area-based conservation measures. (CBD 2008)

2.2 The science behind the development of Commonwealth marine reserves

2.2.1 Integrated Marine and Coastal Regionalisation of Australia and the use of surrogates

The national network of CMRs aims to represent provincial-scale bioregions recognised in Commonwealth waters, as identified by the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) v4.0 (see box 2.1). These provincial bioregions are the result of detailed compilation and analysis of available scientific information and expert opinion. IMCRA classified Australia's marine environment into 41 distinctive ecological regions (CoA 2006).

Box 2.1 The Integrated Marine and Coastal Regionalisation of Australia and the concept of biodiversity 'surrogates'

In the early 1990s, the Australian Government and the states and territories commenced scientific processes that would contribute to the inshore component of the Integrated Marine and Coastal Regionalisation of Australia (IMCRA). Their purpose was to provide an ecosystem-based scheme that could be used for spatial planning purposes—in particular, the development of the National Representative System of Marine Protected Areas (IMCRA is the marine equivalent of the Interim Biogeographic Regionalisation for Australia, which underpins the National Reserve System on land).

In 1994, relevant Commonwealth agencies (CSIRO and the Australian Geological Survey Organisation) formed a Technical Consortium to develop biophysical regionalisations for offshore waters. The state and Commonwealth groups came together in late 1996 at a national technical meeting to commence integration and in 1998 IMCRA v3.3 was released (IMCRA Technical Group 1998). IMCRA v3.3 was the first layer in a broad ecological planning framework within which more detailed information on ecosystems, communities and/or species distributions can be added to and used to assist decision-making across or within a region (CoA 1998). An updated version of IMCRA (IMCRA v4.0) that extends to Australia's offshore waters was released in 2006 (CoA 2006). This updated version provided a spatial framework for classifying Australia's marine environment into bioregions that 'made sense' ecologically and at a scale useful for regional planning.

A key concept used in IMCRA, and widely applied in conservation planning where direct observations of biodiversity distribution are rarely available, is surrogacy. Surrogates of distribution of biodiversity in the marine environment are usually physical attributes, such as seabed geomorphology or depth, that provide a reasonable proxy for the distribution of biodiversity. Geological and oceanographic surrogates, combined with available data on the biota in some places, were used to underpin the development of IMCRA v4.0, which in turn underpins the design of the CMR networks. Harris *et al.* (2008) provide an overview of the use of surrogates and IMCRA in the establishment of the CMR networks. Key surrogates for Commonwealth marine reserve design are identified in the Goals and principles for the establishment of the National Representative System of Marine Protected Areas in Commonwealth waters.

2.2.2 Marine Bioregional Planning Programme

In 2006, the Australian Government commenced the Marine Bioregional Planning Programme for the South-west, North-west, North and East (covering both the Temperate East and the Coral Sea) regions. The Programme was designed to provide a clearer focus on conservation and sustainable management of Australia's marine environment. It was a process based on the EPBC Act principles of ecologically sustainable development.

The Marine Bioregional Planning Programme was undertaken for Commonwealth waters (generally from three nautical miles offshore to the edge of Australia's EEZ) and sought to deliver on two streams of related but separate information. These were to allow the development of Marine Bioregional Plans under the EPBC Act and the establishment of a network of CMRs in each bioregion.

2.2.3 Marine Bioregional Plans[1]

The Marine Bioregional Plans were developed in consultation with stakeholders and with input from scientists and other experts. There are a number of ways that scientific information was used in the marine bioregional planning process:

- Bioregional Profiles for each marine region were prepared using scientific information about the region's biophysical and socio-economic characteristics and conservation values. For each region, an Ecosystem Report and several Key Species Groups reports were prepared by scientists with relevant disciplinary and regional expertise. These reports were commissioned by the Department and peer reviewed. Scientists were also involved in the identification of key ecological features (KEFs)[2] through regional multidisciplinary workshops. Biologically important areas (BIAs)[3] were defined for listed species through expert scientific input. Information on the socio-economic characteristics of the marine regions was also consolidated by commissioning expert reviews of existing data. The Bioregional Profiles were critical in building the information base for each marine region and a common shared understanding that underpinned subsequent marine reserves design work and consultations.
- As draft Marine Bioregional Plans were developed, scientific information and expertise were used to assess pressures on the conservation values for each marine

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[1] This section attributable to DoE c.

[2] **Key ecological features** (KEFs) are elements of the Commonwealth marine environment in the marine regions that, based on current scientific understanding, are considered to be of regional importance for either the region's biodiversity or ecosystem function and integrity.

[3] **Biologically important areas** (BIAs) are areas where a protected species displays biologically important behaviours such as breeding, foraging, resting and migration. These areas serve to highlight the parts of a marine region that are particularly important for the conservation of protected species. Both the KEFs and BIAs can be viewed on the Department of the Environment's Conservation Values Atlas (DoE d).

region. Scientific information used in assessments included environmental and impact assessment studies, risk assessments, expert advice and research conducted both within Australia and elsewhere. Again, scientists were also involved in the identification of KEFs and BIAs for marine species. The risk assessments and conservation value report cards were independently reviewed by relevant experts.

- In 2011, four draft Marine Bioregional Plans were released, giving scientists and other experts as well as stakeholders and the wider community the opportunity to provide input, including by identifying new and/or more detailed information that would assist in the completion of the plans. This input helped to ensure that the final Marine Bioregional Plans were based on accurate and best-available information and presented a shared understanding of the conservation objectives and priorities within a region.

The available science, expert advice and process used to develop the Marine Bioregional Plans also identified BIAs for marine species and KEFs for each region. This information was used to inform the identification of potential CMRs. Appendix 3 lists the primary scientific and expert reports commissioned by the Australian Government Department of the Environment that were relied upon during the marine bioregional planning process and subsequent CMR design.

2.3 Designing the Commonwealth marine reserves

Key inputs to the design of the CMRs included:

- existing scientific information underlying IMCRA v4.0 (for example, bathymetry, geomorphic features and distribution of endemic biota)
- additional regional information on habitats, species distribution and ecology gathered during the marine bioregional planning process (including the identification of KEFs and BIAs)
- data on the location and distribution of human activities in a marine region
- perspectives of ocean users and other stakeholders in each marine region
- consideration of the contribution that existing spatial management measures can make to the NRSMPA
- consideration of potential management effectiveness (for example, practicality and feasibility of compliance).

2.3.1 The Goals and Principles

The underlying Goals and Principles for CMR design were informed by the available science while recognising from the outset that knowledge of biodiversity in some areas was poor or absent (DoE b). A significant proportion of each marine region is far offshore in very deep waters and these areas had not been the subject of detailed study or data gathering. In these circumstances, existing peer-reviewed data were supplemented with information drawn from known linkages between biodiversity and the physical environment. Where detailed information on species and habitat data was lacking, surrogates for diversity (such as water depth, substrate and geomorphology) were used.

The four Goals provide direction on how to ensure that all types of marine ecosystems and their biodiversity could be represented within the national network of marine reserves.

The 20 Principles provide direction on the location, selection, design and zoning of reserves within networks. Collectively, the Goals and Principles prioritise the placement of reserves in areas that should best represent marine biodiversity but have the least impact on resource users. For example, the Principles state that socio-economic impacts should be minimised and that the regional network should aim to include some highly protected (IUCN I and II) zones within each provincial bioregion.

2.3.2 Areas for Further Assessment

The release of Areas for Further Assessment (AFAs) for public comment in 2009–10 was a first step to assist in the identification of new CMRs, not as the proposed boundaries for new marine reserves but as the areas in which future marine reserves were likely to be located based on outcomes of the marine bioregional planning process that was still under way. Consultations on the AFAs assisted in focusing the attention of stakeholders and identifying potential social and economic impacts and how those impacts could be minimised (DoE e).

Consultations on the AFAs occurred through meetings and targeted data-gathering projects. Detailed information collected through this phase of consultation contributed directly to the process of designing marine reserve network proposals for each marine region. In addition, the information gathered was being used to help minimise potential impacts of marine reserves on parties who use marine resources.

Following on from the AFA process, draft CMR network proposals were developed for each marine region. This involved iterative conservation planning that included further consultation with stakeholders and consideration of threats and possible zoning arrangements.

2.3.3 The science of conservation planning

Conservation planning requires an understanding of spatial configuration of habitats and biota and where conservation efforts are most urgently needed (Grantham *et al.* 2011). The design of MPAs can be informed by identification and mapping of biodiversity hotspots, iconic features (for example, seamounts and reefs); critical habitats for threatened, endangered or protected (TEP) species; and representative habitats (Harris *et al.* 2008). Based on available data and unbiased multivariate classification procedures, maps of seascapes can be produced and combined with maps of geomorphic features (Harris *et al.* 2008; Harris and Whiteway 2009). Software like Marxan (Ball *et al.* 2009; Ball and Possingham 2000), which was used in the design process for the expanded CMR estate, can provide decision support for locating reserves, defining reserve size and generating maps useful for stakeholder consultation (Grantham *et al.* 2011; Ruiz-Frau *et al.* 2015).

Newly developed biological seascapes data was also included in the refinement of CMR design at this stage. Biological seascapes combine biological and physical data to predict the distribution of biodiversity at a finer spatial scale than other IMCRA datasets (Dunstan and

Foster 2009; Ellis *et al*. 2009; Ellis and Pitcher 2009a; Ellis and Pitcher 2009b; Dunstan and Foster 2010a; Dunstan and Foster 2010b; Dunstan and Foster 2010c; Ellis *et al*. 2010).

2.3.4 The approach to zoning

Zoning is a key management tool for protected areas (Kenchington and Day 2011; Shafer 2015), and the EPBC Act (section 346) requires that areas within reserves are assigned to one of the categories defined by the International Union for Conservation of Nature (IUCN). Table 2.1 shows how Australia applies IUCN zoning to its CMRs.

Table 2.1 Commonwealth marine reserve zones and International Union for the Conservation of Nature Categories

<table>
<tr><th>CMR zone type</th><th>IUCN Category assigned</th><th>Assigned IUCN Category description</th></tr>
<tr><td>Sanctuary Zone</td><td>IUCN Ia—Strict nature reserve</td><td>Managed mainly for science</td></tr>
<tr><td>Marine National Park Zone</td><td>IUCN II—National Park</td><td>Managed mainly for ecosystem conservation and recreation</td></tr>
<tr><td>Habitat Protection Zone</td><td rowspan="2">IUCN IV—Habitat/species management area</td><td rowspan="2">Managed mainly for conservation through management intervention</td></tr>
<tr><td>Recreational Use Zone</td></tr>
<tr><td>Multiple Use Zone</td><td rowspan="3">IUCN VI—Managed resource protected area</td><td rowspan="3">Managed mainly for the sustainable use of natural ecosystems</td></tr>
<tr><td>General Use Zone</td></tr>
<tr><td>Special Purpose Zone</td></tr>
</table>

The IUCN’s 2012 guidelines provide clear guidance for applying the IUCN Categories to MPAs. Table 2.2 sets out the primary objectives of the IUCN Categories, their applicability to MPAs and the compatibility of activities with each other (Day *et al.* 2012). These IUCN guidelines were used to inform CMR activity matrices, which set out which activities can occur in which CMRs or zones within CMRs. Following development of these matrices, all reserves and zones within reserves were assigned an IUCN Category.

Table 2.2 Matrix of marine activities that may be appropriate for each International Union for the Conservation of Nature Category (after Day *et al.* 2012)

Activities	Ia	Ib	II	III	IV	V	VI
Research: non-extractive	Y*	Y	Y	Y	Y	Y	Y
Non-extractive traditional use	Y*	Y	Y	Y	Y	Y	Y
Restoration/enhancement for conservation (e.g. invasive species control, coral reintroduction)	Y*	*	Y	Y	Y	Y	Y
Traditional fishing/collection in accordance with cultural tradition and use	N	Y*	Y	Y	Y	Y	Y
Non-extractive recreation (e.g. diving)	N	*	Y	Y	Y	Y	Y
Large-scale, low-intensity tourism	N	N	Y	Y	Y	Y	Y
Shipping (except as may be unavoidable under international maritime law)	N	N	Y*	Y*	Y	Y	Y
Problem wildlife management (e.g. shark control programmes)	N	N	Y*	Y*	Y*	Y	Y
Research: extractive	N*	N*	N*	N*	Y	Y	Y
Renewable energy generation	N	N	N	N	Y	Y	Y
Restoration/enhancement for other reasons (e.g. beach replenishment, fish aggregation, artificial reefs)	N	N	N*	N*	Y	Y	Y
Fishing/collection: recreational	N	N	N	N	*	Y	Y
Fishing/collection: long-term and sustainable local fishing practices	N	N	N	N	*	Y	Y
Aquaculture	N	N	N	N	*	Y	Y
Works (e.g. harbours, ports, dredging)	N	N	N	N	*	Y	Y
Untreated waste discharge	N	N	N	N	N	Y	Y
Mining (seafloor as well as sub-seafloor)	N	N	N	N	N	Y*	Y*
Habitation	N*	N*	N*	N*	N*	Y	N*

Key:

No	N
Generally no, unless special circumstances apply	N*
Yes	Y
Yes because no alternative exists, but special approval is essential	Y*
Variable; depends on whether this activity can be managed in such a way that it is compatible with the MPA's objectives	*

2.3.5 Assessing threats to biodiversity

CMRs were not established to mitigate threats to biodiversity, although threat mitigation within reserves is considered in decisions on reserve zoning and the activity matrices that determine what activities can be permitted within zones.

It is important to note that biodiversity conservation objectives inform decisions about whether activities proposed to be undertaken within reserves are compatible with these objectives. In practice, this means that, in assessing activities and their potential impacts within reserves, greater weight is placed on their impacts on the reserve's conservation value than might otherwise be the case outside the reserve—that is, the 'environmental bar' is higher inside reserves. This principle is articulated in the EPBC Act Policy Statement 1.1—Significant Impact Guidelines, which apply to the assessment of activities with the potential to impact on Matters of National Environmental Significance, including the Commonwealth marine environment (DoE 2013a). The guidelines state that *actions in or near marine protected areas, or other areas with high conservation value, have a greater likelihood of significant impacts on the Commonwealth marine environment* (DoE 2013a).

A zoning framework was developed that took this into account and assessed the compatibility of different activities with the conservation objectives of the zone types proposed in the CMR networks.

Commercial fishing activities were assessed under Fishing Gear Risk Assessments (FGRAs) for all regions. The FGRAs (considered in detail below and in section 3.1) were a key input into the application of Principles 19 and 20 of the Goals and Principles in that they determined the potential risk that fishing gear types pose to marine reserve conservation objectives/values and provided a key input into decisions on whether a fishing activity was compatible with the conservation objectives of a reserve. Fishing was likely to be impacted more than any other marine activity by the introduction of CMRs given the spatial extent of fisheries and impact on marine species and habitats that generally occurs in a consistent way. Commercial fishing covers a larger area more frequently than any other marine activity. These assessments were therefore undertaken early in the CMR design process to ensure that socio-economic impacts on the sector could be minimised.

Recreational fishing, oil and gas, research, tourism and other activities were not assessed in the same generic way as commercial fishing. Decisions were made at the time that broad risk assessments of these activities were not required, in part due to the legislative risk management arrangements (and, in the case of oil and gas and mining, project- and activity-specific risk and impact assessments) that apply to those activities (summarised at appendix 2). Other reasons included:

- other activities (for example, mining, tourism and research) usually being site-specific and generally time-limited in comparison to fishing
- recreational fishing gear types being similar to commercial gear types that were considered 'acceptable' through the FGRA process (and therefore being permitted in all IUCN IV and VI) zones
- international obligations—in relation to shipping, for example.

The ESP is of the view that these decisions were and continue to be sound and that ongoing risk management arrangements (summarised at appendix 2) were, and remain, a sound basis for identifying and managing the risks of activities in CMRs.

Commercial Fishing Gear Risk Assessments

All extractive activities, including commercial fishing, are prohibited in Sanctuary Zones (IUCN Ia) and Marine National Park Zones (IUCN II), but commercial fishing is permissible in Habitat Protection Zones (IUCN IV) and Multiple Use Zones (IUCN VI) with prescriptions that manage risks associated with the fishing method and gear type (table 2.2).

Commercial fishing in CMRs is regulated primarily under relevant Commonwealth and state/territory fisheries Acts, which generally have objectives that are complementary to the objectives of the EPBC Act. For example, the objectives of the Commonwealth's *Fisheries Management Act 1991* include:

> *ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (which include the exercise of the precautionary principle), in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment.*

As such, the Australian Fisheries Management Authority (AFMA) implements management strategies under an ecosystem-based fisheries management (EBFM) framework that considers the impacts of fishing on:

- target species
- by-product species
- bycatch/discard species
- threatened, endangered and protected species
- habitats and communities.

In CMRs, Commonwealth, state and Northern Territory laws and regulations apply to the extent that they can operate consistently with management plans and broader EPBC legislation (DNP 2013a). Under the EPBC Act, actions for commercial purposes that involve the taking, killing, injuring, moving or keeping of native species in CMRs are subject to the Act and the provisions of management plans.

FGRAs for the South-west Marine Region (DSEWPaC 2010), East Marine Region (Morison and McLoughlin 2010) and the North and North-west Marine Regions (Lack 2010) were based upon findings of the South-east Marine Region Fishing Risk Assessment (SEFRA) in 2005 (E-Systems 2005). This assessment was undertaken by a Technical Working Group of industry and other stakeholders tasked with identifying and categorising risks to benthic conservation values and protected species. Following the SEFRA, AFMA developed an ecological risk management (ERM) framework (see figure 2.2) that details a process for assessing and progressively addressing the impacts that fisheries have on five aspects of the marine ecosystem: target species; by-product and discard species; and TEP species, habitats and communities (AFMA 2010a).

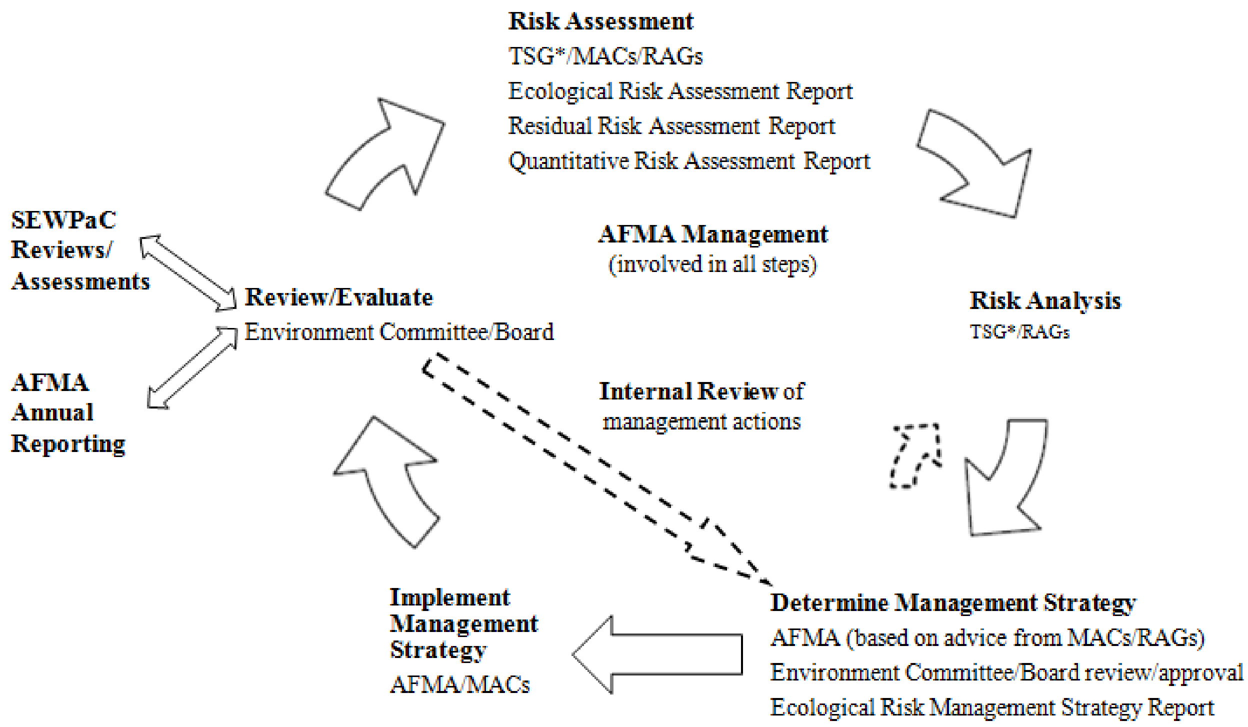

Figure 2.2 Ecological risk management framework (TSG*—Technical Support Group, MACs—Management Advisory Committees, RAGs—Resource Assessment Groups) (after AFMA 2010a).

The FGRAs were desktop analyses that drew on the outcomes of the SEFRA and the results of Ecological Risk Assessments (ERAs) undertaken for Commonwealth fisheries by AFMA. Where appropriate they drew on qualitative Ecologically Sustainable Development Assessments (ESDAs), conducted for state and Northern Territory managed fisheries using the National Ecologically Sustainable Development (ESD) Framework (Fletcher *et al.* 2004). Like the Ecological Risk Assessment for Effects of Fishing (ERAEF) methodology, these involve substantial stakeholder engagement. Finally, they drew on Department of the Environment fisheries assessment reports prepared under the EPBC Act[4] and available information on the management and status of fisheries published by state, Northern Territory and Commonwealth fisheries management agencies.

[4] The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) requires the Australian Government to assess the environmental performance of fisheries and promote ecologically sustainable fisheries management. All export and all Australian Government managed fisheries are subject to assessment under the EPBC Act (see www.environment.gov.au/marine/fisheries) (DoE f).

Australian Fisheries Management Authority Ecological Risk Assessments

ERAs are determined using the ERAEF methodology developed by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) (Hobday *et al.* 2007). This process progresses through a number of steps and involves a hierarchy of risk assessment methodologies progressing from a comprehensive but largely qualitative Level 1 Scale Intensity Consequence Analysis (SICA), through a more focused and semi-quantitative Level 2 Productivity Susceptibility Analysis (PSA), to a fully quantitative model-based Sustainability Assessment of Fishing Effects (SAFE) analysis at Level 3 (see figure 2.3). Between Level 2 and Level 3, residual risk assessments evaluate and refine ERA high-risk outcomes by taking into account additional information not considered through the ERA process—in particular, the mitigating effects of some current management arrangements. This approach is a cost and time efficient means of screening out low-risk activities and focusing more intensive and quantitative analyses on those activities assessed as having a greater environmental impact on AFMA managed fisheries resources. It is also precautionary in that risks are scored high in the absence of information, evidence or logical argument to the contrary (Hobday *et al*. 2007).

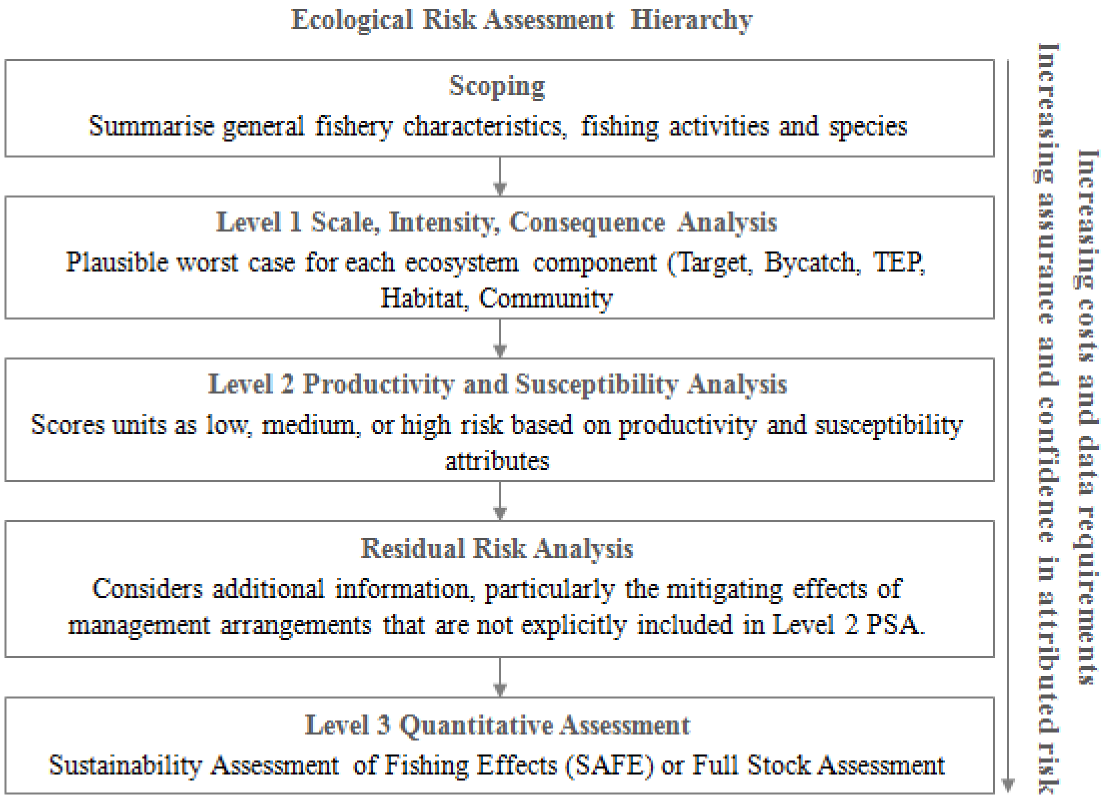

Figure 2.3 Risk assessment hierarchy (after AFMA 2010a)

ERAs have been completed (to varying degrees—either Level 1, 2 or 3) for all major Commonwealth managed fisheries. AFMA's expectation is that each fishery will be periodically reassessed using the ERA methodology in line with the review of any wildlife trade operation (WTO) accreditation in place for the fishery (AFMA 2010a). Approvals of WTOs are made by the Australian Government Minister for the Environment after assessment of fisheries under the EPBC Act. Most approvals currently in place have a three-year duration.

Translating Ecological Risk Assessments and Ecologically Sustainable Development Assessments into Fishing Gear Risk Assessments ratings

In the South-west, North, North-west and East Marine Region FRGAs, ERA results relevant to a particular gear type were used as the primary basis for assessment rather than the workshop approach used in the South-east. This approach was considered appropriate since CSIRO's ERA process was based on the best available science and expert input as well as extensive stakeholder input.

As described above, the methodology applied also used information from ESDAs and EPBC Act assessment reports (including AFMA and state and Northern Territory government submissions to the EPBC Act assessments) and the latest available information on the management and status of fisheries published by state, Northern Territory and Commonwealth agencies.

Lack (2010) noted, however, that the outputs from these processes vary in both their form and in the rigor underlying them. Some of the issues associated with the use of the outcomes of these different processes included:

- some fisheries have only been subject to the EPBC Act assessments, which do not provide a risk rating
- ESDA risk ratings for fisheries that utilise more than one gear did not always discriminate between gear types
- a very small number of fisheries have not been subject to any of the three assessment processes.

In the absence of risk ratings from ERAs or ESDAs, risks ratings arising from the SEFRA were utilised where they were considered relevant. However, in some cases no relevant risk ratings could be applied and, where no ERA results were available to inform the risk assessment, a more precautionary approach has been taken in interpreting the available information, consistent with Principle 20.

The 'translation' from ERA/ESDA risk ratings to an assessment of acceptability of the method provided the overall FGRA rating for each region. ERA/ESDA risk ratings informed, but did not dictate, the overall FGRA risk rating. An example for the North and North-West is given in table 2.3 (after Lack 2010).

Table 2.3 Relationship between Ecological Risk Assessment/Ecologically Sustainable Development Assessment risk ratings and the North and North-west Marine Regions' acceptability rating

Overall FGRA rating	ERA ratings comparison and policy considerations
Incompatible/Unacceptable	This overall assessment was given to fishing methods when ERAs or ESDAs found that: potential or actual high risk exists for elements of the marine environment that are identified as conservation values to be protected AND for which mitigation measures were not found or are of limited effectiveness. higher levels of precaution were used for those conservation values also identified as regional conservation priorities and where no ERA/FRA was available to inform the assessment.
Incompatible/Unacceptable pending further assessment	This overall assessment was given to fishing methods when ERAs or ESDAs found that: potential or actual high risk exists for elements of the marine environment that are identified as conservation values to be protected AND there is uncertainty about the effectiveness of mitigation measures. higher levels of precaution were used for those conservation values also identified as regional conservation priorities and where no ERA/FRA was available to inform the assessment.
Compatible/Acceptable with mitigation measures and conditions	This overall assessment was given to fishing methods when ERAs or ESDAs found that: a range of risk levels exists for elements of the marine environment that are identified as conservation values to be protected AND for which there are mitigation measures currently in place, or in the process of being implemented, which have been shown to have some effectiveness. higher levels of precaution were used for those conservation values also identified as regional conservation priorities and where no ERA/FRA was available to inform the assessment.
Compatible/Acceptable (some conditions may be required)	This overall assessment was given to fishing methods assessed in the South-east FGRA, ERAs or ESDAs as having a low risk and were not further assessed.

The South-west, North, North-west and East Marine Region FRGAs included quality control reviews undertaken by external independent experts and reviews by experts nominated by the commercial fishing industry (see table 2.4).

Table 2.4 Fishing Gear Risk Assessment quality control reviews

FGRA	Quality control reviews
South-west Marine Region	Smith (2010) *Review of the South-west Fishing Risk Assessment* Knuckey *et al.* (2011) *South-west Bioregion Fishing Gear Risk Assessment review – Report to the National Seafood Industry Alliance* Smith (2011) *Review of the DSEWPaC response to "South-west bioregion fishing gear risk assessment review – report to the National Seafood Industry Alliance"*
East Marine Region	Daley (2010) *Review of East Region Fishing Gear Risk Assessment* Bodsworth and Knuckey (2011) *Review of the Fishing Gear Risk Assessment for the North, North-west and East Marine Regions—Report to the National Seafood Industry Alliance*
North and North-west Marine Regions	Griffiths (2010) *Analytical review of "Assessment of risks that commercial fishing methods may pose to conservation values identified in the Areas for Further Assessment of the North and North-west Marine Regions" for the Department of the Environment, Water, Heritage and the Arts* Bodsworth and Knuckey (2011) *Review of the Fishing Gear Risk Assessment for the North, North-west and East Marine Regions—Report to the National Seafood Industry Alliance*

<u>Evaluating the Fishing Gear Risk Assessments process</u>

The ESP has determined that the process used for the FGRAs was robust and made use of the best information available at the time. This echoes the reviews that were undertaken for the FGRAs, which, while pointing out some inconsistencies, information gaps and areas for improvement, considered that the work done was extensive and detailed and underpinned by a reasonable methodological approach (for example, Knuckey *et al*. 2011; Smith 2010).

The reliance of the FGRAs on findings from the ERAs and, when these were not available in state fisheries, on ESDA assessments was appropriate. Here it is noted that both ERAs and most state ESDAs were undertaken in consultation with industry and other relevant stakeholders. The ESP also considered that the precautionary approach taken in the translation from those findings to a determination of compatibility/acceptability of the fishing methods in CMRs was appropriate given the policy context for the establishment, zoning and management of the CMRs.

The following sections of this report contain further analysis by the ESP of a number of gear types against the new information.

ESP finding

The Expert Scientific Panel concluded that findings of the Fishing Gear Risk Assessments were well founded in the context of the information available at the time they were conducted. However, the Expert Scientific Panel found that a significant amount of research has since been published that is relevant to the assessment of the risk to biodiversity and ecosystems from commercial fishing operations.

2.4 Finalising the Commonwealth marine reserves

Following on from the conservation planning process, CMR network proposals were developed for the South-west, North, North-west, Coral Sea and Temperate East Marine Regions. Public feedback was sought on the proposals between May 2011 and February 2012 (DSEWPaC 2012a). The key elements of the draft network proposals were the outer boundaries and the proposed zoning boundaries within the CMRs. The consultation process for each region lasted 90 days and information resources specific to each proposed network were made available to interested parties. Over half a million submission were received, and the 245 meetings held by the Department of the Environment during the consultation process attracted nearly 2000 attendees.

At this time, the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES) was engaged to assess the social and economic implications of each of the draft regional CMR network proposals. This work, undertaken with the assistance of the commercial fishing industry, looked at the direct and indirect impacts of the draft network proposals on the fishing industry (including commercial and charter fishing) and the potential impacts on related communities (DoA 2012). Socio-economic effects of marine reserve network proposals on tourism, research, shipping and recreational fishing were not assessed in this way.

2.4.1 Final Commonwealth marine reserve network proposals

Information received through public submissions and stakeholder consultations undertaken between May 2011 and February 2012, together with the socio-economic assessments undertaken by ABARES, were considered by the Government in finalising the CMR network proposals for each region. The combination of these inputs informed refinements made to the final CMR network announced on 14 June 2012 (DSEWPaC 2012a).

A consultation process of 60 days duration was held on the final CMR network proposal between July and September. Consistent with the EPBC Act requirements, the Director of National Parks prepared a report on the comments received, along with the Director's views on them (DNP 2012). The Minister considered this report and a Regulation Impact Statement (DSEWPaC 2012b) before recommending that the Governor-General proclaim the CMRs.

2.4.2 Commonwealth marine reserves proclaimed

The Governor-General's proclamation declaring the new CMRs was registered on the Federal Register of Legislative Instruments on 16 November 2012. The CMRs came into effect on 17 November 2012 along with transitional management arrangements to cover the period during which the statutory management plans are developed and then given effect. The Director of National Parks has responsibility to ensure management plans are in place as soon as practicable. There are no changes for users of these marine reserves until management plans are in place.

2.5 Performance of the proclaimed Commonwealth marine reserve estate against the Goals and Principles

2.5.1 Introduction

The CMR networks under review were declared for the following purposes:

- to protect and maintain biological diversity
- to contribute to the objectives of the NRSMPA, the primary goal of which is to establish and manage a CAR system of marine protected areas to contribute to the long-term ecological viability of marine and estuarine systems, to maintain ecological processes and systems, and to protect Australia's biological diversity at all levels (DNP 2012).

The key objectives of a CAR system are that it is comprehensive (representing the full range of Australia's ecosystems; adequate, in that it includes reserves of appropriate size and configuration to ensure the conservation of marine biodiversity and integrity of ecological processes; and representative, reflecting the marine life and habitats of the area they are chosen to represent) (DNP 2012).

The Goals and Principles (also discussed in section 2.3.1) were developed by the Australian Government to guide the systematic identification of areas representative of the diverse ecosystems and habitats in Commonwealth waters and the design of CMR networks to meet the CAR objectives using biodiversity surrogates. These surrogates include provincial bioregions, depth ranges, key ecological features and seafloor features. This section considers how the CMR estate (excluding the South-east CMR Network, which is not under review) performs against the following Goals and Principles:

- Goal 1—Each provincial bioregion occurring in the marine region should be represented at least once in the marine reserve network. Priority will be given to provincial bioregions not already represented in the National Representative System.
- Goal 2—The marine reserve network should cover all depth ranges occurring in the region or other gradients in light penetration in waters over the continental shelf.

- Goal 3—The marine reserve network should seek to include examples of benthic/demersal biological features (for example, habitats, communities, sub-regional ecosystems, particularly those with high biodiversity value, species richness and endemism) known to occur in the marine region at a broad sub provincial (greater than hundreds of kilometres) scale.
- Goal 4—The marine reserve network should include all types of seafloor features. There are 21 seafloor types across the entire Exclusive Economic Zone. Some provincial bioregions will be characterised by the presence of a certain subset of features, such as continental slope or seamounts.
- Principle 12—Features should be replicated wherever possible within the system, of marine reserves (that is, included more than once)
- Principle 18—The regional marine reserve network will aim to include some highly protected areas (IUCN Categories I and II) in each provincial bioregion.

2.5.2 Overview of the Commonwealth marine reserve estate proclaimed in 2012

A summary of the CMR estate is presented in table 2.5. The CMR estate covers a total area of 2 374 719 km^2, which is 36 per cent of the Commonwealth marine area (6 523 950 km^2). The establishment of this CMR estate as a system of ecologically representative reserves is a major step in addressing the commitment in the CBD 2020 Strategic Plan's Aichi Target 11, which states:

> *By 2020, at least 17 per cent of terrestrial and inland water areas and 10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape.* (CBD 2008)

While the proportion of each network contained in highly protected Sanctuary Zones and Marine National Park Zones ranges from 11 per cent to 51 per cent, the proportion of each CMR region that is contained in highly protected Sanctuary Zones and Marine National Park Zones ranges from three per cent in the North to 51 per cent in the Coral Sea.

Table 2.5 Key figures for Commonwealth marine reserve networks

	South-west[5]	North-west	North[6]	Temperate East	Coral Sea	Total
Area of marine region[7] (km^2)	1 292 015	1 067 731	625 690	1 466 792	989 842	5 442 070
Area of network (km^2)	508 605	335 437	157 483	383 352	989 842	2 374 719
Number of reserves	14	13	8	8	1	44
Proportion of region in the network	36%	37.1%	19.6%	26.1%	100%	43.6%
Proportion of the network in SZ and MNPZ (IUCN Categories I and II)	35.3%	31.1%	10.8%	15.7%	50.8%	36.4%
Proportion of region in SZ and MNPZ (IUCN Categories I and II)	12.7%	9.7%	2.7%	4.1%	50.8%	15.6%

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

[5] These figures include reserves that are in the North-west Marine Region but were subsequently included in the South-west CMR Network for management purposes—specifically the Abrolhos (Kalbarri and Wallaby extensions) CMR, which was included in the South-west CMR Network (as the Abrolhos CMR).

[6] These figures include two reserves that are located within the North-west Marine Region but were subsequently included in the North CMR Network for management purposes—specifically the Joseph Bonaparte Gulf and Oceanic Shoals CMRs.

[7] Referring to the marine regions defined in Commonwealth waters—for example, the South-west Marine Region.

2.5.3 Performance of the Commonwealth marine reserve estate against the Goals and Principles

Provincial bioregions

IMCRA v4.0 defines 41 provincial bioregions for Australia based on geomorphic features and biogeographic patterns in the distribution of bottom-dwelling fish. The first Goal states that each provincial bioregion should be represented at least once in the CMR estate. Of the total number of provincial bioregions, 32 lie within the area covered by the four marine regions and the Coral Sea. Seven of the remaining provincial bioregions are represented in the South-east CMR Network. Two provincial bioregions—Cocos (Keeling) Island Province and Christmas Island Province in the Indian Ocean Territories—are not represented in the CMR estate.

Table 2.6 Performance of the proclaimed Commonwealth marine reserve estate against the Goals and Principles (excluding the South-east Marine Region and the Great Barrier Reef Marine Park)

Goal	Primary conservation feature	Total number	Features represented within estate	Features represented in SZ and MNPZ (IUCN Categories I and II)
1	Provincial bioregions	32	31	26
	Meso-scale bioregions	35	33	21
2	Depth by provincial bioregion	347	325	200
3	Key ecological features	41	39	26
	Biologically informed seascapes	68	60	38
4	Seafloor types	21	21	20
	Total	544	509	331

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

All but one of the 32 provincial bioregions that occur within the four marine regions and the Coral Sea are represented in the proclaimed CMR estate that is the focus of the CMR Review (see table 2.6). The one provincial bioregion not represented is the Southeast Transition, which straddles the Temperate East and South-east regions, but this is included in the East Gippsland CMR, which is part of the South-east CMR Network. Each of these 32 provincial bioregions is therefore represented in the national CMR estate (that includes the South-east CMR Network).

The design and inclusion of CMRs representing the two provincial bioregions in the Indian Ocean Territories will be a further step towards ensuring a comprehensive CMR estate.

Principle 18 for the establishment of the NRSMPA states that *the regional marine reserve network will aim to include some highly protected areas (IUCN Categories I and II) in each provincial bioregion*. Over 80 per cent of provincial bioregions are covered, at least in part, by Sanctuary Zones or Marine National Park Zones and there are six provincial bioregions not represented in a Sanctuary Zone or a Marine National Park Zone.

Meso-scale bioregions

Meso-scale bioregions are defined on the continental shelf using biophysical information and geographic distance along the coast (DEH 2006). IMCRA v4.0 defines 60 meso-scale bioregions, of which 35 fall within the area of the four marine regions and the Coral Sea. Of these, 33 are represented in the proclaimed CMR estate (see table 2.6). Two meso-scale bioregions are not represented in the CMR estate (Groote and Hawkesbury shelves in the North and Temperate East regions respectively). Twenty-one meso-scale bioregions (60 per cent) are represented in Sanctuary or Marine National Park zones.

Depth range by provincial bioregion (Goal 2)

The second Goal states the estate should cover all depth ranges in a region or other gradients in light penetration in waters over the continental shelf. For the design of the CMR estate, 347 water depths by provincial bioregion classes were defined. The proclaimed estate includes 325 of these depth classes (94 per cent), with over half (200) represented in Marine National Park Zones (table 2.6). There are 22 depth classes not represented in the proclaimed CMR estate; however, three are represented in the GBRMP and 14 are represented in the South-east region. The remaining five depth classes are not represented (one each in the South-west, North-west and Temperate East and two in the North). Against this criterion, the estate is not fully comprehensive, although it does include the great majority of water depths.

Key ecological features and biologically informed seascapes[8] (Goal 3)

Over 90 per cent of KEFs and BISs are represented in the CMR estate (table 2.6). This outcome is close to comprehensive, with only two KEFs (Seringapatam Reef and Commonwealth waters in the Scott Reef complex; and Glomar shoals—both in the North-west region) and eight BISs (three in the Temperate East, one in the North-west and four in the South-west regions) not represented anywhere in the CMR estate.

Seafloor types (Goal 4)

Of the 21 seafloor types, all are represented in the CMR estate.

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8 **Biological informed seascapes** (BISs) represent a combination of physical and biological information that predicts where species are likely to occur using scientific modelling of ecosystems. The use of these seascapes as surrogates for biodiversity allowed the variety of biodiversity associated with different substrates to be captured within the CMR network.

2.5.4 Summary of Commonwealth marine reserve estate performance

Of the total of 544 primary conservation features defined and identified, 509 (94 per cent) are included in the four marine regional networks and the Coral Sea CMR proclaimed in the CMR estate, excluding the South-east CMR Network. With respect to Goal 1, 31 of 32 provincial bioregions and 33 of 35 meso-scale bioregions are represented in the proclaimed CMR estate (96 per cent coverage overall for Goal 1). Coverage of depth ranges by provincial bioregion (Goal 2) is 94 per cent—325 of the possible total of 347. Goal 3 features are 90 per cent covered and coverage is 100 per cent for Goal 4. Against Principle 18, 70 per cent of provincial bioregions and meso-scale bioregions are represented. Overall, 60 per cent of primary conservation features are in Sanctuary Zones or Marine National Park Zones in the proclaimed CMR estate. These two zones comprise 36.4 per cent of the CMR estate by area and 15.6 per cent of the five regions.

There are 20 primary conservation features not represented in the CMR estate as a whole. The missing features include two provincial bioregions (of the four provincial bioregions missing from the proclaimed estate, one is located in the South-east CMR Network and one is located in the GBRMP), two meso-scale bioregions, seven depth ranges, two key ecological features, and seven biologically informed seascapes. The South-east CMR Network includes 15 conservation features that are shared with the Temperate East region (14 depth ranges and one provincial bioregion).

These figures demonstrate that, while the estate is very largely comprehensive, there are gaps. Some of the gaps in coverage of features in Sanctuary Zones or Marine National Park Zones can be addressed within the outer boundaries of the current CMR estate. Other gaps can only be addressed by extension of outer boundaries of the CMRs and/or by new reserves. Coverage of the provincial bioregions in the Indian Ocean Territories can only be attained through establishment of new reserves.

2.5.5 South-west Commonwealth Marine Reserve Network summary

The South-west CMR Network covers 36 per cent of the South-west region. All provincial bioregions and meso-scale bioregions are represented (Goal 1), and almost all of the other primary conservation features (95 per cent) are included in the network (table 2.7). Only one depth range, four BISs and one seafloor type are not represented in the network (Goals 2, 3 and 4). Of the 124 primary conservation features in the South-west region, 118 are represented in the South-west CMR Network.

All provincial bioregions are represented in Sanctuary Zones or Marine National Park Zones, meeting Principle 18, and 103 (over 80 per cent) of all primary conservation features are represented in these zone types. Sanctuary Zones or Marine National Park Zones cover 35.3 per cent of the area of the network and 13.9 per cent of the region.

Overall, this is comprehensive coverage in terms of the four Goals and Principle 18.

Table 2.7 Performance of the South-west Commonwealth Marine Reserves Network

Goal	Primary conservation feature	Total number	Features* represented within network	Features represented in SZ and MNPZ (IUCN Categories I and II)
1	Provincial bioregions	7	7	7
	Meso-scale bioregions	7	7	7
2	Depth by provincial bioregion	62	61	50
3	Key ecological features	13	13	13
	Biologically informed seascapes	19	15	14
4	Seafloor types	16	15	12
	Total	124	118	103

* This regional summary covers the features occurring in the region. The network also includes features that occur in neighbouring regions because of reserves whose borders extend into other regions (Argo-Rowley CMR includes features in the North-west region but is accounted for in the South-west CMR Network, and features in the North-west region that are included in Argo-Rowley CMR are accounted for in the North-west summary. Western Eyre CMR includes features in the South-east region but is counted in the South-west CMR Network, except for the South-east region features that it includes). This table includes only those features occurring in the South-west region that are represented in network CMRs. For example, two provincial bioregions of the North-west are included in Argo-Rowley CMR but are accounted for in the North-west summary, not the South-west.

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

The average size of the 14 reserves of the South-west is 36 329 km^2, and individual CMR areas range from 630 to 271 898 km^2.

2.5.6 North-west Commonwealth Marine Reserves Network summary

The North-west CMR Network covers 37 per cent of the North-west region. All provincial bioregions and nine of the possible 11 meso-scale bioregions are represented in the North-west CMR Networks. The remaining two meso-scale bioregions are represented in the Oceanic Shoals CMR, which is accounted for in the North CMR Network. Two depth ranges are not captured in the North-west CMR Network. Of these, one is captured in the North CMR Network and one is not captured by any network. Of the 13 KEFs, eight are represented in North-west CMR Network, two are represented in North CMR Network and one is represented in the South-west CMR Network. Of the 20 BISs, 19 are represented in the network and the remaining one is not captured in any CMR. Of the 19 seafloor types in the region, 15 are located in North-west CMR Network and the other four are in CMRs in other networks (table 2.8).

In terms of meeting the Goals and Principles, Goal 1 is met, Goals 2 and 3 are almost met (one depth range, two KEFs and one BIS missing) and Goal 4 is met. Of the 154 primary conservation features in the North-west CMR Network, 140 are in North-west CMRs and 149 are represented in CMRs altogether.

Six of the eight provincial bioregions are represented in Sanctuary Zones or Marine National Park Zones in the North-west CMR Network and one is represented in the South-west CMR Network (Principle 18). Over half of the primary conservation features of the region (77) are represented in these zone types in the North-west CMRs and another seven features are in the zone types in either the South-west or North CMR Networks. These zones comprise 31.1 per cent of the CMR network and 9.7 per cent of the region.

Overall, the outcome in the North-west is close to comprehensive in terms of the four Goals, although addition of the remaining provincial bioregion (Central Western Shelf Transition) would provide a fully comprehensive coverage. The major deficiency in the North-west CMR Network is better coverage of depth ranges in Sanctuary Zones or Marine National Park Zones (nearly half of the 44 depth ranges that are not represented in the network are on the shelf or shelf edge). Addressing this would improve the performance of the North-west CMR Network against Principle 18.

Table 2.8 Performance of the North-west Commonwealth Marine Reserves Network

Goal	Primary conservation feature	Total number	Features* represented within network	Features represented in SZ and MNPZ (IUCN I and II)
1	Provincial bioregions	8	8	6
	Meso-scale bioregions	11	9[1]	5
2	Depth by provincial bioregion	83	81[2]	34
3	Key ecological features	13	8[3]	4
	Biologically informed seascapes	20	19	14
4	Seafloor types	19	15[4]	14
	Total	154	140	77

* This regional summary covers the features occurring in the region. The network also includes features that occur in neighbouring regions because of reserves whose borders extend into other regions.

[1] The two missing meso-scale bioregions are covered in the North CMR Network.

[2] One depth range is captured in the North CMR Network; one is not captured by any network.

[3] Two KEFs are captured in the North and one in the South-west; two North-west KEFs are missing from any network.

[4] All seafloor types are represented in a CMR in the North-west, South-west or North CMR Networks (however, the four features missing from the North-west CMR Network are: Basin, included in the North CMR Network;

Saddle, in the South-west CMR Network (Wallaby Saddle); Sill, in the North CMR Network; and Tidal–sandwave/sandbank, in the Joseph Bonaparte Gulf CMR (North).

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

The average size of the CMRs in the North-west is 25 803 km^2 and individual CMR areas range from 172 to 146 099 km^2.

2.5.7 North Commonwealth Marine Reserves Network summary

The North region is represented in eight CMRs and covers 20 per cent of the North region. The North CMR Network meets Goals 3 and 4, with all KEFs, BISs and seafloor types represented (see table 2.9). In terms of Goal 1, all provincial bioregions are represented in the network, but one meso-scale bioregion (Groote) is missing. Most depth ranges are included in the network, with two missing from any CMR. Of the 86 primary conservation features, 83 are included in the network. In terms of meeting the four Goals this is very good coverage, but a substantially smaller proportion (20 per cent) of the region is within the network—the least coverage of the four networks.

The North CMR Network does not perform well on Principle 18, with only two of the four provincial bioregions included in Sanctuary Zones or Marine National Park Zones. Less than one-third (28) of the 86 primary conservation features are represented in these zones, with depth ranges (four out of 24) and BISs (six out of 20) particularly poorly covered. Overall, only 10.8 per cent of the network and 2.7 per cent of the region is in Sanctuary Zones or Marine National Park Zones—the lowest proportions in the CMR estate. As no-take zones are key elements within CMR network design, this outcome was seen to be unsatisfactory.

The average size of the CMRs in the North CMR Network is 19 685 km^2, ranging in area from 1399 to 71 743 km^2.

Table 2.9 Performance of the North Commonwealth Marine Reserves Network

Goal	Primary Conservation Feature	Total number	Features represented within network	Features represented in SZ and MNPZ (IUCN I and II)
1	Provincial bioregions	4	4	2
	Meso-scale bioregions	15	14	6
2	Depth by provincial bioregion	24	22	4
3	Key ecological features	8	8	3
	Biologically informed seascapes	20	20	6
4	Seafloor types	15	15	7
	Total	86	83	28

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

2.5.8 Coral Sea Commonwealth Marine Reserve summary

The Coral Sea CMR covers the entire Coral Sea region and therefore meets all four of the Goals. At 989 842 km^2, it is a very large reserve by global standards.

It is close to meeting Principle 18 (five of six provincial bioregions in Marine National Park Zones) (see table 2.10). The one provincial bioregion (Central Eastern Transition) not represented in a Marine National Park Zone in the Coral Sea CMR is well represented in a GBRMP green zone. The one seafloor type not represented in Coral Sea Marine National Park Zone is represented in the Marine National Park Zone of the Central Eastern CMR in the Temperate East CMR Network.

The proportion of the CMR that is included in Marine National Park Zone (51 per cent) is the highest in the CMR estate. With 93 of a possible 119 primary conservation features represented in Marine National Park Zones, including 15 of 16 seafloor types, coverage of these features in Marine National Park Zones is very good. The majority of features not represented in Coral Sea Marine National Park Zones are depth ranges. Of the 24 depth ranges not represented, 23 are within two provincial bioregions (Cape Province in the north and Central Eastern Transition in the south). Most of these are shallower shelf and slope depth ranges and many are represented in GBRMP green zones. Nonetheless, the majority of Marine National Park Zones coverage of primary conservation features of the Coral Sea CMR is in the deeper waters of the reserve, and the only complementarity with adjacent GBRMP green zones occurs in the far north of the reserve.

The Coral Sea CMR bears some similarities with the four networks in terms of representativeness, with Marine National Park Zones covering large expanses of deep water, and with shallower depths and continental shelf in particular less well represented.

Table 2.10 Performance of the Coral Sea Commonwealth Marine Reserve

Goal	Primary conservation feature	Total number	Features represented within network	Features represented in SZ and MNPZ (IUCN I and II)
1	Provincial bioregions	6	6	5
	Meso-scale bioregions	–	–	–
2	Depth by provincial bioregion	94	94	70
3	Key ecological features	3	3	3
	Biologically informed seascapes	–	–	–
4	Seafloor types	16	16	15
	Total	119	119	93

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

2.5.9 Temperate East Commonwealth Marine Reserves Network summary

The Temperate East is the least comprehensive of the CMR estate, with 26 per cent of the Temperate East region in the network and 110 of the 155 primary conservation features in the region represented in the network (see table 2.11). While seven of 10 provincial bioregions are represented in the Temperate East CMRs, the remaining three are represented elsewhere in the CMR estate, with two in the Coral Sea and one in the South-east CMR Network. One meso-scale bioregion (Hawkesbury Shelf) is not represented in any CMR. The Temperate East CMR Network could be regarded as nearly meeting Goal 1.

The Temperate East CMR Network performs poorly on depth representation (Goal 2), with 36 depth ranges missing (one-third of the 109 depth ranges; however, three are represented in GBRMP, 17 in the Coral Sea CMR, 14 in South-east CMRs and one in state waters, leaving only one depth range missing entirely from the CMR network). Depth ranges comprise the majority of the 45 features in the region missing from the Temperate East CMRs. All KEFs and six out of nine BISs are better represented (Goal 3—80 per cent met), as are seafloor types (Goal 4—88 per cent included).

Representation of provincial bioregions (four out of 10) and primary conservation features (56 out of 155) in Sanctuary Zones or Marine National Park Zones is low, with 15.7 per cent of the network and 4.1 per cent of the region included in Sanctuary Zones or Marine National Park Zones.

Against these metrics, and especially in comparison to other networks, the Temperate East CMR Network performs poorly against the Goals and Principles. The major deficiency in representation is coverage on the continental shelf and representation of conservation features in Sanctuary Zones or Marine National Park Zones, most notably the three provincial bioregions that are primarily located on the continental shelf.

The average size of eight CMRs in the Temperate East is 47 919 km^2—the largest of the four networks—and individual CMR areas range from four to 188 443 km^2.

Table 2.11 Performance of the Temperate East Commonwealth Marine Reserves Network

Goal	Primary conservation feature	Total number	Features represented within network	Features represented in SZ and MNPZ (IUCN I and II)
1	Provincial bioregions	10	7	4
	Meso-scale bioregions	4	3	1
2	Depth by provincial bioregion	109	73	35
3	Key ecological features	6	6	4
	Biologically informed seascapes	9	6	1
4	Seafloor types	17	15	11
	Total	155	110	56

(MNPZ—Marine National Park Zones; SZ—Sanctuary Zones)

2.5.10 Discussion and findings

Comprehensiveness and representativeness

Overall, the proclaimed CMR estate includes the vast majority of the biodiversity surrogates (primary conservation features) on which the design of the networks was based. Measured against the four Goals it is largely comprehensive but with the Temperate East region the least comprehensive.

The Temperate East and North CMR Networks cover the smallest proportion of their regions and include the lowest proportion of network and region in Sanctuary Zones or Marine National Park Zones, contrasting with Marine National Park Zone coverage in the South-west and North-west CMR Networks.

The Goals and Principles recognise that there are constraints, especially socio-economic constraints, that must be balanced in designing a reserve network. The effects of these constraints, and minimising socio-economic costs, is most apparent when considering the design of the Temperate East CMR Network overall and the location and coverage of Marine National Park Zones in the Temperate East and North CMR Networks, but this is also apparent in the Coral Sea. Broadly, what is missing or deficient is coverage by CMRs and

Marine National Park Zones on the continental shelf, which reflects the greater use and immediate economic value of these waters.

For these reasons in particular, the CMR estate has attracted criticism from members of the scientific community for failing to meet CAR objectives. Examples of criticisms include extent of coverage (Barr and Possingham 2013; Hobbs 2014; Grech *et al.* 2014); adequacy of protection for threatened species (for example, Devitt *et al.* 2015); governance and process (for example, Vince 2014); lack of integration and loss of coherence and complementarity with state MPA planning processes and MPAs (for example, Vince *et al.* 2015); and the approach taken on socio-economic assessment and impacts on the fishing industry (Ernst and Young 2012). Some of these criticisms are valid, as shown above. However, broad statements about representation of conservation features and lack of comprehensiveness are not consistent with the above assessment when considering the overall CMR estate.

The analysis of representativeness of the national MPA estate, including state and territory waters and the GBRMPA, by Barr and Possingham (2013) was based on representation of IMCRA bioregions, some of the geomorphic and ecological features in each CMR planning region (but not consistently between regions) and four types of seafloor topography as bathymetric classes: continental shelf, continental slope, continental rise, and abyssal plain. As described elsewhere in this report, the approach taken to design the CMR network involved the use of a wide range of biodiversity surrogates, including 347 depth ranges. The analysis of Barr and Possingham (*op. cit.*) included a measure (protection equality) of how equal representation is between regions. They concluded, on this basis of these criteria and focusing on no-take zones, that the proclaimed estate did not meet the basic measures of representation. Some of their criticism, echoed by others, is the absence of quantitative targets in the design of the CMR estate and especially for representativeness or coverage by no-take areas. Much of this criticism is valid and is generally consistent with the performance assessment in this section, particularly in terms of representation of continental shelf in no-take zones.

The assessment in this section identifies the North and Temperate East regions as the least comprehensively covered by the CMR networks. However, it should be noted that there is some complexity in comparing past analyses that examine the proclaimed CMR estate network by network (or region by region), as the figures depend on which network is regarded as including particular CMRs. Oceanic Shoals, which extends across the North-west and North regions, is regarded in the analysis in this section as occurring in the North region, and the Abrolhos CMR, which extends from the South-west into the North-west region, is included in the South-west calculations. An additional complexity in taking a region-by-region approach is that some features, notably provincial bioregions and depth ranges, extend across regions and could be double-counted if an overall picture is produced by simply summing the outcomes from each region.

The observation by Hobbs (2014) that the Indian Ocean Territories that include Christmas Island and the Cocos (Keeling) Islands were not included at all in the design of the proclaimed estate is evident. This is a gap in conservation planning and the comprehensiveness of the CMR estate. While some preliminary assessment had been conducted for the Government on the conservation values of the region as a basis for the design of a CMR network in the Indian Ocean Territories (Brewer *et al.* 2009), this did not advance to a proposed network.

In one of the few analyses published on threatened species in marine reserves in Australia, Devitt *et al.* (2015) assessed the adequacy of protection of four species of sawfish—arguably the most threatened group of marine fishes (Faria *et al.* 2013; Dulvy *et al.* 2014)—and concluded that marine protection targets had been met for all four species.

<u>Adequacy</u>

The core element of adequacy is the extent to which a reserve or network has long-term viability. Persistence, integrity and resilience are key concepts underpinning adequacy of a reserve network. Well-designed systems of individual reserves are generally considered to be superior to isolated individual reserves, as they can provide meaningful spatial relationships amongst sites for the maintenance of ecosystems and connectivity and offset the effects of local catastrophes (McCook *et al.* 2010; Rice and Houston 2011; Grorud-Colvert *et al.* 2014; Lagabrielle *et al.* 2014). Two key design features for adequacy are replication and size (that they are large enough for natural processes to persist and that the populations, communities and species protected are ecologically viable) (ANZECC 1998). Replication improves the likelihood of regional persistence, spreading the risk of failure by providing greater opportunity for recolonisation from other viable and connected areas (Magris *et al.* 2014). Large protected areas are generally held to be more effective for biodiversity conservation than small areas, as more species and associated ecosystem processes will be protected in a larger area and individual species are more likely to have their critical life stages protected (Edgar *et al.* 2014)—although, as discussed in chapter 3, the science underpinning the adequacy and size of no-take areas is a matter of debate.

The size of the individual 44 CMRs in the proclaimed estate ranges from four to 989 842 km^2, with a mean area of 53 971 km^2 and a median area of 6217 km^2. All but one of the 44 CMRs that comprise the four networks and the Coral Sea CMR are larger than the 100 km^2 minimum size suggested by Edgar *et al.* (2014). Given the dimensions and location of the majority of the CMRs, and their overall coverage of over one-third of the marine area, size is likely to be more important than replication in contributing to the adequacy of the CMR estate. These new CMRs are very large in comparison with the vast majority of the marine protected areas and no-take reserves that have been studied and reported in the scientific literature. Studies on the efficacy of very large pelagic reserves (greater than 100 000 km^2) are in their infancy, as most of these very large reserves have only recently been established.

In summary, while the establishment of the CMR estate through the four networks and the Coral Sea CMR proclaimed in 2012 and the South-east CMR Network proclaimed in 2007 represents the most extensive and comprehensive ‘whole-of-ocean’ approach to marine conservation by any country, there are some gaps to be addressed in due course. In terms of the CBD Aichi Target 11, the most significant issue ahead is to ensure that the key element of that target, that the reserves are ‘effectively and equitably managed’, is clearly and resolutely addressed.

ESP finding

The proclaimed Commonwealth marine reserve (CMR) estate constitutes a credible outcome based on biodiversity surrogates that are, in the great majority, represented in the CMR networks and CMRs.

Some significant gaps in coverage exist and should be addressed in due course to ensure a more comprehensive and adequate inclusion of a representative sample of Australia’s marine biodiversity in the national CMR estate.

The Expert Scientific Panel recognises the constraints on CMR design from socio-economic factors that have limited the capacity to obtain full representation of all surrogates within the CMR estate and that these factors will remain limitations given the importance of continuity of access for many users of the marine environment. However, the ESP encourages the current and successive governments to address the significant shortfalls in representativeness of the CMR estate as opportunities arise and during future planning cycles, with a priority on amending the outer boundaries of existing CMRs and/or designing new reserves to improve representation in the Temperate East Marine Region and Indian Ocean Territories in particular.

2.6 Conclusions

In light of the information set out in this chapter and appendix 2, the ESP is of the view that the CMR estate makes a significant contribution to the NRSMPA, though there are areas that can be improved in the Temperate East CMR Network and the provincial bioregions associated with Australia’s Indian Ocean territories that were not considered as part of the Marine Bioregional Planning Programme.

Based on the information available at the time:

- The marine bioregional planning process, which was underpinned by IMCRA and the use of surrogates and complemented by scientific workshops and literature review, was a sound basis for designing the CMRs that were proclaimed in 2012.
- The process for determining fishing gear risk was appropriate.
- The risk management processes in place for activities in CMRs were appropriate.

Notwithstanding these conclusions, a number of areas of contention have been identified since the CMRs were proclaimed. Those areas of contention which relate to the science underpinning zoning and allowed uses for the CMRs have been addressed by the ESP, in response to requests for advice from the BAP, in chapter 3 of this report.

Chapter 3 Assessments of new scientific information to support Commonwealth marine reserve zoning and management decisions

The Expert Scientific Panel (ESP) terms of reference included providing advice on options for zoning and allowed uses consistent with the Goals and principles for the establishment of the National Representative System of Marine Protected Areas in Commonwealth waters (the Goals and Principles). Noting the extensive scientific process that underpinned the design of the Commonwealth marine reserves (CMRs) proclaimed in 2012, as outlined in chapter 2, and mindful of work of the Bioregional Advisory Panel (BAP) to identify possible new zoning boundaries for the CMR estate, the ESP focused its work on this term of reference on new science directly relevant to the needs of the BAP.

The BAP referred a number of matters to the ESP for advice. These matters related to areas of contention identified through the BAP consultation process. They are listed in table 3.1 and are addressed in this chapter. The associated findings were communicated to the BAP for consideration in formulating recommendations on zoning options. Broadly, these matters related to:

- concerns about the applicability of Fishing Gear Risk Assessment (FGRA) findings to certain gear types in certain areas of the CMR estate (section 3.1)
- concerns about the impact of recreational fishing (section 3.2)
- concerns about the effectiveness of different zone types (section 3.3)
- the need to have up-to-date scientific information for particular marine features and particular CMRs (sections 3.4 and 3.5).

Table 3.1 Issues referred by the Bioregional Advisory Panel to the Expert Scientific Panel for advice

Advice request	CMR and/or network to which the request related	Relevant section of ESP report
Evaluate the process used to determine fishing gear risk for CMRs.	Estate-wide	2.3.5
Review the FGRA rating for demersal automatic longline gear in the Southern and Eastern Scalefish and Shark Fishery.	Central Eastern CMR Coral Sea CMR	3.1.1
Review the FGRA rating for demersal (prawn) trawl in the Northern Prawn Fishery.	Gulf of Carpentaria CMR North CMR Network	3.1.2
Review the FGRA for the former Northern Territory Finfish Trawl Fishery in relation to semi-demersal trawl.	Oceanic Shoals CMR Arafura CMR	3.1.3
Review the FGRA rating for Western Australian trawl fisheries in relation to demersal (scallop) trawl.	Bremer CMR Geographe CMR	3.1.4

Advice request	CMR and/or network to which the request related	Relevant section of ESP report
Assess recreational fishing in relation to CMRs.	Estate-wide	3.2
Assess how different CMR zone types contribute to achieving conservation objectives and the potential merits of split zoning over coral reefs in the Coral Sea.	Estate-wide	3.3
Assess the value of specific marine features, systems and processes, including: • connectivity • the pelagic system • the continental shelf and slope • canyons and seamounts.	Estate-wide	3.4
What new information is there on the conservation values of the: • Coral Sea CMR • Geographe CMR • Bremer CMR • Perth Canyon CMR • Oceanic Shoals CMR	Coral Sea CMR Geographe CMR Bremer CMR Perth Canyon CMR Oceanic Shoals CMR	3.5

3.1 Fishing Gear Risk Assessment reviews

As discussed in chapter 2, a series of FGRAs were undertaken to assess the risk of fishing gears to biodiversity in marine regions. The ESP assessed that the process which underpinned the 2010 FGRAs drew on the best information available at the time and was appropriate in the circumstances. However, new scientific information relevant to several of the 2010 FGRAs—specifically for trawling in areas of the North, North-west and South-west CMR Networks and demersal longline in the Temperate East—is available. At the request of the BAP, the ESP reviewed this new information against the original FGRA outcomes to assist the BAP's development of recommendations on zoning options.

3.1.1 Review of the Fishing Gear Risk Assessment rating for demersal automatic longline gear specifically in relation to operations in the Coral Sea Commonwealth Marine Reserve and the Central Eastern Commonwealth Marine Reserve

Description of the location and habitat[9]

The Coral Sea and Temperate East Regions cover deepwater tropical and sub-tropical ecosystems which are dominated by the East Australian Current (EAC). With its associated eddy fields, the EAC forms large-scale, spatially predictable and ecologically important pelagic features off the east coast of Australia. The flow of these localised features is thought

[9] DEWHA (2009a) except where otherwise indicated by in-text references.

to create a barrier to larval dispersal, thus contributing to the high endemism and localised distribution of species in the region.

The majority of the eastern side of the Coral Sea CMR is deepwater, between 500 m and 2000 m, but has a significant number of seamount/guyot and saddle features which are part of the northern extent of the Tasmantid seamount chain. This chain of submerged volcanoes extends for 2000 km from the southern Coral Sea to the Tasman Basin, running north–south at approximately 155°E longitude. In the Coral Sea CMR it includes Kenn, Wreck, Cato and Fraser seamounts (DNP 2014a). Further south in the Central Eastern CMR are the Queensland and Brittania guyots and the Stradbroke, Derwent–Hunter, Barcoo and Taupo seamounts. None of these southern seamounts breaks the surface and the tops of the seamounts range in depth from around 130 m at Taupo to approximately 1800 m at Stradbroke (DNP 2014b).

The Tasmantid seamount chain is shown in figure 3.1. Taupo seamount is the largest seamount at 60 km in diameter at its base. It rises from 4800 m to a flat top only 130 m below sea level. This shallow platform, with relief of less than 10 m, is approximately 40 km north to south and up to 15 km wide. In addition to those seamounts mentioned above, many smaller unnamed and unsurveyed seamounts occur along the chain as well as subsidiary cones on the flanks of larger eminences (DNP 2014b).

The slopes on the sides of the seamounts are commonly in the range of 10 to 20 degrees but locally can be much steeper or form flat terraces cut at historical sea levels. These slopes consist of rugged rock outcrops, with boulders and blocks covered by a relatively thin layer of sediment. The seamounts shed sediment to the adjacent seabed to form an apron at their base. In some cases, this apron is removed by bottom currents to form a moat.

The seamounts have been found to have different morphologies supporting a diverse range of habitats in temperate and subtropical waters, with high levels of endemism. They comprise a unique deep-sea environment characterised by substantially enhanced currents and a fauna that is dominated by suspension feeders such as corals. Seamounts form distinctive marine habitats that provide topographical structure across the continental slopes and abyssal plains of the deep sea, altering oceanic circulation patterns with local upwellings, turbulent mixing and closed circulation cells. Topographically-induced upwelling at seamounts and the interaction between eddies and seamounts can create conditions that lead to concentration of pelagic productivity around seamounts and conditions conducive to the establishment of deep-reef communities dominated by filter feeders. Flow acceleration is favourable for recruitment and growth of passive suspension feeders, as shown by the relatively high abundance of corals on seamount peak edges where periods of flow acceleration have been observed.

The Tasmantid seamount chain is a key ecological feature (KEF) of both the Coral Sea and Central Eastern CMRs (DNP 2013b, 2013c). The major conservation values in the Coral Sea and Central Eastern CMRs are described in tables 3.2 and 3.3.

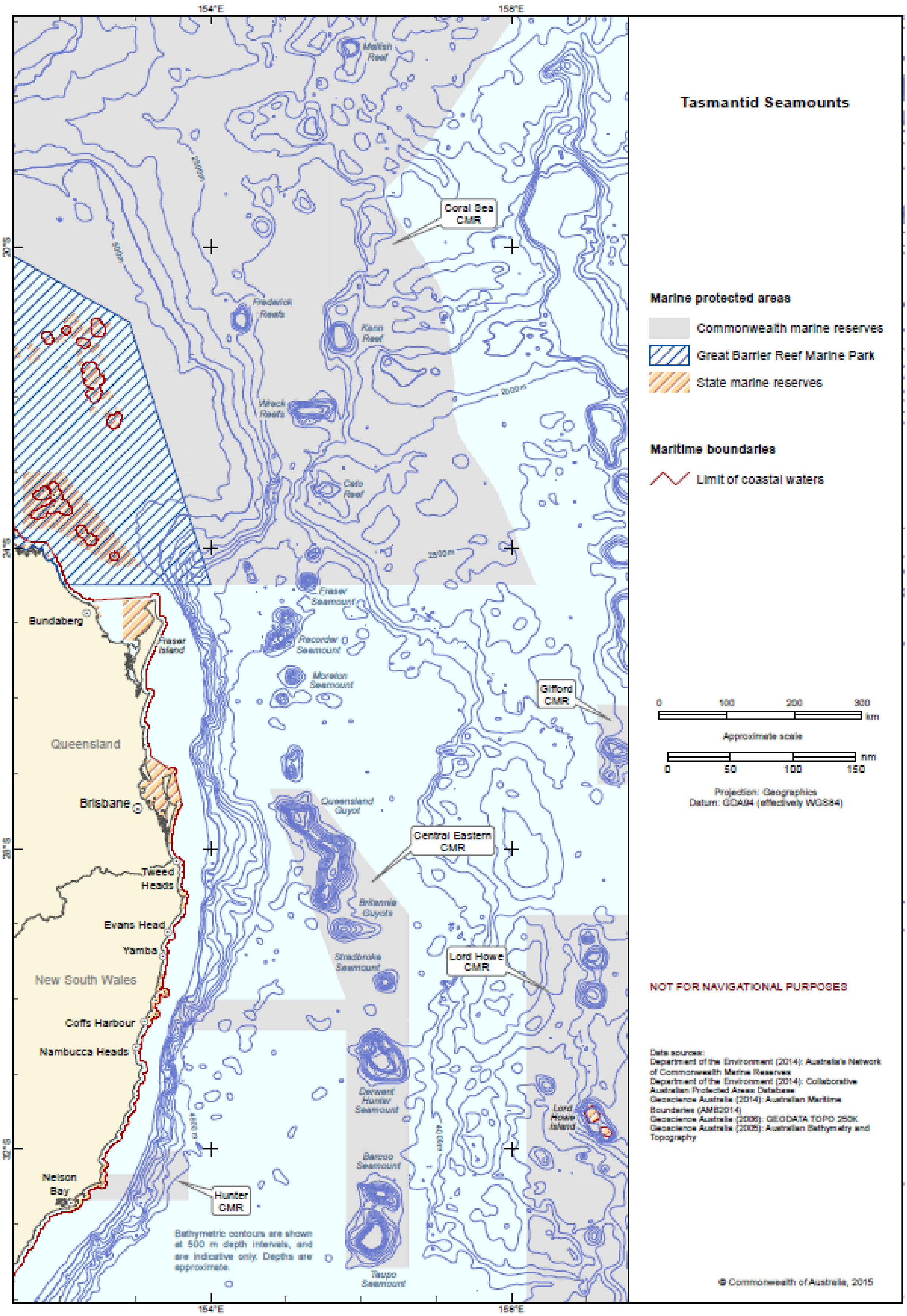

Figure 3.1 The Tasmantid seamount chain and its relationship to the Coral Sea and Central Eastern Commonwealth Marine Reserves

Table 3.2 Conservation values of the Coral Sea Commonwealth Marine Reserve* (after DNP 2014a and 2013c)

Conservation values	Description
Depth	15–5000+ m.
Seafloor features	Abyssal plain / deep ocean floor; apron / fan; basin; canyon; continental rise; deep/hole / valley; knoll / abyssal hill / hill / mountain / peak; pinnacle; plateau; reef; ridge; saddle; seamount/guyot; slope; terrace; trench / trough.
Key ecological features	Reefs, cays and herbivorous fish of the Marion Plateau. Reefs, cays and herbivorous fish of the Queensland Plateau. Tasmantid seamount chain.
Species	The reserve supports: • populations of large pelagic fish, including blue trevally, barracuda and tunas, as well as grey reef, silvertip and whitetip reef sharks • populations of highly migratory pelagic species, including small fish schools • manta rays and other fish, including humphead maori wrasse, yellowfin and bigeye tuna, and potato cod. Black marlin undergo seasonal movements into the Queensland Plateau area • high sponge diversity and endemic demersal sponge communities that are distinct from those found on the Great Barrier Reef • communities of shallow and deepwater corals, as well as crabs, echinoderms and cephalopods. Habitats and important areas for species in the reserve include: • breeding and calving grounds for humpback whales during their annual migration along the east coast of Australia • nesting and inter-nesting sites for green turtles • likely foraging grounds for hawksbill turtles • an aggregation site for whale sharks • breeding and foraging areas for a number of seabirds, including masked booby, black noddy, black-naped tern, brown booby, common noddy, crested tern, lesser frigatebird, red-footed booby, red-tailed tropic bird, sooty tern and wedge-tailed shearwater.

* Representing the Cape Province, Central Eastern Transition, Kenn Province, Kenn Transition, North-east Province, North-east Transition provincial bioregions.

Table 3.3 Conservation values of the Central Eastern Commonwealth Marine Reserve* (after DNP 2014b and 2013b)

Conservation values	Description
Biological seascapes	Represents two seabed assemblages (which are derived from sediment and depth data). Cluster 7: 137–235 m depth; very low range of seabed oxygen; very low range of water temperature at the seabed; low range of benthic irradiance. Cluster 8: 275–357 m depth; very low range of benthic irradiance.
Depth	120–6000 m.
Seafloor features	Abyssal plain / deep ocean floor; canyon; knoll / abyssal hill / hill / mountain / peak; pinnacle; seamount/guyot; slope.
Key ecological features	Canyons on the eastern continental slope (part of one of three shelf-incising canyons occurring in the region). Tasmantid seamount chain (known breeding and feeding areas for a number of open ocean species such as billfish and marine mammals).
Species	The reserve contains biologically important areas for the protected humpback whale, vulnerable white shark and a number of migratory seabirds.

***** Representing the Central Eastern Province, Central Eastern Shelf Transition and Tasman Basin Province provincial bioregions and the Tweed–Moreton meso-scale bioregion.

Gear type and relevant fisheries

Automatic longline (auto-longline) refers to the fishing method also known as demersal or bottom longline, whereby automatically baited lines are set horizontally on or in close proximity to the seafloor and held in place with anchors and floats (see figure 3.2). Longlines can be many kilometres in length and can incorporate as many as 15 000 hooks, but they typically involve one to four magazines, with each magazine storing 1500 hooks. The gear usually comprises a main line with hooks spaced every 1.3 m on 40 cm monofilament or braided cord lines called ‘snoods’. The main line is anchored at each end and attached to a downline which is buoyed with a dan pole and flag for ease of location. Auto-longline differs from other demersal longline fishing in that hooks are baited by a machine rather than by hand.

Gear is often deployed at dusk and normally left to ‘soak’ for around six to eight hours before being hauled. The main line is lowered over the stern of the vessel, where tori lines[10] are used to deter birds from diving on the baits. Hauling is done from one end over a roller mounted on the gunnels using hydraulic winches (Daley *et al.* 2007).

[10] Bird-scaring lines used to minimise seabird bycatch while fishers are setting longline gear (AFMA a).

Auto-longlines are deployed to catch finfish on or near the seafloor, typically in waters between 200 m and 800 m deep along Australia's continental shelf break and slope.

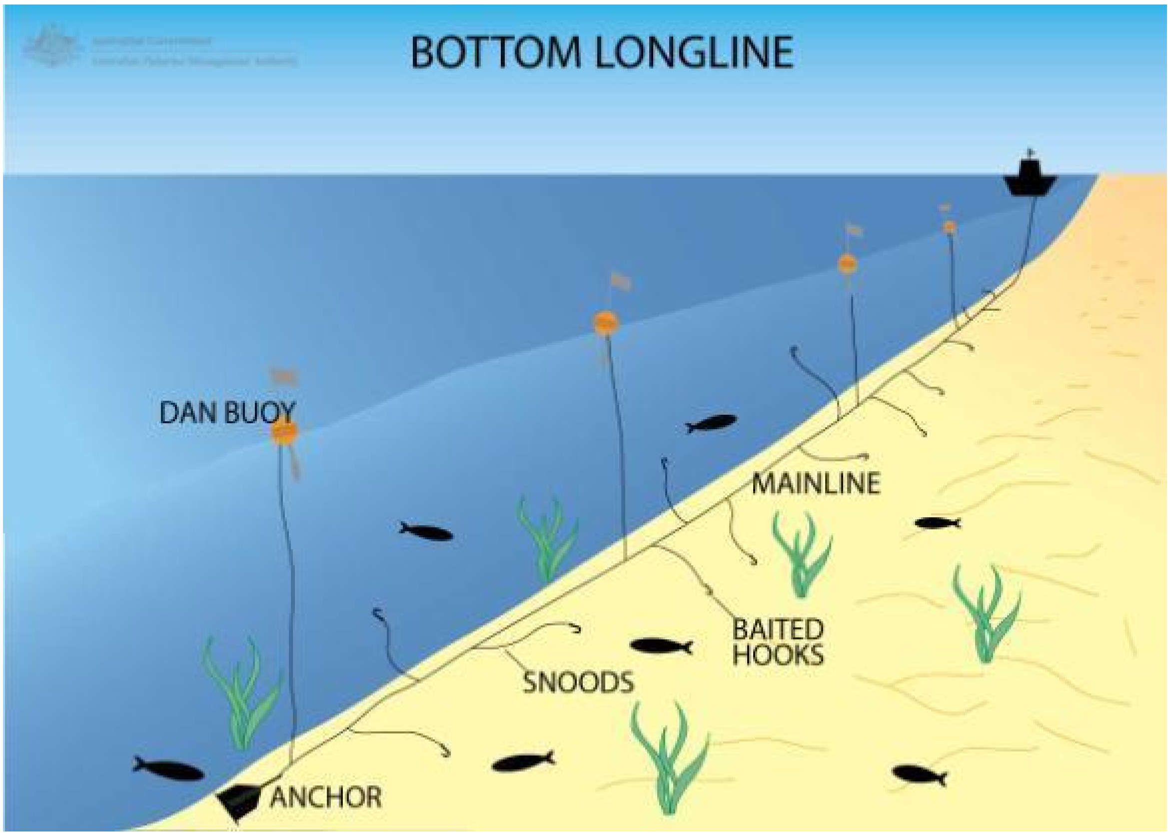

Figure 3.2 Bottom (demersal) longline fishing gear (AFMA)

In the Temperate East Region demersal longlining is part of the Gillnet, Hook and Trap Sector of the larger Commonwealth Southern and Eastern Scalefish and Shark Fishery (SESSF). This is a multi-sector, multi-species fishery that occurs in almost half of the Australian fishing zone (AFZ). It stretches south from Fraser Island in southern Queensland, around Tasmania, to Cape Leeuwin in southern Western Australia. The auto-longline fishery includes all Commonwealth waters of the AFZ off South Australia, Victoria and Tasmania that are deeper than 183 m. It also includes waters off southern Queensland (south of Sandy Cape) and New South Wales from approximately the 4000 m depth contour (60–80 nm from the coast) to the extent of the AFZ. Waters inside this line off the New South Wales and Queensland coasts, and inside 3 nm around South Australia, Victoria and Tasmania, are managed under the jurisdiction of the state governments (AFMA 2014a).

Current management arrangements in the SESSF restrict fishing by scalefish auto-longline vessels to waters deeper than 183 m to prevent targeting of school and gummy shark. The main target species are blue-eye trevalla (*Hyperoglyphe antarctica*), pink ling (*Genypterus blacodes*), with ribaldo (*Mora moro*), hapuku (*Polyprion oxygeneios*) and ocean perch (*Helicolenus barathri* and *H. percoides*) being other important commercial species.

The major markets for the scalefish auto-longline sector are in southern and eastern Australia. The amount of effort in this sector peaked in 2005 at 9 776 448 hooks set, decreasing to 4 280 916 hooks set in the 2011–12 season.

In the Coral Sea CMR, demersal longlining (including auto-longlining) is part of the Line, Trap and Trawl Sector of the Commonwealth Coral Sea Fishery, which targets finfish and shark species. The fishery extends from Sandy Cape, Fraser Island, to Cape York and east of the Great Barrier Reef Marine Park (GBRMP) outer boundary through to the edge of the AFZ. There is a small focus on the Northern Plateau edges, with most fishing on localised areas of the seamounts. Fishing occurs between 30 m and 600 m, but observer coverage indicates that 50 per cent of lines are set at depths greater than 200 m. Because of small numbers of vessels, confidentiality agreements prohibit disclosure of catch and effort. Reef and seamount species are targeted: this includes a broad range of finfish, including tropical snappers and emperors (*Lethrinidae*, *Pristipomoides* or *Lutjanidae*), eyeline snapper (*nemypterids*), coral cod (*Epinephelus* spp., *Serranidae*), jobfish (*Lutjanidae*) and coral trout (*Plectropomus leopardus*). Depending on the area being fished, other species, such as blue-eye trevalla and shark (Furlani *et al.* 2007), may also be targeted.

East Marine Region[11] Fishing Gear Risk Assessment

Demersal longline (including auto-longline) was assessed as part of the East Marine Region FGRA (Morison and McLoughlin 2010). This assessment noted several fisheries that were entitled to use this method, including the Coral Sea Fishery, the SESSF, the New South Wales Ocean Trap and Line Fishery and several Queensland line fisheries.

The fisheries of interest here are the SESSF Scalefish Hook Sector, which uses auto-longline gear in the Central Eastern CMR; and the Line, Trap and Trawl Sector of the Coral Sea Fishery, which uses demersal auto-longline.

Morison and McLoughlin (*op. cit.*) noted that the majority of effort by line fishing methods takes place in waters to the south of the East Marine Region, though there had been a small amount of exploratory activity in the Tasmantid – Lord Howe Area for Further Assessment. They noted that the SESSF auto-longline Level 2 Ecological Risk Assessment (ERA) (Daley *et al.* 2007) examined 149 habitat types and found 17 at high risk, predominantly on the upper continental slope (200–700 m). This risk arose partly from ability of auto-longline fishing to target bottom types not fishable by trawling. A key uncertainty was the effect of movement of the main line itself on large, erect and fragile epifauna. The Level 2 ERA found 56 species to be at high risk, mostly shark and seabird species (two target species, 13 by-product species, 14 bycatch species and 27 TEP species). By taxa, 21 were chondrichthyans, 26 were marine birds, eight were teleosts and one was a marine mammal.

[11] The Coral Sea CMR and Central Eastern CMR are located within the former East Marine Region, which was used as a planning region in the marine bioregional planning process.

Residual risk assessment and the Level 3 Sustainability Assessment of Fishing Effects (SAFE) ERA identified nine species (two teleosts, two skates and five deepwater sharks) at high ecological risk. These species, high priorities for ecological risk management (ERM), were blue-eye trevalla, hapuku, bight skate, grey skate, blackbelly lantern shark, Harrisson's dogfish, greeneye dogfish, platypus shark and southern dogfish (AFMA 2010a).

Morison and McLoughlin (*op. cit.*) describe two key issues that emerged from the available analyses of demersal longline fisheries in the East Marine Region which they state were consistent with the findings for risk analyses in other regions. Both were related to direct impacts from fishing:

- potential damage to seafloor habitats by the longline gear
- potential impacts on turtles and impacts on sharks and rays (in particular, deepwater shark species).

The ERA for the auto-longline sector of the SESSF identified high risks to both hard and soft bottom habitats on the outer shelf (100–200 m) and the upper slope (200–700 m) and in upper slope canyons (100–1500 m). Many of these habitats were also accessible to trawl. Morison and McLoughlin (*op. cit.*) noted that the Coral Sea Fishery ERA acknowledged the potential risks to habitats from demersal longlines, but the assessment was silent on risks to seamounts. All six species of turtle are listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), but data on interactions with turtles by auto-longline is limited.

Morison and McLoughlin (*op. cit.*) noted that chondrichthyans were a common component of demersal longline catches in the East Marine Region. Catches of shark were often poorly documented and limited information was available detailing where shark catches were taken and which species were taken. Several species have been identified at high risk in assessments across the East Marine Region demersal longline fisheries and the risks assessed for chondrichthyans using the Level 3 SAFE method (Zhou *et al.* 2007) were thought to have been underestimated (Zhou *et al.* 2009).

Based on their assessment, demersal longline gear (including auto-longline) was rated as an 'Unacceptable' level of risk (pending further assessment). This assessment took into account:

- the high risk findings for benthic habitat impacts by the ERA for auto-longline gear
- a lack of information about the nature and extent of the grounds fished by these methods
- the high risk findings for several chondrichthyan species, including deepwater shark, which are considered to be least sustainable; and potential interaction with grey nurse shark.

Review of the assessment of the East Marine Region Fishing Gear Risk Assessment

A review of the FGRA undertaken by Daley (2010) suggested that the FGRA for the East Marine Region was largely accurate for the gear types considered in terms of their current use and foreseeable use in fisheries in the medium term (10 years). In part this time frame was constrained by use of ERA reports based on current effort footprints.

Overall the methodology was supported, but it cautioned against the use of ERA results from other fisheries in assessing risk in the East Marine Region. There was also concern that data limitations could lead to an underestimation of risk, especially to chondrichthyans.

While the review of the FGRA for the East Marine Region by Bodsworth and Knuckey (2011) considered aspects of the broader FGRA process, it did not address issues of direct relevance to auto-longline in the Central Eastern CMR or Coral Sea CMR.

Ecological Risk Assessment

Southern and Eastern Scalefish and Shark Fishery:

The Australian Fisheries Management Authority (AFMA) continues to update detailed ERAs for all major and minor Commonwealth managed fisheries as a key part of the move towards ecosystem-based fisheries management. A Level 2 Probabilistic Safety Analysis (PSA) Residual Risk Analysis for non-teleost and non-chondrichthyan species in the auto-longline sector of the SESSF was completed (AFMA 2012a). This assessment focused on species assessed as at high risk in 2010 (AFMA 2010a). Overall, 29 high risk species were reassessed, including 27 seabird species and two marine mammals. All of these had their risk scores reduced, as a Threat Abatement Plan (TAP) had been introduced for all bird species, which has a high level of compliance within the scalefish auto-longline sector of the Gillnet, Hook and Trap Sector. The Australian fur seal was added to the assessment because of 59 interactions in 2009; however, no interactions have been recorded since. For this reason, based on the number of interactions in the fishery, both Australian fur seal and Hector's beaked whale had their risk scores reduced (AFMA 2014a).

The Level 3 SAFE methodology was updated to include the most recent fishery distribution and effort data, and new species from logbook and observer data. The analysis was applied to all teleost and chondrichthyan species for six major methods in the SESSF, including auto-longline in the Gillnet, Hook and Trap Sector (Zhou *et al.* 2012).

The Level 3 SAFE analysis was applied to all teleost and chondrichthyan species in the SESSF regardless of their Level 2 PSA scores. However, without application of the residual risk guidelines, it was likely that a number of the high risk species were false positives, as management arrangements and bycatch mitigation strategies were not considered. AFMA in consultation with the Commonwealth Scientific and Industrial Research Organisation (CSIRO) agreed that it would be appropriate to apply residual risk guidelines and expert overrides to some of the 2012 risk scores. This allows management measures and interaction levels to be taken into account to determine the risk level (AFMA 2014a).

The following methodology was used:

1. For all species scored as high risk in the 2012 Level 3 SAFE analysis, record the Level 2 PSA risk score from 2007. The productivity and susceptibility scores are unlikely to have changed.
2. Apply the residual risk guidelines to the Level 2 PSA risk scores from 2007.
3. Those species which have had their risk scores downgraded will be removed from the list of priority species to be addressed in the Ecological Risk Management response.

This assessment found that five species had an estimated fishing mortality rate greater than F_{crash}—the minimum unsustainable fishing mortality rate that will lead to population extinction in the long term. When uncertainty in both estimated fishing mortality rates and reference points are included in the analysis, 15 species were assessed as at least precautionary high risk. However, when a Residual Risk Analysis was performed on this group, the number of species that remained as high risk was reduced to seven. They were Harrisson's dogfish, southern dogfish, greeneye spurdog, grey skate, sawtail catshark, bight ghost shark and hapuku.

A recent comparison of fish assemblages off south-east Australia based on automatically baited longlines and baited remote underwater video (BRUV) revealed that longlines were particularly effective in catching chondrichthyans (McLean *et al.* 2015). Their study also revealed an expected fishing mortality of greater than 50 per cent for gulper sharks, as only 43 per cent were in a condition suitable for tagging.

Coral Sea Fishery:

For the Coral Sea Fishery, the preliminary Level 1 ERA and a semi-qualitative Level 2 ERA for chondrichthyans and TEP species has been undertaken (AFMA 2010b). No ecological components were eliminated at Scoping or Level 1 (there was at least one risk score of 3—moderate—or above for each of the components). Most hazards (fishing activities) were eliminated at Level 1 (risk scores 1 or 2). Six issues emerged from the ERA Level 1 analysis of the Coral Sea Fishery auto-longline sub-fishery (Furlani *et al.* 2007):

- Fishing capture was identified as a hazard to Target, By-product, Habitat and Communities components, largely as a result of repeated effort on fairly limited fishing grounds and the consequent risk of localised depletion. Information on target and bycatch species is limited.
- Fishing activity without capture was identified as a habitat hazard due to the nature of the gear set and the lack of regeneration information for tropical-water habitats. Erect, inflexible and fragile fauna are at risk, especially during setting and recovery if currents are strong. Regeneration times for most deepwater species are thought to be long.
- Gear loss without capture was identified as a hazard to species components, with Fishing Activity Reports noting the regular occurrence of gear loss. The absence

of data, or mitigating measures, has produced a low confidence score in the assessment of this moderate hazard.

- Translocation of species was identified as a moderate hazard to Target, By-product and TEP components and a major risk hazard to Habitat and Community components. This risk arises through hull fouling and bilge water as well as the use of imported baits.
- Provisioning was identified as a hazard to the TEP component. Birds are known to be attracted to baited hooks, and the hazard presented by auto-longline fishing has been well documented in other fisheries. For the Coral Sea Fishery, the use of tori lines is a permit condition as a means of mitigating this risk.
- Gear loss impact, through the addition of non-biological material, was identified as a hazard to species components. Remaining lines and hooks continue to present an entanglement hazard. The lack of data to assess this risk has resulted in a low confidence score.

Additionally, for the Coral Sea Fishery line sector, three main groups—turtles, bathyl sharks (at water depths greater than 200 m) and reef sharks—were identified through the semi-qualitative Level 2 ERA process. The greatest bycatch issue identified to date in the Coral Sea Fishery is considered to be the potential interaction of TEP species such as turtles and sharks (AFMA 2010b).
Information on this fishery is sparse. Williams *et al.* (2012) highlighted the lack of data in relation to protected shark species for the Fraser Seamount, noting it is within the distribution range of the Harrisson's dogfish. There is no bycatch action plan currently in place for the Coral Sea Fishery, with the Coral Sea Fishery Bycatch and Discarding Workplan 1 July 2010 to 30 June 2012 (AFMA 2010b) being on hold pending finalisation of the Coral Sea CMR and any associated industry adjustment (AFMA 2013). Monitoring of all catches of target species has been recommended for this sector to allow consideration of trends and develop management responses (Furlani *et al*. 2007) Under the 2010–2012 bycatch and discarding workplan, a fisheries monitoring programme was in place. This programme required verification of catch logbooks and deployment of observers (AFMA 2010b).

AFMA continues to monitor the catch of target species, which is reported in its annual fishery status reports (Patterson *et al.* 2015).

Provisions to limit catches in the Coral Sea Fishery include trip limits for deepwater sharks (introduced in 2010) and limits (in kilograms per permit, similar to those used in the SESSF as part of the stock-rebuilding strategy for the upper-slope dogfish) for all deepwater sharks that occur in the Coral Sea Fishery, believed to be about 19 species (AFMA 2010b).

The diverse range of species in the Coral Sea Fishery, frequent exploratory and variable fishing undertaken in the fishery, generally low level of fishing activity and limited opportunity to undertake research and collect data means that differentiating target species from bycatch and discard species can be difficult (AFMA 2010b).

Ecological Risk Management

There is no ERM strategy for the Coral Sea Fishery. The ERM strategy for the SESSF (AFMA 2015) sets out the management actions necessary to support the objectives of the *Fisheries Management Act 1991* and Commonwealth Policy on Fisheries Bycatch 2000—in particular:

> *ensuring that the exploitation of fisheries resources and the carrying on of any related activities are conducted in a manner consistent with the principles of ecologically sustainable development (which include the exercise of the precautionary principle), in particular the need to have regard to the impact of fishing activities on non-target species and the long term sustainability of the marine environment.*

To pursue this, the objectives of this ERM strategy are to:

- implement management arrangements to minimise fishing impact on non-target species and habitats, with a particular focus on high-risk species and habitats assessed through AFMA's ERA process
- minimise interactions with species listed under the EPBC Act, excluding conservation dependent species.[12]

The ERM strategy describes a number of management tools, which broadly fall into two categories: input controls and output controls. Input controls limit the amount of effort in a fishery, indirectly controlling interactions with target, by-product, bycatch and threatened, endangered or protected (TEP) species. Output controls directly limit the number of species which can be taken from the water or interacted with.

Key to this ERM strategy is addressing the seven high-risk species as assessed through the ERA process (AFMA 2014a); however, it also addresses broader aspects of bycatch and habitat interactions, with a number of measures aimed at mitigating impacts as outlined below (AFMA 2015).

Marine mammals

While no marine mammals were identified at high risk from auto-longline, mitigation strategies include:

- spatial closure
- hook limitations
- anchorage of gear to the seafloor
- electronic monitoring on all vessels.

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[12] Some key commercial species are listed under the EPBC Act in the category of conservation dependent. However, these species are managed in accordance with the Commonwealth Fisheries Harvest Strategy Policy under species-specific rebuilding strategies and therefore do not fall under the ERM framework, with the exception of school shark, which is currently assessed as high risk under the ERA.

Sharks, skates and rays

Mitigation strategies include:

- size limits and trigger limits
- fishers must not retain Harrisson's dogfish, southern dogfish, endeavour dogfish and greeneye dogfish
- mandatory handling practices for species of the family *Centrophotidae* (excluding *Deania* spp.) and *Squalidae*
- regulations in relation to finning and shark livers
- gear restrictions (hook limits and prohibition of wire trace)
- anchorage of gear to the seafloor
- spatial and temporal closures:
    - restriction of auto-longline gear to waters deeper than 183 m
    - closures under the Upper-slope Dogfish Management Strategy
- bycatch and discarding workplan (AFMA 2009)
- chondrichthyan guide for fisheries managers (Patterson and Tudman 2009)
- upper and lower reference limits for species of concern
- National Plan of Action for the Conservation and Management of Sharks (DAFF 2012)
- Upper-slope Dogfish Management Strategy (AFMA 2012b).

Industry has also implemented a code of conduct aimed at improving the handling practices and the release of live sharks. The bycatch working group has noted that most sharks reach the surface alive and there is thus the potential for them to be released.

Seabirds

Seabirds are no longer identified as a high-risk group in the most recent ERA re-evaluation. This is primarily due to strict management arrangements through the TAP (AAD 2014) process.

Teleosts

Mitigation strategies for teleosts include:

- hook limits
- anchoring longlines to the seafloor
- depth restrictions
- spatial closures
- electronic monitoring on all vessels.

Habitat

Several habitats are at least potentially at risk from auto-longlining operations. A key uncertainty remains the effect of movement of the main line itself on large, erect and fragile epifauna. This risk is mitigated through the several closures in the fishing area, including CMRs.

Upper-slope Dogfish Management Strategy[13]

Harrisson's dogfish have been shown to be present on the Tasmantid Seamounts and that area closures and gear restrictions would significantly enhance protection and recovery of the species. Noting that trawl was not permitted on the seamounts, it was proposed that line fishing be limited to hydraulic reel drop-line fishing only (this method also called power-handline fishing or minor-line fishing). Using this method, lines are always attended, fewer hooks are used and soak times are short. As a consequence, gulper sharks are brought to the surface in a vigorous condition, may be quickly released and are expected to have survival rates greater than 90 per cent (Williams *et al.* 2013). Bycatch using this method was negligible.

This strategy was revised in 2012 to promote the recovery of two species of dogfish: Harrisson's dogfish (*Centrophorus harrissoni*) and southern dogfish (*C. xeehaani*). The strategy relies primarily on a network of spatial closures (see figure 3.3) complemented by a range of non-spatial operational measures. The network builds on existing closures by implementing new closures, extending existing closures and revising existing closures (see table 3.4). It also provides some protection to endeavour dogfish (*C. moluccensis*) and greeneye spurdog (*Squalus chloroculus*).

The types of management arrangements which apply under the strategy include:

- a prohibition on the take of Harrisson's dogfish and southern dogfish
- area closures
- monitoring obligations through observers or electronic monitoring
- a limit for bycatch of Harrisson's dogfish and southern dogfish when undertaking permitted types of line fishing in specific areas
- handling practices to improve post-capture survival for released sharks.

[13] AFMA 2012b, except where otherwise referenced.

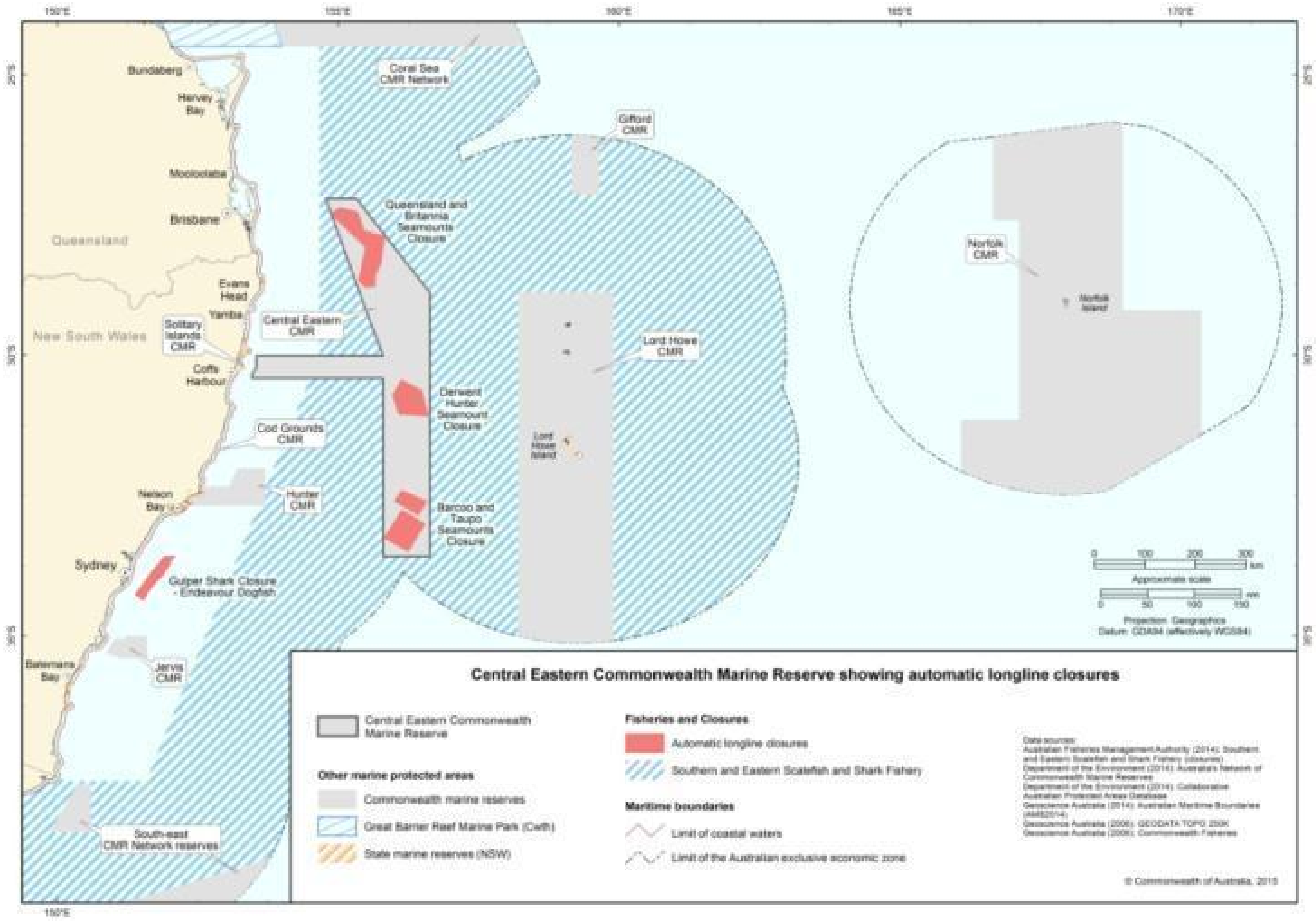

Figure 3.3 The Temperate East CMR network showing the extent of the SESSF and auto-longline closures

Table 3.4 Closures under the Upper-slope Dogfish Management Strategy that are relevant to the Central Eastern Commonwealth Marine Reserve (after AFMA 2015)

Spatial closures	Details	Complementary management arrangements where fishing is permitted inside closures
Extended closures		
Extended endeavour dogfish closure off Sydney	Extended closure to all methods of fishing across the core depth range	Fishing is not permitted, so complementary measures are not applicable
New closures		
Derwent Hunter Seamount	Closed to all fishing methods	Fishing is not permitted, so complementary measures are not applicable
Queensland and Brittania Guyots	Closed to demersal longline (including trotline and auto-longline) Open to hydraulic hand reel drop-lining only	Line fishing subject to regulated handling practices, interaction limit per boat and 100% monitoring* Vessel interaction limit of three gulper sharks. If limit is reached, the closure will apply to that boat for 12 months Trigger limit removed for power handline method
Revised Closures		
Barcoo Seamount and Taupo Seamount	Will remain closed to all trawl methods Will be open to line fishing	Line fishing subject to regulated handling practices and 100% monitoring* Vessel interaction limit of three gulper sharks. If limit is reached, the closure will apply to that boat for 12 months Trigger limit removed for power handline method

* 100 per cent monitoring by an approved AFMA method.

Impacts on the benthos

The global expansion of deep-sea fisheries has raised alarm about its sustainability (Norse *et al*. 2012; Watson and Morato 2013; Watling 2013), especially because it has predominantly been through trawl. Mobile gears such as dredge and trawl have been shown to cause significant reductions in the heterogeneity of habitats (Pitcher et al. 2000; Glover and Smith 2003; Clark and Rowden 2009). Static gear such as demersal longlines have been less well studied, but research is emerging to suggest that demersal longlining has a significantly lower footprint than trawling and may be viewed as a sustainable alternative for deep-sea fisheries. Pham *et al.* (2014) showed that demersal longline fishing had little impact on vulnerable marine ecosystems in the Azores, less impact than trawl on deepwater coral species and limited damage to benthic communities. However, earlier work, including that of Munoz *et al*. (2011), reached a different conclusion and suggested that, although bottom longlines are expected to be much less damaging than trawls to deepwater coral and other erectile benthos, they may still represent a threat if fishing intensity is high. In a detailed study of the impact of demersal fishing gear on deepwater benthic ecosystems in the Heard Islands and MacDonald Islands toothfish and icefish fisheries, Welsford *et al*. (2014)

showed that longlines were static on the benthos but exhibited significant lateral movement during hauling. Bycatch, although less in quantity, was taxonomically similar to trawl.

ESP finding

Recent management arrangements implemented by the Australian Fisheries Management Authority, particularly those relating to spatial closures, together with use of tori lines and industry codes of practice designed to improve the survival of bycatch, have significantly mitigated the threat of demersal longline fishing to vulnerable chondricthyans and seabirds in the Central Eastern Commonwealth Marine Reserve. In addition, current fishery closures limit demersal longline fishing on most of the seamounts in this reserve.

Information on the impact of the auto-longline sector of the Coral Sea Fishery in relation to target species, bycatch species and habitat is poor, but closer monitoring of logbooks and placement of observers has been recommended.

The impact of demersal longline fishing on deepwater habitats such as those found in the Central Eastern and Coral Sea Commonwealth Marine Reserves remains uncertain, as to date no research has specifically assessed this risk.

In some circumstances and under appropriate management arrangements, demersal longline may be a more sustainable method relative to trawl for deepwater fisheries off the continental slope and on seamounts. However, this will depend largely on the habitat characteristics of the area fished and the intensity of fishing.

Spatial closures appear to offer the best protection where catch rates of non-target species are high.

Until such time that these relationships can be properly understood, a precautionary approach to deepwater fishing should be maintained. For this reason, demersal longline fishing (including auto-longlines) should remain a method that is incompatible with the conservation values of the Central Eastern and Coral Sea Commonwealth Marine Reserves, particularly those relating to seamounts.

3.1.2 Review of the Fishing Gear Risk Assessment rating for the Northern Prawn Fishery, specifically in relation to the Gulf of Carpentaria Commonwealth Marine Reserve

<u>Description of the location and habitat</u>

The Gulf of Carpentaria CMR covers the marine environment from waters adjacent to the Wellesley Islands into the Gulf of Carpentaria Basin (DNP 2014c). The Gulf of Carpentaria is a large, shallow, muddy marine bay with marked seasonality in temperature, rainfall, salinity and wind regimes. The dominant weather feature is a seasonal summer monsoon, with associated northerly winds and rain, and a very dry winter period with south-east trade winds (Delaney 2012).

It has a diversity of land forms, including offshore islands, fringing coral reefs, sandy, muddy and cliff-lined coastal topographies and extensive mud/sand tidal flats. Extensive open coastline seagrass communities have been reported in the southern Gulf in the past, mainly of the genera *Halodule* and *Halophila* intertidally, and *Syringodium* and *Cymodocea* subtidally (Roelofs *et al.* 2005)

Sediments throughout the Gulf of Carpentaria are predominantly fine muds (Long *et al*. 1995), and these are easily resuspended due to the shallow bathymetry resulting in increased turbidity. Cyclones and storms also readily disturb and shift sediments in this shallow environment (Roelofs *op. cit*.), affecting benthic distributions (Post *et al*. 2006).

The Gulf of Carpentaria is unique in that it is the largest tropical epicontinental sea in the world. The gulf basin functions as a predominantly closed ecosystem, with biological productivity strongly dependent on benthic nutrient cycling and mixing of nutrients through the water column. The benthos (the assemblage of organisms inhabiting the seafloor) is dominated by deposit feeders and scavengers, including echinoids (heart urchins and sand dollars), bivalve molluscs, polychaete worms, prawns and demersal fish (sharks and rays). Sponges, sea pens, solitary corals and ascidians are common in areas where the seafloor is exposed to stronger currents. Dugongs, marine turtles, dolphins and large numbers of birds migrate through the basin waters to internationally significant breeding, nesting and feeding sites on the Gulf of Carpentaria coastline. Rich assemblages of schooling fish feed on diverse and abundant plankton and in turn attract aggregations of higher order predators (for example, sharks, mackerels, snappers, seabirds, cetaceans and sea snakes) (DEWHA 2008a).

The conservation values of the Gulf of Carpentaria CMR are summarised in table 3.5.

Table 3.5 Conservation values of the Gulf of Carpentaria Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d)

Conservation values	Description
Biological seascapes	Represents eight seabed assemblages (which are derived from sediment and depth data). Cluster 1: Moderately high variation in seabed oxygen, moderately low chlorophyll A, moderately low turbidity, primarily sandy, deep mid-shelf. Cluster 4: High sediment mud content, low sediment sand content, low chlorophyll A, low turbidity, high salinity average, high variation in seabed oxygen, mid-shelf depth. Cluster 7: High variation in sea surface temperature, very high salinity average, high variation in water temperature at the seabed, inner-shelf depth range. Cluster 12: Low sediment mud content, moderately high sediment sand content, inner-shelf depth range. Cluster 13: Very high variation in sea surface temperature, very high benthic irradiance, very shallow, high sediment sand content, very high average seabed oxygen, high chlorophyll A, low sediment carbonate, relatively low average sea surface temperature, high turbidity. Cluster 14: Very low sediment mud content, high sediment sand content, high sediment gravel content, high sediment carbonate, relatively low average sea surface temperature, very high variation in salinity, very high variation in bottom stress, very high bottom stress, moderately shallow. Cluster 16: Moderately high salinity average, moderately high variation in seabed oxygen, depth range. Cluster 20: Very high sediment sand content, low sediment mud content, low sediment gravel content, relatively low sediment carbonate, high average seabed oxygen.
Depth	The reserve covers a depth range of approximately 10–55 m. It represents the coast to shallow shelf transition of the Northern Shelf Province.
Seafloor features	Plateau, saddle, shelf, canyon, deep hole / valley, reef, specifically submerged coral reefs that support large plate corals (*Turbinaria* spp.), abundant hard corals and a large proportion of soft corals.
Key ecological features (KEFs)	The Gulf of Carpentaria CMR represents four KEFs: - the Gulf of Carpentaria coastal zone, recognised as a unique seafloor feature with an important ecological role and for its feeding and breeding aggregations of species - the plateaux and saddle of the Wellesley Islands, made up of living patch reefs that support reef fish that are unique within the Gulf of Carpentaria. Octocorals, sponges, acsidians and gorgonians are also likely to occur in the area - submerged coral reefs of the Gulf of Carpentaria - the Gulf of Carpentaria Basin.

cont'd overleaf

* Containing representative examples of the Northern Shelf Province provincial bioregion and the Carpentaria, Karumba–Nassau and Wellesley meso-scale bioregions.

Table 3.5 Conservation values of the Gulf of Carpentaria Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d) cont'd

Conservation values	Description
Species	Important inter-nesting habitat for threatened green and flatback marine turtles preparing successive egg clutches for laying on nearby coasts. Important foraging habitat for breeding aggregations of migratory birds, including the lesser frigatebird, brown booby and roseate tern, and for the listed marine crested tern. Large aggregations of dugong. Breeding and aggregation habitats for many fish species, refuges for sea snakes and apex predators (such as sharks), and important habitat for invertebrates such as crustaceans and polychaete worms. Heart urchins and sand dollars, sponges, solitary corals and sea cucumbers, as well as top predators such as snappers.

* Containing representative examples of the Northern Shelf Province provincial bioregion and the Carpentaria, Karumba–Nassau and Wellesley meso-scale bioregions.

<u>Gear type and fisheries in the Northern Prawn Fishery</u>

Trawl nets are designed to be towed by a boat along the seafloor (bottom trawl). They are shaped like a cone or funnel with a wide opening to catch fish or crustaceans and a narrow, closed 'cod-end'. Bottom trawls use trawl doors known as otter boards to keep the mouth of the net open (AFMA b).

Vessels in the Northern Prawn Fishery may tow a range of nets in a variety of configurations that are regulated by the *Northern Prawn Fishery Management Plan* 1995 (AFMA 2014b). These include multiples of two, three or four nets, with long arms (or booms) extending out from each side of the boat to allow the nets to fully open. Prawn trawl nets use ground chain for weight, which skims the seabed and encourages prawns living on the sea floor up into the trawl mouth. In addition to the main fishing gear, smaller 'try-nets' are used to test the potential of catches in a given area (Banks *et al.* 2012).

Physical devices, such as excluder and bycatch reduction devices within trawl nets, are used by fishers to divert unwanted species out of the net. This is important, as it allows small fish, larger animals and protected species to escape the net (Eayrs *et al.* 1997).

The fishery targets several species in three distinct sub-fisheries (Banks *op. cit.*). These are:

- the banana prawn sub-fishery (usually from 1 April and up to mid-June, but may be shortened using applied input control rules), targeting white banana prawns (*Fenneropenaeus merguiensis*) in water depths less than 20 m
- the tiger prawn sub-fishery (usually from 1 August and to 30 November but may be shortened using applied input control rules), generally (but not exclusively) comprising mixed catches of adult brown tiger prawns (*Penaeus*

esculentus) between 10 m to 20 m, grooved tiger prawns (*P. semisulcatus*) over fine mud and often in deeper water, and blue endeavour prawns (*Metapenaeus endeavouri*) and red endeavour prawns (*M. ensis*), usually between 30 m and 45 m

- the Joseph Bonaparte Gulf sub-fishery, targeting red-legged banana prawns (*Fenneropenaeus indicus*), which historically has operated in both seasons but has been closed in the banana prawn season from 2007 to 2010 inclusive as a trial to improve the economic return from the fishery. Fishing takes place in deeper water at depths of 45 m to 85 m.

Although the gear is the same in each sub-fishery, the method of deployment changes depending on the type of prawn targeted.

In the tiger prawn sub-fishery, the trawl is generally lowered to fish as close as possible to the seabed and towed for three to four hours. The white banana prawn sub-fishery gear is lowered for less than an hour on aggregations in the water column identified by an echo sounder, whilst in the red-legged prawn sub-fishery the gear is towed above the seabed. Both are considered to have a lighter ‘touch’ than that of the tiger prawn fishery (Banks *et al.* 2012).

Therefore, most of the benthic impacts from Northern Prawn Fishery operations are likely to be associated with the tiger prawn sub-fishery and to a lesser extent the banana and Joseph Bonaparte Gulf sub-fisheries. The impacts of the banana prawn sub-fishery are likely to be water column or pelagic impacts and not benthic impacts.

In recent years in the Northern Prawn Fishery, fishing effort has declined significantly from 286 vessels in 1981 to 52 vessels in 2009. Although intensity and frequency of trawling are fisheries management issues and therefore outside the purview of an FGRA, it is worth noting that surveys show only about three per cent of the fisheries management area is trawled (Brewer *et al.* 2007). Furthermore, the large number of spatial and temporal closures adopted by the Northern Prawn Fishery serves to protect vulnerable habitats such as seagrass beds and coral and rocky reefs (Kenyon *et al.* 2005).

<u>North and North-west Fishing Gear Risk Assessment</u>

This assessment for the North and North-west CMRs was based on risks that commercial fishing methods posed to the conservation values identified in the AFAs in the North and North-west Marine Regions (Lack 2010).

Lack’s 2010 assessment relied on the outputs of the AFMA ERAs for Commonwealth fisheries (Griffiths *et al.* 2007). ERAs are determined using the Ecological Risk Assessment for Effects of Fishing (ERAEF) methodology developed by the CSIRO (Hobday *et al.* 2007). ERAs were supplemented by qualitative Ecologically Sustainable Development Assessments (ESDAs) for state and territory fisheries, DEWHA EPBC Act assessment reports and available information on the management and status of fisheries published by state, Northern Territory and Commonwealth fisheries management agencies.

Level 3 ERAs (using the fully quantitative SAFE method), which calculate *absolute* levels of risk, have been conducted for teleosts and chondrichthyans in all Commonwealth managed fisheries authorised to operate in the North and North-west Marine Regions (Brewer *et al.* 2007; Zhou *et al.* 2009). Level 2 assessments, which lead to an assessment of *potential* risk, have been carried out for target species and in most cases for by-product/bycatch, TEP species and habitats, although in some cases some of these elements were eliminated from further analysis in Level 1 (see table 3.6). Both Level 2 and Level 3 ERAs were used in the FGRA. This results in a mixture of 'potential' and 'actual' risks being assessed; however, it ensures that the best available information is used to inform the assessment (Lack *op. cit.*).

Table 3.6 Authorised fisheries / main methods and key information available (after Lack 2010)

North Marine Region		**North-west Marine Region**	
Fishery	Risk assessment information	Fishery	Risk assessment information
Northern Prawn Fishery (AFMA)	ERA: Level 1—communities eliminated Level 2—target, by-product/bycatch and TEP species and habitats Residual Risk Analysis of the 28 high-risk species Level 2.5 (earlier version of Level 3) analysis of 26 high residual risk species Level 3 SAFE for sea snakes	Northern Prawn Fishery	ERA: Level 1—communities eliminated Level 2—target, by-product/bycatch and TEP species and habitats Residual Risk Analysis of the 28 high-risk species Level 2.5 (earlier version of Level 3) analysis of 26 high residual risk species Level 3 SAFE for sea snakes

The outcome of Lack's (*op. cit.*) assessment was that demersal trawl (prawn trawl) posed an unacceptable level of risk to sawfishes and habitat types in the Gulf of Carpentaria. In summary, two areas of concern were raised from the analysis of demersal and/or semi-demersal trawl on the Conservation Values of the North Marine Region:

1. risks associated with impacts on benthic habitats
2. risks posed to sawfishes and other chondrichthyans.

Benthos

Lack (*op. cit.*) reported that the banana prawn sub-fishery of the Northern Prawn Fishery targeted aggregations in waters generally less than 20 m, was very selective and used smaller trawl gear and shorter shots than the tiger prawn sub-fishery. This fishery, which trawls at night in waters of more than 20 m in depth, was less selective and used heavier/larger gear and longer shots. As a consequence, the tiger prawn sub-fishery was thought to pose a higher risk to seabed habitat than did the banana prawn sub-fishery.

Lack (*op. cit.*) noted that the Level 1 scoping results for the ERA, as reported in Griffiths *et al*. (2007), confirmed the uncertainty about the recovery of erect, rugose and inflexible octocorals (which are associated with soft, muddy substratum) that are damaged through interaction with trawl gear, particularly the heavier and more intensive use of gear in the tiger prawn sub-fishery. The results indicate the need for data on resilience and recovery times of mud-based habitats. The ERA report notes that regeneration times of damaged tissues will vary between species and that, while in coastal margin depths (0–25 m) and inner shelf depths (25–100 m) regeneration can be expected to be reasonably rapid as fauna are likely to be well adapted to frequent and considerable disturbance regimes (for example, strong currents, run-off and cyclones), more structurally complex forms/communities may take more than one year to recover. Therefore, it might be inferred that, in areas where trawling is conducted annually, there is potential for the gear to impede the recovery of more complex forms/communities.

However, Lack (*op. cit.*) notes that, since the ERA was conducted, the results of the Great Barrier Reef Seabed Biodiversity Project (Pitcher *et al*. 2007) were released. These results suggest that less than seven per cent of the 850 species (bycatch and benthic species) were significantly affected by trawl effort. However, Pitcher (2014) notes that the impact was related to trawl effort and that uncertainty in the distributions, relative catch rates and natural mortality rates of several species required a precautionary response. Nevertheless, Lack (*op. cit.*) suggested that these findings, if they are transferable to the areas fished by the Northern Prawn Fishery, may suggest that trawling poses less of a risk to benthic habitats and communities than implied by the qualitative assessment of the Level 1 ERA.

Lack (*op. cit.*) noted that the Level 2 ERA for the Northern Prawn Fishery assessed 157 habitats, none of which were found to be at high risk. Sixty-five habitats were assessed to be at medium risk and 92 were at low risk. Of the medium-risk habitats, 48 were inner shelf habitats (0–100 m) dominated by flat to highly irregular unconsolidated sediments of mud to coarse grained biogenic gravels, with large erect sponges, hard and soft corals, complex communities of mixed fauna, and individual animals. The remaining 17 medium-risk habitats were coastal margin habitats (0–25 m), which also include several soft sediment seabed types but which were dominated by seagrass communities not identified from the inner shelf.

However, Lack (*op. cit.*) notes that the ERA report by Griffiths *et al.* (*op. cit.*) cautions that:

> *A complication of the construction of the PSA model means that no NPF habitats can appear at high risk from prawn trawling. This is largely because of the way that the PSA calculation is influenced by the scoring of the Productivity attributes, with shallow habitats assumed to be quite productive with good recovery rates.*

Therefore, Lack concludes that further analysis is required to validate the Level 1 and Level 2 ERA findings on the impact of demersal trawl gear on benthic habitats in the North Marine Region to ensure that there are no high-risk impacts.

Sawfishes and chondrichthyans

A key component of the initial FGRA for the North/North-west was consideration of the potential impact of fishing gear on TEP species. It identified risks posed to sawfishes and other chrondrichthyans as an area of concern.

All trawl nets in the Northern Prawn Fishery are required to be fitted with approved turtle excluder devices (TEDs) and bycatch reduction devices (BRDs) and it was one of the first fisheries to explicitly focus research on bycatch reduction and implement measures to mitigate impacts on bycatch (AFMA 2011). For example, the mandatory use of TEDs since 2000 has been shown to reduce turtle bycatch by 97 per cent, reduce the capture of large sharks and rays by 86 per cent and 94 per cent respectively, and reduce the narrow sawfish bycatch by over 93 per cent.

Lack (*op. cit.*) noted that the refinement of the SAFE methodology had led to the application of a more conservative relationship between reference points and life history. Sawfishes were identified as a draft conservation priority in the North Marine Region. Lack noted that three of the five species were listed as vulnerable under the EPBC Act and all five species were listed (four species on Appendix I and one species—freshwater sawfish—on Appendix II) on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Lack (*op. cit.*) noted that, while TEDs had been successful in reducing elasmobranch bycatch, they were not effective in excluding sawfish species, specifically the green and freshwater sawfish. Level 2 ERA results rate sawfishes at high risk due to low fecundity and high susceptibility to being caught in nets (AFMA 2008); however, the Gulf of Carpentaria ESDA found sawfish to be at a medium risk in the Gulf of Carpentaria Demersal Finfish Trawl Fishery (Zeller and Snape 2006). Brewer *et al.* (2007) did not find sawfishes to be at risk from the Northern Prawn Fishery alone, as they were widely distributed and subject to being caught in other fisheries. They recommended that a precautionary approach be adopted because they were subject to cumulative risk.

Lack (*op. cit.*) noted that the SAFE assessment for the Northern Prawn Fishery, and subsequent incorporation of expert opinion, had resulted in the blotched fantail ray and the porcupine ray being assessed as at extreme high risk in the Northern Prawn Fishery. Patterson and Tudman (2009) provide some guidance on potential mitigation measures for the blotched fantail ray, but note that there are no proven mitigation measures available to specifically reduce interactions with the blotched fantail ray and the porcupine ray.

In summary, Lack's analysis led to a finding of 'Unacceptable' risk for demersal (and semi-demersal) gear based on:

- the need to apply the more precautionary, high-risk findings of the Level 2 assessment for sawfish species given the acknowledgement that the Level 3 Northern Prawn Fishery assessment for chondrichthyans was not sufficiently conservative and the lack of proven measures to mitigate this impact
- the lack of proven measures to mitigate the impact on the high-risk species of blotched fantail ray and porcupine ray
- uncertainties arising from the application of the PSA model to habitats in the Northern Prawn Fishery.

Use of the Fishing Gear Risk Assessments

The FGRA findings were an input into the zoning matrices for the draft and final proclaimed North and North-west CMR Networks. The Gulf of Carpentaria CMR was proclaimed with two zones—Marine National Park Zone and Multiple Use Zone. Demersal trawl is excluded from these zones.

Subsequent consultation on the draft management plan for the North CMR Network resulted in a change to the zones for the Gulf of Carpentaria CMR, replacing the Multiple Use Zone with a General Use Zone (Carpentaria) to allow demersal trawling to continue. This confirmed the consistent application of the International Union for Conservation of Nature (IUCN) categories across CMRs and allowed for the continuation of additional or existing commercial fishing activity. The Director of National Parks report concerning responses to public comments on the North Commonwealth Marine Reserves Network Management Plan (2013) (DNP 2013f) made the following observation:

> *This amendment reflects consideration of information in a submission on the economic significance of this area to the Northern Prawn Fishery, the long history and more recent results of research and monitoring on the environmental impacts of bottom trawling in this specific area, the fishery's focus on long-term sustainability, and its accreditation by the Marine Stewardship Council.*

Additional information

In 2012 the Northern Prawn Fishery received certification against the strict environmental standards set by the Marine Stewardship Council (MSC). As part of this certification process, an assessment was done of all relevant literature, including the ERAs, against the criteria of the MSC. Principle 2 is specifically relevant to this process in that it examines five components (retained species, bycatch species, TEP species, habitats, ecosystems) which are considered to cover the range of potential ecosystem elements that may be impacted by a fishery, taking into account the status, management strategies and information relevant to each of these components (Banks *et al.* 2012).

Impacts on benthos

Key environmental concerns related to trawling usually focus on the physical disturbance to the benthic habitat and ecological impacts to the associated communities, with the key effects being a combination of mortality, short-term damage and long-term modification impacts.

In the MSC assessment, Banks *et al.* (*op. cit.*) refer to a study by Haywood *et al.* (2005) as follows:

> *Detailed analyses of the impacts of trawling on the benthos in the NPF are provided by a 2005 study conducted near Mornington Island and a more recent study focused on the sedimentary shelves and submerged river beds of the southwestern Gulf of Carpentaria. Based on these studies, there are no known unique, exclusive habitats in either area.*
> *The majority of the ecologically important habitats are located in untrawlable ground. However, there are some areas of high biodiversity, such as marginal reefs and sponge gardens, within trawlable areas and it is not known whether these are permanent structures or whether they form and are dispersed in response to natural environmental disturbance. In the 2005 study, experiments simulating commercial fishing operations through repeated intensive trawling of study sites showed that most benthic assemblages were primarily influenced by seasonal factors rather than trawling. Recovery in a number of sessile or slow moving taxa was found to occur within 6-12 months.*
> *While these studies did not examine habitat per se, findings indicating that trawling has little effect on the infaunal community suggest that trawling also has relatively little effect on benthic habitat.*

The ERA (AFMA 2012c) also addresses this issue, noting that regeneration times of damaged tissues will vary between species and that, while in the coastal margin (0–25 m) and inner shelf depths (25–100 m) regeneration can expect to be reasonably rapid because fauna are likely to be well adapted to frequent and considerable disturbances of regimes (for example, strong currents, run-off and cyclones), more structurally complex organisms may take more than a year to recover. Banks *et al.* (*op. cit.*) also considered the impact of the Northern Prawn Fishery on ecosystem structure and function, noting that:

> *Previous research has characterized the NPF ecosystem as driven by land-sea interactions, particularly freshwater input which triggers productivity in the form of benthic diatoms and tropical plankton. These studies found no evidence that the fishery affects this ecosystem in a significant way*.

Previous findings were re-examined in a recent study focused on the tiger prawn sub-fishery, which had the highest diversity and quantity of bycatch of the three Northern Prawn Fishery sub-fisheries (Bustamante *et al.* 2010). This study confirmed that the effects of trawling at the current scale of the Northern Prawn Fishery do not affect overall biodiversity and cannot be distinguished from other sources of variation in community structure. In particular, recent analyses showed that the composition and density of demersal fish, epibenthic invertebrates and infauna in the Gulf of Carpentaria were more strongly related to region and, in some cases, time of day than to the intensity of trawling as mapped by Northern Prawn Fishery vessel monitoring system (VMS) data.

Despite the finding that the benthic impacts of trawling may not be as severe as first thought, there can be no doubt that commercial fishing can have a profound impact on marine ecosystems (Thrush and Dayton 2002). Various habitats with different histories of disturbance may be expected to exhibit a variety of responses (Thrush and Dayton 2010). Also important is the intensity of fishing. Dell *et al*. (2013), for example, found differences in the benthic diet of predatory fish between areas of high and low fishing intensity, suggesting shifts in benthic communities with the intensity of prawn trawling in the Gulf of Carpentaria.

Sawfishes and chondrichthyans

The MSC assessment noted that:

> *Subsequent to the quantitative Level 2.5 ERA, Level 3 SAFE assessments were carried out for elasmobranch species which included the five species of sawfishes identified as being at high risk in Level 2.5, i.e., Pristis zijsron (green sawfish), Anoxypristis cuspidata (narrow sawfish), P. pectinata (wide sawfish), P. microdon (freshwater sawfish) and P. clavata (dwarf sawfish). Applying the results of the Level 3 SAFE, and taking into consideration the EPBC Act TEP species, three sawfishes (dwarf, green and narrow) were included in the NPF priority species list for monitoring although they were considered not to be at high risk given the SAFE findings. Monitoring for some TEP sawfish species is required under the EPBC Act, but it has been recommended that all sawfish species continue to be monitored as they are highly vulnerable to the impacts of fishing. A recent update to the SAFE assessment was undertaken for the period 2007-2009 but the assessed risk levels for sawfishes remained unchanged, i.e. they are not considered to be at high risk.* (Banks *op. cit.*)

National recovery plan for sawfish and river sharks[14]

A draft recovery plan for sawfish and river sharks has been published by the Department of the Environment (DoE 2014). This plan applies to the largetooth sawfish (*Pristis pristis*), green sawfish (*Pristis zijsron*) and dwarf sawfish (*Pristis clavata*) that can be present in the Oceanic Shoals and/or Arafura CMRs.

The recovery plan notes:

> *[The] Commonwealth marine reserves network protects habitats important for threatened species. Their location outside of state waters (three nautical miles off the coast) means they relate to solely marine environments and therefore would support adult sawfish and river sharks once they mature and utilise offshore areas. There are 21 Commonwealth Marine Reserves in the North and North-west Commonwealth Marine Reserve Network that sawfish and river shark species may utilise.*

The primary objective of the recovery plan is to assist the recovery of sawfish and river sharks in Australian waters, including through reducing and, where possible, eliminating adverse impacts of commercial fishing on sawfish. Additional management measures other than those contained in the recovery plan are being implemented through a number of agencies (AFMA, Department of Agriculture, Fisheries and Forestry, and state and territory governments). These measures include area and seasonal closures, compulsory recording of incidental capture, mechanisms to encourage recreational fishers to report interactions and a number of observer programmes that provide independent measures of mortality in state and Commonwealth waters.

Other threatened, endangered or protected species

The other group of TEP species requiring further action based on the Level 2.5 ERA was the sea snakes. A study dedicated to this topic was completed in 2008. It found that catch rates for the 10 most common species have remained stable since 1976. This study also concluded that trawl mortality was below reference points and no species appear to be at risk based on current levels of fishing effort in the fishery. Since sea snakes are protected species under the EPBC Act, interactions with the Northern Prawn Fishery will continue to be monitored as required through logbook and observer reporting; however, there are currently no sea snakes on the list of Northern Prawn Fishery priority species as a result of concerns based on risk assessment (Banks *et al.* 2012).

New BRDs have recently been trialled in the Northern Prawn Fishery which, unlike previous BRDs, appear to significantly reduce the capture of small bycatch and

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[14] DoE 2014.

particularly those species of concern—sawfish, sea snakes and, potentially, rays. The report (Burke *et al.* 2012) notes that:

> *Trials of the Popeye Fishbox and Witches Hat BRD Enhancer both demonstrated the greatest potential for reduction in small bycatch of all BRD designs trialled in the NPF to date. These devices have been tested and found to be successful in the tiger prawn season, though their effectiveness in the banana prawn season remains unknown.*

Further trials are planned, with mechanisms for adoption by industry in development. The Northern Prawn Fishery also has a Bycatch Action Plan, the aims of which are to develop strategies that will:

- respond to high ecological risks assessed through AFMA's ERAEF and other assessment processes
- avoid interactions with species listed under the EPBC Act
- reduce discarding of target species to as close to zero as practically possible
- minimise overall bycatch in the fishery over the long term (AFMA 2011).

ESP finding

Recent research and better identification of the conservation values suggest that the Northern Prawn Fishery operations (demersal trawling) may not impact as significantly on the benthic environment in the Gulf of Carpentaria Commonwealth Marine Reserve as previously thought, particularly as operations avoid ecologically important habitats such as sponge gardens and reefs, which are located in what is considered untrawlable ground and which are protected within fishery spatial closures.

More recent evaluations of the risks to elasmobranchs suggest that none were at risk from trawling because of widespread distributions and/or low overlaps with the fishery.

It is highly likely that a similar situation may apply to other areas of the North and North-west, such as the Wessels Commonwealth Marine Reserve and the Joseph Bonaparte Gulf Commonwealth Marine Reserve. However, consideration must be given to ensuring that sufficient areas are protected from the impacts of trawl, especially where there is an absence of Marine National Park Zones.

3.1.3 Review of the Fishing Gear Risk Assessment for the former Northern Territory Finfish Trawl Fishery (now amalgamated into the Northern Territory Demersal Fishery) specifically in relation to the Oceanic Shoals and Arafura Commonwealth Marine Reserves

Description of the location and habitat

Oceanic Shoals Commonwealth Marine Reserve[15]

The Oceanic Shoals CMR lies within the Timor Sea, with its north boundary on the edge of Australia's Exclusive Economic Zone (EEZ). East of the reserve are Bathurst and Melville islands (Tiwi Islands).

The reserve represents a significant area of the Bonaparte Basin and includes some of the deepest waters found in the North Marine Region, at approximately 300 m. The reserve contains a number of shoals, channels and valleys that are found in the carbonate bank and terrace system of the Van Diemen Rise and Sahul Shelf. These KEFs support rich sponge gardens, octocorals, pelagic fish, sharks and sea snakes. The reserve also includes the Pinnacles of the Bonaparte Basin, which are a KEF and are presumed to support high biodiversity, including hard and soft corals, sponges, and aggregations of demersal fish. Threatened flatback, olive ridley and loggerhead turtles are known to forage around the pinnacles, and whale sharks and other shark species occur in the area. The reserve also covers part of the shelf break and slope of the Arafura Shelf, which supports at least 284 demersal fish species.

The waters within the Oceanic Shoals CMR provide important inter-nesting habitat for flatback and olive ridley turtles that are preparing successive egg clutches for laying on nearby coasts. Marine communities dominated by beds of *Halimeda* algae occur in the reserve and these algae play an important role in fixing carbon at rates that are amongst the highest known.

The Oceanic Shoals CMR lies near the Tiwi Islands—an area recognised by the Northern Territory Government as a Site of Conservation Significance.

The conservation values of the Oceanic Shoals CMR are summarised in table 3.7.

[15] DNP 2013c.

Table 3.7 Conservation values of the Oceanic Shoals Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d)

Conservation values	Description
Biological seascapes	Represents 14 biological seascapes (a combination of physical and biological information). Cluster 1: Moderately high variation in seabed oxygen, moderately low chlorophyll A, moderately low turbidity, primarily sandy, deep mid-shelf. Cluster 2: High average water temperature at the seabed, low silicate average, high turbidity, high chlorophyll A, sandy–muddy sediments with high gravel, high variation in bottom stress, inshore depth range. Cluster 3: Moderately high sediment mud content, low sediment sand content, high variation in seabed oxygen, low salinity average, mid-shelf depth range. Cluster 5: Very low average water temperature at the seabed, low variation in sea surface temperature, very low benthic irradiance, upper slope depth range, very high silicate average, very low chlorophyll A, very low average seabed oxygen, very low turbidity, very high nutrients. Cluster 6: High sediment carbonate, high average sea surface temperature, low variation in water temperature at the seabed, moderately high variation in bottom stress, mid-shelf depth range; Cluster 8: Very high average sea surface temperature, low variation in sea surface temperature, low benthic irradiance, outer-shelf depth range, moderately low average seabed oxygen, moderately high silicate average, moderately high sediment mud content. Cluster 10: Low average water temperature at the seabed, low benthic irradiance, shelf-break depth range, high silicate average, low chlorophyll A, low average seabed oxygen, low turbidity, high sediment mud. Cluster 11: Low sediment carbonate, very high sediment mud, very low sediment sand content, very low sediment gravel content, low sediment carbonate, low salinity average, moderately high average water temperature at the seabed, depth. Cluster 12: Low sediment mud content, moderately high sediment sand content, inner-shelf depth range. Cluster 14: Very low sediment mud content, high sediment sand content, high sediment gravel content, high sediment carbonate, relatively low average sea surface temperature, very high variation in salinity, very high variation in bottom stress, very high bottom stress, moderately shallow. Cluster 15: High average water temperature at the seabed, high benthic irradiance, low silicate average, very low salinity average, shallow depth. Cluster 16: Moderately high salinity average, moderately high variation in seabed oxygen, depth range. Cluster 17: Low average water temperature at the seabed, high silicate average, low average seabed oxygen and very high variation in seabed oxygen, high nutrients and very high variation in nitrate, outer-shelf depth range. Cluster 19: High average sea surface temperature, very low variation in sea surface temperature, very high sediment carbonate, high bottom stress with high variation, typical depth range with shoals to around 20 m.
Depth	To approximately 300 m.

cont'd overleaf

* Containing representative examples of the North-west Shelf Transition and Timor Transition provincial bioregions and the Bonaparte Gulf, Oceanic Shoals and Tiwi meso-scale bioregions.

Table 3.7 Conservation values of the Oceanic Shoals Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d) cont'd

Conservation values	Description
Seafloor features	Banks/shoals, basin, deep/hole/valley, pinnacle, reef, shelf, slope, terrace, tidal sandwave/sandbank.
Key ecological features	Carbonate bank and terrace system of the Van Diemen Rise. Carbonate bank and terrace system of the Sahul Shelf. Pinnacles of the Bonaparte Basin. Shelf break and slope of the Arafura Shelf.
Species	Important foraging and resting area between egg-laying (inter-nesting area) for the threatened flatback turtle and olive ridley turtle. Area of high biodiversity supporting at least 284 fish species, whale sharks and other shark species.

* Containing representative examples of the North-west Shelf Transition and Timor Transition provincial bioregions and the Bonaparte Gulf, Oceanic Shoals and Tiwi meso-scale bioregions.

Arafura Commonwealth Marine Reserve[16]

The Arafura CMR is located in the Timor Sea and extends from north-west of Croker Island to the tributary canyons of the Arafura Rise. The Arafura CMR includes a continuous transect from the edge of Northern Territory waters (three nm) to the limit of Australia's EEZ (200 nm).

The reserve incorporates four of the eight Tributary Canyons of the Arafura Depression. These canyons are the remnants of a drowned river system that existed during the Pleistocene era and are a KEF. The steep topography of the canyons, their diverse current regimes, nutrient enrichment and entrapment, detritus funnelling and diverse substrate types form widely divergent ecosystems which, in combination with the regional setting and geological origins of the area, strongly influence species biodiversity.

At least 245 macroscopic species have been recorded from the canyons, including a diverse variety of invertebrates such as sponges, corals, sea anemones, tunicates, worms, crustaceans, brittle stars and feather stars.

The waters within the Arafura CMR provide important foraging and inter-nesting habitat for threatened flatback, green, hawksbill and olive ridley marine turtles that are preparing successive egg clutches for laying on nearby coasts. Waters within and adjacent to the southern boundary of the reserve are also important foraging habitats for breeding aggregations of migratory roseate terns.

[16] DNP 2013d.

The Northern Territory Garig Gunak Barlu National Park lies approximately 30 km from the Arafura CMR and the Croker Island Group Site of Conservation Significance lies adjacent to the reserve. The conservation values of the Arafura CMR are summarised in table 3.8.

Table 3.8 Conservation values of the Arafura Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d)

Conservation values	Description
Biological seascapes	Represents 12 biological seascapes (a combination of physical and biological information). Cluster 1: Moderately high variation in seabed oxygen, moderately low chlorophyll A, moderately low turbidity, primarily sandy, deep mid-shelf. Cluster 3: Moderately high sediment mud content, low sediment sand content, high variation in seabed oxygen, low salinity average, mid-shelf depth range. Cluster 5: Very low average water temperature at the seabed, low variation in sea surface temperature, very low benthic irradiance, upper slope depth range, very high silicate average, very low chlorophyll A, very low average seabed oxygen, very low turbidity, very high nutrients. Cluster 6: High sediment carbonate, high average sea surface temperature, low variation in water temperature at the seabed, moderately high variation in bottom stress, mid-shelf depth range. Cluster 8: Very high average sea surface temperature, low variation in sea surface temperature, low benthic irradiance, outer-shelf depth range, moderately low average seabed oxygen, moderately high silicate average, moderately high sediment mud content. Cluster 10: Low average water temperature at the seabed, low benthic irradiance, shelf-break depth range, high silicate average, low chlorophyll A, low average seabed oxygen, low turbidity, high sediment mud. Cluster 11: Low sediment carbonate, very high sediment mud, very low sediment sand content, very low sediment gravel content, low sediment carbonate, low salinity average, moderately high average water temperature at the seabed, depth. Cluster 12: Low sediment mud content, moderately high sediment sand content, inner-shelf depth range. Cluster 14: Very low sediment mud content, high sediment sand content, high sediment gravel content, high sediment carbonate, relatively low average sea surface temperature, very high variation in salinity, very high variation in bottom stress, very high bottom stress, moderately shallow. Cluster 15: High average water temperature at the seabed, high benthic irradiance, low silicate average, very low salinity average, shallow depth. Cluster 16: Moderately high salinity average, moderately high variation in seabed oxygen, depth range. Cluster 17: Low average water temperature at the seabed, high silicate average, low average seabed oxygen and very high variation in seabed oxygen, high nutrients and very high variation in nitrate, outer-shelf depth range.
Depth	5–250 m.

cont'd overleaf

***** Containing representative examples of the Northern Shelf and Timor Transition provincial bioregions and the Arafura and Coburg meso-scale bioregions.

Table 3.8 Conservation values of the Arafura Commonwealth Marine Reserve* (after DNP 2014c and DNP 2013d) cont'd

Conservation values	Description
Seafloor features	Apron/fan, banks, shoals, canyon, deep/hole/valley, ridge, shelf, terrace.
Key ecological features	Tributary canyons of the Arafura Depression.
Species	Important foraging and inter-nesting areas for the threatened flatback, green, hawksbill and olive ridley turtles. Important foraging habitat for breeding aggregations of the migratory roseate tern.

***** Containing representative examples of the Northern Shelf and Timor Transition provincial bioregions and the Arafura and Coburg meso-scale bioregions.

<u>Gear type and fisheries in the former Finfish Trawl Fishery</u>

Semi-demersal trawl (also called semi-pelagic otter trawl or high-aspect semi-pelagic trawl) is a form of trawling that fishes close to the seabed, with only the trawl boards, wing-end weights and chain droppers coming in contact with the seabed (FRDC 2014).

The semi-demersal trawl gear used in the previous Finfish Trawl Fishery was described as having a semi-demersal net separated by two otter boards with mesh that must exceed 110 mm and a footline that must not exceed four kg per linear metre (Wendy trawl net) (DEWHA 2009b). Additionally, a system comprising grids and rails on the fish hopper to enable sharks and rays to be returned to the water via a chute in a timely manner must be in place (DEWHA 2009b). Square mesh codends and BRDs which have a similar design to TEDs were being used on a voluntary basis (DEWHA 2009b).

<u>North and North-west Fishing Gear Risk Assessment</u>

This assessment for the North and North-west CMRs was based on risks that commercial fishing methods posed to the conservation values identified in the Areas for Further Assessment (AFAs) in the North and North-west Marine Regions (Lack 2010).

Lack (*op. cit.*) noted that there were no specific risk assessments of the habitat impacts of semi-demersal trawl gear and that the success of the gear in minimising benthic impacts relied in part on the skill and experience of the operator in deploying and using the gear. As a consequence, information on habitat impacts in the Northern Prawn Fishery was used to assess the impacts of both demersal trawl methods.

Benthic habitat impact assessment

The assessment of the benthic habitat impacts of the Northern Territory Finfish Trawl Fishery was based on information available about habitat impacts in the Level 2 ERA for the Northern Prawn Fishery (Lack *op. cit.*). The assessment determination was that there was an 'Unacceptable' impact from semi-demersal trawl gear on benthic habitats in the Northern Prawn Fishery (see section 3.1.2).

Sawfishes and other chondrichthyans impact assessment

In accordance with the application of the precautionary approach, the Level 2 Northern Prawn Fishery risk ratings for chondrichthyans, as well as the outcomes of the Level 2.5 SAFE findings for chondrichthyans, as further refined in the Northern Prawn Fishery's Ecological Risk Management Report, were taken into account in FGRA analysis. Taking into account the precautionary approach, the FGRA contained a finding of 'Unacceptable' for semi-demersal trawl gear (Lack 2010).

Reviews of the Fishing Gear Risk Assessment

A review of the FGRA by CSIRO (Griffiths 2010) made the following observations:

- From available datasets it may be assumed that gear used in the Northern Territory and Queensland fish trawl fisheries may have lower impact on benthic habitats than the Northern Prawn Fishery tiger prawn fishery since the fish trawl gear is intended to fish above the sea floor. However, anecdotal accounts from scientific observers indicate that fish trawl gear is often fished hard along the seafloor, to the extent where entire coral shelves are caught in the trawl gear. It is therefore reasonable to make the precautionary assumption that the fish trawl fisheries have the same impact as the Northern Prawn Fishery tiger prawn fishery.
- More recent studies have questioned the uncertainty surrounding the recovery of erect, rugose and inflexible octocorals after interaction with trawl gear (Pitcher 2007). Anecdotal evidence suggests that the blotched fantail ray and porcupine ray are rarely encountered in northern Australian fisheries, probably because their primary habitats are outside the high-effort fished regions.
- The biology of sawfish species is poorly understood and more research on sawfishes is critical for understanding how they might respond to fishing pressure.

A second independent review of the FGRA (Bodsworth and Knuckey 2011) commissioned by the National Seafood Industry Alliance noted:

- The FGRA process did not identify a specific risk assessment for habitat impacts of this method and used a precautionary approach also informed by assessment of habitat impacts from demersal trawl gear used in the Northern Prawn Fishery.
- A brief literature search identified two directly relevant examples supporting an assessment that semi-demersal trawl has significantly less impact on the benthos than demersal trawl. Brewer *et al.* (1996) compared the relative performance difference between this gear and standard demersal trawl gear, reporting convincingly fewer (number and biomass) of unwanted species normally taken in trawls.
- Similar research comparing performance of semi-demersal and standard demersal trawl gear in the waters of the North West Slope Trawl Fishery (NWSTF) found that fishing with the semi-pelagic trawl (about 15 cm off the seabed) had no measurable effect on the benthos (Moran and Stephenson 2000).
- Queensland Gulf of Carpentaria Development Finfish Trawl Fishery observer data suggests a very low proportion of benthos in the catch (0.03 per cent of bycatch by weight) (DEEDI 2010).
- Semi-demersal trawl gear was assessed as ‘Unacceptable’ under the North Marine Region FGRA due to assumed levels of risk on sawfish and habitats in the Van Diemen and Arafura AFAs.

<u>Additional information</u>

Fishery amalgamation

The Finfish Trawl Fishery was amalgamated with the Demersal Fishery in February 2012 (DPIF 2012). Traps and lines are permitted across the whole fishery, and finfish trawl (that is, semi-demersal) gear is permitted in two defined zones (Demersal Multigear Areas) as shown in figure 3.4 (DPIF 2012).

The fishery operates in waters from 15 nm from the coastal baseline to the outer limit of the AFZ, excluding the area of the Timor Reef Fishery (DPIF 2014a).

The Northern Territory Fisheries Joint Authority, through the Northern Territory Fisheries Act, manages all finfish taken in the Demersal Fishery, while the day-to-day management of the fishery is conducted by the Fisheries Division of the Department of Primary Industry and Fisheries (DPIF 2012).

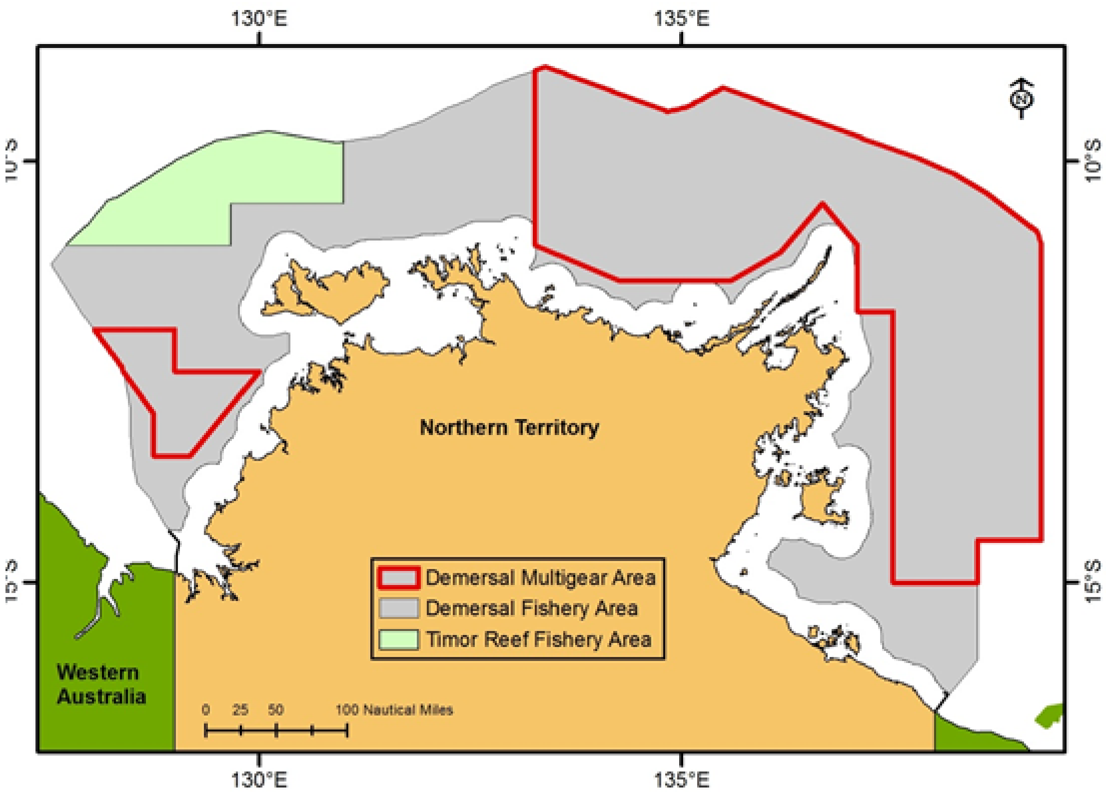

Figure 3.4 Northern Territory Demersal Fishery and Timor Reef Fishery Development Fishery (DPIF 2012) © Copyright, Department of Primary Industries and Fisheries

Gear type and deployment

The semi-demersal trawl net was developed cooperatively between government and industry. It is designed to minimise seabed disturbance and reduce the amount of bycatch and environmental impact in the fishery (DPIF 2012; NTSC 2012). The use of high-aspect trawl boards reduces bottom contact by as much as 80 per cent compared to traditional otter boards used for fish trawling in the past (NTSC 2012). The use of a BRD in conjunction with the square-mesh funnel/codend is stated to further reduce some of the broader ecosystem impacts (DPIF 2012). Semi-demersal trawl gear is permitted only within two defined zones in the Demersal Fishery, neither of which intersect with the Oceanic Shoals CMR.

The Timor Reef Fishery operates in remote offshore waters of the Northern Territory and harvests demersal fish species using traps and lines. Total allowable catches and individual transferable quotas allow for the sustainable harvest of goldband snappers, red snappers, and all other retained fish (‘group’ species) targeted in the fishery. Currently a development permit has been issued to trial finfish trawl gear in the Timor Reef Fishery (DPIF 2014a).

Four precautionary methods are described for the Timor Reef Fishery Developmental Fishery (Australia Bay Seafoods 2015):

‘Semi Demersal Trawl Nets

Fishing operations are conducted using a semi-pelagic demersal trawl. The trawl net was developed cooperatively by Australia Bay Seafoods and the NT government to minimise habitat disturbance whilst ensuring commercial catch rates were maintained.

Bycatch Reduction Device (BRD)

Different styles of aluminium grids are used in many prawn trawl fisheries to allow larger bycatch such as sharks to escape unharmed. Unfortunately these grids are simply unusable in trawling for fish as they would have to be wound onto a net drum which simply cannot occur. To overcome this problem Australia Bay Seafoods have developed a large grid made from stainless steel wire rope which while successfully allowing larger bycatch to escape unharmed can also be wound onto the vessels net drum. A significant drop in shark catches has been seen since the grids implementation and again the quality of retained catch has improved.

Hopper release system

To assist in reducing release mortality, Australia Bay Seafoods has developed a system comprising grids and rails on the fish hopper to enable sharks and rays to be returned alive to the water via a chute with minimal handling. The hopper system is now being evaluated by other trawl fisheries interstate with the intention of incorporating its use as standard operating practice.

Square Mesh Net
This is used to allow small fish to escape. As the Cod end fills with fish there is more tension on the meshes of the net, this tension reduces the size of normal netting and causes excess catch of unwanted small fish. To minimise the catch of small fish, Australia Bay Seafoods utilise a square mesh (T90) Cod end extension. As the tension increases this section of netting stays open and allows small fish to escape.’

Recent descriptions of the habitat in the Oceanic Shoals Commonwealth Marine Reserve[17]

In 2012, four areas in the western sector of the Oceanic Shoals CMR were surveyed, including a range of seabed geomorphic features in water depths from 30 to 180 m, such as carbonate banks, terraces and pinnacles, as well as soft sediment plains and valleys. The survey provides new information about the range of seabed environments occurring on the banks and terraces of the Oceanic Shoals CMR.

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[17] Nichol *et al.* 2013.

Key observations of this survey were that:

- the geomorphic diversity of the Oceanic Shoals CMR is well represented in the western part of the reserve, with numerous banks and terraces providing hard substrate for benthic communities
- the epibenthic biodiversity on banks appears to vary as a function of water depth and related light and turbidity conditions, with shallower banks (less than 45 m) supporting more biodiversity than deeper banks, including hard corals
- species richness and endemism of sponges in the western sector of the Oceanic Shoals CMR may not be as high as those in the eastern sector, with sponges from the west comparatively dominated by species that are common across northern Australia (to be confirmed by taxonomic analysis)
- spatial gradients in epibenthic biodiversity exist as a possible function of marked changes in substrate, light and turbidity levels along the depth transition from bank to terrace to plain
- tidal currents play an important role in regulating levels of suspended sediment (turbidity) and in redistributing sediment across the plains and around banks and terraces, with some smaller banks partly buried by sediment
- demersal fish communities respond to spatial patterns in benthic biodiversity, occurring in larger and more diverse populations on the shallower, less turbid banks
- a wide variety of high-order pelagic fish species occur in these waters.

The preliminary results and conclusions of Nichol *et al.* (2013) are described below:

- Common biological and habitat characteristics were found across all survey areas. Banks and scarps were characterised by coarse, muddy sand with occasional gravel inclusions, whereas plains, terraces and mounds were composed of softer silt or sandy silt. Two different types of depressions were characterised—deep, steep-sided depressions (muddy, silty gravel) and shallower depressions (inferred to have a silt or sandy silt composition). Associations were identified between the geomorphology and substrate types and the distribution of epibenthic and infaunal communities. The survey found that epifauna was rare over the terraces and plains, although in particular areas there were very common burrows and mounds, indicating that abundant or rich infaunal communities were present in the unconsolidated sediments of some plains and terraces. In one deep depression there was evidence of a hard substrate and higher epifaunal biodiversity (sponge and octocoral gardens) compared to the surrounding plains. Moderate to dense biological coverage was found more frequently on banks than on plains or terraces and reef-forming corals were restricted to banks.

- While taxonomic identifications are pending, on board observations suggest that sponges in the survey areas were predominantly common northern Australian species. This is in contrast to results from previous surveys in the eastern sector (Przeslawski *et al*. 2011), which indicated that species richness and endemism of sponges in the western sector of the Oceanic Shoals CMR were probably less than in the eastern sector.

Industry environmental management

The Northern Territory Seafood Council has established a Demersal Fishery Environmental Management System—a voluntary, industry-driven environmental initiative (NTSC 2012). The environmental management systems for the former Finfish Trawl Fishery and the Demersal Fishery were originally developed in 2006 by the Northern Territory Demersal Fishermen's Association and the Finfish Trawl Licensee Committee with assistance from the Northern Territory Seafood Council and the Fisheries Research and Development Corporation (NTSC 2012). These documents were revised in 2011 to cover the amalgamated Demersal Fishery (NTSC 2012).

The goals of the environmental management system include identifying and assessing potential environmental impacts and risks concerning the fishery, their likelihood of occurrence and predicted consequences; providing fishery operators with a defined set of actions to reduce those risks and improve the fishery; and providing an ongoing process for the environment management system and the environmental performance of the fishery, to be continually reviewed and improved (NTSC 2012).

In 2012, bycatch was reported to be less than 20 per cent of the total trawl catch in the Demersal Fishery (DPIF 2012). The presence of larger species, including sharks and rays, was noted to have declined, coincidental with the use of BRDs (DPIF 2012).

It was reported that a small number of interactions with TEP species was recorded by onboard observers in 2012 (DPIF 2014b). The number of interactions was reduced with the improvement of the BRD technology as the fishery developed through the year (DPIF 2014b).

Ongoing research into the impacts of trawl on bycatch species and benthic habitats is encouraged, particularly longer-term monitoring, as the cumulative impacts may be found to be significant (Foster *et al.* 2015).

National Recovery Plan for Sawfish and River Sharks[18]

A draft recovery plan for sawfish and river sharks has been published by the Department of the Environment. This plan applies to the largetooth sawfish (*Pristis pristis*), green sawfish (*Pristis zijsron*) and dwarf sawfish (*Pristis clavata*) that can be present in the Oceanic Shoals and/or Arafura CMRs.

The recovery plan notes:

> *Commonwealth marine reserves network protects habitats important for threatened species. Their location outside of state waters (3 nautical miles off the coast) means they relate to solely marine environments and therefore would support adult sawfish and river sharks once they mature and utilise offshore areas. There are 21 Commonwealth Marine Reserves in the North and North-west Commonwealth Marine Reserve Network that sawfish and river shark species may utilise.*

The primary objective of the recovery plan is to assist the recovery of sawfish and river sharks in Australian waters, including through reducing and, where possible, eliminating adverse impacts of commercial fishing on sawfish. Additional management measures other than those contained in the abatement plan are being implemented through a number of agencies (AFMA; Department of Agriculture, Fisheries and Forestry; and state and territory governments). These measures include area and seasonal closures, compulsory recording of incidental capture, mechanisms to encourage recreational fishers to report interactions, and a number of observer programmes that provide independent measures of mortality in state and Commonwealth waters.

ESP finding

Recent research, an improved understanding of the habitat, a better identification of the conservation values of the area and improvements in gear type and management suggest that Demersal and Developmental Fishery operations (semi-demersal trawling) may not impact as significantly on the benthic environment as previously thought.

More recent evaluations of the risks to elasmobranchs suggest that none were at risk because of widespread distributions and/or low overlaps with the fishery. A national recovery plan is being developed to address threats to these species.

It is highly likely that a similar situation may apply to other areas of the North and North-west Commonwealth Marine Reserves. However, consideration must be given to ensuring that sufficient areas are protected from the impacts of trawl, especially where there is an absence of Marine National Park Zones.

[18] DoE 2014.

3.1.4 Review of the Fishing Gear Risk Assessment rating for Western Australian Trawl Fisheries, specifically demersal scallop trawl in Bremer and Geographe Commonwealth Marine Reserves

Description of the location and habitat

Geographe Commonwealth Marine Reserve

The Geographe CMR lies within and adjacent to Geographe Bay south of Perth, Western Australia, and has a depth range of 15 m to 70 m.

It is an area of high benthic productivity and high biodiversity, where extensive seagrass meadows support habitat for a wide variety of fish and invertebrates (Westera *et al.* 2007). It is also recognised as being an important foraging area for several threatened and migratory seabirds and falls within the migratory pathways of several cetaceans, including both humpback and blue whales (DNP 2014d).

In nearshore waters (2–18 m), seagrass meadows have been well described (Walker *et al.* 1987; McMahon *et al.* 1997; Westera *et al.* 2007) and are dominated by *Posidonia sinuosa* (60 per cent cover), with *Amphibolis antarctica* and other species found around the edges of *P. sinuosa* meadows and on limestone outcrops (McMahon and Walker 1998). In recent tow video footage in deeper water (15–40 m) in the western portion of the area, *Zostera* has also been identified, as well as patchy distributions of dense epiphytes (Van Niel *et al.* 2009). Seagrass contributes large amounts of wrack (detached leaves and stems) to the local beaches, predominantly during winter storms (Oldham *et al.* 2010).

Westera *et al.* (2007) show clear changes with increasing distance from shore with the cover of the seagrasses, *A. antarctica* and *P. sinuosa* decreasing, while *A. griffithii* and the number of rocky reefs increase. Changes in seagrass species composition have been correlated with increasing depth of water, which is typical of other seagrass meadows in the region. Westera *et al.* (*op. cit.*) suggest it is very likely that increases in the number of rocky reefs with distance from shore would have important ecological influences on assemblages of fishes, invertebrates and algal assemblages.

More recent surveys conducted by the National Environmental Research Program have used BRUV drops in deeper water across the CMR. This sampling, using a Generalised Random Tessellated Stratification survey design, indicates that seagrass habitat is more extensive across Geographe Bay and appears to be one of the largest continuous seagrass beds recorded in Australia. BRUV surveys also confirm that fish assemblages differ by depth and between seagrass, reef and sand habitats (Bax and Hedge 2015).

Westera *et al.* (2007) consider that the natural marine habitats of Geographe Bay face potential impacts from increases in population; growth in tourism; recreational and commercial fishing; introduced marine pests; and climate change. Observed decreases in seagrass cover have coincided with extensive land clearing and drain construction during the 1950s, which may have resulted in increased sediment loads and smothering of seagrasses. More recent concerns have centred on high levels of nutrients entering Geographe Bay from agricultural and urban run-off. However, Westera *et al.* (*op. cit.*) conclude that there is insufficient current information to detect current impacts or predict future impacts.

The conservation values of the Geographe CMR are summarised in table 3.9.

Table 3.9 Conservation values of the Geographe Commonwealth Marine Reserve* (after DNP 2014d and DNP 2013e)

Conservation values	Description
Biological seascapes	Represents five seabed assemblages (which are derived from sediment and depth data). Cluster 7: Moderately small variation in sea surface temperature, relatively high sediment carbonate, moderate salinity average, mid-shelf depth range. Cluster 11: High sediment carbonate, high intermediate salinity average, outer-shelf depth range. Cluster 13: Relatively low sediment carbonate, mid-shelf depth range, some areas of high sediment mud content. Cluster 14: Very high sediment carbonate, moderately high salinity average, shelf depth range, moderate average water temperature at the seabed. Cluster 17: Low carbonate, low surface water temperature average and variation, inner shelf depth range.
Depth	15–70 m.
Seafloor features	Shelf.
Key ecological features	The Commonwealth marine environment within and adjacent to Geographe Bay (high benthic productivity, high biodiversity, feeding, resting, breeding and nursery aggregations).
Species	Important foraging areas for the threatened soft-plumaged petrel. Important foraging areas for the migratory wedge-tailed shearwater. Important pre-migration aggregation area for the migratory flesh-footed shearwater. Important migratory habitat for the protected migrating humpback and blue whales. Western rock lobster habitat (species with an important ecological role).

* Containing representative examples of the South-west Shelf Province on the continental shelf as well as the Leeuwin–Naturaliste meso-scale bioregion.

Bremer Commonwealth Marine Reserve

The Bremer CMR extends from the state water boundary close to the terrestrial Fitzgerald River National Park. It covers a depth range from about 15 m at the northern boundary to depths of 5000 m or more at the southern edge of the reserve.

The Bremer CMR covers most of the Bremer Canyon—a major feature in the region and one of nine shelf-incising canyons in the south-west. Shelf-incising canyons provide more diverse marine habitat and intersect major ocean boundary currents on the Australian margin. Associated hydrodynamics such as upwelling enhance the horizontal and vertical exchanges of water and materials between the slope and shelf (Huang *et al.* 2014).

The Bremer CMR is known as an area that supports diverse feeding aggregations of megafauna such as killer whales, southern right whales, sperm whales and sharks (De Barros *et al*. 2013). The area is also a foraging area for Australian sea lions and a range of seabirds, including the Indian yellow-nosed albatross. Hovland and Riggs (2014) have suggested that hydrocarbon seepage in the vicinity of the Bremer Canyon may support a productive phytoplankton feedstock for bait species, higher-order predators and marine mammals.

The conservation values of the Bremer CMR are summarised in table 3.10.

Table 3.10 Conservation values of the Bremer Commonwealth Marine Reserve* (after DNP 2014d and DNP 2013e)

Conservation values	Description
Biological seascapes	Cluster 7 (mid-shelf): Moderately small variation in sea surface temperature, relatively high sediment carbonate, moderate salinity average, mid-shelf depth range. Cluster 10 (shelf): Shelf depth range, moderately high average water temperature at the seabed and surface, moderate low variation in sea surface temperature, intermediate low oxygen average at the seabed, moderately high sediment carbonate. Cluster 11 (outer shelf): High sediment carbonate, high intermediate salinity average, outer-shelf depth range. Cluster 15 (outer shelf and break): Very low surface water temperature average and variation, moderately low average seabed water temperature, high average seabed oxygen, relatively low silicate average and variation, outer-shelf/break depth range. Cluster 18 (upper slope): Very low salinity average, very low average seabed water temperature, very high nutrients, high average seabed oxygen, high silicate average, upper-slope depth range.
Depth	15–5000 m.
Seafloor features	Shelf.
Key ecological features	The Albany Canyons group (high productivity, feeding aggregations).
Species	Foraging areas for the threatened white shark, Australian sea lion, Indian yellow-nosed albatross, soft-plumaged petrel and flesh-footed shearwater. Migratory areas for protected humpback whales. Seasonal calving habitat for the threatened southern right whale. Known aggregation site for sperm whales and killer whales.

* Containing representative examples of the Southern Province and the South-west Shelf Province on the continental shelf and the Western Australia South Coast meso-scale bioregion.

Target species, gear type and relevant fisheries

Target species

While several scallop species are known in Western Australian waters, only the saucer scallop *Amusium balloti* supports a commercial fishery (Harris *et al.* 1999). Saucer scallops tend to be restricted to sandy substrates in sheltered environments and the lee of islands and reef systems and, although saucer scallops are found between Broome in the north to Esperance in the south, the fishery is concentrated in Shark Bay and around the Abrolhos Islands (Joll 1989). The species has been reported in depths from 10 m to 75 m (Dredge 1988). Saucer scallops develop rapidly, growing to a size of 90 mm in just six to 12 months, and are characteristic of short-lived species with high natural mortality, making them susceptible to a 'boom and bust' life history. Recruitment of scallops to the west coast of Australia is highly variable and not thought to be dependent on the density of spawning biomass. As a result, catch rates and annual tonnage vary dramatically from year to year (Caputi *et al*. 1996). Because saucer scallops are capable of flight swimming, fisheries target them using low-opening otter trawls (Sporer *et al.* 2014).

Gear type

Saucer scallops are targeted using twin-rigged otter trawls, each with a 10 mm ground chain and 100 mm mesh size. Twin gear otter trawls are also used to catch scalefish; however, mesh sizes may be larger. These trawl nets are towed along the seabed and are held open by a pair of otter boards on either side attached to the wings of the net. All vessels are required to fish with a BRD and a secondary fish exclusion device (FED) in each net (DSEWPaC 2013). When searching for scallops, fishers test the viability of an area by towing a smaller try-net.

Vessels generally tow two low-opening demersal otter trawl nets at a speed of around 2.5 to 3.5 knots, as this is the most effective speed when targeting scallops. Shot durations can vary from around 20 minutes up to 150 minutes, depending on scallop abundance. The ground chain travels across the sea floor and disturbs scallops so that they swim up from the seafloor and into the path of the oncoming net. Low-opening nets have the headrope set in front of the footrope (which creates a net 'veranda'), ensuring that scallops disturbed by the ground chain do not usually pass over the headrope. The ground chain is designed / set to make it skim over the sand without digging into the sea floor (WA DoF 2005). Figure 3.5 shows the standard twin otter rig and try gear used by trawlers targeting scallops in the South Coast Trawl Fishery.

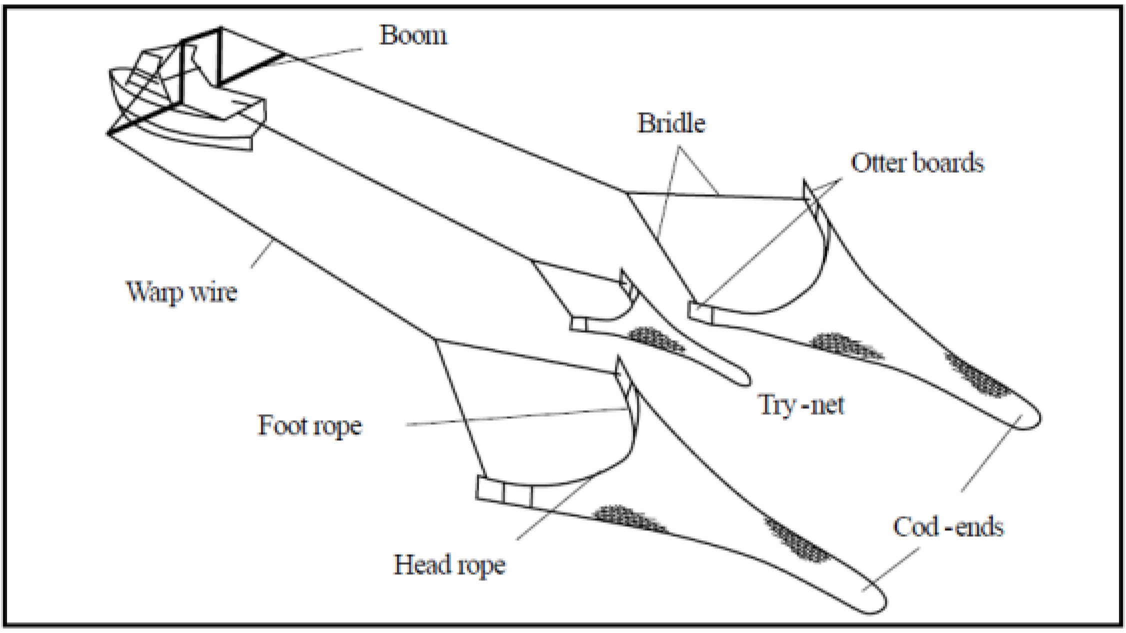

Figure 3.5 Rig and gear used by trawlers targeting scallops in the South Coast Trawl Fishery (WA DoF 2005). Note that the twin otter rig and try-net are shown on the same diagram but used separately as described above © Copyright, Department of Fisheries (Western Australia)

South West Trawl Managed Fishery (covering Geographe Commonwealth Marine Reserve)

The South West Trawl Managed Fishery (SWTMF) includes two of the state's smaller scallop fishing grounds—Fremantle and north of Geographe Bay (WAFIC 2015). It is a multi-species fishery including scallops (*A. balloti*), western king prawns, mixed whiting species, blue swimmer crabs and other mixed fish. Good scallop landings were taken in 1990 and 2010, but catches are generally low due to variability in recruitment (Sporer *et al.* 2014).

The SWTMF is a gear-based managed fishery that operates under an input control system that limits boat numbers, gear sizes, fishing areas and season. The management plan also includes large closures to protect sensitive coastal habitats (including seagrass beds) and nursery areas such as Cockburn Sound, Warnbro Sound and inshore Geographe Bay (Sporer *et al.* 2014).

A total of 13 licences operate. This is seen as a comparatively small, low-activity fishery in which effort is related to the abundance of scallops in any given year, which can be highly variable (Kangas and Zeller 2014).

South Coast Trawl Fishery (covering Bremer CMR)

The South Coast Trawl Fishery (SCTF) principally targets scallops (*A. balloti*) and associated by-product species, although in years of low scallop catches licensees may use other trawl gear to target finfish species. Scallop landings in the fishery are variable, depending primarily on the strength of recruitment (Sporer *et al.* 2014). While the boundaries of the fishery cover a large section of the south coast, the operations of the fleet are effectively restricted to very small areas of higher scallop abundance—mainly the waters of Bremer Bay, the Recherche Archipelago and Israelite Bay (WA DoF 2005).

The SCTF is managed primarily by limited entry, with only four licences permitted to operate in the fishery. Additional management arrangements for the SCTF are set by conditions within the Instrument of Exemption and are aimed at ensuring the stock and environment are protected via gear restrictions and seasonal closures. The Department's VMS monitors the activities of all boats, including compliance with the spatial closures. The Department of the Environment has assessed the SCTF under the provisions of the EPBC Act and granted a three-year export approval for the fishery until 6 May 2016.

South-west Fishing Gear Risk Assessment

The Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) conducted a desktop FGRA for the South-west Marine Region (DSEWPaC 2010). The assessment was undertaken to determine the potential risks posed by fishing methods to the conservation values and marine biodiversity identified within AFAs.

The South-west Marine Region FGRA was completed in two stages:

1. identification of elements of the South-east Marine Region FGRA (E-Systems 2005) that could be transferred to the South-west Marine Region, as well as gaps that existed in terms of fishing methods or conservation values of the South-west Marine Region
2. assessment of the risks posed by the methods found to be of medium- to high-risk in the south-east FGRA.

The two (south-east and south-west) FGRAs differed in that the south-west FGRA applied the Australian Government's quantitative ERAs for the effects of fishing (ERAEFs) findings rather than risk ratings agreed through a workshop, noting that these ERAs had been undertaken in consultation with relevant industry representatives and that these assessments were based on the best available science and expert input (DSEWPaC 2010).

The south-east FGRA finding of 'Incompatible Risk' for demersal/bottom trawl was considered transferable to the south-west based on similar gear types and habitats within which demersal trawl operates. In addition, the ERAs for both the Commonwealth bottom trawl fisheries operating in the South-west Marine Region identified seafloor habitat degradation and mortality rates of non-target species as key concerns, with numerous seafloor habitats and by-product and bycatch species rated as being at potentially high risk (Wayte *et al.* 2007; Daley *et al.* 2007).

However, state managed fisheries had not been assessed under the Commonwealth's quantitative ERA process, including three fisheries that operate demersal trawl within Commonwealth waters of the South-west Marine Region:

1. Abrolhos Islands and Mid West Trawl Managed Fishery (MWTMF)
2. the SWTMF
3. the SCTF.

Due to key differences in target species and the localised nature of these fisheries, specific information was sought for each of these fisheries (DSEWPaC 2010). ESD reports submitted to the Department of Environment, Water, Heritage and the Arts (DEWHA) for assessment found negligible impacts on bycatch, negligible to low impacts on protected species, and low impacts on benthic habitats in the MWTMF, SWTMF and SCTF (WA DoF 2004; WA DoF 2005). The 2008/09 Western Australian State of the Fisheries Report stated that these fisheries also have a low impact on bycatch, protected species and ecosystems (Fletcher and Santoro 2009).

DEWHA (2008b) noted the lack of species-specific identification of small elasmobranches caught in the MWTMF—something that has also been identified as a key issue in the National Plan of Action for the Conservation and Management of Sharks (DAFF 2012).

In the absence of detailed information about bycatch or by-product mortality on shark species, and consistent with a precautionary approach, these fisheries were considered incompatible with the conservation objectives of CMRs (DSEWPaC 2010).

Reviews of the South-west Fishing Gear Risk Assessment

Reviews of the South-west FGRA were conducted by Smith (2010) and Knuckey *et al.* (2011). Both concluded that, given the policy context, the conservation values of interest and the purpose of the paper, the general approach and the methods applied in this analysis seemed appropriate and the conclusions were reasonable given the stated objectives. However, Knuckey *et al.* (2011) criticised the assumption that gear risk ratings could be transferred from one bioregion to another, not only in terms of gear but also in terms of habitat similarity (both extent and composition) between each bioregion. They argued that, although the assumptions about gear can be fairly readily verified, a bioregion, by definition, is characterised by distinctive flora and fauna, so the validity of the second assumption should be scrutinised carefully before the transfer of risk ratings is made. Even within a single bioregion, there can be extensive areas of certain habitat types for which the risk ratings of certain gears may be quite different than other habitat types. Potentially, such areas of habitat type could be captured within a particular AFA or reserve but not in another.

Additional information

Marine Stewardship Council certification

The pre-assessment phase for the MSC approval system is under way for the South West Trawl Managed Fishery and the SCTF (Fletcher and Santoro 2014); however, this information was not available for scrutiny.

Impacts on the benthos

In general, the Western Australian saucer scallop fisheries are considered to have a low risk of adverse habitat effects, with trawling usually occurring over a small proportion of the designated trawl area. The physical impact of this gear on the sandy habitats within these areas is regarded as negligible (Kangas and Zeller 2014).

For example, in Geographe Bay, sampling and underwater observations before and after depletion trawling failed to detect any impact on the benthic communities of existing trawl grounds. In this study the area was completely swept by the trawl gear on four successive occasions during a single night, with one sweep over the area consisting of four trawls (Laurenson *et al*. 1993). Geographe Bay is dominated by seagrass, rock and rubble habitats and is largely untrawlable. The limited availability of suitable ground for trawling for scallop habitats in this sector indicates that further expansion of the area trawled is unlikely (Laurenson *op. cit.*) .

Similarly in Shark Bay, Kangas *et al*. (2006) note that scallop trawling occurs mostly over the sand and shell habitats and has the effect of flattening this otherwise rippled and three-dimensional substrate—and this may also indirectly affect the species that inhabit this area by changing the nature of their habitat—but that the potential impact on the sand and shell habitat as a result of the scallop trawling operations was considered to be of minor consequence. Kangas *et al.* (*op. cit.*) argue that this is due to the small percentage of the area actually trawled as well as the length of the period in which trawling occurs (it usually only occurs for about two months of the year).

These findings are consistent with similar findings in scallop trawl fisheries elsewhere (Dignan *et al.* 2014).

Impacts on threatened, endangered or protected species

The risk of TEP species interactions in the SWTMF and SCTF is assessed as ‘Low’. TEP species do not occur regularly in the fishing areas despite frequenting the surrounding waters and there were no recorded captures of listed species in 2013 for either of these fisheries (Fletcher and Santoro 2014).

The DSEWPaC assessment for the SCTF stated that there has been little evidence of interactions with protected species recorded in the fishery. An ERA for the fishery was completed in 2005, which identified the incidental capture of syngnathids in trawl nets as low risk. Given the low number of boats in the fishery and the limited area trawled, the risk presented by the fishery to protected species is still considered to be low (DSEWPaC 2013).

Impacts on bycatch

The Government of Western Australia's Department of Fisheries has also assessed the impacts on bycatch as 'Low' (Fletcher and Santoro 2014). In the SWTMF trawling for scallops is focused on a few small offshore areas, while the prawn catch is mainly taken from Comet Bay (Zone D). The large-mesh (100 mm) trawl gear used in the SCTF takes minimal bycatch.

For the SCTF, DSEWPaC found that the risk to bycatch species in the fishery was low. The large minimum net mesh sizes (100 mm or greater) used in trawl nets for scallops and demersal scalefish trawling combined with the low number of licenses (four) and the actual area trawled within the fishery (area trawled is much smaller than the extent of the fishery) contributes to a low risk to bycatch species. All trawl nets in the fishery are also required to have BRDs in the way of grids, which also lowers the risk to bycatch species (DSEWPaC 2013).

Impacts on the food chain and ecosystem

The Government of Western Australia's Department of Fisheries has also assessed the impacts on the food chain as 'Low' (Fletcher and Santoro 2014). The total biomass taken by these fisheries is generally very small. Moreover, due to the high natural variability of scallop stock abundance, it is unlikely that any predators are highly dependent on this species.

For the SCTF, the DSEWPaC assessment was that the variable recruitment, resultant fluctuating biomass of the scallops and the low retained catch of scalefish species suggests the fishery is likely to have a minor impact on the general food chain in the region. Scallops have a high natural variability and therefore trophic impacts on the fishery's removal of scallops are likely to be low (DSEWPaC 2013). DSEWPaC also notes that vessels in the fishery operate over a small proportion of the licensed area and therefore benthic impacts are contained to this small area. In addition, trawling is restricted to areas of high scallop abundance, which is predominantly sand-based habitat and resilient to impacts from trawling.

ESP finding

The South-west Fishing Gear Risk Assessment for demersal/bottom trawling, which had been transferred from the South-east Fishing Gear Risk Assessment, was not applicable to demersal scallop trawling in Western Australia.

For this reason, the fishing risk was assessed against ecologically sustainable development reporting conducted by the Western Australian Department of Fisheries. It concluded that demersal scallop trawl was incompatible with the conservation objectives of Commonwealth marine reserves, based primarily on the lack of information on the impact of these fisheries on small shark species.

More recent research on the impact of scallop trawling on soft substrates in Western Australia in both the South West Trawl Managed Fishery and the South Coast Trawl Fishery, together with state Ecologically Sustainable Development Assessments, suggest that the habitat impacts are both localised and minor. Similarly, current ecologically sustainable development reporting suggests that impacts on bycatch and threatened, endangered and protected species is low.

This suggests that scallop trawl fisheries operating on soft sediment substrates in the Bremer and Geographe Commonwealth marine reserves should be considered as being 'Compatible' with respect to the conservation values of these areas.

These findings may be applicable to all scallop trawl operations in Western Australia; however, care should be exercised when transferring risk assessments between areas of similar geomorphology but inherently different biodiversity assemblages.

3.2 Assessment of recreational fishing in relation to the Commonwealth marine reserve estate

In this section, we examine aspects of recreational fishing that relate to zoning and management arrangements within the CMR estate and discuss specific issues, including no-take catch-and-release, consume-on-site and pelagic fishing.

Unlike a number of commercial fishing gears, FGRAs were not specifically undertaken for different recreational fishing gear types with respect to CMRs. This was primarily because all recreational fishing gear types (see below) are similar to equivalent commercial gear types and all are allowed in IUCN zones IV and VI subject to recreational fishing restrictions such as size and bag limits (see also chapter 2).

3.2.1 Recreational fishing methods

Recreational fishing methods include hook and line (either using a rod and reel or handline), netting (set and throw nets), hand collecting, trapping and spearfishing.

Line fishing may include the use of live or dead baits as well as a wide variety of lures that may be cast and retrieved or towed (trolled) behind a moving boat. Single hooks are normally used for bait fishing, while double or treble hooks are often used with lures. Fishing reels are normally wound by hand, but mounted electric reels may also be used when fishing in deep water.

Cast nets are legally used by recreational fishers in some states, as are gillnets in others. Underwater spearfishing by speargun or handspear is another form of recreational fishing, but spearfishing while using scuba or surface air supply ('hookah') gear is not permitted by any state or territory. A variety of nets and traps are used by recreational fishers to catch prawns, crabs and crayfish, while specifically designed jigs are used to catch squid.

Recreational fishing may be undertaken from the shore, including rock platforms, beaches and jetties; and from boats ranging in size from kayaks to large long-ranging game fishing vessels. Recreational fishing also takes place from charter boats, but this is generally regarded as a form of commercial fishing and/or tourism operation in that operators of the charter business charge a fee from recreational fishers to fish from their vessels.

3.2.2 Management of recreational fishing

Management of recreational fishing, especially in relation to CMRs, is detailed in appendix 2. Reiterating two pertinent points from that summary:

- The relevant provision of the EPBC Act means that 'take' includes catching and releasing fish.
- Recreational fishing, like other extractive activities, is not allowed in Sanctuary Zones (IUCN Ia) or Marine National Park Zones (IUCN II).

Some additional aspects of management of recreational fishing are as follows.

While Commonwealth regulations determine whether or not recreational fishing may take place in CMRs, state-determined size limits, bag limits, closed seasons, gear restrictions and other regulations governing recreational fishing apply in areas zoned to allow recreational fishing. Recreational fishers fishing in salt water are required to hold a licence to fish in New South Wales and Victoria. In Western Australia, fishing in salt water from a powered boat requires a licence. In most state and territory jurisdictions, charter operators must maintain logbooks and also when fishing in permitted zones of marine reserves such as the GBRMP. Private recreational fishing vessels are not required to maintain logbooks. It is illegal in all states and territories for recreational fishers to sell their catch. This also applies to fish caught on charter vessels.

While state and territory regulations of recreational fishing apply to state and Commonwealth waters, appendix 2 of this report also notes that, in addition to management plan prescriptions, the Director of National Parks' powers under the EPBC Act in relation to recreational fishing in CMRs include the ability to specify:

- the number, species and size of fish that can be taken and/or possessed
- the type of gear and bait that can be used
- spatial and temporal closures.

However, as also stated in appendix 2, the Director of National Parks does not commonly apply additional restrictions.

3.2.3 Recreational fishing surveys

There has been only one national survey of recreational fishing participation and catch in Australia (Henry and Lyle 2003), although a repeat survey every five years is being planned. This National Recreational and Indigenous Fishing Survey, undertaken in 2001, was a comprehensive diary-based survey that ran for 12 months and covered all states and territories. The study estimated the total catch of finfish by recreational fishers in 2000–2001 to be at least 27 000 t, plus an additional 3000 t of invertebrates (molluscs and crustaceans). Estimated catches were based on reported numbers of organisms caught, which were then transformed to weights, with inherent errors in different jurisdictions. Nevertheless, the results are thought to be reasonable 'order of magnitude' estimates of total recreational catches. Removing freshwater fish from these totals (since these are not relevant to CMRs) results in a nationwide estimate of about 23 000 t of marine finfish harvested by recreational fishers in 2000–2001, most of which would have been taken in nearshore waters.

Recreational catches of marine finfish were greatest in Queensland (about 7500 t), followed by New South Wales (5100 t), Western Australia (4700 t) and South Australia (2900 t).

Complementing this national survey, there have been several statewide surveys conducted from time to time, the most recent being, for Western Australia, in 2012 (Ryan *et al.* 2013); for Queensland, in 2010 (Taylor *et al*. 2012); for South Australia, in 2007 (Jones 2009); for the Northern Territory, in 2009–2010 (West *et al*. 2012); and, for Tasmania, in 2012–2013 (Lyle *et al.* 2014). A statewide survey is currently under way in New South Wales.

It is important to note that, with respect to CMRs, while results of these surveys are usually broken down into smaller geographic regions (for example, Ryan *et al.* 2013), there is limited specific information on previous or current recreational fishing catches or fishing effort within the boundaries of the CMRs.

Relevant to this report is the general perception that recreational fishing participation, and therefore catches, are growing through time. In fact, this is not the case, with many studies indicating continuing declines in participation rates in recreational fishing in Australia (for example, Henry and Lyle 2003; Jones 2009; Taylor *et al.* 2012).

ESP finding
Previous national recreational fishing surveys provided substantial information on recreational fishing catches, but this information is dated, although individual jurisdictions continue to conduct surveys. The Expert Scientific Panel notes that the spatial scope of these surveys is not directly applicable to Commonwealth waters or specific to Commonwealth marine reserve zones.

3.2.4 Comparisons and interactions with commercial catches

A relative indication of effects of recreational fishing on biodiversity may be derived by considering relative catches of the recreational and commercial fishing sectors. Considering Australian commercial catches in 2000–2001 (the same period as the National Recreational Survey), the commercial wild seafood catch was of the order of 190 000 t (Dundas-Smith and Huggan 2006). This figure includes non-finfish (molluscs, crustaceans and other invertebrates), so it would compare with the total estimated recreational catch (including invertebrates) of about 26 000 t. It should be noted in such comparisons, though, that there may be little overlap in species caught by either sector. For example, the current annual commercial catch of Australian sardine is of the order of 33 000 t, but recreational catch of the same species would be very small.

In South Australia, Jones (2009) estimated some relatively high percentages of total catches taken by recreational fishers. These included (with recreational percentage of total catch in brackets), flathead (88 per cent), mulloway (67 per cent), King George whiting (49.6 per cent), Australian salmon (45 per cent) and southern calamari (40.5 per cent). On the other hand, the recreational percentages of total catches were less for many of the targeted commercial species, including blue swimmer crab (29.8 per cent), yellowfin whiting (22 per cent), snapper (19 per cent), gummy shark (16 per cent), southern rock lobster (2.6 per cent) and abalone (less than 0.5 per cent). Care needs to be taken in making some of these comparisons, since the total commercial catch may actually be quite small. In the above, the commercial component of the total catch of flathead represents just 2.5 t, so is clearly not an important target species of that sector.

In Queensland, Taylor *et al.* (2012) estimated the catches of some selected species taken by recreational fishers in 2010 (recreational catch as a percentage of total catch) to be: barramundi (10.4 per cent), Spanish mackerel (48 per cent), spotted mackerel (56.6 per cent), whiting (38 per cent), tailor (66.5 per cent) and pink snapper (65.8 per cent).

In Western Australia, estimates of recreational catches in 2011–2012 were made for the whole coast, divided into four regions (Ryan *et al.* 2013). The comparative catches by species for commercial and recreational sectors were not presented in this report, but, as a result of the study, explicit resource allocations between commercial and recreational fisheries were subsequently determined as follows: Western rock lobster (five per cent recreational, 95 per cent commercial), Roe's abalone (quotas—40 t recreational, 36 t commercial), and the West Coast demersal scalefish fishery (36 per cent recreational, 64 per cent commercial).

The majority of the recreational catches cited above were taken in state waters. However, as noted, state-managed recreational fishing may extend much further offshore and does overlap with some Commonwealth fisheries to varying degrees. Griffiths and Pepperell (2006) developed a matrix of such interactions, or shared species, in each of the Commonwealth fisheries. These do not inform directly on the recreational fishing impact or importance in the CMRs but do provide information on the species of fish of importance to the recreational sector that might be found in CMRs covering parts of the geographic range of each of the Commonwealth fisheries.

The main Commonwealth commercial fisheries in which the interaction with recreational fisheries was identified as being significant were the Eastern and Western Tuna and Billfish Fisheries (ETBF, WTBF), the Southern Bluefin Tuna Fishery (SBTF) and some parts of the Southern and Eastern Scalefish and Shark Fishery (SESSF). The tuna and billfish fisheries are relevant to all CMRs. The southern bluefin tuna and components of the SESSF are both relevant in the Temperate East and South-west CMRs.

The potential significance of recreational fishing on pelagic species is underscored in an assessment of catch and effort in the pelagic sport fishery off eastern Australia, which concluded that the catch estimates for the seven most commonly caught species varied between 27 per cent and 206 per cent of total commercial catch (Zischke *et al*. 2012). This study noted that catch-and-release rates varied between species, with sport species like billfishes released in every instance but species favoured for eating commonly retained and less than 10 per cent of desirable table fish (for example, Spanish mackerel and wahoo) being released. Only five per cent of respondents in the study tagged and released fish. The authors conclude that, given the significance of recreational catch for some pelagic species, future stock assessments require reliable estimates of catch and catch rates by recreational fishers.

Relevant to future planning and monitoring for CMRs, Griffiths and Pepperell (2006) recommended species in three broad categories for inclusion in long-term monitoring of recreational fishing in Commonwealth fisheries (which would also apply to monitoring in the CMRs). These include: pelagic fishes (tunas, billfishes, mackerels, and sharks); demersal slope and shelf species (trevallies, snapper, elephantfish, gummy shark, flatheads, trevallas, warehous, gemfish, morwongs, trumpeters and barracouta); and tropical reef species (emperors and snappers, coral trouts and cods, and amberjacks). They also identified numerous existing and potential data sources which may be useful for monitoring recreational fishing in Commonwealth fisheries, including state fisheries agencies, universities and community programs—noting, however, that many have inadequate spatial and temporal coverage. The most useful data sources suggested were studies from state fisheries agencies where on-site surveys collected catch, effort, and size composition of recreational catches across relatively large spatial and/or temporal scales. Some novel methods for estimating catches and catch per unit effort (CPUE) in specialised recreational fisheries, which would have relevance to future monitoring within the CMRs, have subsequently been tested. These include chain-referral sampling as a form of respondent-driven sampling (Griffiths *et al.* 2010a) and time–location sampling as more efficient and cost-effective than access point surveys (Griffiths *et al.* 2010b; Griffiths *et al.* 2013).

ESP finding

Recreational catches of fish can be significant components of total catches of fish, often of the same order of magnitude and sometimes exceeding commercial fishing on the same species. At the spatial level of Commonwealth marine reserves, and for specialised fishing, such as for pelagic fish, research and monitoring is needed to quantify recreational catch and effort. The Expert Scientific Panel notes that recently-developed novel methods may show promise in this regard.

3.2.5 Effects of recreational fishing on biodiversity

As indicated above, specific FGRAs were not deemed to be necessary for recreational fishing activities with respect to CMRs. The opportunity is taken here to examine some aspects of recreational fishing activities that may have impacts on the biodiversity conservation values of the CMR network or individual reserves.

While recreational anglers may target desirable species of fish, non-target or bycatch species are also often caught in the process of fishing with rod and line or other gear (nets, traps). In the recreational fishing surveys discussed above, retained bycatch is regarded as ‘harvest’, whereas discarded bycatch would be included in the category ‘released’. Commonly discarded bycatch (undesirable species) would include toadfish, pufferfish, rays, rabbitfish, moray eels, wirrah or any species that is regarded as dangerous, poisonous or of dubious eating quality. Post-release survival of key recreationally targeted fish species is discussed in detail in a paper written to inform the ESP’s review (Pepperell 2015).

Survival of routinely discarded species is not well studied or quantified, and few studies have been undertaken in relation to survival rates of fish commonly targeted by recreational fishers in Commonwealth waters. In Australia there has been only one major study on post-release survival of tropical reef species (Brown *et al.* 2008). That study recorded survival rates of over 75 per cent for coral trout, redthroat emperor, red emperor and crimson snapper, while saddletailed snapper survival was below 50 per cent.

Studies in Australia and overseas using pop-up satellite tags on marlin caught on recreational gear estimated survival rates of between 74 per cent and 100 per cent (Domeier *et al.* 2003; Horodysky and Graves 2005; Musyl *et al.* 2005; Graves and Horodysky 2008; Pepperell and Kopf 2011; Domeier and Speare 2012). A single study of 60 tuna caught in south-eastern Australia estimated post-release survival between 80 per cent and 90 per cent (Tracey *pers. comm.*). One study recorded a 100 per cent survival rate for 20 white marlin caught on circle hooks and a 65 per cent survival for 21 fish caught on more traditional 'J' hooks (Horodysky and Graves 2005).

Recreational fishers also harvest bait. In inshore areas, this includes ghost shrimp, prawns, beachworms and other polychaetes, and many species of small fish. The latter would include mullet, scad (yellowtail), mackerel (*Scomber* spp.), pilchards and, for game fishing, larger scombrids and carangids such as skipjack tuna, mackerel tuna, double-lined mackerel, queenfish and rainbow runner. Many of the recreational fishing surveys mentioned above do record catches of such organisms but not necessarily in a category defined as 'bait'.

Importantly, catches of recreational fishing need to be taken into account as part of stock assessments since they are part of the total fishing mortality to which a stock of fish may be subjected. The level of fishing mortality caused by recreational fishing can vary from very light to significant depending on the number of fishers and their catch rates. As well as these direct effects of recreational fishing on fish populations, there are also potential indirect effects of the activity. McPhee *et al.* (2002) considered a broad range of such indirect effects, which are discussed below.

McPhee *et al.* (2002) cite some overseas examples of trophic interactions caused by selective removal of carnivorous fish, for instance, an increase in populations of some invertebrate prey species. They speculated a high likelihood of such effects in some Australian cases (for example, mulloway, coral trout and tailor) but did not provide any evidence to support this contention. They also cite a number of references regarding entanglement of marine animals in fishing line or recreational crab pots and note that boat strike is the leading cause of mortality of turtles in Queensland, although this would include all forms of boats, not just recreational fishing boats. While many of these aspects of recreational fishing may occur, it is important to note that the actual level of impact of most have not been quantified in any meaningful way.

ESP finding

While recreational fishing can have significant impacts on target species of fish, these impacts and the possible indirect effects of recreational fishing on biodiversity are not well understood or quantified, especially in Commonwealth waters. Risks to biodiversity need to be better understood.

3.2.6 Relative risks of recreational fishing

In a CMR, the relative risk of recreational fishing to fish populations—and therefore to some aspects of biodiversity—will be directly proportional to the level of fishing effort and efficiency of that effort. The impacts of fishing on reef-associated species are well understood, especially for long-lived, slow-growing and sex change species (referenced below). Proximity to the coast and/or to urban or major holiday centres would be the strongest correlates of recreational fishing effort and therefore potential impacts (Buxton 1993; Mapstone *et al*. 1997; Mapstone *et al.* 2003). Conversely, the more remote a given location, the less likely that there would be visitations by recreational fishers, although the attraction of pristine, remote reefs may result in some targeting of such locations by long-distance charter and private operators. However, as noted, recreational fishing data has usually been gathered on broad geographic scales not directly applicable to the scale of CMRs. Some localised studies of recreational catch and effort have been carried out from time to time, but none with respect to the specific zoning as indicated in the CMRs.

In Australia, effects of recreational fishing within MPAs has usually been studied by comparing ‘populations’ of fish within no-take zones with those in comparative areas that are open to fishing. Relative abundance is estimated by means of visual counts along transects by divers, either by surface swimming, deeper scuba swimming or manta board towing. Some studies have also made use of baited remote underwater video gear. Estimates of the sizes of some species of observed fish may also be made during such censuses.

The GBRMP has been studied in greatest detail in this regard, especially since the zoning there allowed comparisons between large numbers of no-take areas and areas open to fishing following creation of the park in 1975 and after significant expansion of no-take zones in 2004. Many of the studies have focused on a key group of species caught by recreational and commercial fishers—for example, the coral trouts, *Plectropomus* spp.

Evans and Russ (2004) noted that earlier studies on the effects of no-take reserves on the abundance of coral trouts in the GBRMP were somewhat contradictory. Some studies showed higher densities in protected versus fished zones around Heron Island (Goeden 1978; Craik 1981), while others found no differences in other paired comparisons (for example, Ayling and Ayling 1984; 1986—unpublished reports to GBRMPA cited in Evans and Russ 2004; Ayling *et al*. 1993; Mapstone *et al*. 1997). Further studies showed increased densities of coral trouts in no-take zones in some, but not a majority of comparisons (Mapstone *et al*. 2003). On the other hand, Williamson *et al*. (2004) found almost five times the biomass of coral trouts in inshore no-take zones compared with open, presumably heavily fished areas. Evans and Russ (2004) found variable results with respect to density of coral trouts in no-take versus open areas, resulting in an overall non-significant difference between protected and fished zones. However, when size of fish was taken into account, highly significant differences in estimated biomass of observed fish were found between fished and not-fished reefs across the study area. This is similar to work done on temperate reefs in Tasmania (Barrett *et al.* 2007).

Such studies evolved over time. In a follow-up study to those above, Russ *et al.* (2008) found significant increases in density of coral trout in both inshore and offshore areas within two years of expansion of no-take zones within the GBRMP. And Miller *et al.* (2010) systematically surveyed coral trout over a six-year period on more than 20 pairs of more offshore reefs open to and closed to fishing since 2004, when no-take areas were expanded considerably within the GBRMP. The study area stretched from north of Cairns to south of Rockhampton—a distance of over 1000 km. The results showed that coral trout populations on no-take reefs were significantly higher than on reefs open to fishing and that populations on open reefs combined declined over the period of the study but were stable on the no-take reefs.

It is important to note in reviewing this series of case studies on coral trout densities and biomass in no-take versus fished zones that the areas open to fishing are open to both recreational and commercial line fishing. The coral trouts are highly sought commercial species and, while it is true that the commercial fishery tends to operate further offshore than the recreational fishery, confounding effects of commercial fishing on all open reefs cannot be discounted.

Another example of this is shown in the study of Nardi *et al.* (2004), who monitored the abundance of two commercially and recreationally important fish species—baldchin groper or bluebone (*Choerodon rubescens*) and, again, coral trout (*Plectropomus leopardus*) in protected and open areas off the Houtman Abrolhos Islands, Western Australia, between 1995 and 2002 (protection had been established in 1994). Populations of baldchin groper were similar in no-take versus open areas and, for the first three years of the study, coral trout populations were also similar between the two areas. However, after eight years, coral trout populations were significantly higher in no-take areas. Again, this study showed that removal of line fishing can have beneficial effects on stocks of some but not all target species, but it could not discriminate between recreational and commercial fishing as to the degree of impact caused by either.

Boaden and Kingsford (2015) compared numbers and biomass of a number of piscivorous fish species (including coral trouts) and herbivorous fish on reefs within the GBRMP that were closed to fishing, open to fishing and with ‘limited fishing’. In general, biomass and numbers of predatory fish were greater on the reefs that were closed to fishing and, to a lesser extent, on reefs open to limited fishing. In addition, there was evidence of 'prey release' (an increase in some prey species due to depletion of predators) in some open reefs but not others.

Reefs that were open to 'limited fishing' appear to be reefs where only recreational fishing was assumed to occur (because they were 'inshore') but, in fact, may have been fished commercially since they were not closed to commercial fishing.

In fact, there are few studies in which only recreational fishing effects have been considered in comparing no-take with fished zones within Australian MPAs. In one such study, Westera *et al.* (2003) compared no-take and open areas at four inshore sites within the Ningaloo Marine Park, Western Australia. Importantly, only recreational fishing was permitted in the open areas, not commercial line fishing. Using surface visual survey and BRUV, they found significant differences in the composition of fish families/genera targeted by fishers (*Lethrinidae*, *Lutjanidae*, *Haemulidae*, *Serranidae* and the genus *Choerodon* of the family *Labridae*) in terms of biomass between no-take and open reefs.

ESP finding

There is good evidence that line fishing does have impacts, if not always on numbers of fish then on biomass per unit area of targeted relatively sedentary species. It is important to note, though, that these studies have been primarily conducted on reef habitats and, with respect to effects of recreational fishing per se, are often confounded by the additional impact of commercial line fishing on the same areas that are open to fishing. There is a good case for investment in specific experiments on effects of solely recreational fishing on fished versus no-take areas, including on non-sedentary species.

3.2.7 Catch and release fishing

This topic is covered in detail in Pepperell (2015) and a summary is provided here. A considerable volume of quantitative data has been accumulated on post-release survival of a range of fish species caught and released using typical recreational hook-and-line fishing methods. In Australia, many studies in which released fish are confined for subsequent observations of mortalities have been conducted on inshore marine species, but relatively few have been conducted on reef species. Pop-up archival tags have been used in increasing numbers to derive post-release mortality data on pelagic species—in particular, the billfishes.

The overall conclusions across these studies are that post-release survival of recreationally caught fish is generally high (as a 'rule of thumb', usually between 65 per cent and above 95 per cent—sometimes even 100 per cent) under the conditions of the experiments. Pelagic fish—in particular, billfish, but also pelagic sharks and tunas—have high post-release survival (86 per cent to more than 90 per cent), especially if shark predation on released fish is minimal. On the other hand, studies on catch and release of several reef fish and deepwater species show that mortality can be significant, even with a range of handling techniques to minimise impacts such as barotrauma.

A number of these studies were also designed to quantify predictors of mortality and therefore how post-release mortality might be mitigated. These include how to deal with barotrauma, the use of certain hooks that reduce tissue damage, cutting the line if the hook is swallowed and, more recently, not removing some species from the water (minimising air contact). Some studies also provide data on predation events by sharks on released fish, indicating that in some cases this can be a significant factor in post-release mortality. Again, some of these results suggest ways of mitigating predation immediately after release.

Catch-and-release provisions in some areas could have the added potential benefit of encouraging citizen science based research on aspects of the biology of the fish caught and released—from studies of movements and post-release behaviour to refining information on factors that increase post-release survival to the provision of biological samples from released fish for a wide variety or research purposes. A recent example of the value of citizen science in recreational fishing was a successful broad-scale population genetics study of black marlin utilising finclips taken from fish released by recreational fishers on both the Pacific and Indian ocean coasts of Australia (Williams *et al.* 2015a; Williams *et al.* 2015b).

ESP finding

The Expert Scientific Panel notes that post-release survival for some pelagic species may be high. However, for others, especially reef-associated species which are subject to barotrauma, survival may be considerably reduced, especially when caught from deep water. The prospect of post-release mortality and the unknown impact of capture on the physiology of survivors makes this form of fishing incompatible with Marine National Park protection. It is likely that post-release survival of most species can be further enhanced by encouraging experimentally-determined gear and handling techniques.

The voluntary practice of catch-and-release and the willingness of the recreational sector to assist research is a good basis for future beneficial citizen science studies. The Expert Scientific Panel believes that investment in the monitoring of the levels of catch-and-release by recreational fishers in key regions of the Commonwealth marine reserve estate, especially in remote areas, and further engagement of recreational fishers in regulated and supervised citizen science activities will be an important component of Commonwealth marine reserve management into the future.

3.2.8 Effects of recreational fishing on pelagic fish

The potential effects on pelagic species targeted by recreational fishers is dependent on the species, fishing techniques used and intensity of effort. As noted, much of the research on effects of recreational line fishing in no-take versus fished areas has focused entirely on reef-associated species. Relatively sedentary reef species such as coral trout, which rarely move between reefs (Davies 2000, cited in Miller *et al.* 2010) are far more susceptible to targeted site fishing by line fishing (both recreational and commercial) than offshore pelagic species such as billfish, tuna and pelagic sharks, which have extensive ranges, are highly mobile and are capable of moving large distances in short periods (Pepperell 2010). Furthermore, the method of recreational fishing for pelagic fishes is confined to surface waters, minimising physical effects of gear on substrate-based habitat and where the proportion of pelagic fish surviving catch and release can be high (Pepperell 2015).

While no studies were found comparing the effects of recreational and/or commercial hook-and-line fishing between no-take and fished areas on pelagic species, one Western Australian study, using pelagic stereo BRUVs, found no differences in numbers of pelagic fish (mainly carangids, mackerels and sharks) in a 22 km^2 area closed to fishing when compared with nearby open areas (Santana-Garcon *et al.* 2014).

ESP finding

While recreational fishing for pelagic species at low levels of effort would be unlikely to impact on the populations of these species, especially for catch-and-release fishing, the limited studies on catch and effort suggest reserve managers should adopt a cautious approach to recreational fishing for pelagic species until better data is available and there is an improved understanding of impacts on populations, particularly of targeted species.

3.2.9 Consume-on-site

The concept of ‘consume-on-site’, whereby fish caught within a reserve must not be taken away but, rather, must be consumed while on-site, is relatively novel.

It appears that this activity was initially permitted within the vast United States Papahanaumokuakea Marine National Monument, encompassing the north-western Hawaiian Islands, but this is no longer the case. Subsistence fishing by native Hawaiians is permitted and some provision is made for consuming fish in this area for vessels in distress.

In Australia, a form of consume-on-site regulation exists in the Lalang-garram / Camden Sound Marine Park—the largest in Western Australian state waters. Within the Jungulu Special Purpose Wilderness Conservation Zone, a low level of recreational fishing is permitted, but a possession limit of one fish per person (or two fillets) applies, and the fish must be consumed on site. Possession of baitfish species above this limit is allowed (DPW 2013).

No specific studies of relative effects of consume-on-site versus normal recreational fishing activity were found. Such effects would depend on the prevailing bag and possession limits for taking fish away, the number of boats visiting and the number of fish of given species each boat took for consume-on-site.

Even in the absence of specific studies, it is reasonable to assume that zoning which stipulated consume-on-site would result in less fishing mortality within the zone than a fully open area since existing bag and possession limits are generally higher than an individual would consume in one day. This suggests a reduction of impact on vulnerable species, especially slow-growing, long-lived and sex change reef-associated species.

Taking Queensland as an example, in that state an individual recreational fisher is permitted to have considerable numbers of fish in his or her possession at any point in time. For example, an angler fishing on an offshore reef would be permitted to possess up to 20 coral reef finfish. This could include, for example, seven coral trout, eight snappers, and/or combinations of other species, including emperors, parrotfish, tuskfish, sweetlips and fusiliers. The same angler, using trolling techniques in the same area, could also catch and have in his or her possession 23 mackerels (*Scomberomorus* spp.), five mahi mahi, two wahoo, various combinations of other species and an unlimited number of tuna or billfish of any species (QLD DAF 2015).

Since there are no boat limits in Queensland, these numbers could be multiplied by the number of anglers on a given vessel, including a charter boat. Thus, a boat with, say, five anglers could legally have on board 100 coral reef finfish, 115 mackerels, 50 shark mackerel, 25 cod/grouper, 25 mahi mahi, 10 wahoo, five sharks or rays and unlimited numbers of tuna and billfish. Furthermore, the possession limit for coral reef finfish per angler on a charter boat would increase from 20 to 40 if the charter is longer than 72 hours, and to 60 if the charter is longer than seven days (QLD Government 2008).

In contrast, consume-on-site zoning would mean that one angler may have only one or two fish in possession or, in the case of a party of anglers on a boat and for larger fish over several kilograms in weight, less than one fish per person. Similar calculations can be made for other state jurisdictions, but the principle would remain—that consume-on-site regulations would greatly reduce the potential recreational take of fish from a given site.

ESP finding

Consume-on-site provisions for recreational fishing in some areas, especially remote reefs, have the potential to minimise impacts while allowing limited fishing to occur in such areas. Controlled experiments could be conducted on effects and practicality of consume-on-site arrangements (if implemented) on pairs of more remote reefs within the Commonwealth marine reserve estate.

3.3 Zonation

In a system of marine reserves designed to achieve biodiversity conservation while simultaneously accommodating a range of other uses, zoning plays a key role by prohibiting, constraining and spatially allocating different activities, particularly extractive uses across a reserve or network. To help inform specific zoning recommendations and the matrix of allowable uses in each zone, the ESP examined how different zone types contribute to achieving conservation objectives. The evaluation in this chapter also informs the identification of research needs to inform future zoning decisions (see chapter 4).

This section provides a discussion of the conservation value of different zone types used in the CMR estate, each of which is assigned to one of the IUCN Protected Area Categories, based on their management objective (see section 2.3.4 for more detail on Australia's approach to zoning). They include:

- Sanctuary (IUCN Ia)
- Marine National Park (IUCN II)
- Habitat Protection (IUCN IV)
- Multiple Use and Special Purpose (IUCN VI).

The terminology and definitions for IUCN Protected Area Categories were articulated by Day *et al*. (2012) with the aim of providing greater consistency in the use of these zoning categories in marine areas.

The primary purpose of CMRs is the protection and conservation of biodiversity and other natural and cultural values. Secondarily, they provide for ecologically sustainable use of natural resources where this is consistent with the primary objective. CMRs have specifically not been proposed for fisheries management purposes. While considerable debate exists over the use of marine protected areas as a fisheries management tool (Gell and Roberts 2003; Jones 2007; Hilborn *et al.* 2006; Gaines *et al.* 2010) or as an approach to mitigate threats to the marine environment (Kearney *et al*. 2012; Kearney and Farebrother 2014), their conservation benefit is generally accepted. It is also widely accepted that reserves play an important role as research reference sites.

3.3.1 Marine National Park Zones (International Union for Conservation of Nature Category II)

Terminology on MPAs varies considerably in the literature. For example, the terms 'no-take MPA', 'marine reserve' and 'marine sanctuary' are often interchanged and used to denote the same thing. 'No-take' is used in the CMR for areas where extraction of biological or physical resource is prohibited. In accordance with Australian Government practice, no-take zones may either be Sanctuaries (where non-extractive and extractive uses are generally prohibited) or Marine National Parks (where non-extractive activities like nature-based tourism and recreation uses and research activities are allowed). These two zone types are assigned to IUCN Categories I and II respectively and have the most restrictions on human usage (Day *et al.* 2012).

In the CMR context, a Marine National Park Zone was defined in the set-aside management plans as an area protected and managed to preserve its natural condition. Marine National Park Zones are intended to provide a high level of protection for the ecosystems, habitats and biodiversity within the area and, as such, activities involving the taking or harvesting of either living or non-living resources will generally be prohibited. Areas where harvesting of living resources is prohibited are a key component of any conservation planning, as recognised in the Goals and Principles (Principle 18).

The greatest concentration of scientific effort in examining the effects, value and utility of 'no-take' has been focused on inshore and coastal ecosystems. While this may partly be due to ease of access and cost for researchers, there is also a much longer history of MPAs closer to shore and on coral reefs than in remote, deeper waters. In evaluating the role of Marine National Park Zones, consideration was given to the latest scientific literature; however, few studies are available on offshore reserves and most of the discussion refers to near-shore no-take reserves.

There is a large body of published research that illustrates the importance and value of no-take areas from a conservation perspective, including the protection and/or recovery of species, habitats and ecosystems from the effects of exploitation. Some of this work, particularly longer-term studies, also demonstrates changes in ecological processes and food webs. Key differences between exploited and 'no-take' areas include increases in species richness, abundance, biomass and body size of target fish, although effects on non-target fish or benthic assemblages vary (Stobart *et al*. 2009; Barrett *et al.* 2007; Barrett *et al.* 2009; Lamb and Johnston 2010; Miller *et al*. 2012; Wing and Jack 2013; Williamson *et al*. 2014; Emslie *et al*. 2015; Starr *et al*. 2015).

Response to protection in no-take areas can be slow, complex and species-specific (for example, Barrett *et al*. 2007; Edgar *et al*. 2009), but the benefits associated with 'no-take' include:

- stable populations of targeted fish inside no-take reserves contributing to resilience of these species (Babcock *et al*. 2010)
- greater stability in the food web due to the presence of large omnivorous fish (Wing and Jack 2013)
- contribution of 'no take' areas to recruitment in reef-associated species (Wen *et al*. 2013; Harrison *et al*. 2012)
- spillover to adjacent areas and improved catch per unit effort, particularly where the area adjacent to the reserve is overfished (Buxton *et al.* 2014)
- recovery of kelp forest as a consequence of increased predation by large lobsters and fish on destructive herbivorous grazers such as urchins (Babcock *et al*. 1999; Edgar *et al*. 2009; Leleu *et al.* 2012; Alexander *et al.* 2014; Costello 2014)
- increased resilience against climate change or large-scale disturbance events such as floods or cyclones (Williamson *et al*. 2014; Emslie *et al*. 2015).

In a global assessment of marine reserves, Edgar *et al*. (2014) showed that 'no-take' is one of five key features—no-take, enforced, old, large and isolated (NEOLI)—that derive the most effective conservation outcomes for marine reserves in terms of the mean size and abundance of exploited species. The extent of changes in no-take zones also depends on the site history, with previously disturbed or heavily utilised zones displaying more substantial changes than zones located in areas of no or little prior disturbance or human use (Edgar *et al*. 2009; Edgar *et al*. 2014). Conservation benefits, including for fish of commercial value, were more apparent with increasing age of no-take zones (Claudet *et al*. 2008; Molloy *et al*. 2009; Edgar *et al*. 2014). Coral reef fish targeted by fishers in the Philippines increased in densities inside no-take reserves with the age of no-take protection, while non-targeted fish responded more to habitat changes inside reserves (Russ *et al*. 2015).

<u>Value of no-take areas for research and reference</u>

Against a backdrop of a worldwide decline in marine biodiversity (Pimm 2012; McCauley *et al.* 2015) and low recovery success recorded so far for marine species and ecosystems (Lotze *et al.* 2011), no-take zones are important reference areas to inform management and conservation (Rice and Houston 2011). Reduction of human impacts (reduced or no exploitation, habitat protection and pollution control) is the most obvious driver of recovery in marine animal populations and ecosystems (Lotze 2011). No-take areas allow insight into natural relationships and are the best way to understand what 'natural' ecosystems are, including the full functional extent of habitats (Thrush and Dayton 2010; Sheehan *et al*. 2013; Costello 2014).

Assessing recovery can be impossible when the 'normal state' or historical base lines of populations or ecosystems are unknown (Manez *et al*. 2014) due to shifting base lines and controversial methods to reconstruct historical reference points (Lotze *et al*.

2011). For example, three decades of protection in New Zealand led to changes in benthic habitats and communities, which showed that habitats that had been perceived as natural when reserves were established were in fact modified by the lack of large predators (Costello 2014).

Reference areas are also needed to distinguish between natural variability and other (non-fishing) human-induced fluctuations in marine ecosystems (Rice and Houston 2011; Costello 2014). Comparing monitoring data within and outside of no-take zones thus allows specific patterns of variation occurring only in unprotected areas to be attributed to human uses (Edgar *et al*. 2009; Rice and Houston 2011; Alexander *et al*. 2014). Marine reserves provide for experimental Before-After-Control-Impact (BACI) designed studies on otherwise experimentally uncontrolled human activities, including fishing (Barrett *et al.* 2009; Leleu *et al.* 2012; Costello 2014).

Size of no-take areas

The science underpinning the adequacy of size of no-take areas is still a matter of debate. For example:

- In a global synthesis of nearly 150 peer-reviewed publications on effects of no-take zones, Lester *et al.* (2009) showed that the magnitude of effects (increase in size, biomass, density and species richness) appeared irrespective of the size of the no-take zone.
- Sciberras *et al*. (2015), in a study which included no-take areas of between 0.13 and 30 km^2, noted that size of no-take areas relative to partially protected areas did not explain variations in target species density among MPAs. But they did note that size is one of a number of factors of interpretation that are of more general relevance in interpreting MPA studies.
- Edgar *et al*. (2014) showed that larger no-take areas (over 100 km^2) achieved greater biodiversity outcomes, especially when they were well enforced, old and isolated (three of the NEOLI key features).

- For commercial fish, a review of data from 12 marine reserves in Europe showed overall increases in fish densities with size and age of no-take zones and time since reserve establishment accounting for some variability between reserves (Claudet *et al*. 2008). The review indicated that the positive effect on densities of small and large commercial fish was scaled with increasing size of no-take areas. However, the size of the buffer zone had a negative effect on fish density, possibly because of fishing pressure (Claudet *et al*. 2008).

- The required size for conservation outcomes is also subject to the species to be protected as, for example, rock lobster populations can benefit from protection, even from small no-take areas (Barrett *et al.* 2009; Bevacqua *et al*. 2010), whereas highly mobile pelagic fish may not benefit from small-sized closures (Santana-Garcon *et al*. 2014). Rice and Houston (2011) proposed that no-take MPA sizes be large enough to meet management objectives and maintain key ecosystem processes structuring pelagic and benthic communities, which mostly require tens or hundreds of square kilometres.

ESP finding

The Expert Scientific Panel (ESP) recognises the significant body of scientific literature that demonstrates the effectiveness of Marine National Park Zones (no-take zones) in achieving conservation outcomes and for their role as scientific reference areas. The ESP notes the emerging consensus that, to attain and preserve natural condition, no-take, size, configuration, enforcement and length of time the area has been protected all need to be considered.

The ESP considers that, because Marine National Park Zones are important scientific reference sites for monitoring change within and outside reserves, each reserve should include at least one Marine National Park Zone and that a significant sample of each primary conservation feature and each provincial bioregion be included in at least one Marine National Park Zone of an appropriate configuration and size to meet conservation objectives.

The ESP also recognises the relative paucity of research on offshore Marine National Park Zones, including most of the Australian estate, and proposes future research to test the applicability of patterns emerging from shallow water no-take zones to their offshore equivalents (see chapter 4).

3.3.2 Habitat Protection Zones (International Union for Conservation of Nature Category IV)

While the primary management objective for all zones in MPAs is the conservation of biodiversity, zones that allow for some economic and social uses and activities that are compatible with the primary objective are often referred to as providing ‘partial protection’. This section focuses on Habitat Protection Zones, which in the Australian marine context have been characterised by the exclusion of activities that physically damage or seriously compromise the conservation values associated with the particular habitat in question. Habitat Protection Zones aim to maintain habitat and to secure and maintain habitat conditions necessary to protect significant species, communities or physical features (EPBC Regulations Schedule 8) (CoA 2015). These zones are assigned as IUCN Category IV. Here, we discuss habitat considerations and review literature findings on the effectiveness of IUCN Category IV.

The importance of protecting benthic habitat has a policy basis. For example, the Goals and Principles specifically identify seafloor features and key ecological features like canyons and seamounts as conservation value to be represented in the CMR estate (see section 3.4). Benthic habitats considered for Habitat Protection Zones include significant seafloor and geomorphic features such as pinnacles, seamounts and canyons but may also include habitat such as seagrass.

Protection of benthic habitats also provides for the protection for organisms that build or create structures that provide habitat for other organisms (ecosystem engineers). A review of cold-water corals, for example, observed they provide niches for many species, with over 1300 species reported as having been found living on cold-water coral reefs in the North-East Atlantic (Roberts *et al*. 2006). Further importance for protection arises from the ecological role played by the benthos in the marine environment (for example, nutrient cycling, primary productivity, source of prey and hosting of critical life stages for pelagic species) (Levin and Sibuet 2012; Snelgrove *et al*. 2014) and from their uniqueness as species and communities (for example, endemism and rarity).

Activities allowed in IUCN Category IV may include selective and/or low-impact harvesting of benthic or demersal species, such as hand collection of sea cucumbers or line fishing (see, for example, the set aside management plan for the South-west CMR Network, which was to exclude demersal gillnet, demersal longline, fish traps, lobster pots, octopus traps and crab pots from Habitat Protection Zones). Activities that are prohibited in IUCN Category IV damage habitat and cause the destruction, disturbance or fragmentation of substrates and organisms that support marine life, including ecosystem engineering structures like corals and sponges (Thrush and Dayton 2002). These damaging activities include a range of demersal fishing practices (Althaus *et al.* 2009; Clark and Rowden 2009; Heifetz *et al.* 2009; Williams *et al.* 2010) and mining and oil and gas exploration and production (Roberts *et al.* 2006; Clark *et al.* 2012; Levin and Sibuet 2012).

While it is not specified in the EPBC Regulations whether ‘habitat’ refers to benthic or pelagic habitat, Habitat Protection Zones are most commonly focused on protecting the benthic and demersal habitats and species assemblages. It is worth noting, however, that in the Macquarie Island CMR, there are two Habitat Protection Zones that protect benthic and pelagic habitat, in part for their importance as foraging areas for seabirds and seals. Further reasons for protecting processes in the pelagic system are evaluated in section 3.4.2. The corollary of protecting the benthos and associated seafloor features is that activities in the water column that damage the habitat will also be regulated.

An evaluation of the effectiveness of Habitat Protection Zones is constraint by the scientific literature on partial protection in marine reserves, in zones where some extractive use or uses are allowed, which is much less extensive than that for ‘no-take’. Drawing generalisations from this literature is challenging because of differing applications of the term ‘partial protection’ and a wide variety in the nature, intensity and frequency of allowed uses (Lester and Halpern 2008). For example, some studies considered the exclusion of commercial fishing but allowing recreational fishing as ‘partial protection’ (for example, Coleman *et al.* 2013), as was banning of spearfishing but allowing other forms of recreational fishing (Curley *et al.* 2013). In another study, excluding recreational fishing but allowing commercial fishing was regarded as partial protection (Di Franco *et al.* 2009).

Few studies report on the efficacy of partial protection and even fewer on management regimes that protect benthic habitats. Most studies investigated fish—in particular, targeted species. From comparisons between no-take zones, partial protection zones and areas open to fishing, the following patterns emerge:

- Biomass increases significantly with higher protection—for example, a threefold higher biomass in the no-take zone than partial protection (Di Franco *et al.* 2009; Ban *et al*. 2014a; Guidetti *et al*. 2014)—as size of fish was larger in no-take zones than in Habitat Protection Zones (Coleman *et al*. 2015).
- Species richness and functional richness were not significantly different between no-take zones and partial protection zones or between all three zones (Di Franco *et al.* 2009; Ban *et al*. 2014a; Coleman *et al*. 2015).
- Abundance was not consistently different between no-take zones and partial protection zones or between all three zones (Di Franco *et al.* 2009; Ban *et al*. 2014a; Coleman *et al*. 2015), depending on habitat (Coleman *et al*. 2015) or type of fish (for example, trophic level) (Guidetti *et al*. 2014; Boaden and Kingsford 2015).
- Top-down control by predatory fish was most pronounced in the no-take zone, less so in partially protected areas (Guidetti *et al*. 2014; Boaden and Kingsford 2015).
- There were distinct fish assemblages with a gradient of effects from no-take (highest benefit) to some effects (partial protection) (Boaden and Kingsford 2015).
- The ecological effectiveness of IUCN Category IV was 60 per cent (confidence intervals from 34 per cent (lower) to 89 per cent (upper)), compared to 100 per cent for no-take areas and 0 for no protection (Ban *et al*. 2014a, based on global meta-analysis).
- Variability in the response to protection can be high and the analysis of species responses challenged by large spatio-temporal variations occurring in species assemblages across the systems (Coleman *et al.* 2013: Ban *et al*. 2014a).

Some studies discussing the importance and effectiveness of protecting benthic habitats have identified habitat dependencies, specialisations and life history characteristics of benthic species as important attributes of demersal species assemblages (for example, Fitzpatrick *et al.* 2012). An additional value of benthic protection will arise from the extent to which benthic habitats—for example, nursery areas, spawning and feeding grounds—and associated demersal communities provide ecosystem services and play a significant role in the life history of pelagic and other mobile species (Levin and Sibuet 2012).

ESP finding

The Expert Scientific Panel (ESP) recognises the value of Habitat Protection Zones to protect habitat, biological diversity and associated ecosystem services and structure. Areas of high conservation value should be captured in Habitat Protection Zones across the Commonwealth marine reserve estate, where socio-economic factors prevent designation as a Marine National Park Zone. Allowed uses in Habitat Protection Zones must be compatible with the conservation of biodiversity and maintenance of the integrity of ecological processes.

The ESP considers that there is a high conservation benefit from zoning areas as Habitat Protection Zones to protect benthic and demersal habitats by excluding damaging activities while allowing activities such as regulated fishing in the water column, including take of pelagic species that do not compromise conservation values and management objectives for these areas.

The ESP notes the general paucity of studies on the value and effectiveness of Marine Protected Area zoning that protect specific habitats and that many studies that have been undertaken were not in Australia. This indicates a need for scientific study on the efficacy and benefits of Habitat Protection Zones and comparisons with Marine National Park Zones, Multiple Use Zones and controls outside of Commonwealth marine reserves. Investments in research and monitoring on this issue should be a priority in the future. This is discussed further in chapter 4.

3.3.3 Multiple Use Zones (International Union for Conservation of Nature Category VI)

The vast majority of global MPAs are managed for multiple use. Of 17 802 MPAs analysed from the World Database on Protected Areas, 93 per cent (or 82 per cent by area) were managed for multiple use. Of the 1124 sites managed for no-take, nearly three-quarters are smaller than 10 km^2 and their median size is 1.7 km^2 (Thomas *et al.* 2014). By contrast, the multiple use component of Australia's CMR estate proclaimed in 2012 (that is, excluding the South-east CMR Network), including Habitat Protection Zones, is 64 per cent by area, with a median size of no-take areas (Sanctuary Zones and Marine National Park Zones) of 907 km^2.

Multiple Use Zones in Australian CMRs allow some extractive uses and are assigned as IUCN Category VI under the EPBC Act and Regulations. This requires their primary purpose to be the protection and maintenance in the long term of the biological diversity and other natural values of the reserve or zone while being managed mainly for the sustainable use of natural ecosystems.

In a recent thorough global meta-analysis that drew on 40 studies of 63 MPAs, Sciberras *et al*. (2015) evaluated the conservation benefits of partially protected areas (that restrict some extractive activities) and no-take reserves against open areas. They subdivided partial protection regimes into those that excluded fishing activities that are damaging to bottom habitats and non-target species, like bottom trawling and scallop dredging; and those that prohibited fishing that affected particular species but not the surrounding environment, like seine nets and pelagic longlines. Their analysis showed that, while partially protected areas had significantly enhanced fish density and biomass compared to open areas and mainly of species targeted by fishers, fish density and especially biomass (92 per cent on average) were much higher in the no-take areas due largely to the response of target fish species that were protected in the no-take area only. Their analysis showed fishery gear-specific effects in the partially protected area, with the key determinant of the efficacy of partial protection being the specific protection regime (that is, gear exclusion). They found the larger response when commercial fishing using mid-water gear, like seine nets and pelagic longlines, was excluded but recreational fishing allowed.

Using the data provided by Sciberras *et al*. (2015), Ban *et al*. (2014a) assigned IUCN categories and reanalysed the same 40 studies for their ecological effectiveness following methods by Sciberras *et al*. (2015). This global meta-analysis revealed a lower effectiveness of IUCN Category VI than IUCN Category IV or no-take areas (see figure 3.6).

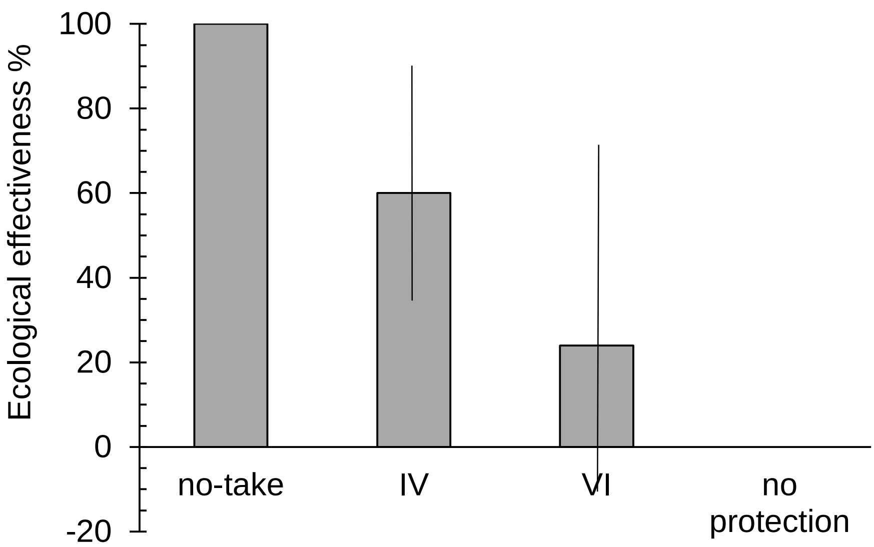

Figure 3.6 Ecological effectiveness of marine protected areas under IUCN Categories IV and VI, rescaled between full protection (no-take) and areas open to all uses (no protection). Error bars indicate upper and lower limits of 95 per cent confidence intervals. Based on meta-analysis of 40 studies worldwide (data from Sciberras *et al*. 2015). Figure adapted from Ban *et al*. (2014a)

Sciberras *et al*. (2015) detected complex and variable effects of size and age of the protected areas. They concluded that MPAs may meet their objectives in a number of ways without necessarily excluding all extractive activities. They observed that the effectiveness of partially protected areas was decreased the larger the size of this zone, possibly from non-compliance and infringement going unnoticed inside large areas. The authors conclude their study suggests that no-take areas provide benefit over less protected areas; nevertheless, the significant ecological effects of partially protected areas relative to open areas suggest that partially protected areas are a valuable spatial management tool, particularly in areas where exclusion of all extractive activities is not a socio-economically and politically viable option (Sciberras *et al*. 2015). The authors raise a number of issues of interpretation that are of more general relevance in interpreting MPA studies: differences in age and size of MPA; effectiveness of compliance; history of exploitation prior to MPA establishment; exploitation intensity inside and outside the MPA; temporal and spatial variability of ecosystem processes; and the need for and frequent lack of strong experimental design in MPA studies.

The study of partial protection zones and no-take zones across a network of MPAs in New South Wales state waters (Kelaher *et al.* 2014) found significant differences between no-take zones and fished areas in the structure of fish assemblages and in fish abundance. In comparing the two partial protection zones—habitat protection and general use—they found no differences between them in the structure of fish assemblages, but the fish assemblage in the Sanctuary Zones was significantly different to both fished zones. Similar findings emerged from the Mediterranean, where fish assemblages in sanctuary zones were distinct, while a greater similarity in fish assemblages and biomass occurred between partial protection and fished area (Guidetti *et al*. 2014). Buffer zones did not achieve a stabilisation of the fish assemblage in the Mediterranean, presumably as they attracted higher fishing effort (Seytre and Francour 2014). Kelaher *et al*. (2014) reported significantly greater species richness in the general use zones than in the Habitat Protection Zone, while richness was not significantly different between Sanctuary Zones and the two fished zones. However, the paper does not report any comparison between either of these two partial protection measures and the fished control sites outside the MPAs. They suggest that management strategies that result in shifting recreational fishing effort towards partially protected areas, which they speculate may have occurred, could limit the conservation benefits of these two areas (Kelaher *et al.* 2014).

ESP finding

While the strongest biodiversity and conservation benefits are delivered by excluding extractive activities from marine reserves, less restrictive management regimes can also deliver biodiversity benefits. The inclusion of some extractive activities in Multiple Use Zones can be compatible with biodiversity conservation as long as the intensity, extent and impact of the activities are known and well managed.

Multiple Use Zones should be used in conjunction with other regulatory controls, such as permits, quotas, bag limits and anchoring and fishing gear restrictions, for managing social, economic and recreational activities (see appendix 2 for discussion of these controls) where conservation objectives are not compromised by the inclusion of these activities.

3.3.4 Split zoning over coral reefs in the Coral Sea

Split zoning involves using two or more different zone types for different areas of a single reef or reef complex. This allows users of an MPA, such as fishers, to continue to access part of the reef while also ensuring that other parts are highly protected. To help inform specific zoning and allowed use recommendations in the Coral Sea, the ESP examined the benefits and risks of this approach for conservation objectives.

Coral reefs are complex ecosystems with a high degree of dependency between the many marine organisms that create, maintain and inhabit them. They support a very high diversity of species and life forms. While covering less than 1 per cent of the world's oceans, they host an estimated 25 per cent of known marine species. The coral reefs represented in the CMR estate are almost all oceanic coral reefs rather than the barrier and coastal reef systems that are closer to shore. Similar to other findings in this report, most experience and scientific research has come from these more coastal reef systems. Oceanic reefs are generally more isolated, with a much higher exposure to waves and storms, than more coastal reef systems. This isolation means they are more dependent on self-seeding for recruitment. Edgar *et al*. (2015) suggest that this raises the risk of local extinctions.

The concept of applying different zones (and hence management objectives) to reefs has been adopted by some park management agencies, but there is little detailed consideration in the scientific literature of the consequences and value of this approach. The Great Barrier Reef Marine Park Authority (GBRMPA) adopted a split zoning approach to a number of reefs in early zoning of the GBRMP (mostly between Marine National Park Zones and Habitat Protection Zones), but many were rezoned as Marine National Park Zones in the 2003 rezoning. Day (2002) noted that, in the GBRMP experience, split zoning had caused problems in public understanding, compliance and enforcement. He also questioned their ecological value, particularly for some of the smaller areas developed in earlier zoning plans. The recommended approach was, as far as practicable, to have single zones or regulatory provisions over areas of a discrete geographical description (for example, single islands or reefs).

The expert scientific committee that developed the Biophysical Operational Principles for the GBRMPA's Representative Areas Program advised that reefs are integral biological units with high levels of connectivity amongst habitats within them and thus they should not be subject to 'split zoning' (Fernandes *et al.* 2009). They recommended a minimum size of no-take areas of at least 20 km in length on the smallest dimension to be adequate for providing the area needed for population maintenance and to ensure against edge effects from use in surrounding areas (Fernandes *et al.* 2009). Despite this, a number of split-zoned reefs remain in the GBRMP (for example, Moore and Opal Reefs) because of social and economic impediments to single zoning. In these and other similar cases, they are substantially smaller that the recommended minimum size of 20 km on their smallest dimension.

The consequence and relative value of different zones on reefs in the GBRMP have not been scientifically evaluated; however, Reef Check Australia surveys of Opal and Moore reefs show that coral cover has increased in both the Marine National Park (green) and Conservation Park (yellow) zones on these reefs (Bauer 2014a; Bauer 2014b). These data suggest that the reefs are in good health despite different levels of protection.

The complexity of coral reef communities is influenced by abiotic factors such as exposure to wind and waves, depth and reef morphology parameters (Fitzpatrick *et al.* 2012; Graham *et al.* 2014; Jankowski *et al*. 2015) as well as by biotic factors such as recruitment success and a range of other life history characteristics. The latter may vary widely, including species with very narrow ecological niches and home ranges, highly mobile generalists that forage and/or migrate considerable distances, species with very limited dispersal capabilities and species whose juveniles or larvae disperse widely (Green *et al*. 2014). Coral trout, for example, have home ranges of 200 m to 1000 m but migrate up to 5 km to form spawning aggregations or to forage on schools of baitfish (Miller *et al.* 2012).

Marine reserve zonation, management objectives and allowed uses should recognise this complexity and the high degree of dependency between many of the constituent species and Green *et al*. (2014) propose the home range of focal species as a starting point for the determination of reserve (or zone) size.

Clearly, split reefs will impact on species with different life history characteristics in different ways. They may be more effective for highly resident and sedentary species than for more mobile ones. This complexity gave rise to the recommendation that management zones in the GBRMP be at least 20 km across.

One risk associated with split zoning is that fishing effort and other impacts may become more concentrated in the less protected part. Emslie *et al.* (2015) found no indication that the displacement and concentration of fishing effort reduced coral trout populations on fished reefs. However, physical damage to the reef can occur from anchor damage and breakage (Kininmonth *et al.* 2014; Lamb *et al*. in press).

ESP finding

The Expert Scientific Panel recognises the integrity of coral reefs, which are structurally and ecologically complex ecosystems with a high degree of dependency between habitat forming and associated species. Given this complexity, different management regimes across reef systems should not be applied across small reefs (less than 20 km across).

Splitting reef systems into more than one zone type should only be considered on reef systems that are large enough to ensure that:
(i) each zone covers a sufficient area to deliver conservation outcomes
(ii) the allowable activities undertaken in one zone are not of a type, scale or intensity to impact on adjacent zones
(iii) one zone type is a Marine National Park Zone.

Individual reefs often form part of larger reef systems which may offer a better opportunity to manage different areas for different objectives if biodiversity objectives are not compromised. The impacts of allowable activities in one zone need to be well managed and monitored to ensure that their impacts do not compromise the management objectives of other zones, particularly Marine National Park Zones.

Split zones and paired sites offer an opportunity to study the effectiveness of different management approaches and can provide useful information to inform and improve future reserve management.

3.4 Values of specific marine features, systems and processes

Marine reserves play an important role in protecting specific marine features, systems and processes, including seamounts, submarine canyons, pelagic ecosystems, connectivity and benthic–pelagic coupling. These features are often integral to the interests and activities of marine users and are therefore important in the consideration of zonation and allowable uses, as recognised in the Goals and Principles. This section summarises recent information on these values to assist future zoning revisions under CAR principles. The section also illustrates the availability of data for planning processes in the CMR network as well as knowledge gaps for consideration of research priorities (discussed further in chapter 4).

3.4.1 Connectivity

Many marine species occur in metapopulations, where spatially separate populations or different life history stages of the same species occur in different areas. Ecological connectivity, which encompasses the dispersal of larvae or propagules as well as the movement of adults, is an important mechanism underlying the persistence of these populations and is therefore relevant to marine reserve design (Magris *et al.* 2014; Berumen *et al.* 2012).

Physical oceanographic processes largely determine the degree to which planktonic stages disperse and hence the connectivity and exchange of genetic material between sessile or relatively sedentary adults stages (Coleman *et al.* 2011). Improved understanding and modelling of ocean currents and oceanographic processes is helping to understand and predict factors affecting connectivity. Major current patterns can be characterised by remote sensing, and more localised effects like upwellings, downwellings and eddies are being studied more intensively to help understand and predict biodiversity distribution and abundance (for example, Rennie *et al*. 2009; Feng *et al.* 2010; Currie *et al.* 2012; Holliday *et al.* 2012; Matis *et al.* 2014; Scales *et al.* 2014).

Entrainment in frontal eddies of boundary currents has been shown to be important for dispersal and retention of fish larvae and hence cross-shelf and latitudinal connectivity (Feng *et al*. 2010; Holliday *et al*. 2012; Mullaney and Suthers 2013; Matis *et al*. 2014). The main two boundary currents around Australia differ in their local retention and cross-shore transport, as the Leeuwin Current promotes much more onshore transport than the EAC (Condie *et al*. 2011). While the Leeuwin Current provides important alongshore transport, meso-scale features like eddies and upwellings, such as those occurring in the Perth Canyon (Rennie *et al.* 2009), create areas where shelf-to-ocean connectivity is high. The strengths of boundary currents determine the connectivity of kelp and other seaweeds around southern Australia (Coleman *et al.* 2011; Wernberg *et al.* 2013), and it is suggested that extreme weather such as cyclones can enhance connectivity by increasing the distance that larvae are advected (Radford *et al*. 2014).

Much of the understanding of connectivity comes from the fisheries literature that illustrates the importance of connectivity for the dispersion and recruitment of fish (Geffen 2009, Condie *et al.* 2011, Bode *et al.* 2012). Tagging has been a traditional approach to understanding movements of individuals, but advances in ocean observation, genetic analyses and modelling have greatly improved the understanding of connectivity in recent years (Berry *et al*. 2012). Growing understanding includes the spatial and temporal dynamics of populations, and recovery potential after disturbances in habitat-forming species such as kelp (Coleman *et al*. 2011), coral (Underwood *et al*. 2009; Radford *et al*. 2014) and seagrass (Sinclair *et al.* 2014) and can inform considerations of resilience in conservation planning.

Harrison *et al*. (2012), using genetic parentage analyses, showed that larval export from no-take reserves in the GBRMP was occurring and influencing the recruitment for coral trout and snapper in areas outside of the reserves. They also found larval retention within reserves and connectivity between neighbouring reserves, which may be important for single, isolated reserves or reefs for which there are no other reliable sources of larvae (Berumen *et al*. 2012). Protecting recruitment hotspots can thus improve the performance of reserves (Wen *et al*. 2013). Recent research has also shown that localised recruitment and long-distance dispersal are not mutually exclusive and that an understanding of connectivity patterns subject to dispersal capabilities of species and hydrodynamic conditions will improve the design of protected areas (Underwood *et al*. 2012). Linking knowledge of larval stages and dispersal with population models could improve reserve design (White *et al*. 2014).

Other approaches used to detect connectivity for protected area networks include hydrodynamic models with particle tracking or biophysical models linked with metapopulation models (Condie and Andrewartha 2008; Berglund *et al*. 2012; Puckett *et al*. 2014; Soria *et al* 2014). Using a four-dimensional biophysical dispersal model for larval connectivity off the north and west coast of Australia (Kool and Nichol 2015) demonstrates the potential for complex and varying degrees and directions of simulated larval connectivity which also shifted with seasons. Patterns emerging included southerly transport of larvae from the Gascoyne CMR with the Leeuwin Current, seasonal shifts in the direction of larval transport, low connectivity between the Oceanic Shoals and Kimberley CMR, corridors for marine larvae between several CMRs and high levels of self-connectivity among the CMR network.

Based on field data of plankton sampled off the Kimberleys, McKinnon *et al*. (2015) detected along-shore metacommunities with weaker cross-shelf connectivity, which varied seasonally for mesopelagic fish larvae. However, Underwood *et al*. (2012) found restricted connectivity and low dispersal of coral reef fish between coral atolls off the Kimberley coast. Genetic analyses of damselfish (*Chromis margaritifer*) revealed a lack of panmixia across the study region, including genetic discontinuity between adult damselfish from Rowley Shoals and Scott Reef.

Integrating the underlying physical processes as well as the functional and structural aspects of connectivity in conservation planning for the size and placement of protected areas has received recent attention, and objective quantitative measures for connectivity are emerging (Treml and Halpin 2012; Gerber *et al.* 2014; Lagabrielle *et al*. 2014; Magris *et al*. 2014). Criteria for improving the inclusion of connectivity considerations in conservation planning could include proximity of habitat features, juxtaposition of sources and destinations, and functional aspects of connectivity, including spatial and temporal dynamics (Magris *et al*. 2014).

ESP finding

Connectivity is integral to the functioning of marine ecosystems. Recent studies illustrate the complexity and dynamics of dispersal processes and the need for further research. However, scientific understanding of connectivity in marine systems is steadily improving. The movements of species during one or more of their life stages are complex and not yet well described for the vast majority of species, especially in Commonwealth marine reserves. Computer modelling of ocean currents and oceanographic processes is increasingly being used to improve understanding and facilitate better predictions of how marine species are connected, reproduce, disperse, forage and migrate.

The identification of sink or source areas for recruitment can support reserve design and known patterns of connectivity should be included in conservation planning.

Further research into connectivity will benefit future improvements of the Commonwealth marine reserve network. Future research will also need to address how connectivity might be affected by changing current strengths and other effects of global warming.

3.4.2 Pelagic ecosystems

Pelagic ecosystems, defined as the physical, chemical and biological features of the marine water column of the open oceans or seas, constitute 99 per cent of the biosphere volume, supply more than 80 per cent of the fish consumed by humans and account for half of the photosynthesis on Earth (Game *et al.* 2009). Deep ocean ecosystems, including the high seas, generate ecosystem services that include commercial and recreational activities (fishing and wildlife tourism) and ecological functions (oxygen production and carbon capture and storage) (Rochette *et al.* 2014). Less than three per cent of the world's oceans are found in MPAs and fewer protected areas exist in the pelagic ocean than any other ecosystem on Earth (Rochette *et al.* 2014). Pelagic ecosystem protection has been termed the missing dimension in ocean conservation (Game *et al.* 2009); however, the need for pelagic marine reserves has been increasingly recognised around the world and extends to areas beyond national jurisdictions (Rochette *op. cit.*, Selig *et al*. 2014).

Conservation planning for a representative network is based on the distribution of biodiversity and key habitats, which is challenging for pelagic ecosystems because of the highly dynamic nature of oceanographic processes and constantly moving boundaries and features (Maxwell *et al*. 2014; Marchese 2015). However, dynamic physical processes can be used as surrogates for pelagic biodiversity (Game *et al*. 2009; Grantham *et al*. 2011). Areas where physical conditions promote high biological activity, such as upwelling, meso-scale eddies and fronts, are equivalent hotspots with aggregations of primary and secondary consumers and increased prey for top predators (Marchese 2015). Such areas are becoming increasingly better understood through ocean observation programs and remote sensing (Game *et al*. 2009).

Hobday *et al*. (2011) were able to characterise seven different pelagic habitats off the eastern Australian coast that varied both spatially and temporally. Some oceanographic processes may be linked to geomorphic features such as seamounts or shelf breaks and are thus spatially fixed, while others may be spatially predictable (for example, coastal upwelling) but temporarily variable (Game *et al*. 2009). Upwelling and downwelling in meso-scale circulation features generated by boundary currents are examples of highly dynamic pelagic processes (Matis *et al*. 2014). Reserve networks should capture features such as fronts or upwellings, particularly networks of representative MPAs (Rice and Houston 2011).

Pelagic ecosystems are also three-dimensional in space and trophic structures in the water column and sediment are linked through benthic–pelagic coupling (Graf 1989; Graf 1992; Cummings *et al*. 2013; Bulman and Fulton 2015). A detrital nutrient flux, consisting of marine snow (particulate organic carbon (POC), faecal pellets, dead plankton) or larger carcasses that sink to the seafloor provide a food source for organisms at greater depths, including deposit feeders and scavengers. Large episodic pulses of particulate organic matterflux have been shown to affect the structure and function of deep sea communities, highlighting that conditions in the surface ocean cannot be seen in isolation from the deep sea and benthic environments underneath (Marchese 2015).

Benthic–pelagic coupling through detrital flux is stronger on the shelf and upper slope than in offshore environments. In the former, it can determine the abundance of benthic fauna (Cummings *et al*. 2013; McCallum *et al*. 2014; Kopp *et al*. 2015). Along the ‘Central-Western Transition Zone’ (IMCRA v4.0), species archetypes were found to be matched with unique environmental signatures and driven by the flux of particulate organic carbon, which was higher over the shelf than slope (Woolley *et al*. 2013). Regional differences in pelagic productivity are reflected in the degree of benthic–pelagic coupling and condition of benthic megafauna on the seafloor underneath (Cummings *et al.* 2013). Patterns of sediment infauna on the continental margin of Western Australia were strongly correlated with productivity, indicating the importance of benthic–pelagic coupling (McCallum *et al.* 2015). Yet, for decapods alone, species richness decreased with high and variable POC flux (McCallum *et al.* 2013). With greater depth, the connectivity between surface productivity and benthic systems becomes more distant, and trophic connections for deep-sea abyssal plains are poorly understood. In deep-sea sediments, signs of activity of benthic organisms (‘Lebensspuren’) increased with higher freshness of organic matter in the sediments (Przeslawski *et al.* 2012). Such dependence on surface production for the benthic fauna in sediments on the shelf and deep sea further emphasises the need for three-dimensional protection.

A further trophic biological flux links the pelagic and benthic realms. The main primary production occurs through phytoplankton in the surface waters of the oceans, which is consumed by zooplankton, including gelatinous plankton and fish larvae. These are in turn preyed upon by small planktivorous pelagic fish or squid (Bulman and Fulton 2015*)*. This micronekton can be directly preyed upon by bentho-pelagic feeding demersal fish or it is preyed upon by piscivorous fish, which are in turn becoming prey to benthic–pelagic feeding fish (see figure 3.7).

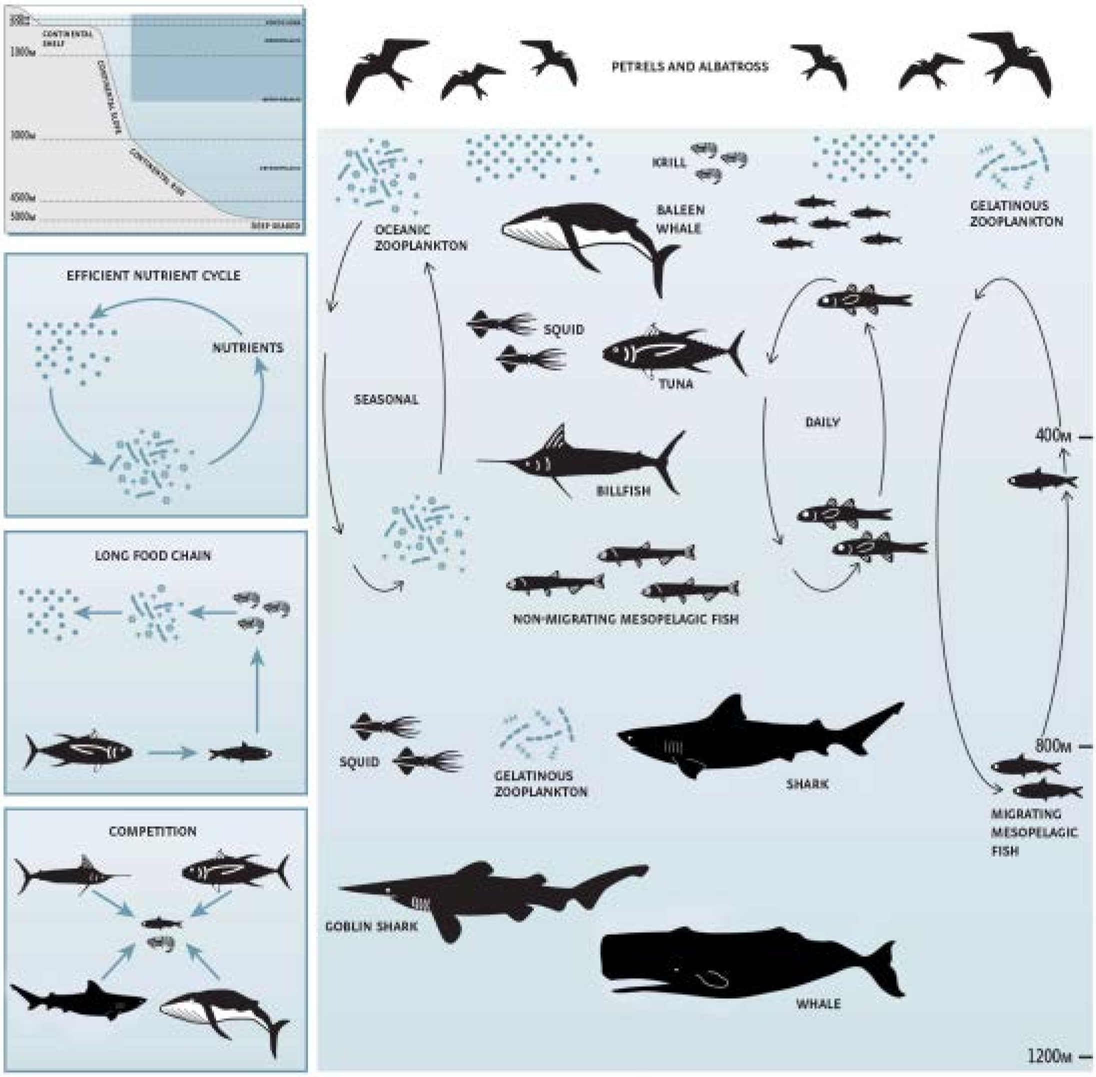

Figure 3.7 Conceptual model of offshore pelagic ecosystem in the South-east Marine Region (NOO 2002)

Bulman and Fulton (2015) note:

> *Our best available knowledge suggests that in shallow systems (like reefs) pelagic and benthic pelagic production flows in both directions, mediated through invertebrates and fish and their predators. In upper slope waters the linkages are more one way (at least at shorter time scales) where pelagic production filters to depth through physical settling as well as via trophic links mediated by horizontal and some vertical movement of epipelagic species such as jack mackerel, and by*

micronekton like mesopelagic fish, squid and gelatinous species. At deeper depths on seamounts and the rugged terrain of steep slopes, the return of pelagic production from overlying waters via settling diminishes even further and the dense populations of demersal fishes found in these can only be supported by advected allochthonus production originating from probably quite some distance away. On longer time scales physical and chemical linkages also operate, where deep water nutrients are brought to the surface by current systems and upwellings – though we have put less attention on such linkages here. Comparing what is known around Australia with similar depths elsewhere suggests that these general patterns seem to hold fairly broadly.

The design of marine reserves for the conservation and protection of pelagic habitat and highly mobile species requires a different approach to that taken for benthic habitats and site-attached fish (Game *et al*. 2009; Ban *et al*. 2014b; Breen *et al*. 2015). In general, larger home ranges will require larger reserves for them to be effective from a conservation perspective (Breen *et al*. 2015). However, protecting highly mobile species covering their entire distribution range, short of protecting entire ocean basins, is not feasible (Game *et al.*, 2009) and requires other approaches. This was illustrated by Santana-Garcon *et al*. (2014), who found no benefits to highly mobile fish from small reserves at the Houtman Abrolhos Islands off Western Australia.

Although the protection of migratory, mobile and far-ranging species presents major challenges for spatial management (Game *et al.* 2009), species are not equally vulnerable over their entire range. Instead, protection could focus on particular habitats linked to life-cycle stages, such as breeding grounds or feeding grounds (Grüss *et al*. 2011; Breen *et al*. 2015). For many species, further studies and time series data are needed to identify the location of such critical habitats (Grantham *et al.* 2011), but progress is being made. For example, the Perth Canyon has been identified as an important foraging habitat for migratory blue whales due to the high diversity and abundance of krill in the canyon (Rennie *et al*. 2009).

Seasonal or inter-annual variation in benthic–pelagic coupling can contribute to variability in foraging efforts, abundance and distribution of top predators such as tuna or fur seals (Hoskins and Arnould 2014; Menkes *et al.* 2015). For example, seasonal spawning aggregations of mesopelagic lanternfish in the Coral Sea provide a foraging resource for concurrent spawning aggregations of tuna (Flynn and Paxton 2012). Spatial and temporal protection would be an obvious approach to the conservation of this feature.

Game *et al.* (2009) note that protected areas are not a panacea for the conservation of pelagic biodiversity and will need to be complemented by other forms of management. In this context, it becomes important to identify areas or situations where pelagic protected areas offer benefits that other regulatory mechanisms cannot. They suggest that a good place to start would be to encourage the protection of representative examples of all pelagic habitats in line with international conventions for biodiversity conservation (CBD 2008) and that such representation could be based on available biogeographic classifications.

ESP finding

Our knowledge of pelagic ecosystems is in its infancy relative to benthic and coastal realms, especially in relation to offshore regions. Clearly there are many geographic gaps. Added to this is the uncertainty associated with broader environmental shifts associated with climate change.

Despite this, much is known about the oceanographic processes in pelagic ecosystems around Australia and it is clear that they play an important role in connectivity (migration and dispersal of marine species) and trophic dynamics, not just in the water column but in terms of benthic–pelagic coupling across the marine environment.

For these reasons, pelagic ecosystems need to be adequately represented and protected through the network of Commonwealth marine reserves.

However, the Expert Scientific Panel recognised that pelagic ecosystems are dynamic and there are challenges for the design and location of pelagic reserves. To be effective in contributing to the conservation of pelagic and associated species and the ecological processes on which they depend, Commonwealth marine reserve design and management must recognise this dynamism and the importance of complementary measures taken in the management of surrounding waters.

3.4.3 Continental shelf and slope

The continental shelf and slope comprise two-thirds of Australia's EEZ, with a depth profile ranging from less than 200 m on the shelf to more than 3000 m in the deep ocean (Heap and Harris 2008). Patterns of biodiversity are influenced by seabed and substrate type (Williams *et al.* 2010; Anderson *et al.* 2011a), exposure and habitat features such as rocky reefs (Saunders *et al.* 2014), geomorphic features and structures such as seamounts and canyons (see section 3.4.4), nutrient and food availability, oxygen concentration, and temperature. Many of these variables vary with water depth and many studies report a strong stratification of species assemblages by depth (Williams *et al*. 2010; Anderson *et al.* 2011a; Schlacher *et al*. 2010).

Shelf environments are generally characterised by warmer temperatures than the deep sea, higher light levels, and nutrients from land-based sources as well as primary production in the ocean. Australia's continental slope is dissected by numerous canyons, many with complex structures (Huang *et al*. 2015) and drainage patterns that can play significant roles in nutrient and sediment transport from the shelf to deep ocean (Porter-Smith *et al.* 2012) and vice versa through upwellings associated with these structures and oceanic currents.

Depth has emerged as the key defining variable in large-scale differentiation on benthic habitat classifications, with nutrients in the water column, bottom water temperatures and seafloor properties explaining smaller scale classifications (Huang *et al*. 2011). The gradients in environmental conditions at the upper slope and shelf define unique faunal communities (McCallum *et al*. 2013). The upper slope and shelf are characterised by high habitat diversity and dynamic oceanographic environments, with gradients in temperature and oxygen, upwelling events and seasonally varying currents and undercurrents affecting biota and their dispersal at a larger scale (Williams *et al*. 2010; Huang *et al*. 2011; McCallum *et al*. 2013). Seabed type, which is used as a surrogate, appeared more important for megabenthic diversity at smaller scales (Williams *et al.* 2010), and patterns of decapod species richness (McCallum *et al*. 2013). Benthic biodiversity patterns on the Carnarvon Shelf, where the highly diverse macrofaunal and infaunal assemblages occur with many rare species, showed no strong relationship with environmental variables, with the authors suggesting that abiotic surrogates maybe a limited value at small spatial scales (tens of kilometres) (Przeslawski *et al.* 2013).

Globally, depth-related gradients vary and various taxa show unique patterns, as deep sea habitats are highly heterogeneous (Ramirez-Llodra *et al*. 2010; Danovaro *et al*. 2014). This lack of consistent patterns across the world is also illustrated in Australia in comparison to the Atlantic, where diversity increases with depth. Examples from Australia indicate a decrease of diversity with depth, as benthic species richness was higher on the continental shelf than the slope off Western Australia (Williams *et al*. 2013; McCallum *et al*. 2015) and, similarly, in the Great Australian Bight (Currie *et al*. 2009). Both fish and macrofauna species richness around Australia was highest on the shelf, shelf break and upper slope and decreased with depth, especially below 1000 m (Coleman *et al*. 1997; Ward *et al*. 2006; Currie *et al*. 2009; Last *et al*. 2010; Dunstan *et al*. 2012; Fromont *et al*. 2012; McCallum *et al*. 2013; McCallum *et al.* 2015; Conlan *et al*. in revision). However, diversity has been found to be increase with depth around some seamounts and within some canyons around Australia (O’Hara *et al*. 2011; Poore *et al*. 2015). Further research in this area would be valuable.

Studies in Australia and elsewhere show that shallow water fauna is always very distinct from deep sea fauna and that major shifts in species assemblages occur in the upper slope and again at the lower slope transition (Ramirez-Llodra *et al*. 2010; O’Hara *et al*. 2011; Levin and Sibuet 2012). While the shelf and bathyal biomes are always fundamentally different, they can each share more similarity across latitudes or longitudes (O’Hara *et al*. 2011). For example, ophiuroid fauna from temperate shelf regions of Australia and New Zealand were very different, whereas bathyal species of ophiuroids had widespread longitudinal ranges within both temperate and tropical regions (O’Hara *et al*. 2011). Using a modelling approach based on the common species found in the surveys, four species archetypes were defined by latitude and depths (Woolley *et al*. 2013). The latitudinal distinction of archetypes aligned with the 'Central-Western Transition Zone' (IMCRA v4.0) at about 21ºS in accordance with findings from other taxon-specific studies and a high degree of rarity in this region, characterised by the Carnarvon Terrace (O'Hara *et al*. 2011; Dunstan *et al*. 2012; McCallum *et al.* 2013). The depths for transition between archetypes varied with latitude and for some taxonomic groups, occurring at approximately 150 m deep north of 20ºS, and around 300 m to 400 m deep south of 20ºS (Woolley *et al*. 2013).

A recent study of benthic invertebrate diversity off the deep continental margin of Western Australia reported a largely novel and endemic fauna, with most species either new to science or not previously reported in Australia (Poore *et al.* 2015). In some regions, the Australian shelf and deep-sea fauna are also characterised by a high proportion of apparently rare species (Coleman *et al*. 1997; Fromont *et al*. 2006; Schlacher *et al*. 2007; Dunstan *et al*. 2012). A similar high proportion of rare species has been predicted to occur in depths of 200 m to 400 m (Dunstan *et al*. 2012). High levels of endemicity are reported for the deepwater fish assemblages of the Coral Sea (Last *et al.* 2014). Decapod crustaceans occurred in very narrow depth ranges (McCallum *et al*. 2013), and bathymetry also defined patterns of sponges (Fromont *et al*. 2012). Some of these studies caution on drawing too firm a conclusion on rarity and endemicity without more extensive sampling, as many of the collections include single samples of species (singletons) (for example, Last *et al.* 2014). However Fromont *et al.* (2012) report a range of studies on the distribution of sponge species in the Australian shelf and slope environment that consistently report finding many rarely occurring species with limited distributions.

Recent surveys along the continental margin of Western Australia have yielded important insight into biodiversity patterns along and across the shelf and slope, which will allow refinement of future biogeographic regionalisation (Woolley *et al*. 2013). Benthic diversity is very high in sediments off Western Australia, with a high degree of rarity (for example, 65 per cent of 890 species of decapods occurred once or twice only) (McCallum *et al*. 2013; Fromont *et al*. 2012; Poore *et al*. 2015). Regions and depths for greatest species turnover vary for different benthic invertebrate taxa and fishes (O'Hara *et al*. 2011; McCallum *et al*. 2013; Woolley *et al*. 2013). Depth-related patterns have been found to vary with distance from shore and habitat-forming benthos have been found for fish assemblages off Australia's east coast (Harvey *et al*. 2013; Malcolm *et al*. 2011; Schultz *et al*. 2014).

Many of Australia's deepwater benthic environments have not been extensively sampled and are consequently not well characterised or understood. Studies over the last decade have progressively improved knowledge on biodiversity patterns on the shelf and continental slope. Findings from these studies have informed and supported conservation planning for the CMR estate. For example, an analysis of macrobenthic species collected from a range of habitats on the deep continental margin off southern Tasmania found highly variable species composition and assemblages and concluded that large areas at a range of depths would be needed to adequately represent these species within reserves (Dunstan *et al.* 2012). These studies have provided additional support for the general approach taken in designing the CMR estate.

ESP finding

Species assemblages vary with latitude, depth and substrate type. Across the range of organisms studied so far, some species appear to be widely distributed, while others appear to have very limited distributions. While knowledge and understanding of patterns of biodiversity distribution have improved and will continue to improve with further sampling of less studied parts of Australia's ocean environment, the evidence so far supports the general approach adopted in the design and planning of the Commonwealth marine reserves, which is to include representative samples of all depth ranges in regional networks that include a wide range of seafloor features and substrates.

3.4.4 Canyons and seamounts

Canyons

Canyons are a common geomorphic feature found on the margins of all continents. They are typically complex in their morphology and interact with ocean currents, tides and internal waves to influence ecosystems and habitats on the shelf, slope and deeper ocean. Canyons are recognised as features associated with enhanced primary productivity, benthic biomass and biodiversity (Huang *et al*. 2014 and references therein).

A comprehensive remapping of submarine canyons on the Australian margin (excluding Norfolk Island and Cocos Island Territories) was completed by Geoscience Australia (GA) in 2014 through the National Environmental Research Program (NERP) (Bax and Hedge 2015). A total of 713 submarine canyons were identified and classified—a substantial increase (76 per cent) from the 405 canyons previously mapped in 2008. Figures 3.14–3.16 in section 3.5 show this mapping for three CMRs (Bremer, Perth Canyon and the South-west corner) in the South-west bioregion. Of the 713 canyons, 254 (36 per cent) are wholly or partly in a CMR (Nichol *et al*. 2015).

The project generated a nationally consistent map and a new classification for submarine canyons on the Australian margin (Huang *et al*. 2014).

Of the canyons mapped and classified, 95 canyons extend onto the continental shelf as shelf-incising canyons that play an important role in connecting the deep ocean and the shelf via upwelling and downwelling. Some shelf-incising canyons in Australia have been shown to harbour high biodiversity. The south-west region has nine shelf-incising canyons (including Perth Canyon and Bremer Canyon, which are discussed in more detail at sections 3.5.3 and 3.5.4). The Perth and Bremer canyons intersect the Leeuwin Current (and Leeuwin Undercurrent). The Huang *et al*. study (2014) classifies both canyons as topographically complex and describes these examples in greater detail as a proof of concept of the value of the mapping. The north-east region has seven unnamed shelf-incising canyons (including in the Coral Sea) (Nichol *et al*. 2015).

Ongoing work by Geoscience Australia is producing a comprehensive assessment of Australian canyons as habitat for benthic and pelagic species. This assessment is using biodiversity surrogates, (such as seafloor rugosity, upwelling strength and current velocity) to classify habitat complexity, productivity and disturbance. Geomorphometrics (measures of seafloor complexity), such as canyon distribution and seafloor rugosity, have an important influence on the movements of large fish predators over macro-ecological scales (Nichol *et al*. 2015).

A new acoustic methodology that consistently differentiates hard from soft substrate was developed to classify potential benthic habitats associated with canyons. A uniform scoring method (developed by the Marine Biodiversity Hub, called Collaborative and Automated Tools for the Analysis of Marine Imagery (CATAMI)) was used to classify epibenthic fauna in these habitats from seafloor video imagery (656 649 records from 12 voyages). Hard-ground habitats in the 150 m to 700 m depth range were both infrequent and quite highly variable between canyons for the 60 shelf-incising canyons for which data were available. Video imagery showed benthic epifauna abundance to be depth stratified and higher inside canyons. Seabed hardness was an important habitat classifier for a large subset of the fauna. Based on the video imagery, the shelf-incising canyons did not support significantly different epibenthic macrofauna when compared to other upper slope hard and soft substrate (Nichol *et al*. 2015)

The NERP project developed an individual-based dispersal model to simulate the movement and connectivity of marine larvae to help understand and predict their collective behaviour and to identify priority areas for future observations and sampling. Canyons with 'high source capacity' (typically topographically complex) have a high potential to contribute to resilience of the protected area network by exporting larvae to other connected locations (Nichol *et al*. 2015). The modelling can also explore connectivity patterns between marine regions and interdependent geographic regions and reveal areas that may have a relatively high role in maintaining the biodiversity of the area. It is not only applicable to canyon connectivity. For example, the models predict strong ophiuroid connectivity between the Oceanic Shoals and Kimberley CMRs (Nichol *et al*. 2015).

In a study of two canyons in south-eastern Australia, species richness and megafaunal biomass declined with depth (Currie and Sorokin 2014). Three distinct community assemblages were identified stratified by depth. The canyons showed significant differences in trophic structure. Differences in faunal diversity and biomass between the two canyons were attributed in part to the location of du Couedic Canyon (with higher diversity and biomass) near the Spencer Gulf—a source of rich organic material (Currie and Sorokin 2014).

In a recent review of studies on the use of submarine canyons by cetaceans, Moors-Murphy (2014) found some evidence that cetaceans are more likely to be associated with large canyons but cautions that potential sampling bias militates against drawing clear conclusions with wider application.

Seamounts

Seamounts are a common feature in the oceans around the world and are among the physical ocean features used as proxies for biodiversity in designing and managing networks of marine reserves. A considerable literature is available on the global distribution and characteristics of seamounts and seamount ecology (for reviews, see Clark *et al*. 2010; Rowden *et al*. 2010; Schlacher *et al*. 2010; Clark *et al*. 2011; Kvile *et al*. 2014) and, in the Australian context, for the east and south-east regions (Williams *et al*. 2010; Williams *et al*. 2011). The seamount field project of the Census of Marine Life has provided the framework and data for a number of recent papers on seamount biodiversity (Schlacher *et al*. 2010; Clark *et al*. 2012; Stocks *et al*. 2012).

Ocean currents displaced by seamounts create turbulent upwelling of deepwater nutrients supporting elevated planktonic and consumer productivity and benthic communities dominated by slow-growing sponges and corals (Kvile *et al*. 2014). Reported geographic differentiation among seamount communities has suggested limited larval dispersal, local speciation and geographic isolation or a combination of these processes. However, genetic studies have documented complex patterns of connectivity that depend on spatial scale and life history characteristics (Schlacher *et al*. 2010).

Earlier hypotheses about seamounts supporting endemic species and diverse and distinct assemblages, being biomass hotspots and acting as biogeographic stepping stones are being increasingly tested and challenged (Rowden *et al*. 2010; Clark *et al*. 2012; Kvile *et al*. 2014). A range of studies have concluded that there are no consistent differences between species assemblages on seamounts and other deep sea habitats at similar depths, at least in the same region (Howell *et al*. 2010; Clark *et al*. 2012). However, differences in hydrothermal activity can modify patterns of benthic species assemblages within a seamount chain (Boschen *et al*. 2015). Recent studies now show that seamounts can have comparable levels of benthic diversity and endemism to continental margins, with many species widely distributed within their preferred depth range, but their communities may also include a distinct composition of species with higher biomass (Rowden *et al*. 2010).

A small number of the world's seamounts have been well studied (Kvile *et al*. 2014). Seamounts support higher biomass than adjacent waters, especially by aggregating pelagic and bentho-pelagic species (review by Clark *et al*. 2010) and are targeted for a range of commercially exploited fish species. There is a widely held view that the biological components of seamounts are sensitive and vulnerable to disturbance, especially from bottom contact fishing (Rowden *et al*. 2010; Williams *et al*. 2010;

Stocks *et al*. 2012) and are particularly vulnerable to trawl fisheries (Pham *et al*. 2014).

Global, climate-driven changes in ocean chemistry and changes to the aragonite saturation horizon suggest that seamounts and canyons, because of their vertically continuous habitat, will offer refuge to deep ocean fauna that are forced out of existing depth ranges (Tittensor *et al*. 2010).

Some confidence is emerging in the use of physical variables, from mapping and acoustic technologies, video and biological sampling, to infer, predict and validate biological patterns (for example, Anderson *et al*. 2011a). Physical characteristics of the seabed, particularly geomorphology, were found to be good predictors of biological assemblage composition and cover of key taxa (Anderson *et al*. 2011a).

ESP finding

Submarine canyons and seamounts are major geomorphic features that hold significant implications for distribution, abundance, dispersal and persistence of a wide variety of marine organisms. While some areas have been well studied, there remain big gaps in the knowledge and understanding of oceanographic dynamics, drivers of productivity and the role played by canyons and seamounts in the structuring and functioning of marine ecosystems and as potential refugia in a climate-driven, changing environment.

Given the role and significance of seamounts and canyons in the functioning of deep sea, continental shelf and pelagic ecosystems and growing concern about the impacts of human activities, it would be prudent to protect representative samples of both and to support further studies that improve understanding and effective conservation of these features and the management of sustainable uses.

3.5 Recent science on specific components of the Commonwealth marine reserves estate

Since the proclamation of the new CMRs in 2012, new scientific information has become available on the conservation values of a number of the reserves and hence to the work of the BAP. This section summarises information on the Coral Sea, Geographe Bay, Bremer, Perth Canyon and Oceanic Shoals CMRs.

3.5.1 Coral Sea Commonwealth Marine Reserve

Reef Life Survey surveyed 160 sites on 17 Coral Sea reefs between September 2012 and July 2013 (see figure 3.8). The objectives were to:

(i) improve knowledge of the state of current biodiversity and the likely species or processes important for ongoing monitoring of the ecosystem health of the Coral Sea CMR

(ii) place the Coral Sea CMR in the context of the broader region

(iii) provide a baseline that can assist in distinguishing future natural ecological change from that arising from management status (Stuart-Smith *et al.* 2013; Edgar *et al.* 2015).

There was a clear distinction in the reef fish communities between the northern (north of Marion Reef) and southern reefs, not just in terms of species composition but also at the level of functional groups. Analysis of Reef Life Survey dataset showed that Coral Sea reefs host faunal communities that are unique to Australia but which are more aligned with isolated Western Pacific oceanic reefs, such as those of Tonga and American Samoa, than with those of the Great Barrier Reef, which are more closely aligned with Papua New Guinea, the Solomon Islands and Vanuatu (see figure 3.9). A defining similarity of Coral Sea reefs and remote Pacific Island reefs is that the shallow-water biota must arrive by long-distance dispersal and inhabit a reduced set of habitat types, with relatively few options for shelter (Edgar *et al.* 2015).

Edgar *et al.* (*op. cit.*) also show that the Coral Sea supported reef shark densities similar to remote locations with little or no human exploitation and suggest that, despite a history of fishing on most of the reefs, food web structure appeared largely intact. Reefs within marine national parks zoned as no-take since 1982, including the Coringa–Herald and Lihou reef systems, supported higher fish biomass (approximately 70 per cent[19]) than comparable reefs where some fishing is allowed. Shark biomass was approximately 90 per cent higher and large predator biomass was 50 per cent higher in these zones than at comparable fished areas nearby (Edgar *et al.* 2015).

These results emphasise the importance of recognising a latitudinal difference in the Coral Sea coral reefs and distinguishing the Queensland and Marion plateau reefs in the CMR. The assumption that the Coral Sea provides connectivity between the Great Barrier Reef and South Pacific for two key ecological features of the Coral Sea—the reefs, cays and herbivorous fish of the Queensland Plateau; and the reefs, cays and herbivorous fish of the Marion Plateau—may need to be revised for macroinvertebrates and herbivorous fish.

Research shows that the Coral Sea offers an environment that is closer to a baseline condition than most other tropical regions and thus provides a reference for assessing changes at locations elsewhere with similar wave-exposed coral reef environments

[19] Edgar *et al.* 2015 reported this figure as 70 per cent but have subsequently revised this figure to 58 per cent (Rick-Stuart Smith IMAS *pers. comm*.).

but greater human-related stresses, including across the wider oceanic Pacific region (Ceccarelli *et al.* 2013; Edgar *et al.* 2015).

Figure 3.8 Reef Life Survey Coral Sea survey sites (Edgar *et al.* 2015) © Copyright, Reef Life Survey

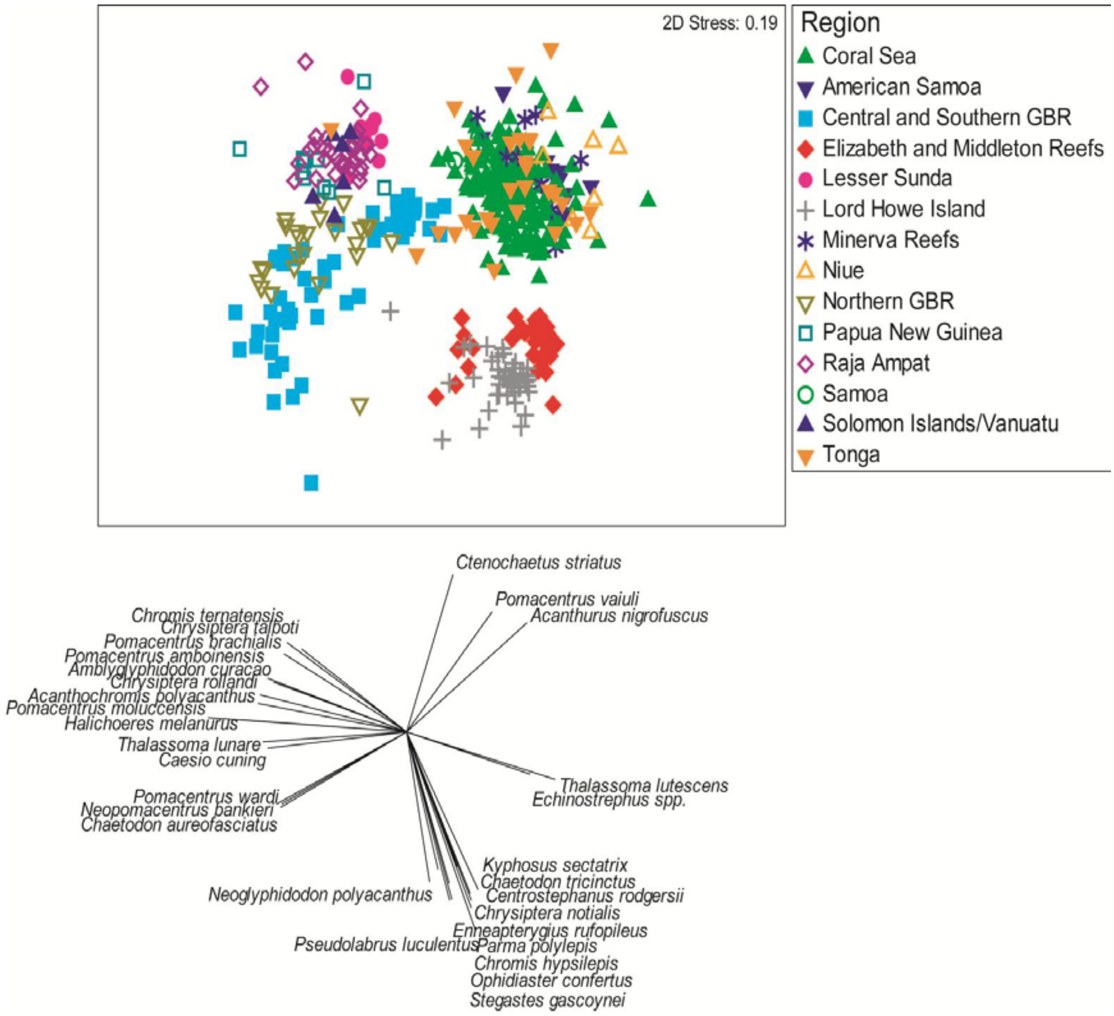

Figure 3.9 Similarity analysis for key Coral Sea species (Edgar *et al.* 2015) © Copyright, Reef Life Survey

A recent study found a previously undescribed clade of giant clam *Tridacna sp*. in the Western Pacific, including in the Coral Sea and Great Barrier Reef (Huelsken *et al.* 2013). Through DNA sequence analysis, the study also found that there was greater geographical distinction between *Tridacna crocea* populations than had previously been thought, with some populations likely to be regionally endemic; while *Tridacna maxima* generally also had geographically restricted populations, with only one population having much broader extension than previously thought (Huelsken *et al.* 2013).

Both the discovery of a new species and substantial geographic differentiation may have implications for monitoring and recovery of giant clams and inform management actions in the Coral Sea: presence of cryptic sympatric species would result in overestimates of species abundance; depleted populations are unlikely to receive recruits from geographically distant locations; and physical relocation of clams could move species outside their natural range and effect genetic population distributions (Huelsken *et al.* 2013). The 2012 Reef Life Survey recorded high densities of tridacnid clams on Mellish and Abington Reefs but only the Herald Cays had significant densities of the giant clam *Tridacna gigas*, which is listed as 'Vulnerable' by the IUCN (Edgar *et al.* 2015).

Sea turtles

A recent analysis of mark and recapture data of green turtles (*Chelonia mydas*) demonstrated that the Coral Sea is an important migration route between multiple nesting and foraging grounds within the Great Barrier Reef and New Caledonia (Read *et al.* 2014). Green turtles are listed as 'Vulnerable' and are a conservation value of the reserve. This research indicates that nearly all the waters of the Coral Sea reserve are traversed by turtles from the northern and southern Great Barrier Reef and New Caledonia. Multiple migrations between these areas show heterogeneous patterns in connectivity (Read *et al.* 2014).

No sites from Coral Sea breeding areas (identified as biologically important areas) were included in the study, although it was noted that no individuals from Australian Coral Sea populations were found in New Caledonia. While there has previously been some tagging work done in the Coral Sea, there is comparatively little known about Coral Sea turtle populations compared to the Great Barrier Reef stocks.

The study found turtles do not necessarily choose feeding areas based solely on abundance and proximity of food sources (for instance, turtles from New Caledonia were feeding at Heron Reef in the Great Barrier Reef and vice versa). Other cues are likely to be used by turtles and it is suggested that significant factors yet to be identified during the 'lost year' of their life cycle may drive migration patterns (Read *et al.* 2014).

Sea snakes

Southern reefs were shown to have high densities of sea snakes, although none were observed on northern reefs in the Coral Sea (Edgar *et al.* 2015). Figure 3.10 shows the clear latitudinal delineation between presence and absence of sea snakes during the Reef Life Surveys. These differences are unexplained; however, sea snakes are a vulnerable group on coral reefs elsewhere, especially those with human impact. Although the role of reserves in safeguarding sea snake populations is unclear (Lukoschek *et al.* 2013), the opportunity to use the Coral Sea as a reference site to understand sea snake ecology was noted.

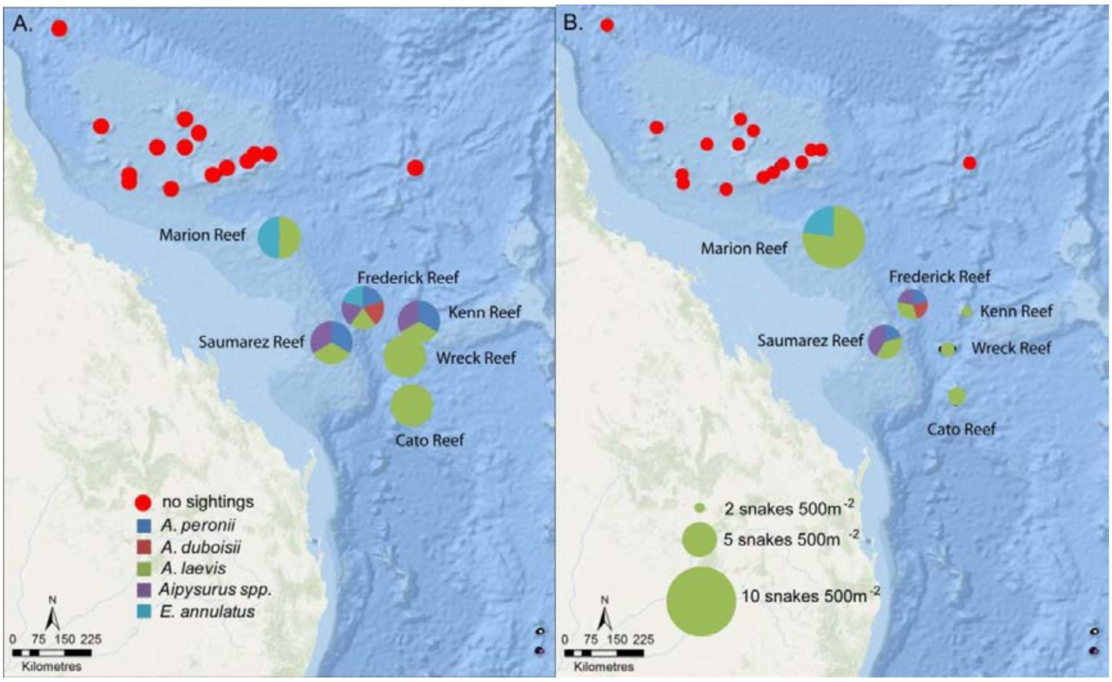

Figure 3.10 Distribution of sea snake species across Coral Sea reefs

A. All reefs with sea snake sightings using several different methods, with unscaled species composition

B. Sea snakes recorded on underwater transects with bubbles scaled according to mean snake density (per 500 m^2) on each reef (circle diameter = density x 2) (from Edgar *et al.* 2015)

© Copyright, Reef Life Survey

Sharks

Coral Sea reefs comprise a globally significant hotspot for reef sharks, with higher numbers sighted by divers than are present at most locations worldwide. Reef shark density for the Coral Sea reefs was ranked fifth highest in comparison to all Indo-Pacific regions surveyed by Reef Life Survey, following the Kermadecs, Elizabeth and Middleton Reefs, French Polynesia and the Marshall Islands (Edgar *et al.* 2015).

The Reef Life Survey analysis shows that the Coral Sea supports reef shark densities similar to remote locations with little or no human exploitation, suggesting that, despite a history of fishing on most Coral Sea reefs (reviewed in Ceccarelli *et al.* 2013), food web structure appears largely intact (Edgar *et al.* 2015).

Acoustic telemetry was used to study site fidelity and residency in sharks at Osprey Reef (Barnett *et al.* 2012). Of the three dominant species that were found—whitetip reef sharks (*Triaenodon obesus*), grey reef sharks (*Carcharhinus amblyrhynos*) and silvertip reef sharks (*Carcharhinus albimarginatus*)—all had relatively high numbers of individuals with year-round residency at Osprey Reef. Five of the 49 tagged individuals moved to Shark Reef, while one travelled to the Great Barrier Reef.

Spatial use by these species was generally confined to the north-west corner of Osprey Reef. Whitetip reef sharks had very low overlap or mixing between sharks residing in areas separated by approximately 10 km, which agrees with previous estimates that their movement is limited to three km to five km. Grey reef sharks also displayed low spatial overlap, contrary to populations on the Great Barrier Reef, which displayed little site fidelity (Barnett *et al.* 2012).

Acoustic telemetry was also used to compare movement, reef fidelity and ocean migration for tiger sharks (*Galeocerdo cuvier*) across the Coral Sea region, with an emphasis on New Caledonia. Although not listed in Australia, the tiger shark is listed as 'Near-Threatened' by the IUCN. Thirty-three tiger sharks (1.54 m to 3.9 m total length) were tagged with passive acoustic transmitters and monitored on receiver arrays in New Caledonia, the Chesterfield and Lord Howe Islands in the Coral Sea, and the east coast of Queensland (Werry *et al.* 2014). Satellite tags were also used to determine habitat use and movements among habitats across the Coral Sea and found that, between 2009 and 2013, 14 sharks undertook wide-ranging movements up to 1114 km across the Coral Sea (Werry *et al.* 2014). This suggests oceanic Coral Sea reefs may be particularly important for this species, both as potential mating grounds and feeding grounds for large individuals.

Seabirds

Seabird monitoring in the Coringa-Herald National Nature Reserve and Coral Sea CMR has been conducted since 1992. Surveys are timed to coincide with periods of peak breeding activity for three species with important breeding populations in the region—red-footed booby, lesser frigatebird and great frigatebird (Baker and Holdsworth 2013).

The data, including from a special patrol in August 2012 after Cyclone Yasi, show strong inter-annual fluctuations, but trends are now apparent for the breeding populations of most species examined on North East Herald Cay:

- The breeding population of red-footed booby in the Herald Cays has increased by 38 per cent since 1992 at an annual rate of increase of +3.3 per cent.
- The breeding population in the Herald Cays of great and lesser frigatebirds has declined by 89 per cent since 1992 at an average growth rate of –7.7 per cent. In 2012, there were a total of 419 nesting pairs on North East Herald Cay.
- The breeding population of black noddy in the Herald Cays has declined by 67 per cent since 1992 at an average growth rate of –3.81 per cent. The count in 2012 was the lowest recorded since monitoring commenced.
- From the surveys and banding data of the masked booby, mean annual adult survival is estimated to be in excess of 90 per cent—a value that would be expected for a long-lived species with a stable population. One bird had

originated as a chick on Phillip Island (near Norfolk Island) in 2000—a distance of 2341 km away.

The results show that, from a regional perspective, the Herald Cays of the Coral Sea contain a significant proportion of the region's breeding populations, particularly for red-footed booby, great frigatebird, lesser frigatebird and red-tailed tropicbird (Baker and Holdsworth 2013).

This research supports and informs a number of biologically important areas for seabirds that have been identified within the Coral Sea. All these seabirds are listed marine species under the EPBC Act.

Species richness and endemism of deep-sea fish of the Western Coral Sea[20]

An unusually high level of local endemicity characterises the deepwater ichthyofauna of the Coral Sea between 162 m and 1200 m depth. Catch data and specimens, obtained from two exploratory voyages in 1985 and 1986 in the Coral Sea, were recently investigated, taxonomically classified and analysed for any patterns according to depth or geographic distribution. The study found very high levels of endemicity (more than 36 per cent) of deepwater fishes in the western Coral Sea, with about 50 per cent of well-studied groups, such as sharks and rays, confined to this relatively small geographic region.

Biogeographically informative fishes such as skates appear to be cryptically partitioned within the region, differing in composition to other Australian regions and those of French territories to the east. Strong depth-related partitioning of the fauna is also evident, and its structure follows zonation patterns observed across the wider Australian region.

The number of fish species known from the Northeast Slope Province increased to 272—more than 36 per cent endemic species. The levels of endemicity in this region appear to be the highest for any Australian continental slope province, and more than 15 per cent higher than the two more comprehensively surveyed tropical deepwater provinces off Western Australia (20.4 per cent and 20.0 per cent). The Cape Province in the north of the Coral Sea (12 per cent endemicity) is largely unexplored and any future surveys are likely to result in major discoveries in biodiversity.

Given the high level of micro-endemicity, regional uniqueness of the fauna and the restricted distributions of members of otherwise widespread pelagic genera (for example, *Polyipnus*), there is a compelling argument for the existence of a faunal gyre in the Coral Sea.

[20] Unless otherwise referenced, this section attributable to Last *et al*. 2014.

Pelagic fish

Analysis of mid-water trawl sampling and fisheries data has found highly seasonal spawning aggregations of the lanternfish *Diaphus danae* associated with aggregations of bigeye (*Thunnus obesus*) and yellowfin (*T. albaceres*) tuna in the north-western Coral Sea (Flynn and Paxton 2012). The bigeye tuna individuals collected from aggregations were estimated to have 81 to 319 *D. danae* specimens in their stomachs. An earlier study (McPherson 1988; McPherson 1991) had shown a synchronous spawning of yellowfin and bigeye tuna associated with the annual lanternfish spawning aggregation but also demonstrated spawning of tuna over a much wider area and longer period.

The minimum depth of the lanternfish aggregation recorded was 200 m, and spawning is likely to occur at night (Flynn and Paxton 2012).

Although biomass was not able to be robustly calculated due to small sample size and lack of acoustic data, the authors indicate that the estimates they were able to make suggest that the spawning biomass of *Diaphus danae* in Australian mainland waters was second only to *Lampanyctodes hectoris* off Tasmania.

On the basis of the location of tuna longline vessels and catches of tuna between 1994 and 2010, but with no historic evidence of lanternfish aggregations, Flynn and Paxton (*op. cit*.) suggested that lanternfish tuna aggregations often occurred in the vicinity of Cairns Seamount, and elsewhere throughout the Queensland trough, with isolated instances in the Townsville trough.

D. danae may be a keystone species because of its importance to the life cycle of two of the most important species of tuna on the east coast of Australia, and unknown other species, in the Coral Sea (AIMS 2011).

In August 2015 the Walker Seafoods MSC public certification (with the corresponding certification report also available) for pelagic longlining was granted (ME Certification Ltd. (2015) and Gascoigne *et al*. 2015). The most relevant material to this review is Griffiths *et al.* (2010c) and AFMA (2014c).

Griffiths *et al*. (2010c) developed an ecosystem model to investigate the potential effects of longline fishing and climate change on the eastern Australia pelagic ecosystem. The model incorporated a large expanse of ocean extending well into the Pacific off eastern Australia, which included part of the Coral Sea but did not specifically analyse that region. Using biomass data and fishery catch data from 1952 to 2006, the model simulated changes in fishing effort and mortality rates on individual target and non-target species for 2008–2018. While simulated increases or decreases in fishing mortality caused biomass decreases or increases of some predators, the reduction in biomass of individual apex predator species, such as billfish, tunas and sharks, had only modest effects on the structure of the ecosystem. Griffiths *et al.* (*op. cit.*) suggested that this was because the removal of the relatively small biomass of a single species from the large group of predators could be compensated by increased consumption of available prey by the various other species that share the same prey base. However, where a large proportion of the biomass from a trophic level is removed, as was simulated by the removal of all shark groups, more dramatic trophic cascades can result. Griffiths *et al.* (*op. cit.*) point out that the models used in this study relied on a vast number of input parameters, many of which were completely unknown. Nevertheless, the authors suggest that the results of the simulations do inform the direction and relative magnitude of biomass change for specific groups and for tracing complex trophic interactions throughout the system.

More recently, on the basis of a Scale Intensity Consequence Analysis (SICA) performed during the ERA process, AFMA concluded that no habitats or communities were at risk from the effects of pelagic longlinine fishing in the Eastern Tuna and Billfish Fishery, which incorporates the Coral Sea (AFMA 2014c).

The black marlin (*Istiompax indica*) spawns annually at the edge of the northern Great Barrier Reef during October and November and afterwards disperses throughout the Coral Sea and beyond (Domeier and Speare 2012). On the basis of the extent of movements of pop-up satellite-tagged fish, Domeier and Speare (*op. cit.*) suggested an extensive area offshore from Lizard Island to Brisbane, and incorporating the Queensland and Marion Plateaux and the Townsville Trough, as 'the Great Barrier Reef Environment'—a region of importance for black marlin spawning. However, they demonstrated spawning of the species only in a region adjacent to the Great Barrier Reef itself between Lizard Island and Cairns.

Domeier and Speare (*op. cit.*) also incorporated the use of popup satellite tags to study movements of black marlin tagged during the spawning aggregation. Of 67 pop-up tags, fewer than 10 remained on fish for more than 100 days—the longest for 180 days. Within these time periods, the majority of fish had travelled 1000 km to 2000 km away from the edge of the Great Barrier Reef, with several travelling more than 4000 km to areas near Fiji, Kiribati and southern Micronesia. On this basis, Domeier and Speare (*op. cit.*) defined a wider 'catchment area' of the south western Pacific extending as far as Kiribati where they suggested the majority of the black marlin stock probably resides during the non spawning season, although conventional tags had demonstrated more extensive movement over longer time periods, some moving well north of the equator or crossing the breadth of the Pacific. Since this study, adult female black marlin, also tagged with pop-up satellite tags at the edge of the northern Great Barrier Reef, have been shown to move rapidly to the central Pacific, even as far as 10 000 km east, within six months of release (www.igfa.org/Conserve/IGMR.aspx (IGFA 2013)).

Mesophotic zone corals

Higher than expected diversity of staghorn corals (*Acropora* and *Isopora* spp.) were found in the mesophotic zone of the Great Barrier Reef and western Coral Sea (Bougainville, Osprey, West and East Holmes, Flora and Flinders Reefs) (Muir *et al.* 2015). The recent discovery of the significant contribution of these genera to the upper mesophotic (30–60 m) communities indicates that it is generally a poorly understood and researched area. This zone may play a significant role in providing refugia for lineages of these genera against shallow water disturbances and temperature changes, particularly for depth generalist and marginal generalist species (Muir *et al.* 2015).

Surveys in 2012–13 used a remote operated vehicle (ROV) to video coral communities in the mesophotic zone to establish the deepest limits of zooxanthellate scleractinian corals at Bougainville Reef in the Coral Sea and selected reefs in the GBRMP. Although zooxanthellate corals were scarce below 80 m, communities of small (less than 10 cm in diameter), *Leptoseris* spp. were found down to 125 m at all locations (Englebert *et al.* 2014). These are the deepest records for zooxanthellate coral in the Coral Sea CMR and GBRMP (Englebert *et al.* 2014). Zooxanthellate scleractinian corals were also found between 40 and 100 m depth at West and East Homes Reefs and Flora Reef, with the deepest recorded at 102 m (Bongaerts *et al.* 2011). Azooxanthellate octocorals on these reefs were observed down to 150 m—the maximum depth of the ROV for that study (Bongaerts *et al.* 2011).

Mesophotic communities are less well described and mapped compared to shallow water corals and communities. With further study, these communities may help to better articulate and inform two of the KEFs of the Coral Sea: the reefs, cays and herbivorous fish of the Queensland Plateau (which includes Bougainville, Osprey, East and West Holmes, Flora and Flinders reefs) and the reef and reefs, cays and herbivorous fish of the Marion Plateau.

Bathymetry

A national remapping exercise recently completed by Geoscience Australia better identified submarine canyons in the Coral Sea (see figure 3.11). Some shelf-incising canyons in Australia have been shown to harbour high biodiversity and several shelf-incising canyons are located in the Coral Sea (Bax and Hedge 2015).

Satellite derived bathymetry (SDB) is being used as a substitute for modern digital bathymetry data as a means of obtaining accurate three-dimensional shapes of the reefs. This novel method has been used over the Flinders and Abington reefs, Coringa Islets and Herald Cays. (Beaman, *pers. comm.*).

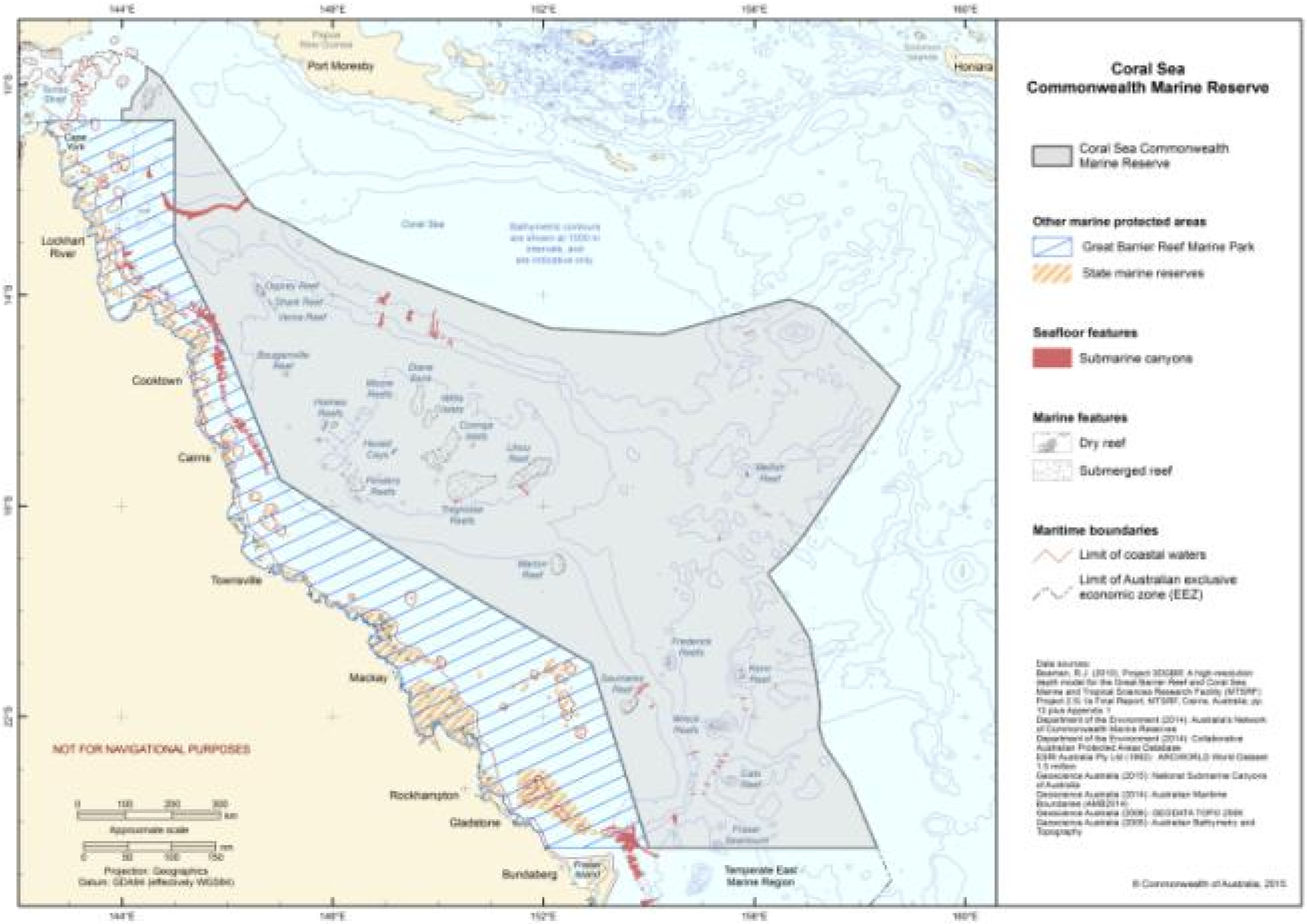

Figure 3.11 Submarine canyons of the Coral Sea CMR identified by recent Geoscience Australia mapping

ESP finding

The coral reefs in the Coral Sea Commonwealth Marine Reserve have been shown to be distinctive at the species and functional group level in southern, central and northern parts of the reserve. The Coral Sea is shown to be a significant biodiversity hotspot for reef-associated sharks and is an important area for pelagic resources such as tuna and marlin. All six species of turtle are found in the Coral Sea and it is also a significant area for breeding seabirds. The Coral Sea Commonwealth Marine Reserve is also significant in that it is one of few remaining areas globally that has not been significantly impacted by human activities.

The diversity of the Coral Sea reefs warrants a higher level of protection, especially in the southern region. Because they are relatively un-impacted by human activity, the reefs, pelagic and demersal biodiversity of the Coral Sea form an important baseline reference area and an adequate representation should be contained in highly protected, no-take reserves.

3.5.2 Geographe Commonwealth Marine Reserve

Benthic habitat

The Commonwealth marine environment within and adjacent to Geographe Bay is a KEF due to high benthic productivity; high biodiversity; and high feeding, resting, breeding and nursery aggregations of several species. The preliminary findings from recent Marine Biodiversity Hub surveys provide additional information to support this. Geographe Bay contains one of the largest continuous seagrass beds recorded in Australia and is shown to contain a much larger extent of continuous seagrass beds and to greater depth that previously reported (see figure 3.12)[21] (Bax and Hedge 2015; Lawrence 2015). Rocky reefs occur throughout the bay and contributes to habitat heterogeneity (see figure 3.13).

The Marine Biodiversity Hub has used BRUV drops in deeper water across the CMR, which confirm that fish assemblages differ by depth and between seagrass, reef and sand habitats (Bax and Hedge 2015).

A recent report investigating the interaction between herbivory by fish, nutrients and water depth in Geographe Bay concluded that, despite the bay's diverse and extensive seagrass beds and high nutrient loads (largely from agricultural sources), the level of grazing by fish was low and not correlated with nitrogen content of seagrass in

[21] During the Geographe CMR project the BRUV sites were selected using two methods: (1) a spatially balanced random approach, and (2) a targeted approach (hand-selected in the field to target specific notable features such as seagrass and reefs).

contrast to studies from other locations and countries. While eight species that were potential seagrass grazers were among the 36 species of fish from 24 families recorded in the study, the abundance of herbivorous fish was low and appeared to be related most closely with the distribution of preferentially grazed seagrass species and habitat heterogeneity (White *et al*. 2011).

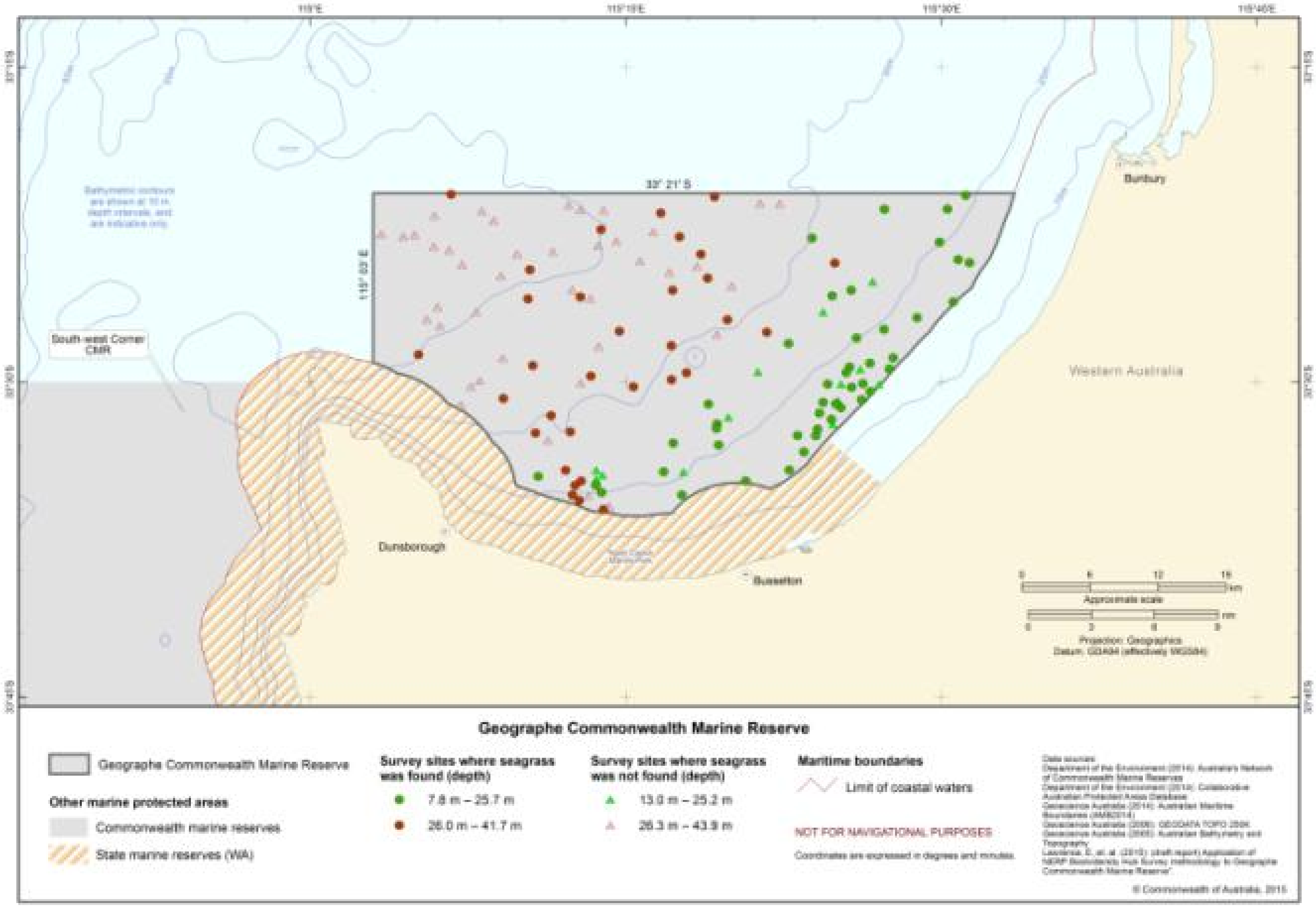

Figure 3.12 Seagrass coverage from 2015 Marine Biodiversity Hub BRUV surveys showing distribution of seagrass across the reserve

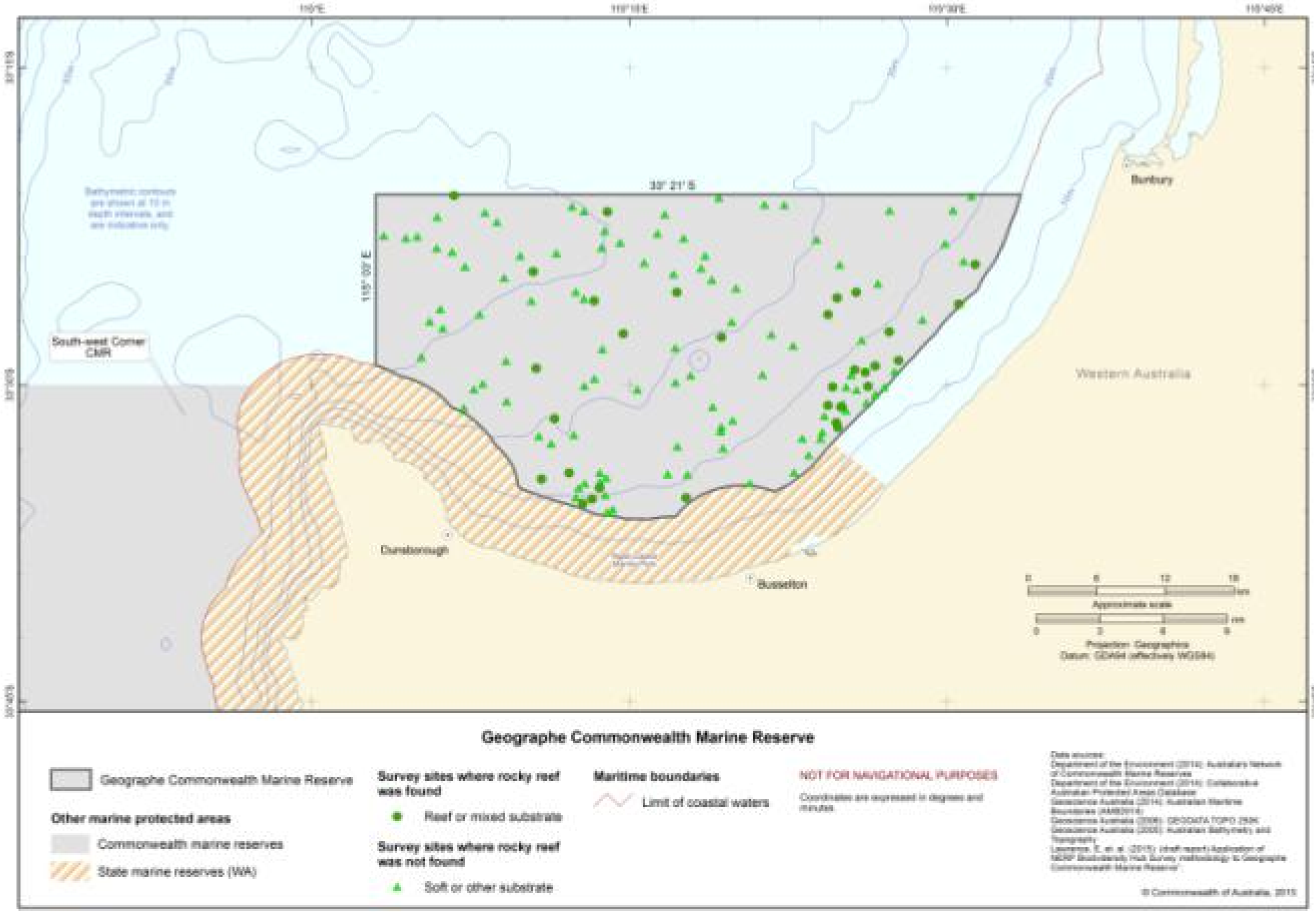

Figure 3.13 Rocky reef coverage from 2015 Marine Biodiversity Hub BRUV surveys showing distribution of rocky reef across the reserve

Cetaceans

Geographe Bay is identified as a biologically important area as migratory habitat for pygmy blue and humpback whales (DNP 2013e). This is supported by recent research on pygmy blue whale non-song vocalisations (Recalde-Salas *et al.* 2014) Five previously undescribed non-song vocalisations were produced by pygmy blue whales travelling in one direction within Geographe Bay, indicative of migratory behaviour (Ricalde-Salas *et al.* 2014).

North Pacific populations of blue whales have been known to vocalise when exhibiting feeding dive behaviours in a foraging area; however, Geographe Bay is not considered a feeding ground (Ricalde-Salas *et al.* 2014).

ESP finding

New information about Geographe Commonwealth Marine Reserve confirms that it contains important habitat and reveals that its seagrass beds extend further and deeper than previously thought. Protection of these extensive and potentially important seagrass beds extents should be maintained or improved.

The Marine Biodiversity Hub surveys provide valuable baseline information to underpin future monitoring of the CMR.

3.5.3 Bremer Commonwealth Marine Reserve

Recent findings

The Bremer Canyon (figure 3.14) is described as one of nine shelf-incising canyons in the South-west bioregion and one of the larger and most topographically complex of the Albany Canyons group (figure 3.15) mapped in a recent Geoscience Australia mapping study (Huang *et al*. 2014).

There is evidence that Bremer CMR is an important location for feeding aggregations of megafauna such as orcas and sharks (De Barros *et al.* 2013). Marine fauna observers on the Ennovation seismic survey, which extended west and east over the Bremer CMR area, sighted 555 marine mammal individuals in nearly 600 hours of observation. They recorded orcas apparently attacking sperm whales and predatory herding behaviour (in both locations within the Bremer CMR) and a nursery aggregation of 40 sperm whales was sighted three times immediately to the west of the CMR (McCarthy and Woodcock 2010). Stakeholder consultation in Esperance reported by Arcadia confirmed that pods of killer whales are seen in certain areas near the Bremer Canyon herding and attacking large fish such as tuna (Arcadia 2012).

The current hypothesis is that hydrocarbon seepage in the vicinity of the Bremer Canyon supports a productive phytoplankton feedstock for bait species, higher-order predators and marine mammals (Hovland and Riggs 2014).

The documentary titled ‘The search for the ocean’s super predator’, which aired on the ABC network in November 2013, reports a significant megafaunal aggregation in the Bremer region (De Barros *et al.* 2013).

Modelling to simulate marine larval dispersal undertaken by Geoscience Australia through the Marine Biodiversity Hub suggests that canyons with ‘high source capacity’ (typically topographically complex) have a high potential to contribute to resilience of the protected area network by exporting larvae to other connected locations (Bax and Hedge 2015).

The Bremer Canyon was predicted to have a medium–high source capacity due to its size and topographic complexity. The connectivity between and across the Albany Canyons (which include the Bremer Canyon) is driven by the Leeuwin Current flowing eastwards, the deeper Flinders Current flowing westwards, and augmented secondary flows that recirculate modelled dispersal clouds westward (Bax and Hedge 2015).

ESP finding

The Bremer Canyon is a biodiversity hotspot, especially in terms of aggregations of megafauna, and is worthy of protection that enhances eco-tourism in the area.

Further research that measures larval transport from the area may be warranted.

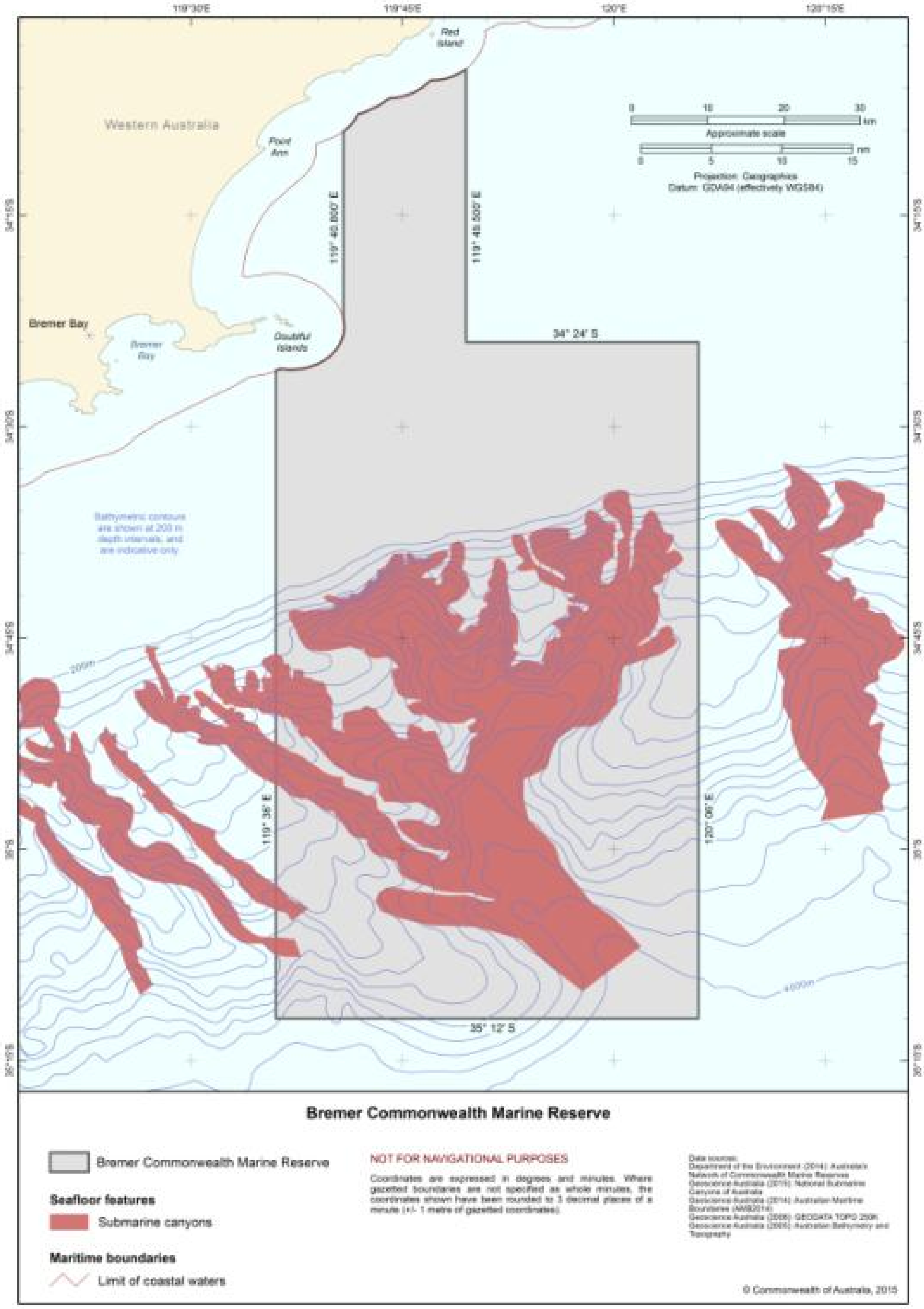

Figure 3.14 Bremer CMR and associated submarine canyons

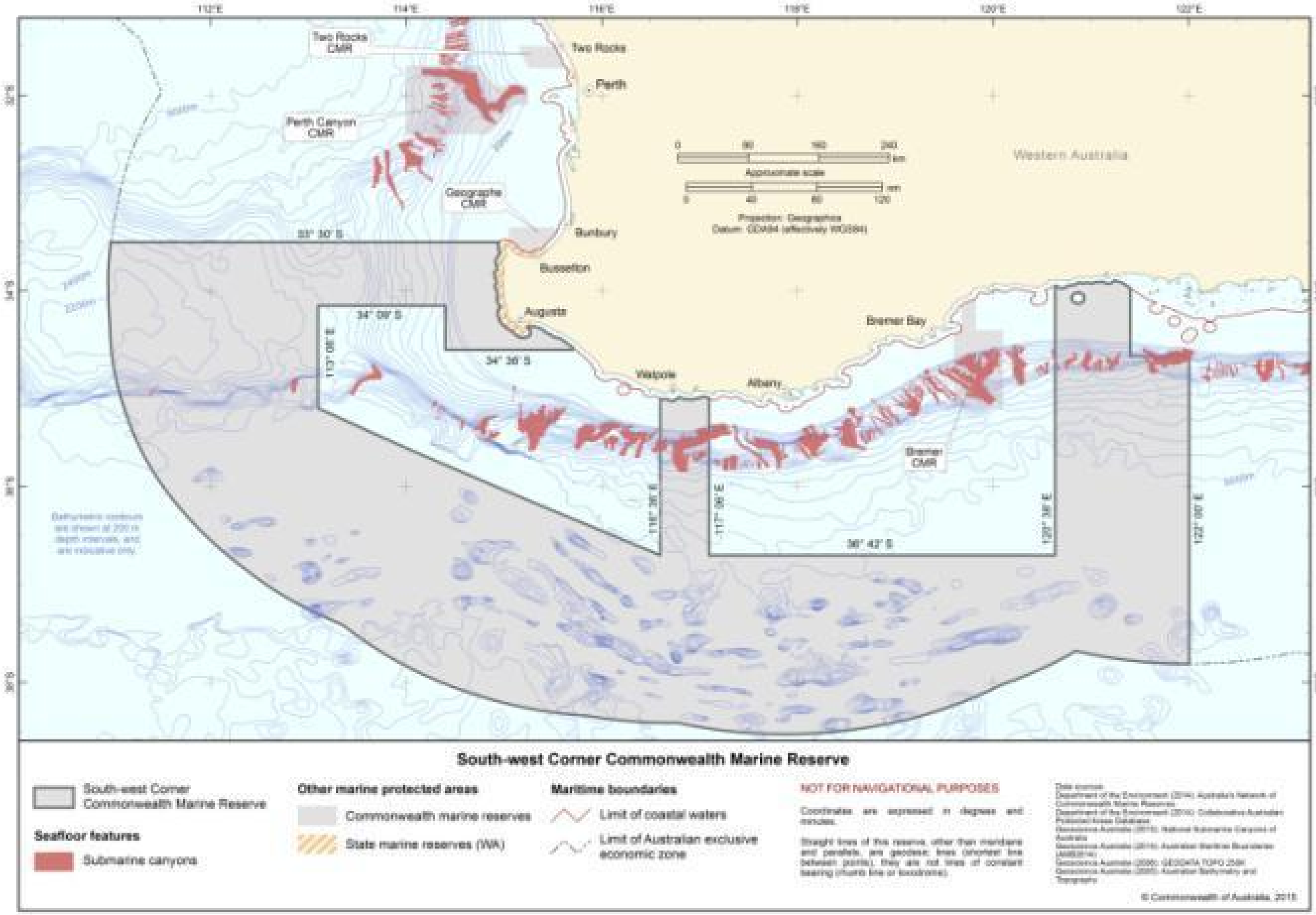

Figure 3.15 South-west Corner, Bremer CMRs and the associated Albany submarine canyons group

3.5.4 Perth Canyon Commonwealth Marine Reserve

The Perth Canyon / Naturaliste Plateau and surrounding region provides habitat for a number of cetacean species and deep-sea communities.

Whales[22]

Recent satellite tagging studies have shown that the greater Perth Canyon / Naturaliste Plateau region is a seasonal feeding area for pygmy blue whales.

The Double *et al.* (2014) study described the migratory distribution and behaviour of pygmy blue whales that feed in the Perth Canyon region, tracking several individuals for over 20 000 km (801 locations).

If the movements of the tracked whales are representative of the broader population that feeds off Western Australian, it can be inferred that pygmy blue whales migrate:

- north from the feeding grounds of the Perth Canyon / Naturaliste Plateau region in March/April, reaching Indonesia by June
- south from Indonesia from September, arriving in the subtropical frontal zone in December
- slowly north again from the subtropical frontal zone to arrive in the Perth Canyon / Naturalist Plateau region by March/April. This temporal pattern of migration as revealed by satellite telemetry is supported by acoustic recordings of Australian type pygmy blue whale calls off south Western Australia.

Genetic evidence indicates mixing between the animals in the feeding areas of the Perth Canyon (off Western Australia) and Bonney Upwelling (off southern Australia), and animals photographed in the Bonney Upwelling have also been resighted in the Perth Canyon. This indicates the potential for individuals from the Bonney Upwelling to follow a similar migration route to those animals feeding in the Perth Canyon.

Drawing on current and historical records, a recent study suggested that the submarine canyons off Albany and Perth provide important habitat for sperm whales (Johnson *et al.* 2013).

Deep-sea communities

Deep-sea communities have recently been surveyed for the first time within the Perth Canyon. Invertebrate and coral species (Pattiaratchi and McCulloch 2015), including live specimens of aragonitic coral (for example, *Desmophyllum*), were recorded

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[22] This section refers to information found in Double *et al*. 2014 unless otherwise referenced.

below 1000 m in water temperatures of 3°C to 4°C and bamboo coral recorded at depths between 1000 m and 1700 m (Schoepf and Falter 2015).

Recent surveys of the expedition of *RV Falkor* have described communities that live in total darkness on the hard rock of the canyon walls 1600 m below the surface (Pattiaratchi and McCulloch 2015). They include Venus flytrap anemones, brisingid seastars, golden coral (*Metallogorgia*), basket star (*Gorgonocephalidae*) and mushroom soft coral (*Anthomastus*) (Hosie 2015).

The data from the expedition has also revealed undersea terrain of varied topography and substrate, including vertical cliff faces of up to 600 m and evidence of landslides. In combination with the nutrient-rich waters of the canyon, these different landforms provide a wide array of habitats (Pattiaratchi and McCulloch 2015).

Fromont *et al.* (2012) completed an assessment of sponges on Australia's deep western continental margin (100 m to 1100 m), which found that highly species-rich sponge assemblages dominate the mega-benthic invertebrate biomass in both south-western (86 per cent) and north-western (35 per cent) areas. The Perth Canyon sits on the boundary of the central western and south-western regions, where many of these assemblages were found to be present. It was noted that lithistid demosponges were only collected within three areas (the north-western and central western provinces and transition zones) and not found south of Perth Canyon (Fromont *et al.* 2012). The data suggests that depth-related factors, substrate type, and current regimes (such as those found within the Perth Canyon) are the most influential when considering sponge distribution patterns.

Upwelling and downwelling

The Perth Canyon (figure 3.16) facilitates nutrient-rich deep water upwelling onto the continental shelf, but at certain times of the year it may also be a conduit for transporting water masses from the shallow continental shelf down into the deep sea. These processes significantly influence the water chemistry and nutrient flows and therefore also impact the marine life within the canyon (Pattiaratchi and McCulloch 2015).

Surveys reported by Pattiaratchi and McCulloch (*op. cit*.) found that, at the Perth Canyon's western, deeper end, the northern wall is much more rugged than the southern wall, with several semicircular features showing evidence of landslides. The dog-leg section of the canyon also features a very narrow gorge. The maximum water depth recorded in the canyon is 4376 m.

Modelling and observation studies have shown that the Perth Canyon interacts strongly with the Leeuwin Current and the Leeuwin Undercurrent, leading to eddy generation and upwelling at all depths in the canyon (Rennie *et al.* 2009). Complex patterns of circulation and upwelling in the canyon that bring nutrients into shallower waters at the head of the canyon and the surrounding shelf support high seasonal phytoplankton biomass accumulations which are likely to be responsible for aggregations of krill near the canyon head, attracting pygmy blue whales (Rennie *et al.* 2009), other megafauna, fish and birds.

These observations confirm that the Perth Canyon oceanography is an important source of localised upwelling and nutrient enrichment and productivity and is an important feeding ground for associated megafauna, including seabirds, cetaceans and pelagic fish. This aggregation is also the basis for an important recreational game fishery.

ESP finding

New information supports the understanding that the Perth Canyon is an area of biological significance, driven by localised upwelling around canyon heads that drives productivity and the associated feeding aggregations of an array of species, from whales and seabirds to pelagic predators such as tuna and marlin.

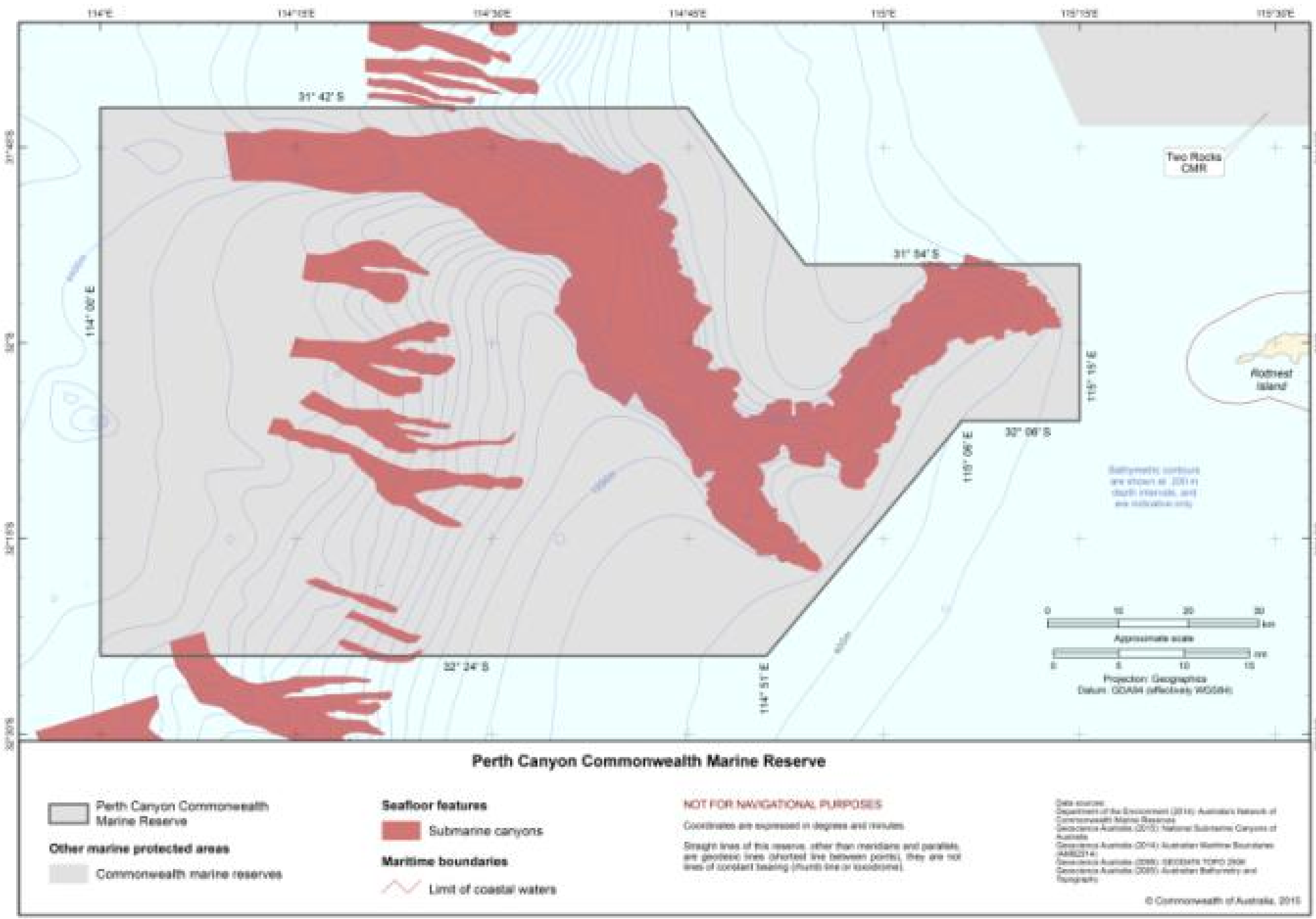

Figure 3.16 Perth Canyon Commonwealth Marine Reserve and associated submarine canyons

3.5.5 Oceanic Shoals Commonwealth Marine Reserve

Marine Biodiversity Hub survey results[23]

In 2012, a voyage of discovery to the western part of the Oceanic Shoals CMR was undertaken by the Marine Biodiversity Hub (Nichol *et al.* 2013). The voyage was designed to complement the findings and discoveries of the two previous surveys completed by Geoscience Australia and the Australian Institute of Marine Science in 2009 (Heap *et al.* 2010) and 2010 (Anderson *et al.* 2011b), and provide better understanding of east–west gradients in the physical environments of the CMR and their relationships to patterns of biodiversity in the region. Key findings from the voyage include:

- A higher variety than previously thought of seabed geomorphic features across water depths from 30 m to 180 m, including carbonate banks, terraces and pinnacles as well as soft sediment plains and valleys, was discovered.
- The high resolution mapping revealed 41 additional banks and pinnacles covering an area of 152 km^2—an increase from 105 km^2. This indicates that hard substrate, which is important to benthic biodiversity, is more extensive than previously thought.
- Benthic biodiversity of invertebrates on banks and pinnacles decreases with water depth and across the transition from the hard substrate of banks to soft sediment plains.
- Banks that rise to at least 45 m water depth support more invertebrate biodiversity, including isolated hard corals, most likely because of greater light penetration at these shallower depths.
- Tidal currents play an important role in shaping the seabed by scouring holes into soft sediments around the base of banks and pinnacles and by extending the length of these pockmarks. Typically, a more complex physical environment will host more species, but such a relationship has not been confirmed in this case.
- Levels of suspended sediment (turbidity) appear higher in the western part of the Oceanic Shoals CMR than the eastern part, with some smaller pinnacles partly buried by sediment. This indicates both ongoing dynamic sedimentary processes and environmental gradients which are likely to be responsible for some of the differences between the structure of invertebrate communities observed at these locations. This high turbidity precluded the analysis of video

[23] This section refers to information found in Caley *et al* (2015) unless otherwise referenced.

collected using demersal baited cameras. Understanding of the local fish communities in the survey area remains an information gap.

- The surveyed area supports a wide range of pelagic vertebrates—32 species were observed, including 11 shark species, black marlin, barracuda, olive ridley turtle, sea snakes and orca.
- Four species of hard corals listed by IUCN as Vulnerable, Near Threatened or Endangered were collected.
- Sediment dwelling invertebrates were highly diverse—266 species were collected, including newly discovered species of sea spider, squat lobster and worm.
- Significant differences were found in polychaete family composition between surveys one year apart, suggesting strong temporal patterns may be operating.
- At least 350 species of marine sponge occur within the Oceanic Shoals CMR, with modelling indicating there may be as many as 900—almost twice the number estimated for the Ningaloo CMR.
- Twenty-nine sponge species are new to science, with as many as 100 potential new species yet to be confirmed.
- Among all observed and/or sampled biota, 57 species are first-time observations for the Sahul Shelf and Northern Territory, seven are first-time records for Australia, and 13 are new for the Indo-Pacific region.
- The survey confirmed that this area supports large numbers of marine species and that many of these species rely on the KEFs that are present.

The data collected during the 2012 survey provided sufficient information to build a qualitative model of the KEFs in the Oceanic Shoals CMR. Qualitative modelling of the carbonate banks, terraces and pinnacles of the Sahul Shelf and Van Diemen Rise within the Oceanic Shoals CMR found five plausible threats for these KEFs over the next 50 years: oil and gas spills, illegal fishing, ocean acidification, increased storm intensity and increased agricultural run-off. The areas surveyed are shown in figure 3.17.

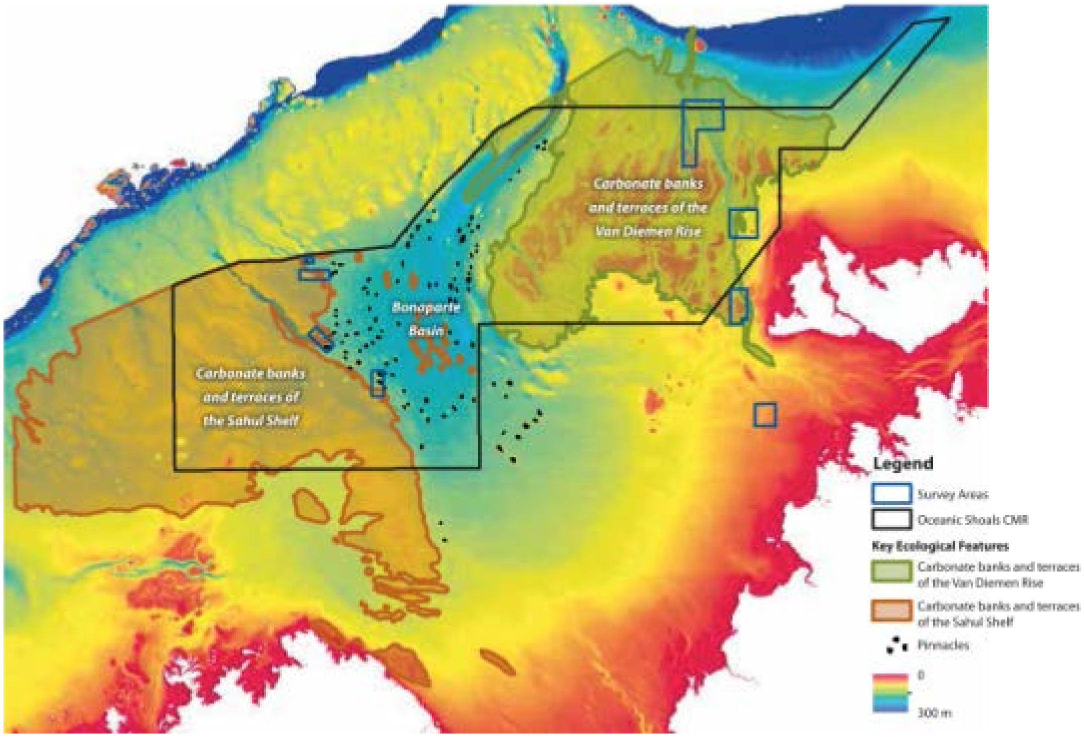

Figure 3.17 Carbonate banks, terraces and pinnacles in the Timor Sea region, showing the intersection with the Oceanic Shoals Commonwealth Marine Reserve. Areas surveyed during voyages in 2009, 2010 (Eastern CMR) and 2012 (Western CMR) voyages are also shown © Copyright, Marine Biodiversity Hub

Other findings indicate that demersal fish communities appear to correlate with the spatial patterns observed for the benthic biodiversity, occurring in larger and more diverse communities on the shallower, less turbid banks (Bax and Hedge 2015).

Sponges[24]

Research by the Marine Biodiversity Hub found a total of 283 species of sponges from the Oceanic Shoals CMR, representing four classes, 53 families and at least 117 genera. Sponge diversity was generally highest further offshore and on raised geomorphic features, particularly banks. Distinct sponge assemblages may occur on each bank in the eastern Oceanic Shoals CMR, suggesting that fine-scale monitoring programs and/or management at the level of individual banks may be appropriate.

Sponge richness, biomass and morphology may be proxies for other taxa and represent one of the key surrogate taxa for biodiversity assessments in the northern region.

Diverse sponge assemblages were confirmed for banks and other raised geomorphic features, supporting the use of the carbonate banks and terrace systems as KEFs due to associated high biodiversity and feeding aggregations. The terraces and banks of

[24] This section refers to information found in Przeslawski *et al.* 2014 unless otherwise referenced.

both the Sahul Shelf and the Van Diemen Rise, each a KEF, are associated with high biodiversity and feeding aggregations and are biodiversity hotspots for sponges, with at least 350 species of marine sponge occurring, including 29 species new to science. It is estimated that up to 900 sponge species may exist in the reserve.

Connectivity[25]

The data collected during the 2012 survey (Nichol *et al.* 2013) enabled the development of a new dispersal model that predicts connectivity patterns among Australia's north-western CMRs (including the Oceanic Shoals). The model is provides quantitative information on regional connectivity, how and to what extent the marine reserves may contribute larvae to areas outside of the reserves, and where this may occur.

The dispersal modelling suggests areas of relative stability connecting several CMRs: Arafura, Oceanic Shoals, Kimberly, Argo Rowley Terrace, Gascoyne and southwards. This modelling warrants testing by physical sampling to confirm the interconnections among the group of reserves of the Yambi Shelf and Joseph Bonaparte Gulf (Oceanic Shoals, Argo Rowley Terrace, Mermaid Reef, Kimberley, Ashmore Reef, Cartier and Josef Bonaparte Gulf) with the Oceanic Shoals CMR identified (along with Joseph Bonaparte Gulf, Arafura and Arnhem CMRs) as a dominant area due to its central location in the northern network.

Linkages among the Argo Rowley Terrace, Kimberley and Oceanic Shoals reserves emerge as key connections.

Seabed geomorphology and benthic habitats[26]

Geoscience Australia has integrated their new data from high-resolution seabed mapping with existing information on seabed geomorphology and associated benthic habitats and has used this to develop a framework that maps geomorphic features and habitats and characterises their spatial and temporal processes, enabling the development of conceptual models of seabed–basin connectivity and benthic ecosystems.

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[25] This section refers to information found in Kool and Nichol 2015 unless otherwise referenced.

[26] This section refers to information found in Heap *et al.* 2014 unless otherwise referenced.

ESP finding

The carbonate banks and terraces of both the Sahul Shelf and Van Diemen Rise are associated with high biodiversity and feeding aggregations. A higher level of protection could be provided for a representative sample of these key ecological features.

The survey sites established by the Marine Biodiversity Hub study of the Oceanic Shoals Commonwealth Marine Reserve warrant protection as scientific reference sites that provide valuable baseline information for the reserve.

Chapter 4 Establishing robust, evidence-based decision-making for the management of the marine reserves

Over the last decade, understanding of Australia's marine environment has grown considerably, as evidenced by recent reports of the Marine Biodiversity Hub and Census of Marine Life (see, for example, Butler *et al.* 2010). This review of the Commonwealth marine reserve (CMR) estate has been informed by these developments and was greatly assisted by a Marine Science Expert Forum held on 11 June 2015.

In preparing to 'advise the government on the science underpinning the Commonwealth marine reserves including proposed zoning boundaries and allowed uses', the Expert Scientific Panel (ESP) reviewed the use of science leading up to the 2012 declarations. The ESP found that that the process of establishing the CMR estate made use of the best available scientific information and input from stakeholders to establish initial reserve boundaries, which were then finalised following further consultation with stakeholders. The principal source of information that provided scientific input into this process was the Marine Bioregional Planning Programme that led to the development of a series of Marine Bioregional Plans for Commonwealth waters (see section 2.2). This process was informed by a high level of engagement with the marine science community.

The development of the CMR 2012 zoning boundaries was guided by the Goals and principles for the establishment of a National Representative System of Marine Protected Areas in Commonwealth waters (the Goals and Principles) and CMRs were assigned International Union for Conservation of Nature (IUCN) categories, as required by the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Again, the drawing of zone boundaries and zone management policies made use of the best available science at the time and was also informed by a process of consultation with experts and interested stakeholders (see chapter 2). This process exceeded the minimum statutory requirements of the EPBC Act.

There is a large body of scientific literature on marine reserves globally and in Australia. However, most pertain to the coastal zone and such is the size of the Australian Exclusive Economic Zone (EEZ) and the CMR estate that fine-scale biodiversity data for the estate is limited (see chapters 2 and 3). This necessitated the use of surrogate indicators (see section 2.2, box 2.1) and expert workshops to discuss options in relation to the defining of reserve boundaries and zones. The science of surrogates and knowledge of the distribution of biodiversity at finer scales can and should be progressively improved, as should our understanding of broad-scale oceanographic processes. While further insight has been gained in some areas since the 2012 proclamation, there are a number of areas where improved knowledge will assist in more precise targeting of management actions and increase management effectiveness. Increasing knowledge will have to be addressed over future planning cycles and, given the extent of the CMR estate, will require an approach that embraces all the areas of science necessary for evidence-based management of the diverse range of reserves that make up the CMR estate. This clearly requires that needs be identified and information be delivered through a strategic framework of research. Specific needs will arise and these, as well as opportunities that might arise to conduct research outside this framework—such as might arise through the availability of a new facility or technologies—will have to be addressed in the course of a management plan cycle for the CMRs.

Establishing an efficient and effective monitoring system for marine biodiversity in the CMR estate that is fit for purpose is critical to effective management and performance evaluation.

Monitoring of marine biodiversity does not simply involve a survey that identifies the range of species that occur in different areas of the CMR estate at particular times. It also relates to the processes that influence these distributions. Such processes are complex and often either imperfectly understood or unknown. In addition, they are variable in time and space. To complicate these issues, threats which could modify species distribution and ecosystem function are often unknown either in an absolute sense (for example, an invasive species) or in terms of their long-term effect until expressed and observed over time. For example, a change in oceanographic processes can naturally occur or have an anthropogenic cause. In addition, localised changes can be the result of direct anthropogenic impacts such as oil spills, recreation and tourism. Addressing these information gaps for Australia's marine environment represents a project of national significance that will have to be established and maintained over generations. It is reasonable to assume that over the long term, as knowledge improves, zoning may need to change and some adjustments to reserve boundaries may even be necessary to improve the CMR estate in line with comprehensive, adequate and representative (CAR) principles. This is a future priority to be addressed in successive statutory management cycles.

The ESP has considered these issues and recommends a framework for resolving them over successive management planning cycles (each cycle is statutorily set at 10 years). A long-term perspective is needed, as there is no other practical way to deal with them quickly in either the current or any foreseeable future scenario of available Government resources.

4.1 Managing the Commonwealth marine reserves effectively

The marine environment, including the CMR estate, is subject to significant temporal and spatial variability. We do not understand in sufficient detail the seabed topography, its substrates and their variability in space and time and have even less understanding of the biota in these sediments and the sea above it. Furthermore, we need to better understand how natural variability and climatic drivers affect currents, seawater layering and upwelling, as these affect important marine systems and processes (see section 3.4.1, for example).

The ESP is of the opinion that the establishment of the CMRs provides a framework in which Australia can build its capabilities for the management of both the reserve estate and the broader Commonwealth component of the EEZ. Managing these areas is in Australia’s long-term strategic interests, as it more clearly elaborates and demonstrates Australia’s responsibilities for its EEZ. However, the approach needs to be measured and clearly focused on the progressive building of national capability to undertake high-quality research and to monitor and evaluate performance of marine systems and their management. This must embrace the existing capacity of both the governmental and private sectors through partnerships with the marine research community more generally. The relevance of science to underpin the management of the CMR estate must be presented to the Australian people in such a way that they understand its value and importance.

In order to build on current knowledge and respond to new information, an adaptive management approach is needed.

ESP Recommendation 1

The Expert Scientific Panel recommends the adoption of an adaptive management approach for the Commonwealth marine reserve estate and that the first management planning cycle include a period for transition to this approach.

The ESP is of the opinion that there will be a need to emphasise research, monitoring and evaluation together with a significant communications effort over the next decade (see ESP Recommendation 2). This is done with the background assumption that this will not be at the expense of necessary day-to-day management of the CMR estate that, to be clear, cannot be achieved without a long-term, adequate and systematic investment. While this may initially be modest, the real challenge is to ensure that such investments are enduring, maintain their focus and demonstrate their usefulness. Any other approach would be, in the long term, ineffective and a waste of resources.

4.2 Research and monitoring needs and priorities

4.2.1 Overview

Research and monitoring, together with the evaluation of both for the CMR estate, takes place within the legislative framework set out for the management of the reserves under the EPBC Act. The statutory CMR management plans are implemented through a framework determined by the Director of National Parks (the Director) and approved by the Minister for the Environment.

To establish an effective management planning and subsequent management regime, Parks Australia must build and maintain strong links with the marine research community and, as an extension of that, encourage the use of good citizen science (see section 4.4.2). One strategy requiring specific investment is the further building of a knowledge broker network involving Parks Australia, state jurisdictions, private enterprise, the research community and organised citizen science.

In its consideration of research and monitoring, the ESP had three primary sources of information: its own evaluation of the existing science, the views of the Director and the results of a national Marine Science Expert Forum conducted as part of this review.

4.2.2 Research in the Commonwealth marine reserve estate

The ESP sees the research requirements for the CMR estate at two levels:

- At the strategic level, the research investment would be geographically- and process-defined to improve understanding of the structure and function of the biophysical systems that constitute the reserves and the adjoining seas. It is evident that the resources currently available to the Director are not sufficient to address research and monitoring gaps at this level. Programs like the National Environmental Science Programme (NESP) and its successors, together with what may develop from the National Marine Science Plan (NMSP) (see box 4.1) will be very important for strategic CMR research. Opportunities for the Director to leverage funds through strategic partnerships to conduct such research will also be important at this level.

- At the tactical level, the research investment would be on high-priority issues that are directly relevant to the management of the CMR estate. These issues would vary significantly between components of the CMR estate, as they would be driven predominantly by interaction between management and stakeholders. This includes research in response to poorly understood or emerging threats. High-priority tactical research issues will not always be foreseen and will often require a fast response. For this reason, funding needs to be available to the Director to develop and enable effective and timely responses to issues and opportunities as they arise.

The strategic CMR research needs that are critical for successive planning cycles to continuously improve the management of CMR estate require a systematic approach. This will involve the application of objective evaluations of how the management framework is performing and interacting with research. Recently, significant progress has been made—the Marine Biodiversity Hub has held a series of workshops with a wide range of stakeholders and marine users to identify further research priorities for the hub, including one workshop specifically on research needs for the CMR estate. The Marine Biodiversity Hub is about to discuss and finalise its next five-year research plan with this input. In addition, the NMSP sets out a series of strategic research needs, including for biodiversity, development of baselines, monitoring, decision-support models and tools, and better data management.

Management information needs to be designed in a framework that relates the research and monitoring effort to the management requirements of the CMR estate and other Commonwealth obligations under the EPBC Act. Table 4.1 is a systematic way of bringing these requirements together and some priority areas are elaborated on below.

ESP Recommendation 2

The Expert Scientific Panel recommends the development of a research, monitoring and evaluation framework that will support robust evidence-based decision-making in the management of the Commonwealth marine reserve estate. Such a framework should be designed in a way that it is consistent with that used for environmental reporting in Australia.

The Expert Scientific Panel recommends the development and management of knowledge brokering between Parks Australia, state jurisdictions, private enterprise, the research community and citizen science.

Box 4.1 The National Marine Science Plan 2015–2025: Driving the development of Australia's blue economy

Launched in August 2015, the National Marine Science Plan (NMSC 2015) draws together the knowledge and expertise of marine research organisations, universities and government departments and individual scientists. It identifies critical challenges related to Australia's marine estate and provides recommendations about how marine science can support Australia in meeting those challenges.

The plan recognises marine biodiversity and ecosystem health as one of a number of 'grand challenges' for Australia and makes the following statement in relation to that challenge:

> *To conserve marine biodiversity and keep ecosystems healthy, we must explore and map our marine estate to fill in knowledge gaps; undertake experimental research on ecological processes; monitor key indicators of variability and change; and develop modelling tools and other techniques for evidence-based management. Over the next 10 years, this science will focus particularly on building the knowledge base to support our new National Marine Reserve System.*

The ESP supports this statement and, as noted elsewhere in this chapter, National Marine Science Plan recommendations for:

- the establishment of baselines and monitoring for Australia's marine estate with a focus on helping manage Commonwealth marine reserves
- continued support for the Integrated Marine Observing System (IMOS).

The ESP is also supportive of the plan's broad ambition to develop a more comprehensive scientific understanding of Australia's marine estate to support good decision-making, and notes that in many cases Commonwealth marine reserves provide a sensible focus point for efforts to develop that understanding.

4.2.3 Information gaps identified by the Expert Scientific Panel

Advancing our understanding of the functioning of marine ecosystems

This represents a high priority for the next 10 years. While the ESP has found that the use of surrogates and expert opinion was the best way available to establish the CMR estate and has suggested this needs to be built on, the immediate priority is to ensure that management actions and investments are well targeted and ensure that the objectives that underpin the establishment of the CMR estate are met effectively and efficiently. If this is done in the long term, knowledge of the CMR estate can be refined in terms of its zoning and ultimately its outer boundaries. This can only be done when better information about the CMR estate becomes available to evaluate and improve the existing situation. Success in this area will require novel and efficient approaches to data acquisition, including remote sensing, modelling, hypothesis-driven experimental management approaches, and the use of new technologies such as aerial, surface and underwater drones. It is suggested later that this should be part of a wider national investment in technology development.

Baselines and inventories

The ESP affirms the importance of baselines as being essential to the assessment of condition and trends in the CMRs. Benchmarks and targets against which progress can be measured need to be developed against this baseline information. They should not be confined to highly protected zones and no-take reference areas but should be distributed across the CMR estate and be in all zoning types. This approach would enable CMRs to be part of a long-term management approach for the EEZ that not only reports on condition and trends within the CMR estate but also provides reference and comparative information for areas under different management and/or zoning regimes. Particular outcomes of biophysical and socio-economic baselines and inventories would be the evaluation of the effects of zoning and management regimes and the early identification of emerging threats.

As new information emerges, the system of baselines and benchmarks could be extended to include cooperative research around newly identified areas of scientific, economic and social interest. Managing the estate in this fashion would place Australia in the first rank of international marine science and could help attract research investment from the international community.

The ESP recognises the magnitude of this task and accepts that comprehensive coverage will not be achievable in the short term. The ESP greatly welcomes the emphasis in the NMSP on national marine environmental baselines, a national marine monitoring system, national marine environment and socio-economic modelling, smart technologies and decision-support science, which can all benefit the monitoring of and research on the CMR estate.

ESP Recommendation 3

The Expert Scientific Panel (ESP) recommends the establishment of a series of baselines and development of benchmarks in each network across the Commonwealth marine reserve estate. Further, the ESP stresses that early baseline and benchmark establishment is critical to enable a sound assessment of the effectiveness of subsequent reserve management.

The ESP further recommends that this be done in partnership with the marine research community.

The ESP endorses the recommendation in the National Marine Science Plan 2015–2025 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'*. In addition the ESP encourages a Government commitment to maintaining investment in marine infrastructure and capabilities.

Other values

Although the emphasis of the ESP has been on biophysical science, the importance of the social and economic sciences should not be ignored in the development of better understanding of CMR effects and benefits that go beyond the conservation values as defined by biophysical science. Such work is essential for the CMR estate given its multiple-use nature and is necessary for management to be acceptable to the public in the long term. It also provides Government and the community with information and builds confidence in the values of a well-managed estate.

ESP Recommendation 4

The Expert Scientific Panel recommends that the social and economic sciences be part of the research investment made to support management of the Commonwealth marine reserve estate.

Effectiveness of zones

The zoning of the CMR estate provides a range of opportunities to evaluate and compare the efficacy of different zone types and their management arrangements. The estate also provides an opportunity for the users of different zones in the CMRs to participate in the collection of information that will contribute to a better understanding and improved management of the zones. The paucity of hypothesis-driven, well-designed studies that evaluate and compare the efficacy of different zone types underscores the importance of undertaking these studies in the CMR estate. Here, the importance of baseline data cannot be overemphasised (see above). While of considerable scientific interest, the primary reason to invest in and support research into zone efficacy is to improve the effectiveness of management and to ensure future planning cycles are based on a improving knowledge base, and particularly to ensure that zoning and management arrangements are well targeted, soundly based, better understood and accepted by the community.

ESP Recommendation 5

The Expert Scientific Panel recommends that the Director of National Parks facilitate and encourage research and research collaborations that assist in the evaluation of the efficacy of different zone types.

Threats and mitigation of threats

Most of the literature dealing with threats in marine parks and reserves is based on studies in nearshore and coastal reserves. Far less information is available on the more extensive and remote marine areas such as those covered by the CMR estate. The exception to this is the risk of commercial fishing, which has been comprehensively assessed through the Fishing Gear Risk Assessments. A focus of future monitoring and research should be to improve understanding of other threats to CMR conservation values. This would include activity-generated threats (shipping, for example) and broader anthropogenic threats like climate change. Where multiple threats exist, these can have a cumulative impact on the marine environment.

The intensity and impacts of emerging and cumulative threats in particular are not well understood. Improved understanding of these and other threats can inform efficient and effective management responses, which may help to mitigate the risks posed by those threats. Different zoning arrangements across CMRs provide an opportunity to study changes in marine areas with different threat combinations. The approach proposed in this report is to design monitoring and research to analyse the effects of various stressors and thus ensure that this problem can be effectively addressed.

ESP Recommendation 6

The Expert Scientific Panel recommends that, in developing a research, monitoring and evaluation framework for the Commonwealth marine reserve estate, existing and potential threats be identified and prioritised. Some baseline and benchmark sites within the estate should be established to assist in detecting threats and their impacts.

Requirements for managing effectively

The ESP invited Parks Australia to outline their research and monitoring needs at the expert workshop. Their list was revised in the light of the workshop discussion and feedback from the ESP. This contributed to the summary presented in table 4.1, which provides a draft framework for understanding CMR research and monitoring with respect to CMR management obligations and objectives. Table 4.1 also maps other environmental reporting requirements, such as State of the Environment reporting, to the CMR needs.

ESP Recommendation 7

The Expert Scientific Panel recommends institutionalising a transparent approach to research and management within Parks Australia as part of building relationships with the research community.

The Expert Scientific Panel considers the research and monitoring requirements framework set out in table 4.1 is sound and recommends it as an input to the development of a Parks Australia research and monitoring strategy for the Commonwealth marine reserve estate, with the reserves in the South-east Commonwealth Marine Reserves Network included in its scope.

Table 4.1 The relationship between management and reporting requirements and research and monitoring requirement for the CMR estate

Driver ➔ 🡻 Research or monitoring requirement	Legal or other requirement	Key management issue	Baseline information	Long-term monitoring (including SoE)	Management of human pressures
Research that contributes to increased understanding of values of the reserves and that provides for establishing baselines and ongoing reporting of the condition of the values of the reserves, as required under legislation, and national and international agreements, such as:					
Systematic bathymetry mapping, including depth and locations of seafloor features.		✓ BIA, KEF	✓	✓	
Mapping of the sub-stratum types and depth of sea floor.		✓	✓	✓	
Stratified random sampling of the benthos, particularly habitat forming benthos such as sponges and corals (to build baselines and assess the extent of the differences between the actual habitats and biophysical proxies used to develop the reserve network).		✓ BIA, KEF	✓	✓	
Comprehensive surveys of biological assemblages associated with geomorphic features or habitats (to build baselines and assess the extent of the differences between the actual habitats and biophysical proxies used to develop the reserve network).		✓ BIA, KEF	✓	✓	
Comprehensive surveys of native species to provide baseline information against which to compare natural variation and human induced change.		✓ SoI, CC	✓	✓	✓

Driver ➔ 🡻 Research or monitoring requirement	Legal or other requirement	Key management issue	Baseline information	Long-term monitoring (including SoE)	Management of human pressures
Research into oceanographic features and processes that strongly influence the biodiversity patterns, including distribution of marine species and seabirds.		✓ BIA, KEF	✓	✓	
Development of indicators for use in long-term monitoring to detect changes in ecosystem condition and attribution to pressures (e.g. climate change, uses).		✓ CC		✓	✓
Estimating populations and monitoring trends of threatened species in reserves to assist the implementation of recovery plans and inform biologically important areas.	✓ RP, EPBC	✓ BIA			
Research and monitoring to contribute to the development and implementation of other recovery plans, action plans, Threat Abatement Plans and character assessment of Ramsar wetlands.	✓ RP, TAP, Ramsar	✓		✓	✓
Where practical, remote sensing of vegetation, benthic communities and habitats and other characteristics of islands, reefs and cays.			✓	✓	✓
Studies to better understand biological and hydrographical connectivity in CMRs, including between and within reserves and the broader Commonwealth marine area (e.g. food webs, source and sink locations).	✓ TAP	✓ BIA, KEF			

Driver ➔ 🡻 Research or monitoring requirement	Legal or other requirement	Key management issue	Baseline information	Long-term monitoring (including SoE)	Management of human pressures
Research and monitoring to further understand the impacts of human activities in and around the reserves and threats on the values of the reserves, such as:					
Monitoring the spatial extent and character of human disturbance of 'footprint' (such as the total area impacted by facilities, debris, historic sites, sampling sites, tracks).	✓ TAP	✓ KEF	✓	✓	✓
Monitoring changes in the degree to which anthropogenic threats affect threatened and other key species (e.g. interaction with fishers, marine pollution, disease outbreaks, direct disturbance).	✓ RP, TAP, EPBC	✓ SoI, BIA			✓
Identification of key impacts at a national, network and reserves scale where possible.	✓ TAP	✓ IS, SoI, CC	✓	✓	✓
Surveys to determine the presence and extent of any invasive species.		✓ IS			✓
Investigate the possible impacts on native biota of invasive species, including threatened and key species.		✓ IS, SoI			✓
Research and monitoring to contribute to developing management strategies that will prevent or minimise those impacts, such as:					
Investigating the cumulative impacts of activities on threatened species, key species and habitats and identifying particularly vulnerable areas.	✓ EPBC	✓ SoI, KEF			✓
Auditing of key areas for the presence of invasive species.		✓ IS			✓
Identifying the pathways for and mitigation of		✓ IS			✓

Driver ➔ 🡻 Research or monitoring requirement	Legal or other requirement	Key management issue	Baseline information	Long-term monitoring (including SoE)	Management of human pressures
risk of invasive species.					
Research and monitoring that will assist in addressing emerging reserve management issues consistent with the provisions of the CMR management plans:					
Research that contributes to and informs effective marine management through a nationally integrated approach.				✓	✓
Research to improve understanding of social and economic use and benefits of the reserves:					
Monitoring changing human use and socio-economic significance of CMRs.		✓	✓	✓	✓

(BIA—biologically important areas; CC—climate change; CMR—Commonwealth marine reserve; EPBC—*Environmental Protection and Biodiversity Conservation Act 1999*; IS—invasive species; KEF—Key Ecological Features; Ramsar—Wetlands of International Importance; RP—Recovery Plan; SoE—State of the Environment; SoI—Species of Interest; TAP—Threat Abatement Plan.

4.2.4 The Marine Science Expert Forum

The ESP convened a forum of national marine science experts to consider key management challenges related to the CMR estate. The questions put to the forum were:

- What are the key data and knowledge gaps in relation to CMRs, in terms of:

  (a) biodiversity structure and functional distribution in space and time

  (b) key threats?
- How can these gaps best be prioritised and resolved over the first 10-year management cycle?
- What research capability exists to assist with the above?
- What baselines should be established as a matter of priority?
- What key aspects should be considered for the development of a long-term monitoring program for CMRs?
- What approaches (systems, models, technology) exist and are best placed for facilitating the involvement of all stakeholders in the collecting, sharing, collating and interpreting data that can support adaptive management?

Forum participants considered these issues and came together for a day of discussion in Melbourne. A number key points (see box 4.2) were distilled from the discussion (a list of forum participants is provided at appendix 4).

Box 4.2 Key points distilled from Marine Science Expert Forum held on 11 June 2015

- There is a need for an inventory of current data to be available across government agencies and other sources.
- There is a need for ongoing and comprehensive science communication with stakeholders about progress with Commonwealth marine reserves (CMRs) in the first 10 years of management of the CMRs.
- There is a need for a tactical research capacity to exist within Parks Australia.
- There is a need for effectiveness measures to be developed by Parks Australia.
- The terms of reference of the CMR Review do not cover the South-east CMR Network; however, any research, monitoring and evaluation strategy must include the South-east CMR Network. Any organisations that undertakes relevant projects with any level of Government funding should be required to provide data to the Australian Ocean Data Network.
- Government agencies should invest in long-term data sets, including continued

investment in existing sets and facilities. 'Exemplar' long-term monitoring programmes (both in terms of geographic sites and process) should be highlighted.

- Formal research and other data (including citizen science) collected in CMRs should be done in a consistent manner (e.g. some researchers could be required to use the Collaborative and Automated Tools for Analysis of Marine Imagery and video (CATAMI) classification scheme) so the data can be compared.
- In encouraging the need to address data sharing / accessibility issues, consideration should be given to making available environmental impact statements and general mining and other industry data.
- Considering the CMRs represent over one-third of the Exclusive Economic Zone and that research within CMRs as reference areas informs the broader understanding of the marine system outside the CMRs, some Marine National Facility time should be dedicated to CMR research outside of the competitive programme.
- Performance measures should consider those aspects on which stakeholders seek information with regard to CMRs and their management, including:
    - improving recreational experience
    - the long-term sustainability of commercial and recreational fishing
    - resilience to climate change
    - the economy (through tourism, for example)
    - protection of threatened and endangered species
    - improving opportunities for Indigenous people.
- Research and monitoring in CMRs should consider:
    - how activities impact biodiversity
    - biophysical and socio-economic aspects
    - how the protection of different zone types compare
    - the importance of continuous learning and discovery
    - building on strengths, including through reinforcing the National Environmental Science Programme and the National Marine Science Plan.
- How to prioritise research between areas is a problem that needs addressing.
- There is a need for long-term monitoring sites within the CMRs to be established as baselines and for the consideration of shifting baselines (due to climate change and (associated) shifts in East Coast and Leeuwin currents, for example).

- There is a need to consider ways to address funding constraints. These include:
    - international partnerships and collaborations (e.g. collaborating with international bodies to develop automated processing capabilities; and collaborating with universities and individuals across all research needs)
    - opportunistic discovery should be encouraged, checked and incorporated into data holdings as part of non-government organisations and other projects
    - citizen science should be encouraged.
- Consider new technologies that may provide cost-effective mechanisms for effective research and monitoring (noting that all tools and their use require adequate monitoring program design and data analysis). The new generation of tools currently available (or becoming more cost-effective) include:
    - autonomous underwater vehicles (AUVs) and unmanned aerial vehicles (UAVs)
    - drones
    - genomics
    - lidar
    - satellite imagery (including Landsat 8 and the 'Australian Geoscience Data Cube')
    - acoustics.
- Consider modelling developments on system dynamics and structure.
- Recognise and address the difficulty of linking science to management objectives and the need for defining priorities for data collection.
- There is a need to encourage coordination between the marine science sector and stakeholders (including Government, industry, non-government organisations and the international research community) regarding data and techniques.

There is a significant convergence of the views of the ESP, Parks Australia and the Marine Science Expert Forum. While some details vary, it is clear that the objective of achieving 'robust, evidence-based decision-making for the management of the marine reserves' is a common objective. The establishment of an effective mechanism to facilitate necessary research, manage new and old data and ensure its effective use is also a common theme. ESP Recommendation 1 is for an adaptive management approach to the management of the CMR estate. This section has proposed a framework for identifying the research needs of the CMR estate. In the next section the ESP recommends a system for managing the research necessary to support the adaptive management system by meeting its need for science-based data.

4.3 Managing the proposed research, monitoring, data and evaluation framework

4.3.1 Introduction

The development of a research, monitoring and evaluation framework that will support robust evidence-based decision-making in the management of the CMR estate is essential and it may be desirable to design this in a way that it is consistent with the framework used for environmental reporting in Australia. Adopting the Drivers, Pressures, State, Response and Implications framework (DPSIR) approach would allow data required for the purpose of managing the CMR estate to be applied more widely to reporting on the oceans component of Australia's State of the Environment reporting.

Three components are necessary for an effective and more systematic approach to research, monitoring and evaluation:

(i) a governance structure

(ii) a framework for data acquisition and management

(iii) an evaluation framework that is objective and quality assured.

These need to operate across the geographical and temporal scales involved. If such a system is to enjoy public confidence and continuing government support, it has to be open and publicly accessible so that independent evaluation of the interpretation of data can be made.

ESP Recommendation 8

The Expert Scientific Panel strongly recommends that approvals and support for research and monitoring activities in the Commonwealth marine reserve estate require that the raw data and metadata obtained through these activities are made publicly accessible through the Australian Ocean Data Network to enable independent examination and analysis.

4.3.2 Governance

Beyond what it has recommended, the ESP believes that the details of the governance of any system of monitoring and evaluation are a matter for Government arrangements within the Australian Government and between Australian and international jurisdictions. That said, the principle of collecting once and using for many purposes is a good one and it should be applied. The ESP believes this is possible, but facilitation may be necessary.

4.3.3 Data acquisition and management

Data acquisition in the marine realm is expensive and the geographic extent of the CMR is vast. From the material considered by the ESP and the discussions held at the Marine Science Expert Forum, it is clear that surrogates will play a crucial role in data acquisition and will be assisted by the development of various autonomous platforms, remote sensing tools and other innovations that have the potential to reduce the cost and increase the quality and volume of data collected. National collaboration between research providers and research funders is essential. Information gathering will be complemented by citizen science programmes (for example, Reef Life Survey, Eye on the Reef, Tangaroa Blue, and fish tagging and volunteer programmes by recreational fishers) and should be encouraged.

The Australian Ocean Data Network (AODN) provides a strong national framework for managing marine datasets. The bulk of marine data collected by Commonwealth agencies is accessible through the AODN, which has been developed through a joint venture between six Commonwealth agencies with responsibility for marine data (CSIRO, Geoscience Australia, the Australian Institute of Marine Science, the Australian Antarctic Division, the Bureau of Meteorology and the Royal Australian Navy) with primary datasets contributed by the Integrated Marine Observation System (IMOS)—an Australian Government research infrastructure project. The AODN Data Portal provides a single access point for marine data published by Commonwealth agencies and a large number of other data contributors. The portal provides access to standardised data files and includes a catalogue of metadata and a map interface for AODN datasets. The Integrated Marine Observing System Marine Information Infrastructure is responsible for building and maintaining data and metadata standards and provides a sound basis for managing new data acquired from research in the CMR estate.

ESP Recommendation 9

The Expert Scientific Panel (ESP) recommends that existing marine research and monitoring data be maintained in the long term and that it is made readily accessible to the scientific community, reserve managers and other relevant users so that they may contribute to the adaptive management of Commonwealth marine reserves and the management of Australia's Exclusive Economic Zone.

The ESP recommends that Parks Australia becomes an active contributor and core partner in the Australian Ocean Data Network.

The ESP recommends the continuing support of the Integrated Marine Observation System (noting that the National Marine Science Plan also makes this recommendation) and the Australian Ocean Data Network as vital to the future success of the monitoring and management framework of the Commonwealth marine reserve estate.

The ESP recommends that the Australian guidelines for the ethical conduct of research be emphasised in the collection and use of data.

4.4 A staged approach

As stated earlier, the ESP is of the view that the resources available to the Director alone are unlikely to address the range of research, monitoring and evaluation issues that are needed to ensure the CMR estate is effectively managed. In the following sections the ESP recommends strategies for facing this reality.

One such strategy is to adopt a staged approach to the implementation of CMR monitoring, evaluation and research. Such an approach would recognise the need to focus implementation in particular priority areas over the course of a 10-year management cycle. Sensible priority areas have been identified at a high level by the recently released NMSP (see box 4.1) and at a more detailed level by the Director (table 4.1). However, the ESP notes that the monitoring, research and evaluation resources of the Director, even in conjunction with further strategies—for example, partnerships with the broader marine science community—are unlikely to extend to addressing all of these priority areas in all CMRs from the commencement of management.

A pragmatic approach could involve setting specific targets with an adaptive management approach for addressing information gaps in priority areas over two four-year blocks and finishing the 10-year management cycle with a two-year review period. The two-year review would assess the performance of the two four-year research periods and inform planning for the next 10-year management cycle. In addition to providing sensible time frames for science planning and implementation, a science component of a 4–4–2 adaptive management cycle could help to facilitate more regular communication of new science and science needs between CMR stakeholders. The two-year review period should also involve formal assessment of CMR management effectiveness, preferably by an external reviewer.

4.4.1 Facilitating the setting of research priorities

The ESP was asked to identify specific priorities for research and the information gaps that hinder evidence-based decision-making for the management of the CMR estate.

In chapters 2 and 3 of this report, research gaps have been identified and relevant scientific judgements made to support the work of the Bioregional Advisory Panel (BAP).

Concurrent with the development of this report, the NMSP for Australia sets out expert views on marine research priorities for the coming decades. Many of these proposals are relevant to the management of the CMR estate and the strategic research discussed previously.

During the final stages of this review the Marine Biodiversity Hub released its National Environmental Research Program (NERP) final report, which provides a snapshot of marine biodiversity research findings from scientists. Hub scientists contributed to this review through the Marine Science Expert Forum and Hub outputs will continue to be useful for management planning for the CMR estate.

The ESP has considered what would be a practical list of research priorities that would improve management of the CMR estate (table 4.1). These generally fall into a category of tactical research and should form part of the Director's forward planning.

The critical strategic research investments that would support tactical research needs and significantly improve the management of the CMR estate are those that support and integrate on-going research with the recommendations of this report.

These proposals would be a basis for testing the approach outlined in this report and subsequently, as the approach matures, developing further critical research priorities that should be funded.

ESP Recommendation 10

The priority research investments that the Expert Scientific Panel recommends to the Government as making a significant contribution to the management of the Commonwealth marine reserve estate are:

- the research, monitoring, data and evaluation framework should be established, together with baseline studies
- if a national strategy for the development of platforms and sensors is established then linking research planning for the Commonwealth marine reserve estate with it is important
- if the National Marine Science Plan 2015–2025 is adopted in some form then there should be clear linkages between its execution and the needs of the Commonwealth marine reserve estate.

4.4.2 Research funding

It is unlikely that the scientific information needs for reserve management can be met under a single dedicated programme. As a result, information needs will be realised through a range of approaches:

1. **Research directly funded by the Director**: This is likely to be the way that information needs are realised, as the Director will fund some ongoing monitoring in relation to evaluation and reporting needs and will also have a limited capacity to respond to tactical research needs. A dedicated research budget for the Director would create the basis to leverage additional research investment from third parties.
2. **Research funded through departmental programmes or where the Director is a minor contributor**: Projects funded through the NESP (and analogous future programs), are likely to be the primary means, at least for the first decade of management, to deliver against strategic research priorities for the CMR estate. The Director should work closely with these programmes to seek to deliver key strategic research needs, such as establishment of baselines, development of decision-making tools and the identification of appropriate monitoring techniques.
3. **Other marine research programs and projects:** There are a range of organisations, including the in private sector, that conduct research in the marine environment that is relevant and can contribute to the knowledge base to help manage reserves more effectively. This will require the Director to clearly articulate needs, priorities and standards in order to attract such investments and to best utilise research opportunities that may arise from third-party interest.

4. **Citizen science**: Citizen science has already played a part in the NERP and the work elsewhere in the CMR estate. It is desirable that this be extended and, where possible, include work that is supported and funded by non-government organisations and interested foundations or undertaken by other users of the CMR estate. The ESP recognises that at times the priorities of these groups and the Government agencies at the core of our proposals may differ. The development of a knowledge network involving Parks Australia and its partners that is proposed in section 4.2.1 should develop the capacity to negotiate partnership agreements with these groups to allow them to contribute to the knowledge base for the CMR estate. Developing effective relationships through such a network would lower the potential for data misinterpretation and create a stronger basis for alignment of priorities and investment in future research and management.

4.4.3 Communicating progress

Given the scale of the CMR estate and the timelines involved in establishing and evolving its management, there will need to be a significant effort in building public understanding of the role that the CMR estate plays in Australia's future.

The approach to the management of research, monitoring and evaluation that has been proposed by the ESP means that the potential exists for an ongoing dialogue with the Australian people about the characteristics of, and issues associated with, the management of the CMR estate. Furthermore, such a dialogue should create the opportunities for communicating the concerns, issues and priorities of users of the estate and the general public. Building public understanding of the objectives, benefits and value of the CMR estate is as essential for its effective management into the future as is a good understanding by the managers of the expectations and aspirations of reserve users and the interested public. This would in turn guide the development and implementation of an effectively managed estate that is understood, appreciated and supported by the public.

The key messages of a communication plan would be that it informs the public of:

- where the estate is located
- the estate zoning system
- the legislative and scientific basis of the system
- the way the ongoing management cycle is planned and how new information can be progressively incorporated into the management of the CMR estate
- how threats to the system are identified, including some case studies on how they are dealt with. This may also be expanded to identify risks, but risks should not be speculative; they should be concrete—for example, the introduction of invasive biota. This can be supported by examples where this has already happened

- publication of data summaries, fact sheets and other educational resources
- the spatial and temporal issues associated with such a large system and also the way the system behaves. This is especially important in terms of either event-based or poorly understood stochasticity
- appropriate links that would allow the exploration of websites that are associated with contributors to the data system
- encouragement of involvement in specific, relevant citizen science programmes.

Appendix 1 Commonwealth Marine Reserves Review Terms of Reference

Context

The Coalition Government committed to establish a national representative system of marine protected areas in 1998, and confirmed that commitment at the 2002 World Summit for Sustainable Development.

A key milestone towards the national representative system was the 2007 proclamation of the South-east network of Commonwealth Marine Reserves. In November 2012, forty new Commonwealth marine reserves were proclaimed in the South-west, North-west, North, Temperate East and Coral Sea marine regions, completing the Australian Government's contribution to Australia's national system of marine protected areas.

Commonwealth marine reserves are proclaimed and managed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which requires that statutory management plans be developed and implemented by the Director of National Parks.

To fulfil its commitment, in December 2013 the Government set aside the management plans for the reserves in the South-west, North-west, North, Temperate East and Coral Sea marine regions. New management plans will be developed following a review to ensure that management arrangements reflect appropriate consultation with stakeholders and are informed by the best available science.

As stated in the Government's policy for a *More Competitive and Sustainable Fisheries Sector* an expert marine panel will be appointed to review the science supporting the boundary area for each zone. This process will reconsider proposed zoning boundaries in consultation with stakeholders. The review will restore confidence in the process by bringing genuine consultation.

Scope and process of the Review

The review will comprise two interrelated streams:

- An Expert Scientific Panel of five members including a Chair will review the science supporting the current marine reserves.
- Bioregional Advisory Panels of three members for each marine region covered by the review, with two co-chairs working across all panels, will facilitate enhanced consultation with stakeholders on marine reserves.

Terms of reference for these panels are described below.

The panels will operate and report separately, but will share information to ensure that review outcomes collectively reflect robust consideration of scientific, economic and social evidence. To facilitate this, the co-chairs of the Bioregional Advisory Panels will also participate as members of the Expert Science Panel.

Both components of the review will be conducted with regard for the *Goals and Principles for the Establishment of the National Representative System of Marine Protected Areas in Commonwealth Waters* (the Goals and Principles) and the legislation and regulations for the development of management plans and managing activities within Commonwealth reserves.

The review will only consider the reserves proclaimed in November 2012: that is, those reserves in the South-west; North-west, North, Temperate East and Coral Sea marine regions.

Secretariat support will be provided to the panels by the Department of the Environment. The Department will also facilitate the involvement of other relevant Australian Government departments in the review process, including the Department of Agriculture.

The panels will report to the Government within six months of the first meeting of the panels, unless extended by the Minister for the Environment. The reports will be transmitted to the Government via the Minister for the Environment. The panel chairs are responsible for transmitting the reports of the panels.

The reports of the Expert Scientific Panel and the Bioregional Advisory Panels will be made publicly available.

The Government's response to the reports will inform the development of new management plans for the marine reserves. Further public consultation on the development of new marine reserve management plans will be undertaken in accordance with the EPBC Act.

Terms of reference for the Expert Scientific Panel

The Expert Scientific Panel will advise the government on the science underpinning the Commonwealth marine reserves including proposed zoning boundaries and allowed uses. The Expert Scientific Panel will review the risk assessments that supported zoning, and zoning boundary, considerations and other scientific information related to zoning decisions for individual networks or reserves. Based on this review, the Expert Scientific Panel will advise on:

- options for zoning, and zoning boundaries, and allowed uses consistent with the Goals and Principles
- future priorities for scientific research and monitoring relating to marine biodiversity within the marine reserves, especially any relating to the understanding of threats to marine biodiversity within the marine reserves.
- options for addressing, the most significant information gaps hindering robust, evidence-based decision-making for the management of the marine reserves.

The Expert Scientific Panel will produce a single report addressing these issues. The report will be separate to the report of the co-chairs of the Bioregional Advisory Panels.

Membership

The Expert Scientific Panel will consist of five members selected through agreement between the Minister for the Environment and the Parliamentary Secretary to the Minister for

Agriculture. Two of these members are also the co-chairs of the Bioregional Advisory Panels, in order to facilitate sharing of information across the review panels.

Terms of reference for the Bioregional Advisory Panels

Bioregional Advisory Panels will be appointed for the South-west; North-west, North, Temperate East and Coral Sea marine regions. These panels will share two co-chairs, who will oversee the work of all of the panels and will consult with peak bodies for all relevant sectors. These co-chairs are also members of the Expert Scientific Panel. All Bioregional Advisory Panels will consult across sectors including: industry, recreational users, community groups, tourism, Indigenous communities, environmental interest groups and other parties as appropriate.

The Bioregional Advisory Panels will then provide the government with:

- advice on areas of contention with the marine reserves
- advice on options for zoning boundaries to address those areas of contention
- recommendations for improving the inclusion of social and economic considerations into decision-making for marine reserves, with particular regard for their management
- suggestions for ongoing engagement of regional stakeholders.

The Bioregional Advisory Panels will also report, or provide advice on, any information received through the consultation process they feel may influence, contribute to or improve the drafting of future management plans.

The co-chairs of the Bioregional Advisory Panels will produce a single report addressing these issues and reflecting the inputs of all of the panels. The report will be separate to the report of the Expert Scientific Panel.

Manner of consultation

The Panels will consider views of interested parties provided through a range of mechanisms that may include:

- regional meetings with key stakeholders or stakeholder organisations
- meetings with peak organisations representing relevant business and not-for-profit sectors and with relevant government agencies
- online survey
- other written representations.

Membership

The co-chairs of the Bioregional Advisory Panels have been selected based on their capacity to facilitate input into marine reserves planning from the full range of stakeholders, and based on agreement between the Minister for the Environment and the Parliamentary Secretary to the Minister for Agriculture.

The Bioregional Advisory Panels will consist of three members for each region. Members have been selected for their capacity to facilitate input from a broad range of stakeholders.

Appendix 2 Risk management of activities in Commonwealth marine reserves

The objectives of Australia's Commonwealth marine reserve (CMR) estate acknowledge that Australians use and value the marine environment for different purposes. Recreational activities, including boating, diving and fishing; commercial activities such as tourism, charter and commercial fishing, mining and shipping; and educational activities such as academic research are all important and will continue to occur in areas of the CMR estate.

The vast majority of activities in Australia's marine environment are subject to regulation which aims to prevent or minimise any harm to the environment. Usually activities are regulated on a sectoral basis—for example, fishing through fisheries management—and may also be subject to federal environmental law—the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act)—under which the marine environment of the Commonwealth marine area, threatened species, ecological communities and migratory species are 'matters of national environmental significance'.

Activities within a CMR, therefore, are usually subject to prescriptions in a management plan, relevant sectoral legislation and regulations (either federal or state/territory) and, where applicable, broader EPBC Act environmental protection provisions. However, this does not mean that in CMRs multiple layers of regulation necessarily apply: the Director of National Parks generally imposes prescriptions and regulations through a management plan if and when existing sectoral and environmental regulations are not geared to achieve the objectives for the CMRs. The primary objective of CMRs is to protect the environment.

This section of the ESP's report outlines some of approaches to managing the risk of human activities in marine reserves and places them in the context of the risk management arrangements that apply to them more broadly.

Oil and gas

This section describes the Australian Government's approach to managing oil and gas activities that take place, or are proposed to take place in, a CMR. The legal position that applied more generally in Commonwealth waters at the time the new CMR estate was proclaimed in 2012, which is still current, was that activities conducted under an oil and gas project that are likely to have a significant impact on nationally protected matters, such as listed migratory or threatened species or the Commonwealth marine area, must be assessed under the EPBC Act. Oil and gas activities include seismic exploration. Proposals that will have an unacceptable impact on nationally protected matters are not allowed to go ahead.

At the time the new CMR estate was first proclaimed and until February 2014, the Australian Government Department of the Environment was responsible for assessing oil and gas proposals referred under the EPBC Act.

In addition to the EPBC Act, offshore oil and gas activities were, and continue to be regulated under the *Offshore Petroleum and Greenhouse Gas Storage Act 2006* (OPGGS Act). Before any oil and gas project, including exploration, can take place in Commonwealth waters, they require an Environmental Plan accepted under the OPGGS (Environment) Regulations 2009.

The OPGGS Act is administered by the federal industry department through the National Offshore Petroleum Safety and Environmental Management Authority (NOPSEMA).

Since February 2014, under the Australian Government's streamlining of offshore environmental approval processes, assessments of proposed oil and gas projects are undertaken by NOPSEMA under a general approval that, under the EPBC Act, accredits OPGGS Act environmental processes.

Under the accredited process, companies proposing to undertake oil or gas activities must prepare legally-binding environmental plans, including oil spill contingency plans. NOPSEMA is required to assess the plans to ensure that activities in the Commonwealth marine area are carried out in a manner consistent with the principles of ecologically sustainable development set out in the EPBC Act.

Oil and gas activities in a CMR can only be carried on in accordance with the relevant CMR management plan and may only be allowable activities in some Multiple Use Zones and Special Purpose Zones (IUCN VI). In assessing proposed oil and gas activities in CMRs, in addition to those considerations that apply to the Commonwealth marine environment generally, NOPSEMA will:

(a) not act inconsistently with a CMR management plan in deciding whether or not to accept an environmental plan
(b) if there is no management plan in place, ensure that acceptance of an environmental plan is not inconsistent with the International Union for Conservation of Nature (IUCN) reserve management principles set out in the EPBC Act.

Activities approved through the NOPSEMA process for an area within a CMR zone where mining and oil and gas are allowable activities will be authorised under the relevant management plan, and no additional assessment, approval or permit from the Director of National Parks is required. The South-east CMR Network Management Plan—the only extant CMR management plan—sets out the provision for class approvals (that is, where no further assessment is required by the Director of National Parks) for oil and gas activities assessed as described above (DNP 2013a, sections 5.2.7, 5.2.8 and 5.8).

Oil and gas activities may also require approval under other Commonwealth legislation such as the *Environmental Protection (Sea Dumping) Act 1981* and the *Protection of the Sea (Prevention of Pollution from Ships) Act 1983*. The project proponent is responsible for identifying and deciding whether a proposal needs to be referred for assessment or approval with the relevant regulatory body. Proponents must adhere to the requirements that apply to petroleum activities throughout the life of the activity, including any changes to arrangements that apply to ongoing activities.

Release and awarding of leases for oil and gas exploration in the Commonwealth marine area is separate to the NOPSEMA process to assess activities. The granting of an exploration lease does not constitute approval to commence an oil and gas activity. As part of the leasing process, advice is provided by the Australian Government Department of the Environment to industry on environmental sensitivities:

(a) generally, through its Protected Matters Search Tool (DoE 2013b)

(b) specifically in relation the location and values of CMRs (DoIIS 2015).

This assists industry to identify where subsequent activity proposals may be subject to higher levels of environmental scrutiny or where they may not be allowed to operate, such as in Habitat Protection Zones or Marine National Park Zones of CMRs.

Seabed mining

Seabed mining activities that are likely to have a significant impact on nationally protected matters must be assessed under the EPBC Act.

Sectoral legislation also applies to seabed mining activities. The *Offshore Minerals Act 1994* provides the legal framework for the exploration for, and production of, minerals over the continental shelf in Commonwealth waters. Licences for exploration and production of minerals in Commonwealth waters are administered by the Australian Government in collaboration with the designated authority of the relevant state or territory government. Under the Offshore Minerals Act, licences may include conditions related to protection of the environment (for example, conditions related to protection of wildlife, minimisation of the effect on the environment of the licence area and the area surrounding the licence area and repair of any damage to the environment).

Mining activities in Commonwealth waters require approval by the Minister for the Environment if they will have, or are likely to have, a significant impact on the marine environment or on other matters protected under the EPBC Act. The assessment of seabed mining activities referred under the EPBC Act is done by the Department of the Environment. Seabed mining is not a common activity in Commonwealth waters.

Mining activities can only be carried on in CMRs in accordance with a management plan for the CMR or, when a plan is not in effect, in accordance with approval given by the Director of National Parks under the EPBC Act. The South-east CMR Network Management Plan allows mining activities in IUCN VI zones under a permit or class approval issued by the Director. Before issuing a permit, the Director must be satisfied the proposed activity is not likely to have an unacceptable impact on the area and its values.

Similar to the assessment and approvals process set out for oil and gas activities, a management plan can provide for a class approval authorising all mining activities that are approved under the EPBC Act (DNP 2013a). Separate assessment of the operations by the Director is not then required, as Commonwealth reserve values are taken into account in the decision under the EPBC Act (DNP 2013a).

Research activities

Research and monitoring activities in CMRs are most often carried out by public and private institutions but also occasionally by foreign institutions in collaboration with Australian researchers. Some research and monitoring activities involve private individuals through citizen science programmes (for example, the Reef Life Survey, Reef Check Australia and gamefish tagging programmes). Research and monitoring activities in CMRs must be authorised by, and carried out in accordance with, a management plan (DNP 2013a). Research and monitoring may be allowable in all zones of CMRs in accordance with a permit issued by the Director of

National Parks, although in Sanctuary Zones and Marine National Park Zones extractive activities are generally considered inconsistent with the conservation of biodiversity (DNP 2013a). However, recognising the contribution that scientific research can make to the effective management of marine reserves, management plans can provide for authorisation of extractive research activities in those zones (DNP 2013a). Individual research activities are considered on a case-by-case basis and may require detailed environmental assessment of the proposed research activities.

Additional to relevant prescriptions in a management plan, research activities will also require approval from the Minister for the Environment if they will have, or are likely to have, a significant impact on the marine environment, listed threatened species or ecological communities, or listed migratory species. The EPBC Regulations also control the taking of biological resources of native species for research and development on any genetic resources, or biochemical compounds, comprising or contained in the biological resources from Commonwealth waters.

The South-east CMR Network Management Plan provides for research and monitoring activities to be undertaken (DNP 2013a).

Recreational fishing risk management

Recreational fishing (taking of fish for non-commercial purposes, including by clients of charter vessels) in CMRs is subject to the provisions of the EPBC Act and, more specifically, management plans. The relevant provision of the EPBC Act means that 'take' includes catching and releasing fish. The South-east CMR Network Management Plan provides for recreational fishing to occur in:

(a) Habitat Protection Zones (IUCN IV)

(b) Recreational Use Zones (IUCN IV)

(c) Special Purpose Zones (IUCN VI)

(d) Multiple Use Zones (IUCN VI).

Recreational fishing, like other extractive activities, is not allowed in Sanctuary Zones (IUCN Ia) or Marine National Park Zones (IUCN II).

Most recreational fishing occurs in state and territory waters, with state and territory governments responsible for the day-to-day management of recreational fisheries, including the recreational components of some Commonwealth managed commercial fisheries such as game fishing (DoA). State and territory regulation of recreational fishing extends more generally to the edge of the Exclusive Economic Zone (EEZ), although there is provision for additional or modified requirements for recreational fishers within CMRs.

The South-east CMR Network Management Plan provides for the recreational fishing laws of the relevant states (for example, bag, size and possession limits, and gear and bait restrictions) adjacent to the network CMRs to apply to recreational fishing in those CMRs.

Each state and territory has recreational fishing rules designed to share resources and ensure their sustainability into the future. Size limits are designed to allow fish to reach maturity and complete at least one breeding cycle before they can be legally taken. In New South Wales, for example, size limits are determined through scientific advice about the biology of fish stocks, consideration of consumer preferences, and with reference to existing commercial and recreational size limits (NSW DPI 2015).

In addition to management plan prescriptions, the Director's powers under the EPBC Act in relation to recreational fishing in CMRs include the ability to specify:

- the number, species and size of fish that can be taken and/or possessed
- the type of gear and bait that can be used
- spatial and temporal closures.

However, the Director has not generally used this power to apply restrictions additional to those of the states and territories in CMR zones where recreational fishing is permitted.

Fishing Gear Risk Assessments (FGRAs) similar to those for commercial gear types have not been undertaken for recreational gear. However, the FGRAs on commercial fishing, which were an input into the zoning decisions for Habitat Protection Zones (IUCN IV) and Multiple Use and Special Purpose Zones (IUCN VI) assessed gear similar to that commonly used by recreational fishers (hand lines, rod and reel and lobster pots, for example) as compatible with the management objectives for those zones.

Tourism

The prescriptions in the South-east CMR Network Management Plan provide for commercial tourism to be conducted in most network management zones under either a permit or class approval from the Director of National Parks.

In general the decisions and assessments necessary to meet the above requirements for issuing a permit, or a class approval, for commercial activities such as tourism are undertaken by delegates of the Director of National Parks.

Special rules apply to whale and dolphin watching in all Commonwealth waters under the EPBC Regulations and guidelines (NRMMC 2006) have been published to help tourism operators and the broader community to understand how to interact with cetaceans with minimal impact. The Director may apply additional prescriptions to nature watching or other tourism activities under the EPBC legislation and CMR management plans. For example, the Director can make determinations about use of vessels, including speed limits, or may limit nature watching to certain CMR zones. The South-east CMR Network Management Plan allows nature watching in all zones other than Sanctuary Zones (IUCN Ia).

Appendix 3 Primary scientific and expert reports commissioned by the Department of the Environment that underpinned marine bioregional planning processes and the design of the Commonwealth marine reserves

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Appendix 4 Marine Science Expert Forum participants, 11 June 2015, Melbourne

Scientific experts

Professor Nic Bax, Director, National Environmental Science Programme Marine Biodiversity Hub

Dr John Gunn, Chair, National Marine Science

Dr Terry Walshe, University of Melbourne, National Environmental Science Programme Marine Biodiversity Hub

Dr Beth Fulton, CSIRO

Dr Russ Babcock, CSIRO

Dr Andrew Heyward, Australian Institute of Marine Science

Dr Brendan Brooke, Geoscience Australia

Dr Alan Williams, CSIRO

Mr Patrick Seares, Western Australia Marine Science Institute

Dr Neville Barrett, University of Tasmania

Dr Lynnath Beckley, Murdoch University

Dr Robin Beaman, James Cook University

Dr Ian Poiner, Australian Institute of Marine Science

Dr Roland Pitcher, CSIRO

Parks Australia

Ms Sally Barnes, Director of National Parks

Mr Charlton Clark, Assistant Secretary, Marine Protected Areas Branch

Expert Scientific Panel

Associate Professor R. J. S (Bob) Beeton AM (Chair)

Professor Colin D. Buxton

Mr Peter Cochrane

Professor Sabine Dittmann

Dr Julian G. Pepperell

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Appendix 6 Glossary and Acronyms

ABARES — *Australian Bureau of Agricultural and Resource Economics and Sciences*

AFA — *Area for Further Assessment*

Areas within which new marine reserves were likely to be created and were identified to aid detailed collation and analysis of information, particularly regarding the socio-economic implications of reserve options.

AFMA — *Australian Fisheries Management Authority*

Australian Government agency responsible for the management and sustainable use of Commonwealth fish resources on behalf of the Australian community.

AFZ — *Australian fishing zone*

ANZECC — *Australian and New Zealand Environment and Conservation Council*

AODN — *Australian Ocean Data Network*

BAP — *Bioregional Advisory Panel(s) of the Commonwealth Marine Reserves Review*

Bathymetry — The measurement of ocean depths to determine the sea floor topography.

Benthic/benthos — Refers to the bottom of the sea, the seafloor and including some sub-surface layers, as well as benthic marine organisms living on or within the seafloor.

BIA — *Biologically important area*

Areas where individuals of a species are known to display biologically important behaviour such as breeding, foraging, resting and migration. These areas in a marine region are particularly important for the conservation of protected species.

Bioregion — An area that is defined by relatively homogenous and

	characteristic types of plants, animals and environmental conditions. In Commonwealth waters, those bioregions as defined in the Integrated Marine and Coastal Regionalisation of Australia Version 4.0.
BIS	*Biological informed seascapes* Represent a combination of physical and biological information that predicts where species are likely to occur using scientific modelling of ecosystems. The use of these seascapes as surrogates for biodiversity allowed the variety of biodiversity associated with different substrates to be captured within the marine reserves network.
BRD	*Bycatch reduction device*
BRUV	*Baited remote underwater video*
Bycatch	Species taken incidentally in a fishery where other species are the target.
CAR principles	*Comprehensive, adequate and representative* These were identified as the principles in the ANZECC Guidelines for Establishing a National Representative System of Marine Protected Areas (1998), defined as: Comprehensive—includes the full range of ecosystems recognised at an appropriate scale within and across each bioregion. Adequate—has the required level of reservation to ensure the ecological integrity and viability of populations, species and communities. Representative—areas that are selected for inclusion in marine protected areas should reasonably reflect the biotic diversity of the marine ecosystems from which they derive.
CATAMI	*Collaborative and Automated Tools for the Analysis of Marine Imagery*
CBD	*Convention on Biological Diversity*
CITES	*Convention on International Trade in Endangered Species of Wild Fauna and Flora*

CMR	*Commonwealth marine reserve* A reserve established and managed under Division 4 of Part 15 of the EPBC Act, which must be assigned an IUCN Category and may be subdivided into a number of different zones with different management objectives and IUCN Categories.
Commonwealth marine area	Also known as 'Commonwealth waters'; refers to any part of the sea, including the waters, seabed, and airspace, within Australia's Exclusive Economic Zone and/or over the continental shelf of Australia, excluding state and Northern Territory coastal waters. Generally, the Commonwealth marine area stretches from 3 nm from the territorial sea baseline to the outer limit of the Exclusive Economic Zone, 200 nm from the baseline. The territorial sea baseline is normally the low water mark along the coast.
Commonwealth waters	See **Commonwealth marine area**, above.
Continental slope	The region of the outer edge of a continent between the relatively shallow continental shelf and the deep ocean.
Continental shelf	The section of the seabed from the shore to the edge of the continental slope.
CPUE	*Catches and catch per unit effort*
CSIRO	*Commonwealth Scientific and Industrial Research Organisation*
Demersal	Living on or near the bottom of the sea.
DEWHA	*Department of Environment, Water, Heritage and the Arts* An earlier name for the Commonwealth Department of the Environment.
DNP	*Director of National Parks* The DNP as determined under section 514A of the EPBC Act, including any person to whom the Director has delegated powers and functions under the EPBC Act in

	relation to the Commonwealth marine reserves.
Downwelling	The process whereby surface waters sink, caused by the convergence of different water masses in the open ocean, or where surface waters flow towards the coast.
DSEWPaC	*Department of Sustainability, Environment, Water, Population and Communities* An earlier name for the Commonwealth Department of the Environment.
EAC	*East Australian Current*
EBFM	*Ecosystem-based fisheries management*
EEZ	*Exclusive Economic Zone* The sovereign waters of a nation, recognised internationally under the United Nations Convention on the Law of the Sea as extending up to 200 nm from the shoreline.
Endemic/endemism	Native to or confined to a certain region.
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* The Australian Government's key environmental Act, which came into effect on 16 July 2000; includes any Act amending, repealing or replacing the Act.
ERAEF	*Ecological Risk Assessment for Effects of Fishing*
ERA	*Ecological Risk Assessment*
ERM	*Ecological risk management*
ESD	*Ecologically sustainable development*
ESDA	*Ecological Sustainable Development Assessment*
ESP	*Expert Scientific Panel of the Commonwealth Marine Reserves Review*
ETBF	*Eastern Tuna and Billfish Fishery*

FGRA	*Fishing Gear Risk Assessment* Expert assessment of the potential risk that a fishing gear type poses to the marine reserves' conservation objectives/values. A key input in the application of Principles 19 and 20 (see Goals and Principles) and whether fishing with that gear type is allowed or prohibited in a reserve or network.
GBRMP	*Great Barrier Reef Marine Park*
Goals and Principles	The *Goals and Principles for the establishment of the National Representative System of Marine Protected areas in Commonwealth waters* comprise four Goals and 20 Principles to guide the identification of areas suitable for inclusion in the NRSMPA. Together, they provide direction on how to ensure that all types of marine ecosystems and their biodiversity are represented within the national network of marine reserves.
IMCRA	*Integrated Marine and Coastal Regionalisation of Australia* A spatial framework for classifying Australia's marine environment into bioregions.
IUCN	*International Union for the Conservation of Nature* IUCN, established in 1948, is the world's largest global environmental organisation, with almost 1300 government and non-government organisation members and more than 15 000 volunteer scientists and experts in 185 countries. IUCN's work is supported by almost 1000 staff in 45 offices and hundreds of partners in public, non-government organisation and private sectors around the world.
KEF	*Key ecological feature* Large-scale ecological features that support distinct or important ecological communities at a regional scale. Where these features are considered to be of regional importance for either a region's biodiversity or its ecosystem function and integrity, they are known as

KEFs. The criteria used to identify KEFs in a region are:

- a species, group of species or community with a regionally important ecological role, where there is specific knowledge about why the species or species group is important to the ecology of the region, and the spatial and temporal occurrence of the species or species group is known
- a species, group of species or community that is nationally or regionally important for biodiversity, where there is specific knowledge about why the species or species group is regionally or nationally important for biodiversity, and the spatial and temporal occurrence of the species or species group is known
- an area or habitat that is nationally or regionally important for enhanced or high biological productivity
- aggregations of marine life
- biodiversity and endemism.

Management Plan Under the EPBC Act all Commonwealth reserves (terrestrial and marine) must have a management plan. Once a marine reserve has been proclaimed, the Director of National Parks must develop a management plan for the reserve as soon as practicable. Management plans are prepared by the Director of National Parks, with public input, and approved by the Minister for the Environment before being tabled in both Houses of Parliament for a period of 15 sitting days, during which a motion of disallowance can be moved. The plans provide for the protection and conservation of the reserve. They must set out how the reserve is to be managed, what activities will be allowed and how those activities are to be carried on. Management must be consistent with the relevant Australian IUCN Reserve Management Principles. Management plans have a maximum life of 10 years.

Management principles The Australian IUCN reserve management principles are set out in Schedule 8 of the EPBC Regulations.

MBH *Marine Biodiversity Hub (the MBH operates under the NESP and before then under the NERP and Commonwealth Environmental Research Facilities*

MNPZ *Marine National Park Zone*

MPA	*Marine protected area*
MSC	*Marine Stewardship Council*
MWTMF	*Mid West Trawl Managed Fishery*
NEOLI	*No-take, enforced, old, large and isolated*
NERP	*National Environmental Research Programme*
NESP	*National Environmental Science Program*
NOPSEMA	*National Offshore Petroleum Safety and Environmental Management Authority*
NPF	*Northern Prawn Fishery*
NRSMPA	*National Representative System of Marine Protected Areas* A comprehensive, adequate and representative system of marine protected areas that contribute to the long-term ecological viability of marine and estuarine systems, maintain ecological processes and systems, and protect Australia's biological diversity at all levels.
NWSTF	*North West Slope Trawl Fishery*
OPGGS	*Offshore Petroleum and Greenhouse Gas Storage*
Parks Australia	A division of the Commonwealth Department of the Environment that supports the Director of National Parks.
Pelagic	Associated with the surface or middle depths of the water column.
POC	*Particulate organic carbon*
PSA	*Probabalistic Safety Analysis*
Proclamation	A proclamation by the Governor-General that is registered on the Federal Register of Legislative Instruments.
Provincial bioregions	Large areas of the oceans with broadly similar

	characteristics that have been classified by scientists based on the distribution of fish and other marine species, seafloor types and ocean conditions.
PSA	*Productivity Susceptibility Analysis*
ROV	*Remote operated vehicle*
SAFE	*Sustainability Assessment for Fishing Effects*
SBTF	*Southern Bluefin Tuna Fishery*
SCTF	*South Coast Trawl Fishery*
SEFRA	*South-east Marine Region Fishing Risk Assessment*
SESSF	*Southern and Eastern Scalefish and Shark Fishery*
SICA	*Scale Intensity Consequence Analysis*
State/territory waters	State or territory waters are the coastal waters that extend from the territorial sea baseline for 3 nm seawards, and are under the jurisdiction of the adjacent Australian state or territory. The normal territorial sea baseline is the low water mark measured along the coast.
Surrogates	Knowledge of the occurrence, distribution and ecology of species within the Commonwealth marine environ ment is limited. For this reason, surrogates for biodiversity (such as water depth, substrate and seafloor features) were used to design CMR networks.
SWTMF	*South West Trawl Managed Fishery*
TAP	*Threat Abatement Plan*
TED	*Turtle exclusion devices*
TEP(s)	*Threatened, endangered or protected (species)*
Trophic level	The position an organism occupies in a food chain.
Upwelling	The phenomenon of deep ocean water rising to the surface, usually bringing nutrients that can increase biological productivity.

VMS *Vessel monitoring system*

WTBF *Western Tuna and Billfish Fishery*

WTO *Wildlife trade operation*

Appendix 7 Expert Scientific Panel members

Associate Professor R. J. S. (Bob) Beeton AM (Chair)

Associate Professor, University of Queensland

Associate Professor Beeton is employed by the University of Queensland, where he teaches environmental problem solving. He has held many university positions over his 42 years as an academic.

He was Chair of the Australian Threatened Species Scientific Committee from its establishment in 2000 until 2011. The committee is the principle source of statutory advice to the Australian Government Minister responsible for biodiversity conservation. Bob served on the 2001 Australian State of Environment Committee and chaired the 2006 Australian State of Environment Committee.

He has chaired or served on 30 high-level government bodies. His most recent service was to Chair the New South Wales Government Audit of Marine Parks in 2011–12 and he co-chaired the Australia European Union and Australia–Germany scientific dialogue on Biodiversity in 2012.

Bob has received a 1988 Australian Bicentennial award, the 1994 University of Queensland Excellence in Teaching Award and the 2000 University of Queensland Affirmative Action Commendation. In 2000 he was elected a Fellow of the Environmental Institute of Australia and New Zealand. In 2009, he was appointed a Member of the Order of Australia for his contribution to environmental and natural resource management and was named one of 15 Lockyer Legends for his service to the environment and community. In 2013 Bob was awarded a D.Sc. by Prince of Songkla University.

Bob has supervised over 50 higher degree students and publishes widely in his areas of interest.

A more extensive CV is available at www.gpem.uq.edu.au/staff_docs/CV-Bob-Beeton.doc

Professor Colin Buxton

Colin Buxton and Associates Pty Ltd

Professor Buxton is the Principle Consultant at Colin Buxton and Associates and is an Associate Professor at the University of Tasmania (UTas). He has held several senior positions in the university sector in Australia and South Africa and recently retired as Director of the Fisheries, Aquaculture and Coasts Centre, Institute for Marine and Antarctic Studies (IMAS) at UTas. Professor Buxton's expertise spans the biology, ecology and fisheries of inshore reef associated fishes, particularly those that are important to recreational and commercial fisheries. This includes examining life-history changes in exploited populations using marine protected areas (MPAs) as a baseline for unexploited populations.

He has published widely in his field and is author of 123 publications, 76 in the peer-reviewed literature, and his current research focus includes understanding MPA impacts on the coastal environment and assessing their efficacy as a fisheries management tool. Colin has served as a consultant to governments in South Africa and Australia, recently serving on the New South

Wales Government Audit of Marine Parks in 2011–12. He currently serves on several Boards including the Tasmanian Environmental Protection Authority; Seafood Cooperative Research Centre (deputy Chair); Fisheries, Research and Development Corporation; and Southern Rock Lobster Pty Ltd (Chair). He is also a member of the Tasmanian Marine Farming Planning Review Panel and a member of the IUCN Species Survival Commission.

Mr Peter Cochrane

Mr Cochrane has held senior executive leadership and governance roles for nearly 20 years in the public and private sectors and has a background in environmental science, policy and programmes. He was Director of National Parks and head of Parks Australia from 1999 to 2013 and was recently appointed as Chair of the Steering Committee for the NESP Marine Biodiversity Research Hub. He serves on the boards of three not-for-profit companies. He is a past President, Executive Committee member and Honorary Life Member of the Australian Committee for IUCN. He is a member of Ecotourism Australia, the Australian Institute of Company Directors and the IUCN World Commission on Protected Areas.

Professor Sabine Dittmann

Professor Marine Biology, Flinders University

Professor Dittmann works at Flinders University, South Australia. She has several decades of research experience in temperate and tropical coastal ecosystems. Her research focuses on benthic community ecology—in particular, to understand the ecological roles of ecosystem engineers. As coastal ecosystems are subject to various human impacts, her research is also covering aspects of recolonisation and resilience as well as marine invasive species.

She was Director of the Lincoln Marine Science Centre from 2007 to 2012 and member of the Advisory Committee of Marine Innovation South Australia (MISA) from 2008 to 2012. She was a member of the Marine Parks Council in South Australia from 2011 to 2015 and has been a member of the Scientific Advisory Group of the Coorong, Lower Lakes and Murray Mouth since 2008. She was elected Vice-President of the Australian Marine Sciences Association (AMSA) in 2010 and President from 2012 to 2014, and is now Immediate Past President.

Over this entire time, she represented AMSA at the Oceans Policy Science Advisory Group, now National Marine Science Committee, where she became a member of the Executive that lead the development of the National Marine Science Plan. Since 2013, she is also a member of the National Committee for Ecology, Evolution and Conservation of the Australian Academy of Science.

Dr Julian Pepperell

Director, Pepperell Research & Consulting Pty Ltd

Dr Pepperell has over 35 years experience in fisheries science and research, focusing on recreational marine fisheries—in particular, pelagic species including billfish, tuna and oceanic sharks. He is an internationally recognised authority on Istiophorid billfishes and author of the award-winning book, *Fishes of the open ocean* (UNSW Press). He is a longstanding scientific member of the Resource Assessment Group of the Tropical Tuna and Billfish Fishery (AFMA), a past President of the Australian Society for Fish Biology, a recipient of an individual

Conservation Award from the International Game Fish Association and a recipient of a Lifetime Conservation Award from the US-based Billfish Foundation.